International Conference on

Advanced Materials for Sustainable Development

28 29 March, 2025

Malaviya National Institute of Technology (MNIT) Jaipur, India

ICAMSD 2025

Organised by

Department of Metallurgical & Materials Engineering,
Malaviya National Institute of Technology Jaipur

in association with

The Indian Institute of Metals Jaipur Chapter &
Asian Polymer Association

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Sajjan Jindal
President, The Indian Institute of Metals
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MESSAGE

Dear Delegates,

It is a pleasure to welcome you to ICAMSD-2025, organized in association with the Indian Institute of Metals (IIM) and the Asian Polymer Association (APA). This conference brings together experts to explore the role of advanced materials in driving sustainable development.

Since 1946, IIM has been at the forefront of metallurgy and materials science, fostering collaboration between academia, industry, and policymakers. As sustainability becomes imperative, material science will play a pivotal role in shaping a resilient and responsible future.

I encourage you to engage actively, exchange ideas, and seize the opportunities this platform offers. My appreciation to the organizers, participants, and partners for making this event possible.

SAJJAN JINDAL

Malaviya National Institute of Technology Jaipur

Prof. Narayana Prasad Padhy
Director and Chairman (I/c) BoG
Website: www.mnit.ac.in

Message from the Director

Dear Esteemed Delegates,

It is with great pleasure and pride that I extend a warm welcome to all of you to the **International Conference on Advanced Materials for Sustainable Development (ICAMSD-2025)** organized in association with Indian Institute of Metals (IIM) and Asian Polymer Association (APA) hosted by **Department of Metallurgical and Materials Engineering at Malaviya National Institute of Technology Jaipur (MNIT Jaipur)**. This event marks a significant milestone in our commitment to fostering collaborations and promoting cutting-edge research in the field of advanced materials and sustainability.

As an institution dedicated to excellence, we believe that this conference will serve as a platform for sharing innovative ideas, exploring new thoughts, and nurturing meaningful dialogues among scholars, researchers, and professionals.

At MNIT Jaipur, we take immense pride in our rich legacy of academic excellence. Established as one of the premier technical institutes in India, MNIT Jaipur has been at the forefront of nurturing young minds, encouraging interdisciplinary research, and contributing to the development of advanced technologies. Our state-of-the-art infrastructure, world-class faculty, and commitment to research make us an ideal host.
The conference will feature plenary lectures, keynote lectures, paper presentations and networking sessions. We look forward to the engaging discussions and the opportunity to forge lasting partnerships that will continue to shape the future of research and development in the realm of advanced materials and sustainability.

I would like to express my sincere gratitude to all our speakers, participants, and sponsors for their valuable contributions. Together, we will make this event a resounding success. We are excited to have you at MNIT Jaipur and hope that you will have an enriching and memorable experience.

Warm regards

Prof. N. P. Padhy
Director, MNIT Jaipur

Malaviya National Institute of Technology Jaipur
Department of Metallurgical and Materials Engineering

Rajendra Kumar Goyal
Professor & Head
Email: hod.meta@mnit.ac.in

Message from the Chairman, ICAMSD 2025

Dear Distinguished Participants,

It is with great enthusiasm and honour that I welcome you to the ICAMSD 2025 organized in association with the Indian Institute of Metals and Asian Polymer Association. I am excited to witness the coming together of academia, industries, and research institutions, who play a crucial role in shaping the future of sustainable development. The discussions and presentations will address the most pressing challenges of our time, particularly in relation to how advanced materials can contribute to a more sustainable and environmentally responsible future. Advanced and functional materials are at the heart of addressing modern technological and environmental challenges. These materials are key to developing sustainable systems and products that have minimal environmental impact while meeting the needs of a growing global population.

This conference is proudly hosted by the Department of Metallurgical and Materials Engineering, MNIT Jaipur. With cutting-edge laboratories and world-class faculty, the department focuses on a broad spectrum of research areas. The conference will feature a dynamic mix of plenary/invited lectures, oral contributory presentation/posters, and networking opportunities that will provide knowledge and connections to participants needed to tackle the global challenges in materials science.

I would like to express my sincere gratitude to the speakers, organizing committee, our sponsors, and all the participants who have made this event possible. Your enthusiasm and dedication to this important cause are truly inspiring. I encourage all attendees to make the most of this invaluable opportunity to engage in meaningful discussions, share knowledge, and build lasting partnerships. On behalf of the organizing committee and the department, I extend a warm welcome to you all.

Warm regards,

Rajendra Kumar Goyal

ASIAN POLYMER ASSOCIATION

Bhuvanesh Gupta
President (APA)

c/o Department of Textile Technology
Indian Institute of Technology
New Delhi-110016, India
Ph: +91 -9871639232/ 9643754864
Email: apa.asia@gmail.com
Web: www.asianpolymer.org

Message from the President, Asian Polymer Association

Malaviya National Institute of Technology Jaipur is organizing an international conference on Advanced Materials for Sustainable Development (ICAMSD 2025) on March 28-29, 2025 at Jaipur. The conference is a joint activity of MNIT, Indian Institute of Metals (IIM) and Asian Polymer Association (APA) with a vision to have a broader participation of scientists across the different segments of the science and technology. This the first occasion that APA has joined hands with IIM to make a broader perception of the interface between the metals and the polymeric systems. We wish that the APA participation in the event would open up newer dimensions in the technological aspects of the polymeric materials. I am sure that conference will provide an unparalleled opportunity for in-depth engagement and knowledge exchange among leaders in the various domains of science. It will serve as a pivotal forum for the discussion of cutting-edge developments and emerging trends within the international materials science community.

On behalf of APA, I extend a warm invitation to all participants and look forward to welcoming you in Jaipur. We are confident that this conference will not only be an intellectually enriching experience but also a visionary event that shapes the future of the technological evolution across different fields.

Bhuvanesh Gupta

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Programme

International Conference on
Advanced Materials for Sustainable Development (ICAMSD-2025)

28 29 March, 2025

Malaviya National Institute of Technology (MNIT) Jaipur, India

ICAMSD 2025

IIM Metallurgy Materials Engineering

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Department of Metallurgical & Materials Engineering, MNIT Jaipur
in association with
The Indian Institute of Metals Jaipur Chapter & Asian Polymer Association

INAUGURAL PROGRAM

9:00 - 9:05	LAMP LIGHTING
9:05 - 9:10	WELCOME BY ORGANISING SECRETARY, DR. SWATI SHARMA
9:10 - 9:15	ADDRESS BY CONFERENCE CHAIR PROF. R. K. GOYAL
9:15 - 9:20	ADDRESS BY APA PRESIDENT PROF. BHUVANESH GUPTA
9:20 - 9:30	ADDRESS BY THE DIRECTOR & CHAIRMAN (I/c) BOG, MNIT JAIPUR, PROF. N. P. PADHY
9:30- 9:40	THEME ADDRESS BY THE GUEST OF HONOR BRIG. ARUN GANGULI, SECRETARY GENERAL, IIM
9:40 - 9:55	INAUGURAL ADDRESS BY THE CHIEF GUEST DR. KOMAL KAPOOR, CHAIRMAN & CHIEF EXECUTIVE, NFC, DAE
9:55 - 10:00	RELEASE OF THE CONFERENCE SOUVENIR
10:00 - 10:05	PRESENTATION OF MEMENTOS
10:05 - 10:20	MoU CEREMONY BETWEEN MNIT JAIPUR AND NFC, DAE
10:20 -10:25	VOTE OF THANKS BY SECRETARY DR. VIJAY N. NADAKUDURU
10:25 - 10:30	GROUP PHOTOGRAPH

ICAMSD 2025

International Conference on

Advanced Materials for Sustainable Development (ICAMSD-2025)

28-29 March, 2025 | Malaviya National Institute of Technology (MNIT) Jaipur, India

Day 1 (28th March 2025) Programme

Breakfast | Time: 08:15-09:00
Inauguration | (Venue- APJ Abdul Kalam) Hall | Time: 09:00-10:30
Inaugural Tea | Time: 10:30-11:00

Session 1 (11:00-12:40) Venue- APJ Abdul Kalam Hall

Innovations in Materials Development

Moderator: Abhishek Tripathi

Chairs: M. K. Banerjee, SGVU, Jaipur & Prakash Bagga, SMS Metals Pvt. Ltd., Dewas

Time	Lecture	Title/Author
11:00-11:30	PL	Challenges in special steel production in hot rolled products in India ***Ratnaprasad Atluri**, Evonith Steels, Wardha*
11:30-12:00	PL	Out of the box thinking towards sustainable corrosion protection ***Kallol Mondal**, IIT Kanpur*
12:00-12:20	IL	Recent developments in Stainless steel applications ***Chandra Prakash Agrawal,** Synergy Steels Ltd. Alwar*
12:20-12:40	IL	Expanding the Capabilities of X-ray Diffraction: Applications in Mineralogy and Advanced Materials ***Dr. Komal Jain**, Anton Paar India Pvt. Ltd. Gurgaon*

Session 2 (11:00-12:50) Venue- S Radhakrishnan Hall

Innovations in Materials Development

Moderator: Dr. Kunal J. Borse

Chairs: Bhuvanesh Gupta, President APA & Dilip R. Peshwe, VNIT Nagpur

Time	Lecture	Title/Author
11:00-11:30	PL	Nanoparticles in Hydrogels for Catalytic and Controlled Release Applications ***Badiger M V**, CSIR- NCL Pune*
11:30-12:00	PL	Intelligent Energy Generation and Storage: Game Changer Materials and Chemistry ***Kale B B**, MIT World Peace University Pune*
12:00-12:30	PL	Smart Materials: The Challenges in the 21st Century ***Dibyendu Sekhar Bag**, DMSRDE Kanpur*
12:30-12:50	IL	Effect of Natural Sapindus Mukorossi Treatment Process on Bio-Waste Banana Fibers: An Alternative to Chemical Treatment Processes ***Sanjeev Kumar**, PEC Chandigarh*

Lunch Break | Time: 12:50-13:40

Poster Session (12:50-14:45)

Session 3 (14:45-16:45) Venue- APJ Abdul Kalam Hall		
Sustainable Materials		
Moderator: Abhishek Tripathi		
Chairs: Sushil Kumar Mishra, IIT Bombay & A. K. Bhargava, MNIT Jaipur		
Time	Lecture	Title/Author
14:45-15:05	IL	Microstructure Development and Mechanical Property Assessment of Inconel 718 Fabricated by LPBF and WDED ***Sushil Kumar Mishra,*** *IIT Bombay*
15:05-15:25	IL	Development of Useful Aluminum Alloys with High-Iron (Fe) Impurity through Undiluted-Recycling ***Kameswari Prasada Rao Ayyagari,*** *GITAM Visakhapatnam*
15:25-15:37	OL	Study of rheology, durability and strength of self-compacting mortar with optimized fly ash dosage ***Anubala Jangra,*** *M. D. University*
15:37-15:49	OL	Carbonation and Permeation properties of normal concrete, self-compacting concrete and mortar with the effective usage of Fly ash, Marble powder and Stone dust ***Md Marghoobul Haque,*** *IIT Delhi*
15:49-16:01	OL	Scalability and Cost-Effectiveness of Machine Learning in Solar Air Heater Applications ***Jailal Prabhakar Patel,*** *MANIT BHOPAL*
16:01-16:13	OL	Development of porous membranes of thermoplsastic polyurethane/polyphenylsulfone blends for biomedical applications and water treatment ***Ajay Keloth,*** *DIAT, Pune*
16:13-16:25	OL	Advancing Sustainable Construction Materials through Investigation of Fly Ash Blended Cement Mortar Properties ***Soumyaranjan Panda,*** *IIT Delhi*
16:25-16:37	OL	Development of Eco-Friendly Carry Bags Using TPS-PBAT with Nanofillers via Blown Extrusion Techniques ***Chandramani Batsh,*** *CSIR -ICT, Hyderabad*
16:37-16:49	OL	A Comprehensive Review on methods for Predicting Shrinkage in Recycled Concrete Aggregate ***Moorvi,*** *IIT Delhi*

Tea | Time: 16:45-17:00

Session 4 (14:45-16:45) Venue- S Radhakrishnan Hall		
Additive Manufacturing		
Moderator: Suresh Bandi		
Chairs: Animesh Mandal, IIT Bhubaneswar & Jinesh Kumar Jain, MNIT Jaipur		
Time	Lecture	Title/Author
14:45-15:05	IL	3D printed polymer blends and composites with enhanced mechanical properties ***Kadhiravan Shanmuganathan,*** *CSIR-NCL Pune*
15:05-15:25	IL	3D printing of long chain branched polypropylene and structure-property analysis ***Harshawardhan Pol,*** *CSIR-NCL Pune*
15:25-15:45	IL	Real-Time Defect Detection and Process Control in Directed Energy Deposition via Plasma Plume Monitoring ***Ravi K R,*** *IIT Jodhpur*
15:45-15:57	OL	Machine Learning Perspective of Predictive Modelling for Additive Manufacturing ***Jasvinder Singh,*** *PEC Chandigarh*
15:57-16:09	OL	Upcycling of waste polypropylene into high-grade 3D printing filaments ***Animesh Gopal,*** *CSIR-NCL Pune*
16:09-16:21	OL	Influence of Heat Treatments on Mechanical Properties of LPBF Ti-6Al-4V/Ti-6Al-2Sn-4Zr-2Mo Bimetals ***Akhilesh Goyal,*** *IIT Bombay*
16:21-16:33	OL	Tensile and thermal Properties of 3D Printed High-Performance ULTEM 1010 / Short Carbon Fibers Composites ***Sushant Dattatray Sale,*** *MNIT Jaipur*
16:33-16:45	OL	Mechanical performance of 3D printed high-performance polymer ***Krishna Kumar,*** *IIT Jodhpur*

Tea | Time: 16:45-17:00

Session 5 (14:45-16:45) Venue- VLTC-001

Advances in Steels

Moderator: Suresh Bandi

Chairs: Chandra Prakash Agrawal, Synergy Steels, Alwar & Tapan Desai, JLC Electromet, Jaipur

Time	Lecture	Title/Author
14:45-15:05	IL	Refining of Induction Melted Steel, Enhancing Quality and Efficiency ***Prakash Bagga,*** *SMS Metals Pvt. Ltd. Dewas*
15:05-15:25	IL	Deformation-Induced Martensite: Hard or Tough? ***Avala Lavakumar,*** *IIT Ropar*
15:25-15:45	IL	Waste to Wealth: Engineering a Circular Economy through Ferrous Slag Transformation ***Prince Kumar Singh,*** *IIT Ropar*
15:45-15:57	OL	An investigation into the effects of tempering heat treatment on mechanical characteristics of tool steel ***Krishna Kumar,*** *MNIT Jaipur*
15:57-16:09	OL	Influence of intercritical temperature on cryogenic toughness of 7% Ni steel ***Gautam Mishra,*** *IIT (BHU) Varanasi*
16:09-16:21	OL	Optimization of micro-alloying and composition on the strength and toughness of 0.2%C-1.5Mn steel ***Prashant Kumar Singh,*** *IIT (BHU) Varanasi*
16:21-16:33	OL	Improvement of Stretch Flangeability of Boron Steel by Interrupted Loading ***Aman Mohtta,*** *IIT Madras*
16:33-16:45	OL	Bake-hardening (BH) response of DP590 and FB590 hot-rolled steels subjected to various pre-strain levels and baking conditions ***Saish Gulab Kumbhar,*** *COEP Technological University Pune*

Tea | Time: 16:45-17:00

Session 6 (17:00-18:00) Venue- APJ Abdul Kalam Hall

Functional Materials

Moderator: Abhishek Tripathi

Chairs: Badiger MV,CSIR- NCL Pune & Mrityunjay Doddamani, IIT Jodhpur

Time	Lecture	Title/Author
17:00-17:20	IL	Nanofiller-incorporated reticulated vitreous carbon foam for multifunctional applications ***T Umasankar Patro,*** *DIAT Pune*
17:20-17:32	OL	Designing of Nano-heterostructures for Enhanced Photocatalytic Hydrogen Generation ***Sudhir S. Arbuj,*** *CMET Pune*
17:32-17:44	OL	Designing Bioreceptive Polypropylene for Use in Biomedical Applications ***Chetna Verma,*** *IIT Delhi*
17:44-17:56	OL	Self-healing and Shape-memory Behaviour of Poly (Ethylene-co-Methacrylic Acid)/ Thermoplastic Polyurethane Blend Materials ***Shilpi Tiwari,*** *DMSRDE, Kanpur*
17:56-18:08	OL	Plasmonic Coupling Effect of Annealed Gold Nanoarrays ***Gaurav Pal Singh,*** *PEC Chandigarh*

Session 7 (17:00-18:00) Venue- S Radhakrishnan Hall		
Energy Materials		
Moderator: Kunal J. Borse		
Chairs: Kale B B, MIT World Peace University, Pune & Vivekananda, MNIT Jaipur		
Time	Lecture	Title/Author
17:00-17:20	IL	Advanced Chemistry Cell (ACC) Research: Progress at C-MET and Future Plans ***Milind V Kulkarni,*** *C-MET, Pune*
17:20-17:32	OL	Thermal decomposition behaviour of ammonium perchlorate/LaMn0.4Fe0.6O3 composition: an artificial neural networking investigation ***Pragnesh Dave,*** *Sardar Patel University Anand Gujarat*
17:32-17:44	OL	Effect of Li2O-Al2O3-TiO2-P2O5 Addition on Electrical Behaviour of NMC-811 Cathodes for Li-Ion Batteries ***Kaustubh Ramesh Kambale,*** *PEC Chandigarh*
17:44-17:56	OL	Electrochemical study of transition metal substituted strontium titanate ***Tithi Sen,*** *DMSRDE, Kanpur*

Session 8 (17:0-18:00) Venue- VLTC-001		
Polymeric and Bioengineered Materials		
Moderator: Suresh Bandi		
Chairs: Susheel Kalia, IMA Dehradun & Kadhiravan Shanmuganathan, CSIR-NCL Pune		
Time	Lecture	Title/Author
17:00-17:20	IL	Hemostatic Cryogels and Hydrogels for Faster Clotting ***Vivek Verma,*** *IIT Kanpur*
17:20-17:40	IL	High Performance Organic Fibers for Defence Applications ***Swati Chopra,*** *DMSRDE, Kanpur*
17:40-17:52	OL	Development of Smart Biodegradable Mulch Film for Sustainable Agriculture ***Atiqul Islam,*** *CSIR - ICT, Hyderabad*
17:52-18:04	OL	Ultrasound assisted synthesis of ZnO-PEG-chitosan nanobiocide film using Origanum majorana flower extract ***Garima Ameta,*** *MSU, Udaipur*
18:04-18:16	OL	LiH-Polymer Composite Shield for Enhanced Radiation Protection in Space Applications ***Kavita Lalwani,*** *MNIT Jaipur*

Session 9 (17:00-18:00) Venue- VLTC-101		
Sustainable Materials		
Moderator: Deepankar Panda		
Chairs: Kameswari Prasada Rao Ayyagari, GITAM Visakhapatnam & Upender Pandel, MNIT Jaipur		
Time	Lecture	Title/Author
17:00-17:20	IL	A review on Aluminium-rare earth based alloys ***Animesh Mandal,*** *IIT Bhubaneswar*
17:20-17:32	OL	Review of the Correlation between the Microstructure, Arc Modes, and Corrosion Behaviour of SS316L during Wire Arc Additive Manufacturing (WAAM) ***Naveen Porwal,*** *MNIT Jaipur*
17:32-17:44	OL	Fabrication of Low-Temperature Co-Fired Ceramic (LTCC) Ring Resonators by Digital Light Processing (DLP) based 3D printing Technology ***Lalita Bari,*** *C-MET Pune*
17:44-17:56	OL	3D-Printed Polycarbonate Composites Reinforced with Short Carbon Fibers ***Tejas Dilip Rajput,*** *CSIR NCL Pune*
17:56-18:08	OL	Effect of process parameters and heat-treatment on structure and mechanical properties of directed energy deposited near alphaTi6242 alloy ***Sita Choudhary,*** *IISC Bengaluru*

Departure from conference venue at 18:30

Gala Dinner | Venue: Hari Van Resort (Garden) | Time: 19.00-22:00

Day 2 (29th March 2025) Programme

Breakfast | Time: 08:15-09:00

Session 10 (09:00-10:40) APJ Abdul Kalam Hall		
Innovations in Materials Development		
Moderator: Abhishek Tripathi		
Chairs: Kallol Mondal, IIT Kanpur, Kanpur & V C Srivastava, CSIR-NML Jamshedpur		
Time	Lecture	Title/Author
09:00-09:30	PL	Machine Learning Enhanced Imaging and Materials Characterization Methods ***Nikhil Gupta,*** *New York University USA*
09:30-10:00	PL	Plasma Sprayed Ceramic Membrane for Water Filtration ***Anup Kumar Keshri,*** *IIT Patna*
10:00-10:20	IL	Role of Advanced Packaging in the Semiconductor Industry ***Deepak Goyal,*** *Intel Corp*
10:20-10:40	IL	Development of cost-effective and eco-friendly inhibitor to mitigate the corrosion due to ethanol blended petrol ***Deepak Dwivedi,*** *RGIPT, Amethi*

Session 11 (09:00-10:40) Venue- S. Radhakrishnan Hall		
Sustainable Materials		
Moderator: Suresh Bandi		
Chairs: Dibyendu Sekhar Bag, DMSRDE, Kanpur and Kamlendra Awasthi, MNIT Jaipur		
Time	Lecture	Title/Author
09:00-09:30	PL	Resource efficiency & circular economy through e-waste recycling ***R. Ratheesh,*** *C-MET Hyderabad*
09:30-10:00	PL	Advanced Next Generation Biocomposites for Designing Implant Materials ***Kantesh Balani,*** *IIT Kanpur*
10:00-10:20	IL	Development of New High temperature Ti alloys with improved properties ***Jayaprakash Murugesan,*** *IIT Indore*
10:20-10:40	IL	Advancing from Single Crystal to Polycrystalline Technologies for synthesis of Transparent Ceramics: A Roadmap for Future ***Jagmohan Datt Sharma,*** *PEC Chandigarh*

Tea | Time: 10:40-11:00

Session 12 (11:00-13:00) Venue- APJ Abdul Kalam Hall		
High Temperature Materials and Characterizations		
Moderator: Abhishek Tripathi		
Chairs: Nikhil Gupta, New YorkUniversity & Ravi K R, IIT Jodhpur		
Time	Lecture	Title/Author
11:00-11:20	IL	Crystallization Kinetics of Zr-Co-Al Metallic Glass ***Jatin Bhatt,*** *VNIT Nagpur*
11:20-11:40	IL	Microstructure and texture development in UNS S32101 lean duplex stainless steel ***Rajesh Khatirkar,*** *VNIT Nagpur*
11:40-12:00	IL	High strain-rate plastic flow behavior of Ni base superalloys through indentation experiments ***Kumaraswamy Adepu,*** *DIAT Pune*
12:00-12:12	OL	Microstructural Characterization and Phase Transformation Behaviour of Zr-1Nb Alloy during Thermo-Mechanical Processing **Swarup Acharya**, *NFC, Hyderabad*
12:12-12:24	OL	Micro Electro Discharge Drilling Machine: Precision Machining for Micro-Scale Applications ***Saurabh Jain,*** *MANIT Bhopal*
12:24-12:36	OL	Oxidation Fatigue Interaction Behaviour of CM247 DS LC alloy ***Sharat Chandra,*** *MNIT Jaipur*
12:36-12:48	OL	Comprehensive Exploration of Zinc Oxide Nanoparticles: Unraveling the Intricate Intermolecular Properties through Advanced Characterization Techniques ***Brajesh Kumar Ahirwar,*** *MANIT Bhopal*
12:48-13:00	OL	High temperature oxidation behaviour of powder forged IN718 oxide dispersion strengthened (ODS) superalloy ***Suyog Digambar Gaikwad,*** *IIT Roorkee*

Lunch Break Time: 13:00-14:00

Session 13 (11:00-13:00) Venue- S Radhakrishnan Hall		
Advanced Composites		
Moderator: Kunal J. Borse		
Chairs: R K Goyal, MNIT Jaipur & Sanjeev Kumar, PEC Chandigarh		
Time	Lecture	Title/Author
11:00-11:20	IL	Space & Aerospace Materilas: Present Trends & Future Prospectives ***Ravi Kumar Varma,*** *ISRO, Ahemdabad*
11:20-11:32	OL	Strength and Fracture Analysis of Electroless Coated SiC Reinforced Hybrid GFRP ***Sarbjit Singh,*** *PEC Chandigarh*
11:32-11:44	OL	Synergistic Photocatalytic Degradation of Textile Dye using Novel Polypyrrole-Zinc Oxide Nano composite System ***Nandini Venkat Iyer,*** *COEP Technological University Pune*
11:44-11:56	OL	Microstructural and mechanical behaviour of thermally aged Al6082/TiO2/SiC bimodal composite ***Subodh Kumar,*** *MANIT Bhopal*
11:56-12:08	OL	Tribological analysis of T6 heat-treated Al7075 composites reinforced with ceramic and sustainable particles ***Bhagwan Singh Lovevanshi,*** *MANIT Bhopal*
12:08-12:20	OL	Impact and Post-Impact Damage Assessment of Hybrid Basalt Fiber Composites Reinforced with Flax, Hemp, and Glass Fibers via Hand Layup ***Adarsh Chaurasiya,*** *MANIT Bhopal*
12:20-12:32	OL	Influence of Dispersion Routes on the Multifunctional Properties of LLDPE/CNF Nanocomposites ***Vaibhav Jain,*** *IIT Delhi*
12:32-12:44	OL	Electrical Properties of Uncoated Ni and Carbon Coated Ni Nanoparticles Reinforced Poly(ether-ketone) Nanocomposites ***Roshan D Gadve,*** *MNIT Jaipur*
12:44-12:56	OL	Tailoring electrical and thermal properties of poly(ether-ketone) using Bamboo like-Carbon nanotubes: Prospects for EMI shielding ***Mohini Tiwari,*** *IIT Roorkee*
12:56-1:08	OL	Fabrication and characterization of in-situ A356-TiB2 composites disc through intensive high shear mixing and centrifugal casting process ***Sunil Manani,*** *PEC Chandigarh*

Lunch Break Time: 13:00-14:00

Session 14 (11:00-13:00) Venue- VLTC-001		
Light Metals and Alloys		
Moderator: Suresh Bandi		
Chairs: Kantesh Balani, IIT Kanpur, Kanpur & Swati Sharma, MNIT Jaipur		
Time	Lecture	Title/Author
11:00-11:20	IL	Synthesis of Ti-Al Intermetallic by MASHS Technique and Study its MW Absorption Properties in Ceramic Matrix ***Yojana Janu,*** *DL Jodhpur*
11:20-11:40	IL	Effect of Tensile Twinning on Microstructure and Texture Evolution in AZX311 Mg Alloy under Cyclic Shear Deformation ***Jaiveer Singh,*** *IIT Jodhpur*
11:40-11:52	OL	Micro-alloying and grain refinement of Mg-alloy using friction stir processing ***Kamal Kumar,*** *PEC Chandigarh*
11:52-12:04	OL	Effect of Incident Velocity on damage of layered targets in Ballistic Applications ***Bhonsle Chetankumar,*** *DIAT Pune*
12:04-12:16	OL	Effect of Fragments shapes and materials on damage of layered Targets in Ballistic Applications ***Kirit Prasad Gogineni,*** *DIAT Pune*
12:16-12:28	OL	Effect of Angle of Obliquity on damage of layered Targets with varying thickness in Ballistic Applications ***Saleha Haque,*** *DIAT Pune*
12:28-12:40	OL	Comparison of Uniaxial and Torsional Low Cycle Fatigue Behavior of a Cu-Ni Alloy ***Adarsh Bharti,*** *IIT Jodhpur*
12:40-12:52	OL	Development and characterization of functionally graded A6061-TiB2 composites using high shear mixing and centrifugal casting technique ***Nidhi Sindhu,*** *MNIT Jaipur*

Lunch Break Time: 13:00-14:00

Session 15 (11:00:13:00) Venue- VLTC-101		
Advanced Composites		
Moderator: Deepankar Panda		
Chairs: Amar Patnaik, MNIT Jaipur & Sreekumar V. Madam, MNIT Jaipur		
Time	**Lecture**	**Title/Author**
11:00-11:20	IL	Materials for Critical Technology and Human Space Missions ***Prateek Bansal,*** *ISRO, Ahemdabad*
11:20-11:32	OL	Strain Rate Sensitivity and Energy Absorption Characteristics of PU Foam under Effective Loading ***Vedant Utikar, DIAT, Pune***
11:32-11:44	OL	Poly(ether-ketone) nanocomposites with functionalized MWCNTs for EMI shielding ***Roshan D Gadve,*** *MNIT Jaipur*
11:44-11:56	OL	Adhesives and their Various Applications ***Meenakshi Pal,*** *University of Rajasthan, Jaipur*
11:56-12:08	OL	Study on Poly(ether-ketone)/Silica Nanocomposites for Electronic Applications ***Mandar J Joshi,*** *Dr S and S S Gandhi College of Engineering and Technology, Surat*
12:08-12:20	OL	Effect of fragment mass on damage of hybrid targets in Ballistic Applications ***Rishabh Subhash Almel,*** *DIAT Pune*
12:20-12:32	OL	PEEK Composites: A Promising Structural Material for Space Radiation Protection Sreedevi V V, *MNIT Jaipur*
12:32-12:44	OL	Direct Energy Deposition-Based Composite Fabrication ***Mohit Sharma,*** *IIT Roorkee*
12:44-12:56	OL	Corrosion Resistance and wear analysis of AA7050 through TiO2/BN Reinforcements ***Anil Chourasiya,*** *MANIT Bhopal*
12:56-13:08	OL	Analysis of corrosion behaviour and electrical conductivity of AA7075/HEAp composite ***Pradip Kumar Verma,*** *MANIT Bhopal*

Lunch Break Time: 13:00-14:00

Session 16 (14:00-16:00) Venue- APJ Abdul Kalam Hall		
Corrosion and coatings		
Moderator: Abhishek Tripathi		
Chairs: Jagmohan Datt Sharma, PEC, Chandigarh & Randhir Kumar Singh, MNIT Jaipur		
Time	Lecture	Title/Author
14:00-14:20	IL	Corrosion and Slow Strain Rate Tests of a micro-alloyed Steel and with nano-crystalline Ni-coating by Pulse Plating and Ti-6Al-4V Alloy under Applied Potentials ***Karuna Sindhu Ghosh,*** *NIT Durgapur*
14:20-14:32	OL	Influence of Silicon Addition on the Microstructure, Hardness and Corrosion performance of Al-6.5Mg Alloys ***Kyada Tushal Kalubhai,*** *Dr S and S S Gandhi College of Engineering and Technology*
14:32-14:44	OL	Examination of the corrosion inhibition properties of plant extract on the corrosion of DSS2205 in an acidic environment ***Swati Chaudhary,*** *RGIPT, Amethi*
14:44-14:56	OL	Development of inhouse inhibitor for the application in reduction of corrosion in storage of ethanol blended petrol ***Saurabh Kumar,*** *RGIPT, Amethi*
14:56-15:08	OL	Blister resistive and corrosion resistive additives for zinc primer ***Siddharth Atal,*** *RGIPT, Amethi*
15:08-15:20	OL	Synergistic effect of Al2O3 and MoS2 on the corrosion behaviour of plasma sprayed aluminium matrix composite coating ***Saurav Keshri,*** *IIT Patna*
15:20-15:32	OL	Influence of Novel Thermomechanical Processing on Microstructure, Mechanical Properties, and Tribological Behaviour of Ti-6Al-4V Alloy Sandeep Mahore, *MNIT Jaipur*
15:32-15:44	OL	Impact of particle velocity on HVOF coating properties: A state-of -the -art review ***Atirek Gaur,*** *MNIT Jaipur*
15:44-15:56	OL	Corrosion Behaviour of Alx(CoCrFeNi) high entropy alloys in 3.5% NaCl Aqueous Solution ***Vaibhav Kathavate,*** *MIT World Peace University Pune*

Tea | Time: 16:00-16:15

Valedictory Function | Time: 16:15-17:15

Session 17 (14:00-16:00) Venue- S Radhakrishnan Hall		
High Entropy Alloys and Powder Metallurgy		
Moderator: Kunal J. Borse		
Chairs: Jatin Bhatt, VNIT Nagpur & Vijay N N, MNIT Jaipur		
Time	**Lecture**	**Title/Author**
14:00-14:20	IL	Iron (Fe) rich medium entropy alloy: Microstructural evolutioAn and mechanical properties ***Vikas Chandra Srivastava,*** *CSIR-NML Jamshedpur*
14:20-14:32	OL	Study the effect of different annealing conditions on phase and microstructure evolution of CoCrFeNi-Ti high entropy alloy synthesized through mechanical alloying ***Apoorva Vashishtha,*** *MNIT Jaipur*
14:32-14:44	OL	Evaluation of Microstructural and Mechanical Properties of Microwave Sintered FeNiCoCr High-Entropy Alloy reinforced with SiC Particles ***Radha Raman Mishra,*** *BITS Pilani*
14:44-14:56	OL	Monte-Carlo simulation-based study of the annealing twinning of high entropy alloys and its influence on microstructure and texture evolution ***Lalit Kaushik*** *IIT Jodhpur*
14:56-15:08	OL	Correlating Structural and Mechanical Properties of (MoNbTaW)N films as a Function of Deposition Temperature ***Venkata Girish Kotnur,*** *University of Hyderabad*
15:08-15:20	OL	Development of CoCrFeNiSi0.5 Multi Component Alloy surface coating on plain carbon steel through a novel in-situ weld surface alloying approach ***Veera Sreenu Addepalli,*** *Rajiv Gandhi University of Knowledge Technologies Nuzvid*
15:20-15:32	OL	Effect of Al on microstructure and Phase evolution of CoCrMnNiFeAlx high entropy alloy processed via mechanical alloying ***Uday Pratap Singh Bais,*** *MANIT Bhopal*
15:32-15:44	OL	Structure-Property Co-relation with Hydride Orientation in Zircaloy-4 Seamless Clad and Zirconium Lined Zircaloy-4 Duplex Clad for Water Cooled Reactors ***Swarup Acharya,*** *NFC, Hyderabad*

Tea | Time: 16:00-16:15

Valedictory Function | Time: 16:15-17:15

Session 18 (14:00-16:00) Venue- VLTC-001		
Waste to Wealth		
Moderator: Suresh Bandi		
Chairs: Kameswari Prasada Rao Ayyagari, GITAM University, Vishakhapattanam & Yojana Janu, DL Jodhpur		
Time	Lecture	Title/Author
14:00-14:12	OL	Synthesis of strategic NdF3/PrF3 mixed-fluorides from indigenous sources for strategic applications ***Sai Anuraag Namuduri,*** *C-MET, Hyderabad*
14:12-14:24	OL	Transforming Waste to Value: Sewage Sludge Biochar for Sustainable Dye Removal ***Bhavana Shanmughan,*** *DIAT, Pune*
14:24-14:36	OL	Sustainable Recovery of Valuable Metals from Jarosite Residue Using a Sulfationâ€"Roastingâ€"Leaching Process ***Manorama Swain,*** *The Maharaja Sayajirao University of Baroda, Vadodara*
14:36-14:48	OL	Sustainable Strategies for Recycling and Recovery of Electrical Industrial Waste ***Ankit Bhojani,*** *The Maharaja Sayajirao University of Baroda, Vadodara*
14:48-15:00	OL	Stability behaviour and thermophysical characteristics of nano-particles integrated to improve the performance of refrigeration systems- A review ***Md Jamil Akhtar,*** *MANIT Bhopal*
15:00-15:12	OL	Rice husk ash filled glass epoxy hybrids: A sustainable microwave absorbing material ***Vaibhav Sanjay Darekar,*** *MNIT Jaipur*
15:12-15:24	OL	Applications of Nanomaterials for Soft Robotics: A Review ***Sandeep Mahore,*** *MNIT Jaipur*
15:24-15:36	OL	Tribological Investigation of Fiber Orientation Effect on the Wear Performance of Bamboo Fiber and Recycled Glass Fiber Epoxy Hybrid Composite ***Deepa Ahirwar,*** *MANIT Bhopal*

Tea | Time: 16:00-16:15

Valedictory Function | Time: 16:15-17:15

Session 19 (14:00-16:00) Venue- VLTC-101		
Innovations in Materials Development		
Moderator: Deepankar Panda		
Chairs: Rajesh Khatirkar, VNIT Nagpur & Anup Kumar Keshri, IIT Patna		
Time	Lecture	Title/Author
14:00-14:20	IL	3D Printing - Challenges and Opportunities ***Mrityunjay Doddamani,*** *IIT Jodhpur*
14:20-14:32	OL	Development of Aluminium Alloy Anode Material and a Prototype Aluminium-Air Battery *Utkarsh Bhadauria, VNIT Nagpur*
14:32-14:44	OL	Synthesis of NiO/g-C3N4 Based Nano-Heterostructures: An Efficient Photocatalytic System for Hydrogen Generation ***Amol Gulabrao Kadlag,*** *S.N. Arts, D.J.M. Commerce and B.N.S. Science College (Autonomous), Sangamner*
14:44-14:56	OL	Can PVP-Tuned ZIF-67 Derivatives Enhance Hydrogen Production in Seawater Splitting? ***Manisha Jain,*** *CSIR-NCL Pune*
14:56-15:08	OL	An Ultra-Fast and Facile Fabrication of Turbostratic Holey Graphene and its Electrochemical Behaviour ***Niranjan Pandit,*** *IIT Patna*
15:08-15:20	OL	Innovative Design Strategies for PP Mesh Surfaces in Infection-Resistant Healthcare System ***Vipula Sethi,*** *IIT Delhi*
15:20-15:32	OL	N-Acryloyl phenylalanine and their anti-inflammatory potential on Lipopolysaccharide-induced raw 264.7 macrophages; Systemic inflammation on a rat model ***Divya Pareek,*** *IIT(BHU) Varanasi*
15:32-15:44	OL	Synthesis, characterisation, and comparative assessment of general-purpose flexible polyurethane foam versus medical-grade polyurethane foam ***Jay Hind Rajput,*** *IIT Ropar*

Tea | Time: 16:00-16:15

Valedictory Function | Time: 16:15-17:15

Plenary Lectures

Challenges in special steel production in hot rolled products in India

Ratnaprasad Atluri

Evonith Metallics Limited, Wardha, Maharashtra
India

Abstract

The steel industry has undergone a significant transformation over the past few decades, driven by advancements in metallurgical processes, casting technologies, and sustainable production methods. High-Strength Low-Alloy (HSLA) steels, API-grade steels, automotive exposed steels (IF and ELC), electrical steels, and high-carbon steels serve critical roles across various sectors, including infrastructure, energy, transportation, and manufacturing. The production of these advanced steel grades requires precise control over chemical composition, microstructure evolution, thermomechanical processing, and secondary refining to meet stringent mechanical and operational demands. The transition from ingot casting to continuous casting, the shift from open-hearth furnaces to Basic Oxygen Furnaces (BOF) and Electric Arc Furnaces (EAF), and the incorporation of thin slab casting and direct rolling technologies have significantly improved efficiency, product quality, and sustainability in steel production. Furthermore, secondary steelmaking processes such as vacuum degassing, ladle metallurgy, and desulfurization techniques have enabled the production of ultra-clean, low-carbon, and high-strength steels essential for modern applications. This paper explores the challenges and technological advancements in producing specialized steel grades, emphasizing the role of thermo-mechanical controlled processing (TMCP). Additionally, it highlights how modern innovations contributed to the development of high-performance steels while improving efficiency in the steelmaking industry.

Smart Materials: The Challenges in the 21st Century

Dibyendu S Bag[a]

[a]Defence Materials and Stores Research and Development Establishment
DMSRDE PO, G. T. Road, Kanpur-208013
Email: ds_bag@rediffmail.com

Abstract

Inspiration from nature is a popular theme in today's materials science. The driving force behind the frontier materials' research in the field of smart materials is biomimetics. The idea is to produce artificial systems that should intelligently work like a biological function. The concept of smart materials may be new, but smart materials themselves go back a long way. The Curie brothers discovered the piezoelectricity of minerals in 1880 wherein such materials produce an electrical signal when squeezed. Smart materials have the capability to respond adaptably by reversible changing any of their properties under an external stimulus. The stimuli may be temperature, pressure, light intensity, chemical trigger, electric and magnetic field etc. But electric field stimulus is considered to be very useful as it could be controlled easily. Now-a-days, imparting smart features into materials and components is the demand of fulfilling the requirement of cutting-edge technologies in defence, aerospace, missiles, sophisticated biomedical and other civilian applications. Self-healing materials can repair themselves when they are damaged, which find numerous applications because it can provide safety aspect of the components in its use as well longevity. Therefore, it can also help us to create a more sustainable future. Smart materials have the potential to change engineering, technology and design principles completely toward the creation of 'smart world'. However, lots of challenges must have to overcome for their successful application and sustainable materials' solution. This article describes an overview of smart materials including research at Author's laboratory as well as challenges in the 21st century therein.

Out of the box thinking towards sustainable corrosion protection

K. Mondal

Department of Materials Science and Engineering,
Indian Institute of Technology Kanpur, UP, India - 208016

Abstract

Corrosion of metals and alloys is an unavoidable occurrence, and it leads to several economic losses and safety hazards. Hence, corrosion mitigation has become of paramount importance, and various protective measures have been developed successively. However, current drive for sustainable, environment friendly, cost effective and disrupting solution to corrosion protection has become paramount. We shall cite two such application fields towards corrosion protection.

One of the best ways of corrosion protection is the usage of corrosion inhibitors. Corrosion inhibitors are chemical compounds which when used in very smaller quantities, reduce corrosion rate. These are classified mainly into two types of categories based on the economic feasibility, ease of processing, synthesis, and its effectiveness in reducing corrosion rate at lower concentrations. These are traditional inorganic corrosion inhibitors (TICI) like Ca(NO3)2 and synthetic organic corrosion inhibitors (SOCI) like azomethine polyamides. They are mostly nitrate based inhibitors and despite of their effectiveness; both are detrimental to the environments. The quest for eco-friendly, non-toxic, cheaper alternatives has fostered the research towards the exploration of naturally occurring inhibitors. Nature is an abundant resource of different organic materials with different physical, chemical, and biological properties. There are considerable efforts on finding some alternative inhibitors which can be extracted from plants, plant wastes as well as animal waste. These are termed as Green Corrosion Inhibitors (GCI). In our current work, we have introduced easier and simpler method for extraction of the chemicals responsible for the inhibition of corrosion of mild steel in chloride contaminated electrolyte solution with varying pH of 3 to 13 from plant leaf, cattle manure and its associated biomass, leather buffing dust, etc. These resources (naturally abundant, renewable, however challenging if mismanaged) can become excellent, adaptive, versatile, and sustainable green corrosion inhibitors. Sacrificial anodes are used for cathodic protection of steels from corrosion. It includes pile line, water vessel, rebars, etc. Zn, Mg and Al are popular anodes, which act as anodes in the galvanic couple with the steel. Very recently, a group at IIT Kanpur and Tata Steel Ltd., Jamshedpur have come up with some innovative anodes made of blast furnace metal, which contains 1.5 to 8wt% P. It is like "iron protects iron". Though those anodes have shown successful protection to rebars, the sacrificial anode criterion, -850 mV with reference to Cu/CuSO4 reference, could not be reached. However, after constant collaborative effort could make some well-designed hybrid anodes based on high P pig iron with little Zn, Mg and Al to take the potential well below -850 mV, rendering them to match with Zn anodes. In addition, the coatings made out of simple pig iron show excellent corrosion as well as erosion protection. We have also explored making anodes from Zn as well as galvalume dross. Complete characterization along with efficiency measurement shows that these anodes could pave the path for new generation low cost highly efficient sacrificial anodes.

Acknowledgement: Tata Steels Ltd., IIT Kanpur and all the contributing masters and PhD students

Machine Learning Enhanced Imaging and Materials Characterization Methods

Nikhil Gupta, PhD, FASM

Professor, Mechanical and Aerospace Engineering
New York University, Tandon School of Engineering
Brooklyn, NY 11201 USA

Abstract

Materials characterization relies on advanced imaging and mechanical testing methods to analyze material properties across multiple scales. These techniques generate vast amounts of high-dimensional data, often requiring extensive manual interpretation. Characterizing a material across temperature, strain rate, and materials compositions requires a significant experimental campaign consuming extensive time and material. Machine learning (ML) has emerged as a transformative tool in imaging and materials characterization, enabling automated data analysis, pattern recognition, and enhanced predictive modeling. Deep learning, particularly convolutional neural networks (CNNs), has significantly improved image-based characterization by extracting complex features from microscopy and spectroscopy images with high accuracy. Integrating ML with imaging and characterization techniques not only reduces analysis time but also enhances precision, consistency, and insight generation. Despite these advancements, challenges such as limited labeled datasets, model interpretability, and the need for physics-informed AI persist. This presentation will discuss application of ML in imaging and material analysis to reduce the time and effort and increase precision of results.

Nanoparticles in Hydrogels for Catalytic and Controlled Release Applications

Manohar V. Badiger

Polymer Science and Engineering Division
CSIR-National Chemical Laboratory (NCL)
Dr. Homi Bhabha Road, Pune – 411 008, India
E mail:mv.badiger@ncl.res.in

Abstract

Nanoparticles (NPs) have been extensively used in a wide range of applications, such as, controlled drug delivery, biomedicine, sensors, catalysis and opto-elctronics due to their unique electronic properties, high surface to volume ratios and good biocompatibility. However, issues like aggregation, non-dispersibility of NPs in aqueous medium invariably crops up. Therefore, NPs are incorporated into polymer matrices and particularly, in-situ synthesis of metal NPs in the polymer matrices/hydrogels is an excellent alternative. In the present work, we report on a simple and convenient method for generating and immobilizing gold NPs (Au-NPs) into polyethylene glycol-polyurethane (PEG-PU) hydrogel matrices and demonstrate their catalytic application for a model reduction reaction of 4-nitroaniline (4NA) to p-phenylenediamine (p-PDA) in the presence of sodium borohydride. The gold NPs immobilized PEG-PU hydrogel matrices could be reused and the reusability for 28 cycles yielding a total turnover number of 3220 and turn over frequency of 0.152s-1 is shown. We also report on the Ag-NPs incorporated double cross-linked hydrogels for controlled release applications wherein the degree of crosslinking could be reduced by selective breaking of one crosslinking agent and effecting the release of Ag-NPs due to enhanced swelling.

Intelligent Energy Generation and Storage: Game Changer Materials and Chemistry

Dr. Bharat B. Kale

Emeritus Professor, MIT World Peace University (MIT-WPU), Kothrud, Pune 411 038
Former DG, Centre For Materials For Electronics Technology (C-MET), Pune
Email: bbkale1@gmail.com and bharat.kale@mitwpu.edu.in

Abstract

As humanity shifts toward a renewable energy economy, the demand for cost-effective and efficient energy generation and storage solutions is growing. Advancements in solar cells and hydrogen fuel cells play a crucial role in this transition, with green hydrogen gaining prominence due to its high energy density. Green hydrogen, produced using renewable sources such as biomass, water, and seawater, is becoming an attractive option for sustainable energy. Photocatalytic hydrogen production under natural sunlight has been extensively studied using materials such as CdS, CdIn S , ZnIn S , nitrogen-doped semiconductors, and nano-heterostructures. Additionally, quantum dot-based photocatalysts are emerging as novel materials for efficient hydrogen generation. Beyond production, hydrogen storage is critical for applications in consumer electronics, agriculture, and transportation. Both liquid and solid-state hydrogen storage methods are being explored to enhance safety and efficiency. Rechargeable battery technologies also play a vital role in energy storage, with lithium-ion batteries (LIBs) currently dominating the market. However, their reliance on rare and expensive materials limits their long-term scalability. LIB technology has matured with well-established cathode chemistries such as Lithium Cobalt Oxide (LCO) and Nickel Manganese Cobalt (NMC) variants (e.g., NMC 111, NMC 532, NMC 811). Anode materials, including Lithium Titanate (LTO), Molybdenum Disulfide (MoS), and silicon, have also been widely studied. Despite these advancements, material costs and availability remain challenges. To address these limitations, researchers are actively exploring alternative battery chemistries such as sodium-ion and lithium-sulfur batteries. Investigating their cathode and anode materials, as well as their electrochemical properties, can lead to more cost-effective and efficient energy storage solutions. The development of innovative materials and chemistry that enhance energy density, improve charge/discharge cycles, and reduce environmental impact will be key to next-generation battery technologies.

Resource Efficiency and Circular economy through Urban Mining

R. Ratheesh

Centre for Materials for Electronics Technology (C-MET), Ministry of Electronics & Information Technology (MeitY), Government of India, IDA Phase III, Cherlapalli, HCL (P.O.), Hyderabad 500 051 INDIA
e-mail: ratheesh@cmet.gov.in

Abstract

With the rapid technology innovation and digital product marketing strategies allure replacement of the electronic gadgets at a faster pace resulting in ever-increasing generation of waste electrical and electronic equipment (WEEE) or otherwise known as e-waste. More than 62 million tonnes of electronic waste are generated every year globally, which could bring serious risks to the human health and the environment. India is the second largest e-waste generator in Asia and the third largest generator in the world at an estimated 4.1million tonnes per annum. The unscientific disposal of e-waste leads to leaching of heavy metals and flame retardants into the soil and thereby contaminating the ground water. On the other hand, there are many precious and critical materials are available in the WEEE and hence is known as seventh resources. Recovery of secondary raw materials from e-waste is one of the important pre-requisites for achieving sustainable development goals (SDGs) set forth by United Nations by 2030.

The printed circuit boards (PCBs) are the basic building block on which microelectronic components such as semiconductor chips, capacitors, resistors etc. are mounted. PCBs provide the electrical interconnections between components and are found in virtually all EEE products. Recycling of waste PCBs is an important subject not only from the treatment of waste perspective but also for the recovery of precious metals as well. The typical metals in PCBs consist of copper, iron, tin, nickel, lead, zinc, silver, gold, and palladium. Due to its heterogeneous nature, PCBs recycling requires a multidisciplinary approach intended to separate fibers, metals and plastic fractions and reduce environmental pollution. In India, even in densely populated regions, e-waste recycling is practiced using rudimentary techniques. Most of the participants in this sector are unaware of the risks, possess no knowledge of best practices, or simply have no access to investment capital to finance profitable improvements. Even though there are conventional disposal strategies for e-waste management, these methods have disadvantages from both the economic and environmental standpoints.

A state-of-the-art Centre of Excellence (CoE) on E-waste Management is established at C-MET, Hyderabad for the development of environmentally benign e-waste recycling technologies and dissemination of the same to industries for safe recovery of secondary resources. CoE on e-waste Management is promoting development of cost effective recycling solutions for End of Life Printed Circuit Boards, Li-Ion batteries, Si Solar cells and Permanent Magnets to ensure resource efficiency and circular economy. The empowerment of start up eco-system and skill development in the area of e-waste management are also being taken up by the CoE. Another important objective of the CoE is the upgradation of informal sector activities through Common Facility Centres (CFCs).

Plasma Sprayed Ceramic Membrane for Water Filtration

Anup Kumar Keshri

Associate Professor, Associate Dean, R&D, Project Director, TIH
Metallurgical and Materials Engineering, Indian Institute of Technology Patna
Bihta, Patna, Bihar, 801106

Abstract

The scarcity of fresh water is a pressing issue due to the rapid growth of the population, industrialization, pollution, etc. Therefore, a membrane dealing with various major issues simultaneously could help for application even the pathway of commercialization and fulfil the fresh water scarcity. These issues are as following (i) One step and industrial friendly membrane fabrication technique (ii) high water flux at low transmembrane pressure (TMP) (iii) higher contamination rejection rate (iv) low fouling and (v) mechanically robust. Herein, we demonstrated an impressive approach to fabricate ceramic membranes using a large throughput atmospheric plasma spraying (APS) technique for water filtration. Plasma sprayed YSZ membranes were fabricated with three different thicknesses, viz., 100, 200, and 300 μm containing 30% porosity. Among the pores, 80% of the pores were in the range of 0.3–1.2 μm. The plasma sprayed YSZ membranes unveiled pure water flux, contamination rejection rate, and permeability for various feed water (waste, salt water) up to 370 $Lm^{-2}h^{-1}$, >95% and 380 $Lm^{-2}h^{-1}bar^{-1}$respectively. The membranes also showed excellent fouling resistance, a superhydrophilic nature (Contact Angle < 10°), and outstanding reusability with the added advantage of intact mechanical properties. Their mechanical properties, viz. hardness, elastic modulus, and fracture toughness, range from 5 to 7 GPa, 120–145 GPa, and 2.3–2.5 $MPam^{-1}$respectively. Our plasma sprayed YSZ membranes are cheaper and can be utilized in various sectors such as urban water filtration, industrial waste water filtration, food and pharmaceutical industries, etc.

Advanced Next Generation Biocomposites for Designing Implant Materials

Kantesh Balani, FASM, FNASc, FNAE

Yadupati Singhania Memorial Chair, Professor & Head Department of Materials Science and Engineering, Indian Institute of Technology Kanpur, Kanpur-208016, Uttar Pradesh, India.
Email: kbalani@iitk.ac.in

Abstract

The associated trauma of bacterial infection, especially after post-surgery, becomes very painful for the patients. Thus, the perspective of nanobiotechnology engineer in selecting antibacterial materials and eliciting enhanced resistance to bacterial adhesion is addressed in the current presentation. Herein, attachment of S. Aureus gram positive bacteria on various substrates, i.e. metallic (316L stainless steel and Ti-6Al-4V), polymeric (ultra-high molecular weight polyethylene, UHMWPE), and ceramic (hydroxyapatite, HA) is assessed. The adhesion strength of bacterium is evaluated using atomic force spectroscopy by gluing S. Aureus on its tip-less cantilever. Lowest adhesion strength of bacterium observed on UHMWPE surface contrast with conventional results of lowest colony forming units (with most %dead bacteria on HA surface. Poisson's regress has elicited lower long-range and short-range adhesion forces in UHMWPE compared to that of HA and others. Computational modelling has been utilized to visualize the adhesion of bacterial surface proteins with biomaterial surfaces. Multi length scale damage assessment with antibacterial ZnO and Ag reinforcement have rendered elicited reduced wear. Extension to utilization of 58S Bioglass as bioresorbable material to encourage bone-regrowth, the transient response (up to 1000 ms), and role of antioxidant CeO2 and antibacterial Ag are also elucidated. Further, a step towards 3-D printing is directed for eventual bio-printing. In addition, the design of newer bioresorbable materials also appears to be potential direction for bone-replacement applications.

Keywords: Biomaterials, S. aureus bacteria, Atomic force microscope (AFM), Adhesion strength, Molecular dynamics, 58S Bioglass, 3-D printing.

Invited Lectures

Development of New High temperature Ti alloys with improved properties

[a]Jayaprakash Murugesan

[a]Department of Metallurgical Engineering and Materials Science, IIT Indore, Indore, Madhya Pradesh, India
Email: jayaprakash@iiti.ac.in

Abstract

Titanium alloys especially Ti-Al-Zr-Sn based near alpha Ti alloys are used for high temperature applications in jet engine components. The maximum temperature range that near alpha Ti alloys can be used currently is up to 600°C. At above 600°C, its strength decreases drastically due to the microstructure instability. In the regions temperature over 600°C, Nickel based superalloys are being used, which are two times heavier than that of Ti alloys. If a new high temperature Ti alloy with improved properties to use in the temperature range 600- 700°C has been identified, it would be possible to save weight and increase heat efficiency and thereby reducing the fuel cost. One of the effective techniques to enhance the mechanical properties is by alloying additions. In the present study, the effect of nitride additions on Ti-Al-Zr-Sn based near alpha Ti alloys on mechanical properties and microstructure features at room temperature and high temperature has been investigated. The results revealed that the mechanical properties have significantly enhanced with nitride addition at both room temperature and high temperature. The results were discussed based on the microstructure characterization using optical microscope, SEM, TEM., mechanical properties characterization using micro hardness test, compassion test at room temperature and at 650°C.

Keywords: Titanium alloys, high temperature, alloying addition, mechanical properties, microstructure characterization

Nanofiller-Incorporated Reticulated Vitreous Carbon Foam for Multifunctional Applications

[a]Rohit Bagal, [a]Kaumudi Yadav and [a]T. Umasankar Patro*

[a]Department of Metallurgical and Materials Engineering, Defence Institute of Advanced Technology, Girinagar, Pune - 411025, India
[*]Email: uma.patro@gmail.com

Abstract

Reticulated vitreous carbon (RVC) foam is a lightweight, open-cell, glassy carbon foam with a 3-dimensional network-like structure. The foam is electrically conducting and has a predominant carbon content, i.e., ~97%. Due to its unique structure and physical properties, the foam is used as electrodes in energy storage devices, electromagnetic interference (EMI) shielding material, cathode emission, metal slag filters, biological scaffolds, etc. RVC foam is made by the carbonization of polyurethane (PU) foam, coal tar pitch, and melamine foam. However, it was realized that the incorporation of nanoparticles into carbon foam can further improve its properties and open up new areas of applications. The present talk will highlight our recent efforts in modifying the carbon foam with various nanofillers for EMI shielding, microwave absorption, oil-water separation, supercapacitor energy storage, and biological cell growth properties of nanofiller-embedded carbon foams. To improve the EMI shielding and microwave absorption properties, fumed silica was incorporated into carbon foam by dispersing the fumed silica in isocyanate before making PU foam. A small silica content (~1 wt%) was found to improve the EMI shielding and microwave absorption properties of carbon foam significantly. In another study, NiCo2O4 (NCO) nanoneedle-like structures were grown on the carbon foam surface by hydrothermal method. The NCO-coated foam showed improved microwave absorption than that of pristine carbon foam and also exhibited supercapacitor electrochemical energy storage properties; while the pristine foam did not show any super capacitive behavior. A superhydrophobic RVC foam was prepared by vapor deposition of poly dimethyl siloxane (PDMS) oil. The resulting foam showed a water contact angle of 168□ and excellent oil-water separation behavior. Further, the incorporation of graphene oxide into RVC foam showed improved biological cell growth.

Corrosion and Slow Strain Rate Test of Micro-Alloyed Steel and with Nano-crystalline Ni-coating by Pulse Plating and Ti-6Al-4V Alloy under Applied Potential

K S Ghosh[a], P Siva Prasad[b] and M M Ghosh

[a]National Institute of Technology - Durgapur, India and
[b]Research Scholar, Indian Institute of Technology - Kharagpur, India.
E-mail: ksghosh.mme@nitdgp.ac.in

Abstract

A fine-grained micro-alloyed was subjected to different heat treatments to produce the varying grain-sizes. An optical microscopy and TEM are observed the microstructures of different heat-treated steel. Potentiodynamic polarisation and electrochemical impedance spectroscopy (EIS) were studied in 3.5 wt. % NaCl solution. Slow strain rate tests (SSRT) at a strain rate of ~10−6 s−1 in air and 3.5 wt. % NaCl solution under applied anodic and cathodic potentials were done in both the micro- and Ti-6V-4Al alloys. FETEM fractography studies of SSRT tested samples were observed, and possible stress corrosion cracking (SCC) and hydrogen embrittlement (HE) have been evaluated. The as-received micro-alloyed steel was coated with nano-crystalline (NC) Ni using the pulse current electrodeposition technique. EIS study was done to evaluate the electrochemical behaviour of NC Ni coating. Potentiodynamic polarisation and EIS studies confirmed that NC Ni coating has increased the corrosion resistance of the HSLA steel. SSRT studied have resulted that the micro-alloyed steel was affected by HE, but the steel with NC Ni coating has been observed immune to HE.

Keywords: Potentiodynamic polarisation, electrochemical impedance spectroscopy (EIS); SSRT studies; hydrogen embrittlement (HE); pulse plating of nano-crystalline nickel.

Development of Useful Aluminum Alloys with High-Iron (Fe) Impurity through Undiluted-Recycling

[a]A. K. Prasada Rao

[a]GITAM (Deemed to be) University, Visakhapatnam, Andhra Pradesh, INDIA – 530 045
E-mail: akprasada@yahoo.com, kayyagar2@gitam.edu

Abstract

The development of useful aluminum alloys with high-iron (Fe) impurity through undiluted recycling is an interesting challenge in the field of materials science and recycling technology. Aluminum alloys are highly valued for their light weight, strength, and corrosion resistance, but the presence of iron impurities can negatively affect their properties, particularly in terms of strength and machinability. Nevertheless, high-iron aluminum alloys can still have potential applications if the alloying and recycling process is carefully controlled. Undiluted Recycling is a concept of recycling of aluminum scrap without introducing fresh, "pure" aluminum material. Author's research group has conducted extensive research on supressing the formation of detrimental β-phase (Al5FeSi) in the Al-Si alloys containing exceedingly higher amounts of Fe-impurity through minor alloying additions. And demonstrated that the element which has compatibility with Fe atom in analogy to Hume-Rothery's rule of substitutional solid solution, can act as a β-phase suppressor. Thereby helps in extending the Fe tolerance levels in Al-Si alloys (automotive scrap) leading to recycled alloys with minimum carbon footprints.

Effect of Tensile Twinning on Microstructure and Texture Evolution inAZX311 Mg Alloy under Cyclic Shear Deformation

Mahesh Panchal[a], Lalit Kaushik[b], Shi-Hoon Choi[3] and Jaiveer Singh[b]

[a]Department of Mechanical Engineering, Indian Institute of Technology Jodhpur
[b]Department of Metallurgical and Materials Engineering, Indian Institute of Technology Jodhpur
[3]Department of Advanced Components and Materials Engineering, Sunchon National University, Suncheon, Republic of Korea
Email: jaiveer@iitj.ac.in

Abstract

The present work investigated the deformation mechanisms, microstructure, and texture evolution in AZX311 Mg alloy sheets under in-plane shear (IPS) deformation. The interrupted and cyclic in-plane shear (IPS) deformation was imposed to understand the deformation mechanisms in AZX311 Mg alloy. The different levels of shear strains i.e., 0.05, 0.10, and 0.15 were imposed along the rolling direction with the help of a customized IPS testing jig. The strain measurement for the imposed shear deformation was done using the digital image correlation (DIC) technique. Through-thickness microstructural investigation using the EBSD technique showed that the introduction of IPS strain resulted in the generation of a considerable number of tensile twins (TTWs) in the sheet which reflected the formation of two satellite peaks at the periphery of the pole figure. With increasing shear strain, the fraction of the generated TTWs increased in the material covering the entire parent grain and resulted in what we have called an "all-twinned microstructure". However, in-plane cyclic shear resulted in satellite peaks across all four quadrants of the pole figure. The evolution of texture components across all four quadrants arises from the load variations under forward and reverse loading during cyclic deformation. Thus, in-plane cyclic shear deformation can generate texture components along nearly all directions in the pole figures. Additionally, microstructural and microtextural analyses revealed that TTW is the dominant deformation mechanism, contributing to texture evolution.

Keywords: Mg alloys, Crystallographic texture, DIC, Cyclic Shear deformation.

3D printed polymer blends and composites with enhanced mechanical properties

Animesh Gopal [1,3], Premkumar A. Kothavade,[1,2,3] Staurt Bateman,[4], and Kadhiravan Shanmuganathan [1,2]

[1]Polymer Science and Engineering Division, CSIR-National Chemical Laboratory, Dr. Homi Bhabha Road, Pune, 411008, Maharashtra, India
[2]Academy of Scientific and Innovative Research (AcSIR), Ghaziabad, 201002, India
[3]Centre for Additive Manufacturing, School of Engineering, Royal Melbourne Institute of
[4]Technology University, Melbourne, Victoria, Australia
E-mail: k.shanmuganathan@ncl.res.in

Abstract

3D printing has gained tremendous academic and industrial interest owing to its outstanding ability to create complex geometries with reduced material consumption. Several techniques such as Stereolithography (SLA), Selective Laser Sintering (SLS), Selective Laser Melting (SLM), Fused Filament Fabrication (FFF) etc. are used to create 3D objects. Despite being a simple process, FFF based 3D printing process has certain limitations. Warping and lack of strength of final 3D printed products are some of the most common challenges in FFF, which restrict the range of polymers suitable for 3D printing. Among the various biopolymers, PLA has been widely explored for FFF-3D printing. PLA is a renewable, biodegradable, thermoplastic biopolymer. However, the mechanical properties of 3D printed PLA is inferior to that of conventional melt processed materials. Herein, we demonstrate an approach to obtain luminescent 3D printed nanocomposites with better mechanical properties. We also describe a process to upcycle waste polyolefins into good 3D printing filaments and highlight the structure property relationships in these 3D printed blends and composites.

3D printing of long chain branched polypropylene and structure-property analysis

Animesh Gopal[a, b], Dhammaraj Rokade[a, b] Kadhiravan Shanmuganathan[a, b] and Harshawardhan Pol[a, b],

[a]*Polymer Science and Engineering Division, CSIR-National Chemical Laboratory, Dr. Homi Bhabha Road, Pune, 411008, Maharashtra, India*

[b] *Academy of Scientific and Innovative Research (AcSIR), Ghaziabad, 201002, India*

Email: hv.pol@ncl.res.in

Abstract

Fused filament fabrication is a commonly used 3D printing process for thermoplastic polymers due to the increased design flexibility and reduction in material wastage during production. Polypropylene is a widely used semi-crystalline thermoplastic polymer for large volume commodity applications owing to its good mechanical properties, low production cost, and chemical resistance. However, achieving good mechanical properties along with good printability and build plate adhesion are the major challenges in 3D printing of polypropylene. We report here our systematic efforts to develop long chain branched polypropylene (LCB-PP) suitable for 3D printing. The LCB structure was confirmed by gel permeation chromatography (GPC) and dynamic rheology. LCB-PP showed a lower melt flow rate as compared to linear PP. Small amplitude oscillatory shear (SAOS) experiments show increased complex viscosity as well as increased loss and storage modulus, suggesting the presence of LCB in PP. Additionally, strain hardening behaviour was also observed in extensional rheological analysis. LCB-PP had good printability and exhibited a 6-fold increase in elongation at break (from 23% to 144%) and toughness (from 42 KJ/m3 to 262 KJ/m3) over linear PP.

Effect of Natural Sapindus Mukorossi Treatment Process on Bio-Waste Banana Fibers: An Alternative to Chemical Treatment Processes

Vikas Yadav, Sanjeev Kumar

Department of Mechanical Engineering, Punjab Engineering College (Deemed to be University), Chandigarh, India, 160012

Email: sanjeevkumar@pec.edu.in

Abstract

Natural fiber reinforced composites have captivated attention of researchers in the field of households, construction and automobiles owing to their biodegradability and recyclability. However, despite these advantages, these composites have certain limitations which include moisture absorption, thermal degradability, and weak fiber-matrix adhesion. To address these issues, various surface modification methods such as saline treatment, alkaline treatment, sodium bicarbonate treatment etc., have been employed by the researchers. In the present research investigation, the biocomposites consisting of poly-lactic acid as matrix and bio-waste banana as fibers were developed using injection moulding machine. The banana fibers were subjected to an innovative natural treatment process using Sapindus Mukorossi and citric acid as eco-friendly alternatives to conventional chemical treatments. The treatment was applied for varying durations of 24, 48, 72, 96, and 120 hours. Since traditional chemical treatments are known to have adverse effects on both human health and the environment, this natural approach emerges as a sustainable option. The structural, mechanical, and moisture absorption characteristics of the naturally treated biocomposites were analysed using FTIR spectroscopy and mechanical testing to determine the optimal treatment duration, which was identified as 72 hours. Biocomposites treated for this period demonstrated a 15% enhancement in tensile strength and a 20% increase in flexural strength compared to untreated fiber biocomposites. Additionally, the lowest water absorption rate was observed at a treatment duration of 96 hours, showing a significant improvement of 58%. The surface morphology of the fibers was further examined using optical microscopy and scanning electron microscopy (SEM).

Keywords: Natural Surface Modification; Biocomposites; Injection Moulding; Water Absorption and Mechanical Properties.

Microstructure Development and Mechanical Property Assessment of Inconel 718 Fabricated by LPBF and WDED

[a]Vivek Kumar Singh and [a]Sushil K. Mishra

[a]Department of Mechanical Engineering, Indian Institute of Technology Bombay, Mumbai – 400076, India

Abstract

The microstructure of additively manufactured Inconel 718 consists of a primary dendritic phase and secondary phases, including Laves and carbides. The Laves phase negatively impacts mechanical performance, necessitating post-processing heat treatment for its elimination. This study explores the dissolution of long-chain Laves phase using heat treatment below the δ-solvus temperature and examines the transformation mechanism in real-time. Samples produced via laser powder bed fusion (LPBF) and Wire Direct Energy Deposition (WDED) undergo two heat treatment methods based on Scheil calculations and sub-δ-solvus temperatures. In situ TEM analysis captures δ-phase transformation during annealing, revealing solute redistribution from Laves to the γ-matrix and δ-phase formation at 900°C. These findings provide key insights into the Laves-to-δ transformation in additively manufactured Inconel 718. Furthermore, comparison of mechanical properties of samples produced by LPBF and WDED were conducted.

Keywords: Additive Manufacturing, Inconel 718, In situ TEM, Laves phase, δ-phase, LCF

Iron (Fe) Rich Medium Entropy Alloy: Microstructural Evolution and Mechanical Properties

[a]Vikas Shivam and [b]V.C. Srivastava

[a]Department of Materials Science and Engineering, Seoul National University, Seoul-08826, Republic of Korea
[b]Materials Engineering Division, CSIR-National Metallurgical Laboratory, Jamshedpur-831007-Jharkhand, India
Email: vcsrivas@nml.res.in

Abstract

High-performance materials with a balance of strength and ductility at low cost and lightweight are highly desirable for enhanced engineering reliability and energy efficiency. However, a common challenge faced in conventional alloys is the increase in strength with the loss of ductility. In recent years, high entropy alloys (HEAs), also known as multicomponent alloys, have gained significant attention due to their exciting properties. The high-entropy effect, which helps in stabilizing the simple solid solution phases i.e., BCC, FCC, and HCP phases in equiatomic compositions, does not exhibit superior mechanical properties in comparison to the traditional alloys. The single-phase microstructure of HEAs faced the reasonable problem of balancing the strength and ductility and cost economics. This led to the realization of the heterogeneous microstructure containing the multiphase of FCC and BCC or their derivatives with improved mechanical properties rather than the single-phase microstructure. In the present investigation, we have designed and developed a low-cost non-equiatomic $Fe_{50}Mn_{20}Al_{15}Ni_{10}Co_{5}$ medium entropy alloy (MEA) to understand the microstructural evolution and mechanical properties. The alloys have been characterised in both the as-cast and after thermomechanical treatment. The alloy in the as-cast state has shown the formation of BCC (major phase) and FCC (minor phase), which nucleates near the grain boundary. The alloy after suitable thermomechanical treatment led to the formation of a two-phase microstrture of FCC (major) and BCC/B2 phases. The BCC/B2 phase takes the lamellar shape and is finely distributed in the FCC matrix. This heterogeneity in the microstrture leads to an optimum balance of yield strength of ~450 MPa, and ultimate strength of ~1000 MPa, along with a ductility of ~52 %. The alloy has shown better microstructural stability in the temperature range of 600-800□C along with mechanical properties. These encouraging results of the alloy in the as-cast state and heat-treated conditions have provided the direction to design and develop such economically viable alloys, which could be produced at an industrial scale with the possibility of overcoming the strength ductility trade-off.

Keywords: High entropy alloy, Non-equiatomic Fe-rich alloy; Microstructural evolution; Phase transformation, Mechanical properties.

Crystallization Kinetics of Zr-Co-Al Metallic Glass

Yogesh Prabhu[1], Juhi Verma[a], Abhilasha Jain[a], D. V. Gunderovb[3], Jatin Bhatt[*a]

[a]*Department of Metallurgical &Materials Engineering,Visvesvaraya National Institute of Technology, Nagpur 440010, India*
[b]*Ufa State Aviation Technical University,12 K. Marx str., Ufa, 450008, Russia*
[3]*Institute of Molecule and Crystal Physics UFRC RAS, 71 pr. Oktyabrya, Ufa 450054, Russia*
Email: jatinbhatt@mme.vnit.ac.in

Abstract

Effect of Cu alloying on the crystallization kinetics of Zr-Co-Al metallic glass (MG) is investigated under non-isothermal conditions using differential scanning calorimetry (DSC). Activation energy for Zr72Co24Al4 (ZCA) and Zr72Co16Cu8Al4 (ZCCA) MGs are determined by employing Kissinger's plots. Further, variation of activation energy along the crystallization process is investigated for both ZCA and ZCCA MGs. The influence of nucleation and growth mechanism on crystallization process is understood using local Avrami's exponent from data obtained under non-isothermal conditions. Crystallization pathway in terms of phase formation during devitrification for ZCA and ZCCA MGs is investigated for samples annealed at 973 K and the phases indentification is carried out using X-ray diffraction analysis. Addition of Cu lowers the activation energy and greatly influencesthe phase formation in Zr-Co-Al MGs. Cu destabilizes the transformation of ZrCo in ZCCA and results in precipitation of Zr4Co and ZrCu ($Zr_{0\cdot98}Cu_{0\cdot02}$) phases.

High Performance Organic Fibers for Defence Applications

Swati Chopra[a]

[a]*Polymers and Rubber Division, DMSRDE, G.T.Road, Kanpur-208013*
Email: sdaswal@gmail.com

Abstract

High Performance Fibers are the class of fibers that have been engineered to develop properties such as exceptional strength, modulus, thermal resistance, electrical resistance, chemical resistance and alike. Such fibers play a special role in defence sector such as in personal protective equipments, ballistic protection as well as in aerospace and naval applications. The most commonly used high performance fibers in defence include aramids (Kevlar, Nomex), Ultra-high molecular weight polyethylene (UHMWPE) (Dyneema, Spectra), Polybenzoxazole, Polyether ether ketone (PEEK), carbon, glass, silicon carbide. These high tenacity polymeric fibers can be linear and flexible such as polyethylene or rigid rod as Kevlar or PBO. Nylon and polyester fibers are used for their extraordinary recovery properties because they offer perfect combination of strength and extensibility. Similarly, PEEK offers exceptional chemical resistance. This presentation shall restrict to high tenacity organic fibers with special focus on Nylon, UHMWPE and polybenzoxazole (PBO) as DMSRDE is in a process of developing these fiber technologies.

Keywords: high performance, Nylon, PBO, aramids, UHMWPE

Microstructure and texture development in UNS S32101 lean duplex stainless steel

Rajesh K. Khatirkar[a*] and Tushar R. Dandekar[a]

[a]Department of Metallurgical and Materials Engineering, Visvesvaraya National Institute of Technology (VNIT), South Ambazari Road, Nagpur – 440010, India
Email: rajeshk@mme.vnit.ac.in

Abstract

Duplex stainless steels (DSSs) due to their two-phase microstructure, are scientifically interesting to study. There are many unanswered questions regarding their deformation behaviour, texture development and recrystallization. Particularly, the influence of one phase on the texture evolution/deformation/ recrystallization mechanism of the other phase, effect of stacking fault energy (SFE), effect of grain size, chemical composition etc. In the present work, effect of cold rolling (unidirectional and cross rolling) on the development of microstructure, texture and magnetic properties in UNS S32101 lean DSS (LDSS) is studied. The band thicknesses of ferrite and austenite (along normal direction, ND) decreased with the increase in cold rolling reduction, the decrease being significantly more for austenite than ferrite. Lenticular bulges (which indicate the formation of SIM) were seen in the microstructure after 80% cold rolling. During deformation, more strain was partitioned in austenite than ferrite. SIM gradually increased with the increase in cold rolling reduction (was ~11% for 80% cold rolled sample). The as-received sample showed strong cube ({100}<100>) and Brass ({110}<112>) in austenite and strong α-fibre (RD//<110>) and γ-fibre (ND//<111>) in ferrite. After 80% cold rolling, strong Brass ({110}<112>) and Goss ({110}<001>) were developed in austenite, while the existing α and fibres further strengthened in ferrite. The area under the B-H curve was found to be proportional to strain. Both texture and increased dislocation density in ferrite were found to be responsible for this increase. For 80% cold cross rolling, strong Brass and Goss were developed in austenite, while very strong rotated cube and strong γ-fibre were obtained in ferrite. Recrystallization was carried out at 1050°C for varying times. The morphology of grains changed from lamellar to near globular with an increase in the annealing time. A sharp decrease in stored energy (275 kJ/m^3 to 650 J/m^3 (austenite) and 293 kJ/m3 to 520 J/m3 (ferrite)) and hardness was observed with increase in fraction recrystallized. After annealing for 2 minutes and above, hardness reached a constant value of ~180±5 Hv. R and ΔR calculated from tensile tests increased with increase in annealing time. The maximum R value was obtained after 10 min annealing (0.81) with ΔR of -0.17. Cold rolled samples showed Brass-type texture for austenite and strong α-fibre and γ-fibre for ferrite. The texture intensity reduced after recrystallization for both austenite and ferrite. Both 5 min and 10 min annealing at 1050°C was found to give optimum combination of properties.

Additive manufacturing Technology for LTCC based Multilayer Package fabrication

Shany Joseph

Centre for Materials for Electronics Technology, Panchwati, Off Pashan Road, Pune-411008.
Email: shany@cmet.gov.in

Abstract

Additive manufacturing technology has brought in a revolution in the manufacturing sector and has laid its impact in all sectors. Starting from metal 3D printing to ceramics, plastics and even polymers have all been touched by this technology and we can develop several customized parts and structures for varied applications. Automotive, medical educational, building construction, Food industry, agriculture and electronic sectors have fully exploited this technology. Digital light projection (DLP) based 3 D printing process projects a light beam on the photosensitive polymer or its composite with required functional material as per the layer design and the exposed part gets cured and gets adhered to the platform which then raises up or moves down for the exposure of the next layer. This technology is faster when compared to the stereolithography (SLA) based 3 d printing and is regularly used for several application including dental and jewellery moulds. The DLP process is recently being explored for making ceramic parts in hybrid circuits manufacturing wherein the ceramic part is made by DLP process and the circuit patterns developed by using inkjet technology. The report work presents the DLP based 3D printing of multilayer packages using low temperature co-fired ceramic (LTCC) technology. The LTCC technology is a multilayer substrate and package fabrication technology that is used for packaging of chips, sensors and other devices. The technology finds its application in microwave, microfluidic, optical, thermal, sensor packaging and other applications that can be customized to develop products in automotive, mobile communications, microwave, biomedicals and a lot of industrial applications using sensors. The conventional process uses green ceramic tapes of LTCC and undergoes a series of steps of via punching and filling, screen printing, stacking, lamination steps before it is co-fired to obtain the desired ceramic package. The technology has a host of applications but the fabrication cost restricts its application to high end products. The DLP process for LTCC fabrication will help in achieving rapid prototyping at lower cost. The light is focussed on the composite of the photosensitive polymer and ceramic or metal conductor and the exposure happens as per the digital design of the layer fed to the DLP printer. Depending upon the design of the layer the metal or ceramic composite is used and the part is fabricated. The process is set-up and the LTCC dielectric and Ag/Ag-Pd conductor materials are also synthesized in-house. The process is optimized to 3D print the required multilayering features including via making and its filling, cavity, channels, conductor tracks and cover pads etc and the material properties are tuned to obtain fine lines and features.

Hemostatic Cryogels and Hydrogels for Faster Clotting

[a]Kaushal Shakya and [a]Vivek Verma

[a]Department of Materials Science and Engineering, Indian Institute of Technology Kanpur, Kanpur- 208016, India
Email: vverma@iitk.ac.in

Abstract

In deep wound scenarios arising from accidental situations such as road accidents, gunshots, or battlefield injuries, severe bleeding poses a critical threat to life. Despite various hemostatic measures and advancements in wound care, there remains a need for improved solutions with enhanced hemostatic properties to reduce mortality rates. In our study, we developed three generations of agar-based hemostatic materials. In first and second generation, oxidized bacterial cellulose and polydopamine respectively were used to develop cryogels to reduce clotting time. In the third generation of hemostats, carboxymethyl cellulose was used to produce injectable hemostatic hydrogel. The resulting hemostatic sponges exhibited superabsorbent behavior with a 4200% swelling degree, a faster clotting time (within 60 s), and an enhanced compressive strength of 4.77 kPa. The cryogels and hydrogels demonstrated excellent in vitro hemocompatibility and cytocompatibility. Furthermore, the developed hemostatic dressings exhibited outstanding in vivo hemostatic performance, achieving blood clotting times of 64 s and 35 s, in the rat tail amputation model and the liver puncture models (for deep wound models), respectively. The developed materials hold significant potential as advanced materials for hemostatic dressings, offering promising solutions for wound therapy.

High strain-rate plastic flow behavior of Ni base superalloys through indentation experiments

Adepu Kumaraswamy

Department of Mechanical Engineering, Defence Institute of Advanced Technology (DU), Pune 411025
Email: akswamy@diat.ac.in ; Institute website: www.diat.ac.in

Abstract

Advances in the field of materials science have resulted in the improvement of existing materials and the development of new materials along with a variety of new applications. Major branches of engineering, particularly those involved in the design and construction of new mechanical or structural elements, depend on the results of mechanical tests for measurement of mechanical properties. Users want to know various strengths of the materials they are considering and how that strength relates to the practical problems of forming parts. The evaluation of mechanical properties of structural elements plays an important role in material degradation under high temperature and pressure. This demands property evaluation techniques that are simple, non-destructive and suitable for materials ranging from very thin coatings to large volumes such as forged and cast components having complex geometries. Indentation tests are the most commonly used non-destructive testing procedures in the metal industry and in research because they provide an easy, inexpensive and reliable method of evaluating basic properties of developed or new materials. Indentation tests, in which a plane test surface is plastically indented, are widely used to provide quickly a measure of the flow stress of a material. Consequently, a series of indentations of different sizes can be used to estimate the stress-strain curve of a material. When, for example, there is insufficient material for a stress-strain specimen or machining and bulk deformation of the test piece is undesirable or impossible. Furthermore, for brittle materials, for example ceramics indentation can be a good alternative test because it eliminates the need for expensive tensile specimens. In view of this, an attempt was made in evaluating the high strain-rate plastic flow behavior of Ni base super alloys such as IN718 and Haynes242 alloys in the temperature range of 300-1073K through static and dynamic indentation experiments. Uniaxial compression tests were conducted in the same temperature range to estimate the Constraint Factor of test materials with strain. The effect of temperature on CF, lip height and depth of plastic-zone was also evaluated. The experimental results were compared with the theoretical models.

Keywords: Static indentation; Dynamic indentation; Constrain Factor; Haynes242, In718

Deformation-Induced Martensite: Hard or Tough?

Avala Lavakumar [a]

[a]Department of Metallurgical and Materials Engineering, Indian Institute of Technology Ropar
Email: lava@iitrpr.ac.in

Abstract

Transformation-induced plasticity (TRIP)-assisted multiphase steels are widely used in automotive applications due to their excellent strength-ductility balance. Their complex microstructure consists of ferrite, bainite, martensite, and retained austenite. While the TRIP effect enhances mechanical properties, the precise role of deformation-induced martensite in determining strength and toughness remains unclear. This study investigates the deformation behavior of individual phases in TRIP-assisted steels using in-situ X-ray diffraction (XRD) and Digital Image Correlation (DIC). Stress partitioning (measured by HE-XRD) and strain partitioning (analyzed via μ-DIC) reveal that, at low strains, newly formed martensite accommodates most of the deformation due to the TRIP effect. As strain increases, deformation localizes in ferrite due to strain hardening from the austenite-to-martensite transformation. The findings provide key insights into whether deformation-induced martensite primarily contributes to strength or toughness, helping optimize mechanical performance in multiphase steels.

Keywords: Multi-phase steel, TRIP effect, retained austenite, in-situ XRD, micro-DIC

Advancing from Single Crystal to Polycrystalline Technologies for Synthesis of Transparent Ceramics: A Roadmap for Future Innovations

[a]Jagmohan Datt Sharma

[a]Department of Metallurgical and Materials Engineering,
Punjab Engineering College, Chandigarh, 160012, India

Abstract

Transparent ceramics have various potential applications such as infrared (IR) windows/domes, lamp envelopes, opto-electric components/devices, composite armors, and they can be used as host materials for solid-state lasers. Transparent ceramics were initially developed to replace single crystals because of their simple processing route, variability in composition, high yield productivity, flexibility in fabricating items with large sizes and complex shapes and more importantly cost-effectiveness. As Optical transparency is one of the most important properties of transparent ceramics and in order to achieve transparency, ceramics must have highly symmetric crystal structures therefore, the majority of the transparent ceramics have cubic structures. Moreover, the optical transparency of ceramics is determined by their purity and density; the production of high-purity ceramics requires high-purity starting materials, and the production of high-density ceramics requires sophisticated sintering techniques such as high-pressure (HP) sintering, high isostatic pressure (HIP) sintering, vacuum sintering and spark plasma sintering (SPS) and also, optimized sintering aids. However, producing transparent Y2O3 ceramics is challenging due to the high melting point of yttria (Tm: 2430°C). To overcome high sintering temperatures, sintering additives such as Al2O3, ZrO2, La2O3 and LiF could be used. Among them, using a complex system of ZrO2 or La2O3 could significantly improve the densification of ceramics. Moreover, a range of transparent Y2O3 ceramic containing various rare-earth dopants such as Nd3+, Yb3+, Ho3+, Er3+, could also be synthesize. Among them, Y2O3 doped with Er and Nd exhibits more complex luminescent behaviour, indicating a higher potential for applications. This combination could be prepared via wet chemical synthesis method which is used to produce precursor powders at submicron or even nanometre scales, with significantly improved sinterability. Therefore, work is arranged by starting gives a detailed description on various sintering technologies used to develop transparent ceramics.

Waste to Wealth: Engineering a Circular Economy through Ferrous Slag Transformation

Sheshang Singh Chandel[a], Navneet Singh Randhawa[b] and Prince Kumar Singh[a]

[a]Department of Metallurgical and Material Engineering, Indian Institute of Technology, Ropar 140001, India.
[b]Metal Extraction and Recycling Division, CSIR-National Metallurgical Laboratory, Jamshedpur 831007, India.

Abstract

Decarburization is a critical concern for global industries, particularly the steel and cement sectors, contributing nearly 15% of total carbon dioxide (CO2) emissions. One way to reduce carbon dioxide emissions is to re-utilize industrial waste, such as slags, as a secondary raw material resource. Conventionally, there is a well-developed technology for recycling most of the low iron contains ferrous slag, like ironmaking slag, as a cementitious material, known as ground granulated blast furnace slag cement (GGBS). However, no such proposed technology has been developed for iron-rich industrial waste, especially steelmaking slag. This study introduces an innovative approach to the hot stage to utilizing 100% steelmaking ferrous slag on-site and converting waste into valuable and sustainable feedstock for the steelmaking and cement industries, with minimal operational costs and a high environmental impact. The process involves utilizing available latent heat in molten slag, molten-stage reduction, and optimizing operation conditions for iron separation and recovery during the slag treatment process. The proposed hot-stage treatment of ferrous slag can help to achieve iron recovery of up to 85% by using engineered flux during the ferrous slag hot-stage treatment process. The addition of flux during the hot stage treatment process improves the ability to achieve optimized slag fluidity, achieve required phase formation, and optimize process energy consumption. This proposed hot-stage treatment of ferrous slag can be an innovative approach to utilizing 100% ferrous slag management technology on an industrial scale, potentially serving as a secondary resource for the steel and cement industries.

Keywords: Recycling, Iron Reduction, Metal Separation, Industrial Symbiosis

Materials for Critical Technology and Human Space Missions

Prateek Bansal

Scientist-SG & Head, Human Rating Certification Division
Space Applications Centre SAC, ISRO, Ahmedabad

Abstract

Reliability & safety are mandatory requirements for any Human spaceflight systems. These primarily due to irreparability in space makes systems both effort-intensive and costly. Materials are very important aspect of any space system and needs careful selection, qualification and application. With more focus on advancements in payloads, critical technology development is a key task. This combined with Human Space Missions are completely changing the materials requirement, evaluation and acceptance criterion. Several critical technology developments like High Power Microwave Vacuum Tube devices, High speed digital technology, Human Spaceflight systems each have different expectations from materials. For example, vacuum grade metals, alloys, non-metallic materials, braze alloys, long endurance requirements, safety critical requirements like flammability, outgassing, off gassing etc. are current areas important for space systems. This talk focuses more on these materials & application in broader way.

Expanding the Capabilities of X-ray Diffraction: Applications in Mineralogy and Advanced Materials

Komal Jain

Application Scientist-MCX, Anton Paar India Pvt Ltd

Abstract

The X-ray diffraction (XRD) stands as a cornerstone analytical tool across diverse scientific and industrial domains, providing unparalleled insights into the crystallographic structure and composition of materials. In the mineral and metallurgy industry. XRD plays a pivotal role in phase identification and quantification, enabling accurate characterization of ores, clays, and processed materials. By determining the mineralogical composition, XRD aids in optimizing extraction processes, assessing ore quality, and monitoring the effectiveness of beneficiation techniques.

Beyond routine phase analysis, XRD offers key insights about material properties such as strain, residual stress and texturation. Combined with non-ambient measurements allows for the in-situ study of phase transitions, thermal expansion, and reaction kinetics, crucial for understanding material stability and performance in extreme environments.

Specialized XRD techniques, such as X-ray reflectivity (XRR) and grazing incidence X-ray diffraction (GI-XRD), extend the analytical power of the diffractometer to thin films and surface layers. XRR enables precise determination of film thickness, density, and interfacial roughness, essential for optimizing thin-film deposition processes in semiconductor and coating industries. GI-XRD, on the other hand, provides depth-resolved structural information of thin films and surfaces, revealing strain, phase distribution, and crystallite size variations near the surface. These specialized techniques are vital for characterizing engineered materials and understanding surface phenomena. Consequently, the versatility of the X-ray diffractometer, encompassing routine phase analysis to sophisticated non-ambient and surface-sensitive measurements, renders it indispensable for both fundamental research and industrial applications.

Role of Advanced Packaging in the Semiconductor Industry

Deepak Goyal
Sr. Director, Intel Corporation (Retired)

Abstract

Semiconductor market growth is driven by (a) computing and data storage, leading to explosion of data sharing, storage and analytics (AI) and (b) communication explosion – both wireless and wired. The best response to this is advanced packaging or 3D heterogeneous integration (HI). Packaging is the final manufacturing process transforming semiconductor devices into functional products. Advanced packaging refers to a combination of distinct technologies designed, processed, assembled & tested to enable cost, performance, power, and size optimized interconnection of ICs and supporting elements to each other and to the system, including flip chip on build-up substrates, wafer and panel level packaging, silicon bridge, interposer with & w/o TSV (Through Silicon Vias); inclusive of the lateral (2D) and vertical (3D) architectures.

The role of advanced packaging is to provide unprecedented levels of Heterogeneous Integration (HI). HI refers to the integration of separately manufactured components into a higher-level assembly that, in the aggregate, provides enhanced functionality and improved operating characteristics. This presentation will review the evolution of Advanced Packaging for HI and also discuss the future scaling for HI. The Advanced Packaging technologies must extend along multiple vectors to enable future HI Products. These vectors will be discussed and will include Interconnect Scaling, Mainstreaming Optical Interconnects, High efficiency power delivery networks, Thermal solutions for 2D and 3D, Manufacturing and Yield optimization. Packaging Technology Evolution opens up multiple opportunities for roadmap development and Research.

Recent developments in Stainless steel applications

Chandra Prakash Agrawal
Synergy Steels Limited, Alwar, Rajasthan
Email:cp.agrawal@synergysteels.com

Abstract

Stainless steel is a vital material across industries due to its exceptional corrosion resistance, strength, and longevity. As a leader in stainless steel manufacturing, Synergy Steel specializes in producing high-quality long products, leveraging advanced metallurgical processes to ensure superior performance and reliability. Our manufacturing capabilities include state-of-the-art melting, casting, rolling, and finishing processes with specialized techniques such as Electroslag Remelting (ESR), Vacuum Induction Melting (VIM), and Vacuum Arc Remelting (VAR) for high-purity applications. We cater to diverse sectors, including automotive, oil & gas, construction, power generation, medical, aerospace, supplying bars, rods, wire rods, angles, flats, seamless tubes, and powder metallurgy solutions tailored to end-user requirements. Synergy Steel's long products are widely used in critical applications such as fasteners, structural reinforcements, medical implants, and high-performance engineering components. Our stainless steel solutions offer unmatched corrosion resistance, life cycle cost advantages, reducing maintenance and replacement costs for industries that demand durability and efficiency. Looking ahead, Synergy Steel is committed to future growth through sustainability, innovation, and expansion into emerging technologies such as powder metallurgy for additive manufacturing and seamless tube production for high-performance applications. Our focus remains on delivering high-quality, cost-effective, and sustainable stainless steel solutions that drive industry advancements and enhance global infrastructure.

3D Printing – Challenges and Opportunities

Mrityunjay Doddamani

Department of Mechanical Engineering, Indian Institute of Technology (IIT), Jodhpur
mrityunjay@iitj.ac.in

Abstract

Additive manufacturing (AM) has become a most sought-after technology owing to its capabilities of producing components with complex geometries, minimum manufacturing lead times, component integration, and higher customization flexibility. The first part of the presentation deals with sustainability-integrated digital manufacturing with a backbone of knowledge from Ayurveda that might revolutionize the cure of different diseases. The digitized nature of 3D printing presents a substantial challenge in ensuring the integrity and quality of components. Aspects of secured manufacturing (SM) with a focus on AM is presented next. SM involves the integration of the Internet of Things (IoT), automation, digital technologies, and data analytics into the manufacturing process, which can introduce new vulnerabilities if not appropriately secured. The strategy developed for data security in AM will be briefly presented.

Refining of Induction Melted Steel, Enhancing Quality and Efficiency

Prakash Singh Bagga

Director, Supreme Metallurgical Services Pvt. Ltd.
psbagga@sms.co.in

Abstract

Induction melting has emerged as a preferred method of producing bulk of steel due to energy efficiency, flexibility and low cost of production. Since the steel is melted in Induction Furnace with acid lining and this poses a limitation on the refining capability of Induction Furnace particularly refining for removal of Phos. Since refining plays a critical role in enhancing the quality of Induction Melted Steel. We present a process of removal of Phos from Acid Lined Induction melted steel to meet the specification of any grade of steel to be produced. By adopting this process it is not only possible to produce commercial grades of steel with required specification but alloy steels with requirement of low phos to less than 0.030%.

Real-Time Defect Detection and Process Control in Directed Energy Deposition via Plasma Plume Monitoring

[1]Ravi K R, [1]M. Singh, Manoj

[1]Department of Metallurgical and Materials Engineering, Indian Institute of Technology Jodhpur, Jodhpur- 342037, India Email: ravikr@iitj.ac.in

Abstract

Directed Energy Deposition (DED) is widely utilized for fabricating complex geometries, repairing components, and enhancing surface properties. However, achieving consistent quality remains a challenge due to process variability, including fluctuations in melt pool temperature, dimensions, and cooling rate during continuous printing. These variations contribute to defects, inconsistent microstructures, geometrical deviations from the CAD model, and fluctuating mechanical properties. Traditional defect detection relies on post-mortem analysis of microstructure and mechanical properties. Additionally, non-destructive testing (NDT) techniques, such as micrographs and X-ray tomography, have been used for defect analysis. However, these approaches increase production time and costs, as defects are identified only after manufacturing, leading to material waste, labor inefficiencies, and higher equipment costs. These limitations hinder the widespread adoption of metal additive manufacturing (AM) in industrial production. Therefore, real-time monitoring and closed-loop control strategies are essential for enhancing process reliability in DED technology.

Currently, real-time monitoring and closed-loop control in DED predominantly rely on infrared (IR) thermal imaging, primarily focusing on melt pool width while often neglecting melt pool depth, a critical factor in porosity formation, especially in keyhole regions. IR-based monitoring systems also face challenges such as image distortion, inaccurate data interpretation, and the high computational load associated with deep learning-based data processing, which hinders real-time response rates.In this work, a novel methodology employing Optical Emission Spectrometry (OES) is proposed to develop an automated, smart solution for closed-loop control of defect prediction and geometrical accuracy in the DED process, specifically for SS316 and Inconel 718 alloy parts. Plasma plume characteristics during the DED process are analyzed using OES spectroscopy data, providing insights into process stability, clad quality, and real-time melt pool geometry control. Plasma plume variations at different input parameters—laser power, scan speed, and powder feed rate—are correlated with OES signals and melt pool characteristics.

Additionally, plasma plume area and intensity were measured using a high-speed camera, while melt pool temperatures were assessed with two-color pyrometers for recoil pressure analysis. The integration of multi-sensor data and melt pool geometry measurements, correlated with microstructural analysis, offers a comprehensive understanding of plasma plume behavior during SS316L deposition. Plasma plume analysis using OES and high-speed imaging presents a promising solution for real-time monitoring due to its high data acquisition speed, making it particularly well-suited for DED applications.

Space and Aerospace Materials

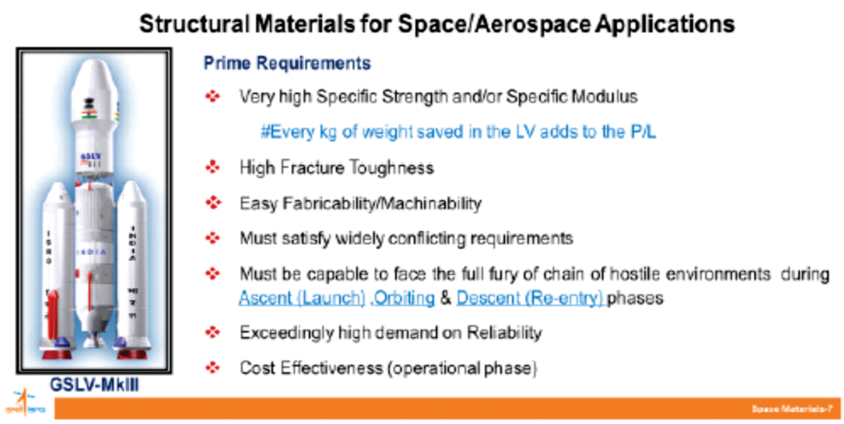
Ravi Kumar Varma

Space Applications Centre (SAC), ISRO, Ahmedabad

Abstract

Space missions require materials that can preserve functional integrity under extreme conditions of heat, impact and radiation. Major advancements in space technology and exploration, have been made possible by many specific breakthroughs in materials and manufacturing processes, enabling the development of highly sophisticated spacecraft systems, rockets and satellite components. Materials used in space missions are exposed to some of the most demanding and hostile operational environments in which human engineering products are required to function. The first challenges for spacecraft materials actually start on Earth. High mechanical loads are induced on structural materials, electronic components and propulsion systems already during manufacturing and assembly. Poor workmanship during manufacturing or assembly and inappropriate storage conditions can generate cracks, residual stresses, internal defects, corrosion, contamination and local damages. The highest loading phase of the entire space mission happens on ground, particularly during static, acoustic and dynamic qualification testing. Loading and risk of contamination or corrosion occur also during transport, which normally happens on wheels, by boat or by plane. Moreover, atmospheric water condensation, exposure to coastal environment at launch sites and the presence of chemical substances such as cleaning agents and solvents, propellants and oxidizers or hydraulic fluids can promote corrosion aggression and stress-corrosion cracking.

Lift-off and launch phases generate significantly high vibrations, acoustic and shock levels, thermal fluxes, lightning and bird strikes. Once in orbit, gravity (hence loading) and atmosphere disappear and spacecraft materials are exposed to vacuum. Effects of vacuum are mainly due to desorption of water from ceramic/oxide layers and polymeric materials, as well as outgassing of gaseous light species released by organic materials or organic residues entrapped in inorganic layers. Water desorption could have a weakening impact on the layer structure, therefore modifying materials electrical and thermo/optical properties. Outgassing and subsequent condensation of the particles' cloud on spacecraft instruments could provoke contamination of highly sensitive optical devices, affecting the mission scientific performances up to instrument 'blindness'. It can also lead to corona effects, arcing and short circuits.



Development of cost-effective and eco-friendly inhibitor to mitigate the corrosion due to ethanol blended petrol

Deepak Dwivedi, Saurabh Kumar

Department of Chemical and Biochemical Engineering, Rajiv Gandhi Institute of Petroleum Technology, Jais, Amethi- 229305, U.P., India
Email: ddwivedi.rgipt.ac.in

Abstract

The development of corrosion inhibitors for ethanol-blended petrol (EBP) has become a critical area of research due to the increasing use of ethanol as a renewable fuel in gasoline. Ethanol, being highly hygroscopic, attracts water from the atmosphere, which can accelerate the corrosion of metal components in internal combustion engines, fuel systems, and storage tanks. This study investigates the formulation of corrosion inhibitors specifically tailored for ethanol- blended petrol, focusing on their effectiveness in mitigating corrosion in ethanol blended petrol. The developed inhibitors corrosion inhibition ability was tested on the steel such as pipe grade carbon steel A106 and X70 and storage grade steel (Ss304). The corrosion inhibition performance of developed inhibitors was compared with commercially available inhibitor. The performance of these inhibitors was assessed using various methods used of corrosion study as per ASTM and NACE standards. The results showed that inhibitors provided effective corrosion protection by forming a protective layer on metal surfaces, reducing corrosion rates significantly. Additionally, the study explores the effect of blending of inhibitor formulation with ethanol blended petrol on engine performance and emission characteristics. The field trail was also performed to test the emission of the ethanol blended petrol with inhibitor formulation using BS-IV and BS-VI vehicle and found within the emission norms set by government of India. Fuel properties of ethanol blended fuel with inhibitors were also tested as per Indian standards. The findings contribute to the development of cost-effective and sustainable solutions for the protection of engine components and infrastructure exposed to ethanol-blended fuels, thereby improving the longevity and reliability of ethanol-based fuels in the automotive industry.

Advanced Chemistry Cell (ACC) Research: Progress at C-MET and Future Plans

Milind V. Kulkarni

Centre for Materials for Electronics Technology (C-MET) Ministry of Electronics & Information Technology (MeitY), Govt. of India, Panchawati, Off Dr Homi Bhabha Road, Pashan, Pune
milind@cmet.gov.in

Abstract

Lithium batteries are characterized by high specific energy, high efficiency and long life. These unique properties have made lithium batteries the power sources of choice for the consumer electronics market with a production of the order of billions of units per year. These batteries are also expected to find a prominent role as ideal electrochemical storage systems in renewable energy plants, as well as power systems for sustainable vehicles, such as hybrid and electric vehicles. In order to develop the Li-ion battery technology Indigenously, C-MET has initiated and is actively working for the development of Active materials (cathode and anode) and has developed state of the art battery fabrication and testing facility for button/coin type, pouch / rectangular and cylindrical cells under one roof. The development of materials for high energy batteries is a continuous process and C-MET is working for the development of novel materials for the high charge capacity and energy density. Under the Centre of Excellence on Rechargeable Battery Technology (CoE RBT), the facility has already been created for the large-scale synthesis of active materials (500 gm batch level). These developed cathode and anode materials were compared with the commercially available active materials (Aldrich and MTI, Corporation USA make) and fabricated prototypes of different form factors of Li-ion cells/battery using the active materials developed by C-MET. The electrochemical performances of these cells are found to be similar to that of the commercially available active materials. Also, we have developed modelling & simulation facility for the detailed investigations/studies of the secondary batteries. Using the inhouse developed active materials and battery fabrication facility we have successfully developed & demonstrated proof -of concept battery pack and modules for two-wheeler and four-wheeler cranking applications. Considering the future trend of flexible and wearable electronics devices, we also have successfully developed thin, flexible/bendable & light weight batteries for flexible & wearable electronics devices. We are also working for the development of Polymer & Polymer-ionic liquid composite-based electrolyte system for Li-Polymer & All solid-state Batteries (ASSBs). We have also initiated the activities for the development of Li-Air, Li-S as well as organic batteries and Na-ion batteries for hybrid/electric vehicles for smart, green & clean transportation.

Synthesis of Ti-Al Intermetallic by MASHS Technique and Study its MW Absorption Properties in Ceramic Matrix

[a]Yojana Janu, [a]VS Chauhan, [a]Dilip Choudhary, [a]MK Patra

[a]Defence Laboratory, DRDO, Jodhpur
Email: yojana.dl@gov.in

Abstract

Microwave absorbers sustainable at high-temperature scenario (above 300 °C) are in great demand in military and civil aerospace applications. Ti-Al intermetallic, specifically -TiAl, is known for its prominent high-temperature performance, lightweight nature, and excellent mechanical properties. Due to these properties this material is widely used in aerospace and automotive industries. However, their potential as microwave absorbing materials has opened new avenues for research and application in recent years, particularly in environments where both high temperature and EM absorption are critical.

In this study we have established a simple, cost effective, energy efficient and scalable Mechanical Activation and Self-Propagating High-Temperature Synthesis (MASHS) approach, for synthesis of titanium aluminide (TiAl).

The preparatory methos involves, predetermined amount of Ti and Al powders subjected to ball milling to increase their reactivity by introducing defects and refining their grain size. The mechanically activated powders were then compacted and ignited to initiate a self-propagating high-temperature synthesis reaction, resulting in the formation of TiAl intermetallic. The synthesized TiAl was characterized using X-ray Diffraction (XRD), Scanning Electron Microscopy (SEM), and X-ray Fluorescence (XRF) to investigate its phase composition and morphology.

A review on Aluminium-rare earth based alloys

[a]Animesh Mandal, [a]Dheeraj Saini, [a]Saswati Nanda, [a]Rahul Gope

[a]School of Minerals, Metallurgical and Materials Engineering,
Indian Institute of Technology Bhubaneswar, Argul 752050, Odisha, India

Abstract

Aluminium alloy components in diesel engines must maintain desired mechanical strength in the temperature range from 200 - 300 C. At present, most commercial aluminium alloys in use do not meet the above criteria. Hence, there has been a growing interest in aluminium-rare earth-based alloys, Al-Ce alloys in particular for such appliations. It has been reported that Al-Ce alloys developed by Critical Materials Institute are lightweight, corrosion resistant and stable in temperatures up to 500 C. Furthermore, these alloys have good castability, require minimal heat treatment and shows good formability. The alloy has been used for components like cylinder heads, turbo chargers, and turbine blades for hydroelectric turbines, pistons, and rotors. The presentation will discuss different aluminium alloys containing rare earth elements for various applications vis-à-vis existing commercial aluminium alloys with similar properties.

Key words: aluminium alloys, high temperature, rare earth elements

Oral Presentations

Innovative Design Strategies for PP Mesh Surfaces in Infection-Resistant Healthcare System

Vipula Sethi[a], Chetna Verma[a], Samrat Mukhopadhyay[a], Amlan Gupta[b], Bhuvanesh Gupta[a]

[a]Bioengineering Laboratory, Department of Textile and Fibre Engineering, Indian Institute of Technology Delhi, New Delhi-110016, India
[b]Department of Pathology, Sikkim Manipal Institute of Medical Sciences SGangtok-737102, ikkim, India
Email: vipulasethi5@gmail.com

Abstract

In recent years, the development of infection-resistant polymeric materials has become a significant area of research. These polymeric materials have emerged as one of the most fascinating domains in the healthcare system. Polypropylene (PP) has an eminence potential to be used as a biomaterial because of its physicochemical properties. However, the major limitation associated with PP is the lack of functionalities on its surface, which makes it difficult to functionalize. To overcome this issue, plasma grafting followed by bioactive nanogel immobilization seems to be a good alternative for the development of functional polypropylene. Thus, the current strategy entails activating the surface with plasma-grafting and then immobilizing biopolymer-based bioactive nanogel to make a bio-receptive surface. The influence of the plasma grafting conditions on the surface functionalization was investigated. The morphology of the functionalized mesh was evaluated using TEM, EDX and FE-SEM. The immobilized mesh exhibited strong antimicrobial behavior against both Escherichia coli and Staphylococcus aureus, which was performed using colony count method.

On the Description of Pitting and Passivation Behaviour of Al_xCoCrFeNi High Entropy Alloys in 3.5% NaCl Aqueous Solution

V.S. Kathavate[a*], T. Shanmugasundaram[b], Murthy Chavali[a]

[a]Dr. Vishwanath Karad MIT World Peace University, Kothrud, Pune 411038, Maharashtra, India.
[b]Defence Institute of Advanced Technology, Defence Research and Development Organization, Girinagar, Pune 411025, Maharashtra, India.
Email: vskathavate@gmail.com, vaibhav.kathavate@mitwpu.edu.in

Abstract

In this work, corrosion behaviour of Al-doped high entropy alloys (Al_x CoCrFeNi), where, x=0.3 and 0.5 wt% have been investigated in 3.5% NaCl solution. The potentiodynamic polarization tests are performed to investigate the effect of Al content (doping) on the corrosion behaviour of Al_x CoCrFeNi system. The results revealed that corrosion resistance of Al_x CoCrFeNisystem decreases with an increase in Al content from 0.3 to 0.5 wt%. In the same vein, potentiodynamic polarization tests on homogenized samples at annealing temperatures 800°C revealed the marked influence of grain size on the corrosion resistance of Al_x CoCrFeNi system. The viable mechanisms for the change in corrosion behaviour such as effect of (i) phase fraction, (ii) lattice distortion due to increase in Al content, and (iii) influence of grain size is discussed with the help post corrosion microstructural analysis. This work is also expected to open up new avenues of understanding the correlation between grain morphology and corrosion characteristics of Al-doped high entropy alloy systems.

Keywords: Corrosion, High Entropy Alloys, Potentiodynamic polarization.

Designing of Nano-heterostructures for Enhanced Photocatalytic Hydrogen Generation

[a]Sudhir S. Arbuj

*[a]Centre for Materials for Electronics Technology (C-MET), Off Pashan Road,
Panchwati, Pune-411008, Maharashtra, India
E-mail: sudhir1305@gmail.com, sudhir@cmet.gov.in*

Abstract

Heterogeneous photocatalysis using Nanostructured semiconductors have been actively studied for various environmental and energy related applications. In 1972, Fujishima and Honda for the first time reported the generation of H_2 from water using TiO_2 as a photo-anode in presence of ultra-violet light. Since then, enormous amount of efforts were taken to generate the H_2 via photocatalytic water splitting. The photocatalytic activity of the catalyst mainly depends upon the band gap and band positions of the materials. Till today various semiconductor oxides as well sulphides have been exploited viz. TiO_2, ZnO, SnO_2, WO_3, Fe_2O_3, CdS, ZnS, SnS_2 and so on, as photocatalyst for energy as well as environment related applications. In order to enhance the activity of catalyst various modifications have been tried, like doping of cations and anions in the existing catalyst, loading of noble metals to minimize the generated electron hole recombination's etc. Furthermore, the change in synthesis methods showed change in the photocatalytic activity as function of surface area and crystallinity. Recently, coupled semiconductor systems of oxide/oxide as well as sulphide/oxide, g-C_3N_4/metal oxide and Mxene /Oxide/Sulphide type also reported to have enhanced photoactivity. This enhanced photoactivity is due to two important reasons. First, in the coupled semiconductor systems contains diferent energy levels, wide band-gap semiconductors can utilize visible light by coupling narrow band-gap semiconductors. Second, charge injection from one semiconductor into another can lead to elcient and longer charge separation by reducing the electron–hole pair recombination's. In the present work we have prepared many coupled catalytic systems and effectively utilized for photocatalytic H_2 generation.

Transforming Waste to Value: Sewage Sludge Biochar for Sustainable Dye Removal

**[a]Bhavana Shanmughan, [a]Amrita Nighojkar and
[a]Balasubramanian Kandasubramanian**

*[a]Defence Institute of Advanced Technology, Pune, India
Email: 0305bhavana@gmail.com*

Abstract

Sewage sludge, a waste material generated in large quantities in India, with an estimated production of 39,000 tons/year (2024), poses significant environmental challenges. In this study conversion of sewage sludge into an environmentally friendly adsorbent can offer a sustainable solution for wastewater treatment. Sewage sludge was converted into biochar through pyrolysis at 500°C. The resulting biochar was characterized using SEM, FTIR, and XRD to analyze its morphology and identify the functional groups present. The porous biochar was employed to treat Remazol Brilliant Blue R (RBBR), a synthetic dye commonly found in textile industry wastewater. Batch adsorption experiments were conducted using a synthetic dye solution. The kinetic studies revealed that dye adsorption follows a pseudo second-order model, implying a chemical composition of the adsorption process. Isotherm studies further revealed that the adsorption data closely followed the Freundlich isotherm model, achieving a maximum adsorption capacity of 112.56 mg/g at pH 7. These findings highlight the ability of sewage sludge biochar as an economical and sustainable adsorbent for the removal of dyes from wastewater. This study emphasizes the promising role of such a reutilization approach in advancing circular economy practices and sustainable waste water treatment solutions.

Development of Porous Membranes of Thermoplastic Polyurethane / Polyphenylsulfone Blends for Biomedical Applications and Water Treatment

[a]Ajay Keloth, [a]T. Umasankar Patro

[a]Department of Metallurgical and Materials Engineering, Defence Institute of Advanced Technology Pune, Maharashtra-673507, India

Email: ajaykeloth202@gmail.com

Abstract

Polymeric membranes find applications in sewage water purification, selective gas separation, dye and heavy metal separation from industrial waste water, oil water separation, selective hydrocarbon separation from crude oil or organic solvent mixtures etc. Thermoplastic polyurethane (TPU) membrane suffers from poor mechanical properties and shrinkage issues. In order to improve the dimensional stability and mechanical properties of TPU, polyphenylsulfone (PPSU) was blended with TPU to prepare porous membranes fabricated using phase inversion technique. For this method N-methyl-2-pyrrolidone was used as solvent and water as non-solvent. The TPU/PPSU blend membranes were in the weight ratios between 100/0 and 0/100 in the intervals of 20 wt.%. The membranes did not show any phase separation regardless of their composition. The membranes were characterised using FTIR, SEM, water contact angle, tensile testing. The hydrophilicity and porosity of the membranes increased with increase in PPSU content. Tensile strength and modulus increased and the elongation decreased with increase in PPSU content in the blend. Biocompatibility tests were conducted to ensure the biocompatibility of the membrane.

Designing Bio-receptive Polypropylene for Use in Biomedical Applications

Chetna Verma, Samrat Mukhopadhyay, Bhuvanesh Gupta

Bioengineering Laboratory, Department of Textile & Fibre Engineering

Indian Institute of Technology, New Delhi-110016, India

Email: vermachetna18@gmail.com

Abstract

Polypropylene (PP) is widely used due to its chemical resistance, non-toxicity, and high tensile strength. However, despite these remarkable properties, the inertness of its surface restricts its application in the biomedical field. Plasma technology offers a sustainable and surface-selective approach to modify the physicochemical properties of materials, enhancing their surface characteristics for specific uses.Plasma functionalization of polypropylene was conducted to create a surface that can be effectively immobilized with a bioactive agent. Additionally, graft functionalization on plasma-treated surfaces provides a promising approach to achieving a high density of desired functional groups on the surface. Itaconic Acid (IA) was grafted on the PP hernia mesh and the influence of polymerization parameters on the degree of grafting was investigated. The plasma grafting led to a shift in contact angle from 131° or virgin to 28° for 1.5 μg/cm2 graft density.The bioactive nanogels of chitosan were used for the finishing of plasma-functionalized fabric and the results confirmed that nanogel finishing significantly improved the hydrophilicity, smoothness, and softness of the fabric surface. Surfaces exhibited strong antimicrobial nature against S aureus and E coli. It was observed that the modified surface has an excellent anti-adhesion nature against microbes, making it useful for developing functional bioactive fabrics.

Synthesis of NiO/g-C_3N_4 Based Nano-Heterostructures: An Efficient Photocatalytic System for Hydrogen Generation

Amol G. Kadlag[a,b], Niteen S. Jawale[b], Amol B. Tambe[b] and Sudhir S. Arbuj[b,*]

[a]Department of Chemistry, S. N. Arts, D. J. M. Commerce & B. N. S. Science College (Autonomous), Sangamner, Maharashtra.
[b]Centre for Materials for Electronics Technology (C-MET), Off Pashan Road, Panchwati,
Pune-411008, Maharashtra, India.
Email: agkadlag@sangamnercollege.edu.in

Abstract

Hydrogen production via water splitting is considered one of the most promising methods for sustainable energy generation. Traditional catalysts like platinum or ruthenium are often expensive and scarce, motivating research into alternative, low-cost catalysts. One such approach is the use of semiconductor-based photocatalysts, such as graphitic carbon nitride (g-C_3N_4), which has been widely studied due to its high stability, earth-abundance, and ability to absorb visible light. However, its performance in photocatalytic hydrogen evolution is often hindered by limitations such as poor charge carrier mobility and rapid recombination of photogenerated electron-hole pairs. To overcome these challenges, coupling g-C_3N_4 with co-catalysts like nickel oxide (NiO) can significantly enhance its photocatalytic activity. In this study, NiO/g-C_3N_4 nanocomposite is synthesized and explored for enhanced hydrogen production through water splitting. The composite material combines nickel oxide (NiO) with graphitic carbon nitride (g-C_3N_4), taking advantage of the unique electronic and structural properties of both components. The NiO acts as an efficient co-catalyst to facilitate the hydrogen evolution reaction (HER), while g-C_3N_4 serves as a semiconducting material that absorbs visible light and enhances photocatalytic activity. The various spectroscopic characterization techniques confirm the formation of the nanocomposite. The NiO/g-C_3N_4 nanocomposite exhibits significantly improved hydrogen production rates compared to individual NiO and g-C_3N_4 materials. The enhancement in photocatalytic hydrogen generation is attributed to the synergistic effects between NiO and g-C_3N_4, which enhance charge separation and reduce recombination, leading to better photocatalytic efficiency. This study demonstrates that NiO/g-C_3N_4 nanocomposites hold great potential for hydrogen production through water splitting, offering a promising route for clean energy applications.

Keywords: Graphitic carbon nitride, Photocatalyst, H_2 generation.

Influence of Silicon Addition on the Microstructure, Hardness and Corrosion Performance of Al-6.5Mg Alloys

Tushal Kyada[a,b], Indravadan Dave[c*], Sonam Patel[b], Vandana Rao[d], Kunal Trivedi[e]

[a]Research Scholar, Gujarat Technological University, Ahmedabad, India
[b]Dr. S. & S. S. Ghandhy College of Engineering & Technology, Surat, India
[c]Government Engineering College, Gandhinagar, India
[d]The Maharaja Sayajirao University, Baroda, India
[e]Institute for Plasma Research, Bhat, Gandhinagar, India
Email: ibdave@gecg28.ac.in

Abstract

Al-Mg alloys are widely used as sacrificial anodes for offshore structures due to their high electrochemical efficiency, superior dissolution characteristics, and excellent depassivation behavior in chloride-rich environments. However, previous studies have not fully explored the combined effects of silicon addition on the microstructure, mechanical properties, and corrosion resistance of Al-6.5Mg alloys. To address this gap, this study investigates the influence of silicon additions (1.5%, 3%, 4.5%, and 6%) on the properties of Al-6.5Mg alloys. Optical microscopy reveals that silicon addition modifies the morphology of Mg_2Si phases, while XRD analysis confirms the presence of α-Al, Mg_2Si, and Al_3Mg_2 phases. Hardness measurements indicate significant improvements, with Al-6.5Mg-1.5Si and Al-6.5Mg-6Si exhibiting the highest hardness values. Corrosion behavior was assessed through an 8-week weight loss study in a 3.5 wt.% NaCl solution, showing that Al-6.5Mg and Al-6.5Mg-1.5Si maintain stable corrosion rates, whereas higher silicon content leads to increased corrosion rates. Potentiodynamic polarization tests further confirm this trend, with Al-6.5Mg-1.5Si demonstrating the lowest Icorr and corrosion rate, while Al-6.5Mg-6Si exhibits the highest corrosion rate. SEM and EDX analyses confirm progressive pitting with increased silicon content. The results demonstrate that Al-6.5Mg and Al-6.5Mg-xSi alloys have potential as sacrificial anode materials for corrosion protection applications.

Evaluation of Microstructural and Mechanical Properties of Microwave Sintered FeNiCoCr High-Entropy Alloy Reinforced with SiC Particles

[a]G. Chandra Mouli*, [a]T L Dora, and [a]Radha Raman Mishra

[a]Department of Mechanical Engineering, Birla Institute of Technology and Science, Pilani, Rajasthan 333031, India
Email: p20240807@pilani.bits-pilani.ac.in, rraman.mishra@pilani.bits-pilani.ac.in

Abstract

This work investigates the reinforcement effect of silicon carbide (SiC) addition on the microstructural and mechanical characteristics of FeNiCoCr High-Entropy Alloys (HEAs) fabricated through microwave sintering: pure FeNiCoCr HEA and SiC-reinforced composites with varying different SiC contents (1%, 3%, 5%, 7%, and 9%). Microwave sintering minimizes processing time and achieves quick, uniform, and volumetric heating. X-ray diffraction (XRD) to characterize the sample's phase analysis and crystallographic structure revealed the formation of FCC solid solution with additional phases due to SiC incorporation. The microstructural studies, elemental distribution, and interface properties of the matrix and reinforcement were examined using energy-dispersive spectroscopy (EDS) and field emission scanning electron microscopy (FESEM) studies. The study demonstrates the potential of SiC-reinforced FeNiCoCr HEAs for advanced engineering applications, providing insights into the role of reinforcement in tailoring microstructural and mechanical properties. Incorporating SiC was found to refine the microstructure and enhance interfacial bonding. Vickers microhardness testing revealed mechanical properties, showing an incremental improvement in hardness with increasing SiC content attributed to dispersion strengthening and load transfer mechanisms.

Keywords: SiC, High-Entropy Alloys, Microwave Sintering, Microstructure, Microhardness.

Adhesives and their Various Applications

[a]Meenakshi

[a]Department of Chemistry, University of Rajasthan, Jaipur.
Email: meenakshialwaraj@gmail.com

Abstract

Adhesives can be defined as natural or synthetic substances capable of joining permanently to surfaces by an adhesion process. It holds two or more materials together with cohesive forces and surface attachment in a practical way. This process involves two dissimilar bodies being held in intimate contact such that mechanical force or work can be transferred across the interface. Adhesive is a chemical substance that can be liquid or solid, inorganic or organic, that forms a bridge, film, or metrics filler and causes a chemical reaction. Polymerization tendency or interlocking crystal habits are actually responsible for their binding behavior. Adhesives can be made from and be composed of a variety of substances such as tree sap, bee wax, cement, and epoxy. Ideally, there are two broad adhesive categories, natural and synthetic adhesives. Most commercially found adhesives are synthetic adhesives, as they provide better consistency, bond strength, and adaptability compared to natural adhesives. Bitumen, tree pitches, and beeswax used in ancient and medieval times were replaced by rubber cements and natural and synthetic components. Nowadays, the focus is on eco-friendly adhesives. Synthetic adhesives are further classified as consumer adhesives and industrial adhesives based on their application. An adhesive's chemical composition determines its application methods, usage, and bonding strength. This paper deals with an overview of different types of adhesives and their applications in various fields.
Keywords: Adhesives, Synthetic adhesives, Natural adhesives.

Study on Poly(ether-ketone)/Silica Nanocomposites for Electronic Applications

Mandar Joshi[a,b,] Roshan Gadve[c], Gautam Upadhyay[a] and R. K. Goyal[c*]

[a]Gujarat Technological University, Ahmedabad, Gujarat, 382424, India [b]Metallurgy Engineering [b]Department, Dr. S. & S. S. Ghandhy College of Engg. & Technology, Surat, Gujarat, 395001, India
[c]Department of Metallurgical and Materials Engineering, Malaviya National Institute of Technology Jaipur, Jaipur, Rajasthan, 302017, India
Email: mandarjoshi999@gmail.com

Abstract

The microstructural, thermal, and dynamic mechanical properties of polyether-ketone (PEK) nanocomposites reinforced with SiO2 nanoparticles were studied. The nanocomposites containing 0 to 30 wt% SiO2 were fabricated using a planetary ball mill followed by hot pressing. The findings demonstrate an improvement in microhardness, thermal stability, and dynamic mechanical properties with increment of SiO2 content. The addition of 30 wt% SiO2 resulted in more than 50% increase in microhardness compared to neat PEK, while thermogravimetric analysis indicated thermal stability exceeding 560°C. Dynamic mechanical analysis revealed more than 100% increase in storage modulus below glass transition while more than 250% increase above glass transition temperature compare to neat PEK. Morphological investigation was done suing scanning electron microscopy. These results highlight the potential of PEK/SiO2 nanocomposites as multifunctional materials for next-generation electronic applications, offering an optimal balance between thermal and mechanical reliability.

Ultrasound Assisted Synthesis of ZnO-PEG-Chitosan Nanobiocide Film Using Origanum Majorana Flower Extract

[a]Garima Ameta and [a]Jyoti Chaudhary

[a]Department of Chemistry, University College of Science, Mohanlal Sukhadia University, Udaipur, Rajasthan - 313001
Email: garimaameta1301@gmail.com

Abstract

This work aims to prepare green synthesized ZnO-PEG-Ch nanobiocide film using the aqueous flower extract of Origanum majorana under the influence of ultrasound and access its biocidal proficiency. This nanocomposite thin film that is formulated utilizing the Origanum majorana flower extract and ultrasound as a green energy source have emerged as nontoxic and ecofriendly in nature. In this investigation, zinc acetate dihydrate was used as a ZnO precursor and PEG and chitosan were used as the polymeric stabilizer and solid support, while Origanum majorana flower extract acts as a green reducing agent to produce ZnO nanoparticles. This metal polymer film was characterized by UV-Vis, FT-IR, TEM, TGA, DSC and biocidal activities. Characterization data clearly reveals that ZnO nanoparticles embedded in a crosslinked polymer matrix. Very fine ZnO nanoparticles (4-6 nm) have been synthesized using ultrasound as a green energy source has been proven by TEM images and TGA-DSC results show that this nanocomposite film is thermally stable. This nanocomposite film possesses synergistic biocidal activities too and can be used as an astringent.

Keywords: Ultrasound, Biosynthesis, crosslinking, nanocomposite film, biocidal activity

3D-Printed Polycarbonate Composites Reinforced with Short Carbon Fibers

Tejas Rajput[a,b,] Animesh Gopal[a,b] and Kadhiravan Shanmuganathan[a,b]

[a]Polymer Science and Engg. Division, CSIR-National Chemical Laboratory, Pune-411008, India
[b]Academy of Scientific and Innovative Research (AcSIR), Ghaziabad-201002, India
Email: tejasrajput300@gmail.com

Abstract

Carbon fibers (CFs) are extensively utilized as reinforcement materials in composite manufacturing due to their exceptional specific modulus, strength, stiffness, electrical conductivity, and low density. Thermoplastic composites reinforced with carbon fibers have found widespread application in aerospace, automotive, and high-speed vehicle industries owing to their superior mechanical properties, low weight, durability, and recyclability. This research investigates the processing and mechanical characterization of 3D-printed polycarbonate (PC) composites reinforced with short carbon fibers (SCFs) using the fused filament fabrication (FFF) process. SCF weight fractions of 1%, 3%, 5%, 7.5%, and 10% were studied to evaluate their effect on the composite's performance. Tensile testing revealed that SCF-reinforced PC composites exhibited significantly improved tensile strength and modulus compared to pure PC, with an accompanying reduction in %elongation at break. In addition, rheological analysis, scanning electron microscopy (SEM), and flexural testing were performed to characterize the composite's flow behavior, microstructure, and flexural properties, respectively. These results highlight the potential of 3D printed SCF-reinforced PC composites in applications requiring high strength-to-weight ratios and customizable mechanical properties.

Harnessing Large Language Models for Sustainable Materials and Manufacturing: A Review of Frameworks, Application & Innovations

Ayush Pratap[a,b], Neha Sardana[a*], and Pao-Ann Hsiung[c*]

[a]Dept of Metallurgical and Materials Engineering, Indian Institute of Technology, Ropar, Rupnagar, 140001, India
[b]Grad. Institute of Ambient Intelligence and Smart Systems,
National Chung Cheng University Chiayi County, Taiwan R.O.C
[c]Dept. of Computer Science and Information Engineering,
National Chung Cheng University Chiayi County, Taiwan R.O.C
Email: pahsiung@cs.ccu.edu.tw, nsardana@iitrpr.ac.in

Abstract

The integration of Large Language Models (LLMs) into materials science and manufacturing has significantly advanced the analysis, prediction, and optimization of material properties and production processes leading to a sustainability. This review examines the evolving landscape of LLM applications in materials and manufacturing, with a focus on their role in accelerating sustainable material discovery, enhancing predictive modeling, and optimizing process control. Fundamental frameworks that enable LLMs to process vast datasets, including Retrieval-Augmented Generation (RAG) and fine-tuning strategies tailored for materials informatics, are discussed. Key applications such as phase prediction, mechanical property estimation, defect detection, and synthesis pathway optimization are categorized. Notable innovations, including the use of open-source LLMs for domain-specific tasks and the development of hybrid AI models that integrate machine learning with physics-based simulations, are also highlighted. Challenges associated with the deployment of LLMs in materials research, such as data scarcity, model interpretability, and computational demands, are critically examined. Emerging trends, including the integration of LLMs with multi-modal data sources are explored as potential strategies to enhance predictive accuracy and applicability. By providing a comprehensive overview of LLM-driven advancements in materials and manufacturing, this review serves as a guide for selecting appropriate models, datasets, and computational techniques leading to a sustainable research and development in this domain. The discussion concludes with future perspectives on the role of trustworthy AI, collaborative frameworks, and domain-specific LLMs in shaping the next generation of intelligent sustainable materials and smart manufacturing.

Keywords: Large Language Models; Materials Informatics; Manufacturing AI; Industry 5.0; Trustworthy AI; Smart manufacturing

Upcycling of Waste Polypropylene into High-Grade 3D Printing Filaments

Animesh G[a,b,] Prashant Patil,[a] Harshawardhan P[a,b], and K Shanmuganathan[a,b*]

[a]Polymer Science and Engineering Division, CSIR-National Chemical Laboratory, Dr. Homi Bhabha Road, Pune, 411008, Maharashtra, India
[b] Academy of Scientific and Innovative Research (AcSIR), Ghaziabad, 201002, India
E-mail: a.gopal@ncl.res.in

Abstract

The growing emphasis on sustainable manufacturing has intensified efforts to recycle thermoplastics for 3D printing applications. This study investigates the potential of recycled polypropylene (rPP) blended with an elastomer to enhance its mechanical performance and mitigate warpage - one of the primary challenges in fused filament fabrication (FFF) 3D printing. By incorporating a compatibilizer in varying concentrations, blends were processed through mechanical recycling and subsequently 3D printed to evaluate their structural and functional properties. The optimized blends exhibited a remarkable improvement in elongation at break, increasing by over 60 times compared to neat rPP, while maintaining tensile strength and significantly enhancing toughness. Warpage was reduced by more than 2.3 times, demonstrating the suitability of blend for 3D printing applications. Isothermal crystallization studies, supported by Avrami analysis, revealed a controlled crystallization behavior that contributes to improved printability. Morphological investigations using scanning electron microscopy (SEM) and in-situ optical microscopy (OM) confirmed a more homogeneous dispersion of phases in the optimized blends, leading to superior interfacial adhesion and enhanced mechanical properties. These findings highlight the potential of compatibilized rPP based formulations for sustainable and high-performance 3D printing, paving the way for broader applications of recycled polypropylene in 3D printing.

Comparative Corrosion Performance of Electroless NiB and Hard Chrome Coatings

Abhishek Soni[a*], A. Kumaraswamy[b], Praveen Kumar B.[c]

[a]Department of Mechanical Engineering, COEP Technological University, Pune-411005, India
[b]Department of Mechanical Engg., Defence Institute of Advanced Technology, Pune-411025, India
cAMT Centre, Armament Research and Development Establishment, Pune-411021, India
**E-mail: abhisheks.mech@coeptech.ac.in*

Abstract

Hard chrome electroplating has been the conventional choice for corrosion protection in gun barrels, but its environmental and health hazards necessitate alternative solutions. Electroless nickel-boron(NiB) coatings have emerged as a promising substitute, and their corrosion resistance was evaluated against hard chrome using electrochemical characterization techniques. The NiB coatings exhibited a distinctive cauliflower-like surface morphology and wheat-earring-type columnar grains, maintaining a uniform thickness of 30±2 µm with an average roughness of 225±25 nm. Electrochemical impedance spectroscopy revealed that the charge transfer resistance of NiB was nearly three times higher than that of hard chrome. Additionally, NiB coatings demonstrated a reduction of 86% in corrosion current density and a 78% decrease in corrosion rate, highlighting their superior corrosion resistance.

Keywords: Electroless NiB coating, Hard chrome, Corrosion, Gun barrels

Electrical Properties of Uncoated Ni and Carbon Coated Ni Nanoparticles Reinforced Poly(ether-ketone) Nanocomposites

R. D. Gadve[a], S. H. Joshi[b] and R. K. Goyal[a]

[a] Department of Metallurgical and Materials Engineering, Malaviya National Institute of Technology Jaipur, J. L. N. Marg, Jaipur, India;
[b] Department of Applied Physics, The Maharaja Sayajirao University of Baroda, Vadodara, India
Email: 2019rmt9514@mnit.ac.in

Abstract

In this work, the effect of uncoated Ni and carbon coated Ni (C@Ni) nanoparticles on the electrical properties of high-performance polymer poly(ether-ketone) (PEK)/Ni nanocomposites was studied. The nanocomposites were fabricated using planetary ball milling followed by hot compaction. Morphological analysis showed uniform dispersion of Ni nanoparticles at lower loadings and few aggregates at higher loadings. The highest DC electrical conductivity of the order of ~ 10-1 s/cm was achieved at ~6 vol.% Ni content which is 13 orders of magnitude higher than the neat PEK. The percolation threshold value for the nanocomposites containing uncoated Ni nanoparticles was found higher than the nanocomposites containing C@Ni. The lower percolation threshold for the PEK/C@Ni than those of PEK/Ni nanocomposites was found due to the effective carbon coating on Ni, which prevented the oxidation of Ni as well as improved the interfacial adhesion between the C@Ni and PEK matrix. This electrically semi-conductive polymer nanocomposite can be used in defense systems, electromagnetic shielding, electronics and information industry.

Effect of Li_2O-$Al2O_3$-TiO_2-P_2O_5 Addition on Electrical Behaviour of NMC-811 Cathodes for Li-Ion Batteries

Kaustubh R. Kambale[a], J.D. Sharma[a], Avinash Ghongate[b] and S.P. Butee[b]

[a]Department of Metallurgical and Materials Engineering, Punjab Engineering College (Deemed to be University), Chandigarh, Sector 12, Chandigarh-160012
[b]Department of Metallurgy and Materials Engineering, COEP Technological University, Shivaji Nagar, Pune - 411005
Email: kaustubhrameshkambale@pec.edu.in

Abstract

LiNi0.8Mn0.1Co0.1O2 (NMC-811) is considered as a promising cathode material in all solid-state Li-ion batteries. Similarly, Li2O-Al2O3-TiO2-P2O5 (LATP) system especially in glass or glass-ceramic form has been considered a potential solid electrolyte for Li-ion batteries. Recent research suggests that a composite of NMC-811/LATP results in improved half-cell electrochemical performance. However, the mechanism of the improvement still needs to be researched thoroughly. Hence, this research focused on the electrical characterization of NMC-811/LATP composites via impedance spectroscopy. NMC-811 powder was prepared by solid state method using Li2CO3, Ni(OH)2, MnO2 and Co(OH)2. The solid-state synthesis of NMC-811 involved heating at 470°C for 5 hours and calcination at 870°C for 10 hours. Formation of single phase NMC-811 was confirmed by X-ray diffraction. LATP was added to NMC-811 in various forms viz. ceramic, glass and glass-ceramic. LATP ceramics were prepared by solid state reaction at 950°C. LATP glass was prepared by melt-quench technique at 1450 and 1500 °C whereas LATP glass-ceramics were prepared by annealing at 850°C followed by glass making. Li2CO3, Al(OH)3, NH4H2PO4, TiO2 (Rutile) were used as raw materials for LATP preparations. NMC-811/LATP composites were prepared in a mass ratio of 70:30. Pellets required for impedance spectroscopy characterization were prepared using uniaxial pressing. The paper discusses ion dynamics in these composites in light of their dielectric constant, ionic conductivity and normalized modulus study.

Comparison of Uniaxial and Torsional Low Cycle Fatigue Behavior of a Cu-Ni Alloy

Adarsh Bharti[a], Hitarth Maharaja[b], Sushil Mishra[b], S. Sivaprasad[c], Abir Bhattacharyya[a*]

[a]Department of Metallurgical and Materials Engg., IIT Jodhpur, Rajasthan-342030
[b]Department of Mechanical Engg., Indian Institute of Technology, Bombay, Mumbai-400076
[c]Materials Engg. Div., CSIR- National Metallurgical Laboratory, Jamshedpur, Jharkhand – 831007
Email: bharti.1@iitj.ac.in

Abstract

Low cycle fatigue (LCF) experiments were conducted on a Cu-Ni alloy under uniaxial and torsional loading conditions at same equivalent strain amplitudes to understand the effect of strain path on cyclic deformation behavior of the alloy and on its fatigue life. The fatigue life is higher for torsional loading as compared to corresponding axial loading. The cyclic stress response exhibits primary hardening followed by softening and secondary hardening under both axial as well as torsional loadings. The primary hardening and softening is higher for axial loading while secondary hardening is higher for torsional loading at same equivalent strain amplitude. The cyclic deformation behavior between axial and torsion loading increasingly deviates with increasing number of fatigue cycles for same equivalent strain amplitude. Electron backscattered diffraction results reveal higher geometrically necessary dislocation density under axial loading as compared to torsional loading.

Study the Effect of Biochar on the Dielectric Properties of Polyolefins

[a]Moumita Naskar and [a]Ankita Deb

[a]Central Power Research Institute, Regional Testing Laboratory, Kolkata 700091, India
E-mail: moumita@cpri.in

Abstract

Biochar produced by thermal cracking of coconut coir (CC) in a limited oxygen atmosphere was successfully used as a doping agent for polyolefin. Scanning Electron Microscopy (SEM) image established the fibrous structure of CC. Polyolefins predominantly polyethylene (PE) and polypropylene (PP) possess high dielectric properties due to nonpolar hydrocarbon based molecular structure. Thermal stability of PE is not satisfactory. PP is not suitable for many uses due to poor dielectric constant and mechanical properties. Introduction of CC could improve thermal stability, tensile & elongation, volume resistivity and break down voltage depending on the amount added. The morphology of the prepared PE and PP composites were studied under SEM. Volume resistivity (VR) was evaluated at 30°C, 60°C and 90°C for the prepared PE, PP compositions to check the safety, efficiency, and reliability aspect at extreme service temperature and activation energy (Ea) was calculated from Arrhenius equation for all the composites. However, challenges related to compatibility, dispersion, and processing need to be addressed for successful commercialization. With continued research and development, biochar-filled polyethylene composites have the potential to become a more sustainable and cost-effective alternative to conventional polymer materials for high voltage insulation applications.

Keywords: Biochar; Polyolefins; thermal stability; Volume resistivity; activation energy

Ammonium Chloride-Assisted Chlorination for Anhydrous Neodymium Chloride Synthesis

[a]Y. Varun, N. Purushotham, [a]K. Balaraju, [a]S. N. Tadka, [a]S. Rajesh Kumar, [a]Y. Purushotham

[a]Centre for Materials for Electronics Technology (CMET), Hyderabad – 500051, India
Email: varunahalya@gmail.com, ypurushotham@cmet.gov.in

Abstract

The chlorination of neodymium oxide (Nd_2O_3) using ammonium chloride (NH_4Cl) was investigated to optimize the synthesis of high-purity Neodymium chloride ($NdCl_3$). A systematic study was conducted by varying the reaction parameters, including mole ratio, reaction temperature, and time, with a specific focus on suppressing the formation of intermediate Neodymium oxychloride (NdOCl). The reactions were performed in a fixed-bed tubular reactor under an inert argon atmosphere to ensure controlled and efficient chlorination. The optimized conditions for maximum conversion and purity were identified as a reaction temperature of 250°C and a purification temperature of 400°C. It was observed that an excess of ammonium chloride significantly enhanced both the yield and purity of $NdCl_3$. Under these conditions, the highest chlorination conversion rate achieved was 96%. The resultant Neodymium chloride was comprehensively characterized to confirm its quality. Phase purity was determined through X-ray diffraction (XRD), while the metal purity was quantified using Inductively Coupled Plasma Optical Emission Spectroscopy (ICP-OES). The high purity and yield of $NdCl_3$ underscore the effectiveness of the optimized parameters. This high-purity $NdCl_3$ is of strategic importance, particularly for the defense and renewable energy sectors. It serves as a precursor in the production of advanced materials, including permanent magnets essential for electric vehicles and other critical applications.

Fabrication and characterization of in-situ A356-TiB2 composites disc through intensive high shear mixing and centrifugal casting process

Sunil Manani[a], Nidhi Sindhu[b], T.P.D. Rajan[c], R.K. Goyal[b], Sreekumar Vadakke Madam[b]

[a]Department of Metallurgical and Material Engineering, Punjab Engineering College, Chandigarh, India
[b]Department of Metallurgical and Material Engineering, Malviya National Institute of Technology, Jaipur, India
[b]Materials Science and Technology Division, NIIST Thiruvananthapuram, Kerala, India
Email: sunilmanani@pec.edu.in

Abstract

The A356-xTiB2 (x =1, 2, 3, 4 wt.%) in-situ composite discs were fabricated by a combination of intensive high shear mixing technique and centrifugal casting process. The microstructural analysis of base alloy and composites disc were carried out using optical microscopy, scanning electron microscopy and transmission electron microscope. A gradient of TiB2 particles from the outer to inner regions of the disc was observed. Also the gradient was prevalent in the composites containing 4-5wt% of TiB2 in A356 alloy. The composite had refined α-Al phases and the agglomerations of TiB2 particles become finer with an increase in TiB2 content. Moreover, the dendritic structure of the α-Al phase in the alloy changed into the cellular structure with the addition of TiB2 concentration (after 3 wt.%). TEM analysis confirmed the presence of nano TiB2 particles at both matrix and eutectic region. The hardness of composites was found to be decreased along the radial direction of the disc from the outer periphery due to variations in the volume fraction of TiB2 from the inner to outer. The wear resistance, tensile strength, and compressive strength of the composites were higher than the base alloy and the properties increased with an increase in TiB2 content up to 3 wt.%.

Synthesis of Strategic NdF3/PrF3 Mixed-Fluorides from Indigenous Sources for Strategic Applications

[a]N. Sai Anuraag, [a]S. Rajesh Kumar and [a]Y. Purushotham

[a]Centre for Materials for Electronics Technology (C-MET), Hyderabad, India
Email: anuraag.namuduri@gmail.com

Abstract

Rare-earth (RE) metals especially Neodymium (Nd) and Praseodymium (Pr) are indispensable today due to their strategic, automotive and medical applications in the form as NdFeB magnets and optical materials. In this regard, there is a need for the establishment of their extraction processes indigenously. These REs occur as Monazite ores in India and Indian Rare-earths Limited extracts them to finally supply Nd-Pr mixed oxide. Since these RE oxides are very stable, thermodynamically it is favourable to convert them into their halides (Cl, F, I) for their reduction to get metals. In this study, we have successfully converted the indigenously procured Nd-Pr mixed oxide to Nd-Pr mixed fluorides using a single step dry-state method. The conventional fluorination methods which utilize highly corrosive, toxic and hygroscopic fluorination agents such as HF, F2 gas, NH4F and often involve multiple steps. The proposed method utilizes easy to handle, less toxic and non-hygroscopic ammonium bifluoride as the fluorination agent. The intimate mixture of Nd-Pr oxide and ammonium bifluoride was loaded into a tubular furnace with continuous inert gas flow. The mixture was then heated up to 600 °C at various heating rates. Finally, the cooled and collected powder was crushed and analysed using characterization techniques like XRD, SEM, ED-XRF and ICP-OES understand the phase-formation, morphology and chemical composition. The powder was also analysed using particle size analyser and ONH analyser for understanding the particle size distribution and oxygen content. The results confirmed the complete fluorination resulting in the formation of NdF3/PrF3 mixed-fluorides with high purity of 99% and a yield of 99.5%.

Can PVP-Tuned ZIF-67 Derivatives Enhance Hydrogen Production in Seawater Splitting?

Manisha Jain†,[‡,*,] Pankaj Poddar[†,‡]

†Physical & Materials Chemistry Division, CSIR-National Chemical Laboratory, Pune 411008, India
‡Academy of Scientific and Innovative Research (AcSIR), Sector 19, Kamla Nehru Nagar, Ghaziabad, Uttar Pradesh- 201002, India
E-mail: m.jain@ncl.res.in.

Abstract

A simple and explicit wet chemical method enables the room temperature crystallization of zeolitic imidazolate framework (ZIF-67) using cotton-cloth (CC) as a substrate; where time-dependent Avrami's kinetic studies demonstrated sluggish nucleation and fast crystal growth resulting in unprecedented morphologies–truncated cubes (synthesized without poly(N-vinyl pyrrolidone); PVP), and rhombic dodecahedra (with PVP) with sizes ranging from c.a. 500 nm to 1.41 μm; wherein amphiphilic PVP plays a crucial function of structure directing agent by modulation of complex formation and deprotonation equilibria. . To study the potential of pristine ZIF-67 (ZP0) and PVP-functionalized ZIF-67 (ZP50, ZP100, and ZP200) grown on the CC substrate for application as a flexible electrode in seawater splitting, ZP0, ZP50, ZP100, and ZP200 were annealed to form CZP0, CZP50, and CZP100, respectively. The PVP-assisted derivatives exhibit significant improvements in catalytic activity, electrochemical stability, and conductivity, leading to superior hydrogen evolution reaction (HER) performance in seawater electrolysis. The findings highlight the potential of PVP-modified ZIF-67 as a high-performance, cost-effective catalyst for sustainable hydrogen production, offering a promising pathway for clean energy generation from simulated seawater.

Next Generation Nanomaterials for Health-Care and Sustainable Food Packaging Applications

Kanchan Yadav [A, B, C, E,] Raman Sankar [B, C*,] Chien-Yuan Pan [D*], Ashok M. Raichur [E*]

[A] *Department of Chemistry, National Taiwan University, Taipei, Taiwan*
[B] *Nano Science and Technology Program, Taiwan International Graduate Program, Academia Sinica, Taipei, Taiwan*
[C] *Institute of Physics, Academia Sinica, Taipei, Taiwan*
[D] *Department of Life Science, National Taiwan University, Taipei, Taiwan*
[E] *Department of Materials Engineering, Indian Institute of Science, Bangalore, India*
E-mail: kanchanyadav@iisc.ac.in

Abstract

Our research study is based on the employment of next generation nano-materials for different bio-applications. The first part of study is based on the employment of 2-Dimensional Nano-sheets (2D NSs) for Fluorescence Biosensing of prostate specific antigen (prostate cancer biomarker) where picomolar sensitivity was obtained in PBS buffer. Further, we have employed polyethylene glycol (PEG) to minimize the non-specific binding in the multiplexed biosensing system of food toxins (i.e. Aflatoxins B1 (AFB1) and Aflatoxins M1 (AFM1)). The designed PEGylated Ternary transition metal sulfides 2D NSs based fluorescent sensor exhibited ultrasensitive detections (~ pM) and a wide linear range (≥ 5 orders) for AFB1 and AFM1 in complex matrix (e.g., low fat milk and human serum), which can serve as a unique platform for facile, ultra-sensitive, selective, cost-effective, and quick multiplexed detection of food toxins and disease biomarkers in complex-matrix. In the second part of research study, UCNPs have been applied for optogenetics as health-care applications. The Optogenetics combines "Optics" and "Genetics" for the study of light sensitive proteins for neurological disorders. In the present study, non-invasive light source for deep-tissue optogenetic purposes has been studied by employing UCNPs which absorbs NIR radiation and emit visible light to study light sensitive proteins. Further, our future research endeavour is based on employment of unexplored 2D NSs and other types of nanomaterials for improvement of the packaging properties and developing a biodegradable or eco-friendly Intelligent Packaging Materials to enable real-time food quality monitoring during storage and transportation. In addition, we aim to develop a portable point of care device for the early detection of dreadful diseases such as cancer. Overall, our project focuses on food and health safety and well-being of society.

Sustainable Innovation: Transforming Tire Waste into Nanosized Onion-like Carbons for Greener Lubrication Solutions

Ravikiran Nowduru[a], Sanjay Dhage[a], Pawan Kumar Jain[a]

International Advanced Research Centre for Powder Metallurgy and New Materials, Hyderabad, India, 500005
Email: kravi3249@gmail.com

Abstract

The growing challenge of tire waste management demands innovative and sustainable solutions. In this study, we present a scalable and eco-friendly approach to convert tire pyrolysis waste into high-value nanosized onion-like carbons (NOLCs) with exceptional lubricant-additive properties. Through an optimized thermal processing governed nano re-structuring, we achieved kilogram-scale production of NOLCs, demonstrating the feasibility of industrial-scale implementation. The synthesized NOLCs exhibit a unique concentric graphitic structure, providing remarkable friction reduction, thermal stability, and dispersibility in lubricant formulations. To evaluate their practical application, we dispersed the NOLCs in a base oil and a commercial 15W40 engine oil using ultrasonication, optimizing the process to achieve stable and homogeneous suspensions. Tribological testing revealed that the NOLC-enhanced lubricant significantly reduced friction and wear, with a 40% improvement in wear resistance and a 30% reduction in the friction preventive properties. The NOLCs also demonstrated excellent thermal stability, maintaining performance under high-temperature conditions typical of engine operations. This work not only addresses the environmental burden of tire waste but also introduces a sustainable pathway for producing advanced lubricant additives. By transforming waste into a valuable resource, our approach aligns with the principles of a circular economy and offers a scalable solution for greener and more efficient lubrication technologies. Future efforts will focus on further optimizing the dispersion process and exploring additional applications of NOLCs in energy storage and composite materials.

Keywords: Sustainable materials, Waste-to-wealth, Lubricant additives, Advanced lubricants

Direct Energy Deposition-Based Composite Fabrication

[a]Mohit Sharma and [a]Amit Choudhary

[a]Department of Mechanical and Industrial Engineering, Indian Institute of Technology-Roorkee, Roorkee, Uttarakhand, 247667, India
Email: mohit_s1@me.iitr.ac.in

Abstract

The increasing demand for advanced engineering materials has driven the development of metal matrix composites (MMCs) with superior mechanical, thermal, and functional properties. This study explores a sustainable and efficient approach for fabricating MMCs using Wire Arc Additive Manufacturing (WAAM). The WAAM process, recognized for its high material utilization, energy efficiency, and suitability for medium-to-large-scale components, is adapted to integrate ceramic reinforcements into a metallic matrix. This research focuses on incorporating tungsten carbide (WC) particles into a steel matrix through a WAAM system equipped with a controlled powder feeder. Systematic investigations were conducted to examine the influence of WAAM process parameters on the microstructural evolution and mechanical properties of the fabricated MMCs. This work highlights the potential of WAAM-fabricated MMCs for demanding applications in aerospace, automotive, and marine industries, contributing to the advancement of environmentally responsible and economically viable manufacturing solutions for next-generation composite materials.

Keywords: Metal matrix composites, Additive manufacturing, Sustainability

Double Doping of Rare Earth Elements (ZrO_2 and La_2O_3) in Y_2O_3 Ceramics: Synthesis, Characterization, and Opto-Electronic Properties

[a]Harshit Tripathi, [a]Nikhil Sharma and [a]Jagmohan Datt Sharma*

[a]Department of Metallurgical and Materials Engineering,
Punjab Engineering College (Deemed to be University), Sector-12, Chandigarh-160012, India.
*[a]*Email: jdsharma@pec.edu.in*

Abstract

In this study, double doping of Rare Earth Elements into Y_2O_3 ceramics was investigated using sintering additives ZrO_2 and La_2O_3. The samples were synthesized via co-precipitation method and X-ray diffraction analysis confirmed the cubic Y_2O_3 structure (JCPDS card No. 41-1105) with a gradual shift at angles observed at 2θ = 29.2°. The effect of doping has been confirmed by XPS studies. The particle sizes variation of the powder revealed by FESEM ranges from 130 nm to 50 nm, showing homogeneous distribution. The powders sintered at 1700°C for 10 hours in an inert atmosphere produced translucent pellets in the 200–2200 nm range, exhibiting non-uniform heating and varied grain sizes. Under 350 nm excitation, the samples emitted blue, green, violet, and indigo wavelengths, indicating transitions from 4F11/2 orbitals, with a reduced band gap from 5.4 eV. The sintered samples showed a dielectric constant of 15. These findings highlight the impact of double doping on $Y2O_3$ for opto-electronic applications.

Enhancing the Bio-Tribological Performance of Plasma-Sprayed Porous Ti-6Al-4V Coatings via Micro-Arc Oxidation for Biomedical Applications

[a]P. Manojkumar, [a]Ch. Phanikumar, [a]L. Rama Krishna, [a]G. Sivakumar

[a]Center for Engineering Coatings, International Advanced Research Center for Powder Metallurgy and New Materials (ARCI),
Hyderabad, Telangana -500004, India
Email: gsivakumar@arci.res.in

Abstract

Porous coatings on biomedical implants are essential for improving osseointegration, as they facilitate cell adhesion, proliferation, and nutrient transport. Ti-6Al-4V is widely used in orthopedic and dental implants due to its excellent biocompatibility and mechanical properties. In this study, plasma-sprayed Ti-6Al-4V coatings with controlled porosity were fabricated using NaCl as a pore-forming agent at varying concentrations (10 and 30 vol.%). While porosity enhances biological performance, it also reduces resistance to bio-tribo-corrosion in physiological environments. To overcome this limitation, a dense and wear-resistant TiO_2 top layer (~10 μm) was developed via micro-arc oxidation (MAO). The duplex coating—combining a porous Ti-6Al-4V structure with a hard TiO_2 layer—was systematically evaluated for its microstructural, mechanical, and tribological properties. Results revealed that the MAO-treated coatings significantly improved wear resistance, reduced friction, and enhanced corrosion resistance, making them suitable for long-term biomedical applications. The synergy of plasma spraying and MAO processing effectively balances biological functionality with mechanical durability, offering a promising surface modification strategy for next-generation implant coatings.

Keywords: Porous Ti-6Al-4V, Plasma Spraying, Micro-Arc Oxidation (MAO), Bio-Tribo-Corrosion, Biomedical Implants

Effect of electrolyte composition on the corrosion behavior of micro-arc oxidation coated AZ91 magnesium alloy

Ch. Phani[a,b*], Lakshman Neelakantan[b], L. Rama Krishna[a]

[a]International Advanced Research Centre for Powder Metallurgy & New Materials (ARCI), Balapur P.O., Hyderabad, Telangana, 500005, India
[b] Corrosion Engineering and Materials Electrochemistry Group, Department of Metallurgical and Materials Engineering, Indian Institute of Technology Madras, Chennai 600036, India
Email: ch.phanikumar654@gmail.com

Abstract

In spite of an intriguing portfolio of properties such as low density and high specific strength, the lower corrosion resistance of magnesium and its alloys is the main limiting factor behind their usage for various industrial applications. Micro-arc oxidation coatings at a constant current density of 0.3 A/cm2 are deposited to modify the surface of AZ91 magnesium alloy by using K2ZrF6 along with aluminates in a silicate-containing base electrolyte. Based on the results obtained, it was found that the addition of K2ZrF6 helps in the formation of the ZrO2 phase in the coating. At the same time, aluminate addition to the electrolyte not only aids the formation of the Al2O3 phase but also concurrently drives the stabilization of the tetragonal ZrO2 phase in the coating structure. Formation of such stabilized t-ZrO2 is, in turn, found to improve the coating hardness, corrosion resistance, and thermal insulation properties. The potentiodynamic polarisation (PDP) and electrochemical impedance spectroscopy (EIS) studies were conducted in 3.5 wt.% NaCl solution highlights that the stabilized t-ZrO2 reduces the porosity and cracks in the MAO coatings, enhancing the corrosion resistance compared to bare by about 3 orders of magnitude.

Keywords: K2ZrF6, AZ91 magnesium alloy, micro-arc oxidation, stabilized metastable t-ZrO2, corrosion, micro hardness

Synthesis, characterisation, and comparative assessment of general-purpose flexible polyurethane foam versus medical-grade polyurethane foam

Jay Hind Rajput[a], Pankaj Yadav[b], Tarush Gupta[c], Atharva Poundarik[d*]

[a],[d]Department of Metallurgical and Materials Engineering, Indian Institute of Technology, Ropar, Punjab 140001
[b]Sheela Foam Ltd, Noida, Uttar Pradesh, India
[c]Department of Plastic Surgery, Postgraduate Institute of Medical Education and Research, Chandigarh, Punjab 160012, India
E-mail: jay.20mmz0002@iitrpr.ac.in, atharva@iitrpr.ac.n

Abstract

Flexible polyurethane foam (PU) has gained significant interest across numerous domains, from automotive to biomedical engineering. Nowadays, advanced flexible PU foam has become an ideal choice for wound care as a dressing material that has undergone continuous innovation over recent decades. In the global market, a variety of soft PU foam-based products are available, ranging from general-purpose to wound care applications. Nevertheless, there is a dearth in the availability of the literature to offer a comprehensive understanding in the context of how general-purpose soft PU (GPPU) foam features differ from medical-grade PU (MGPU) foam. In this study, GPPU and MGPU flexible foams were synthesized and characterized along with a comparative assessment. The GPPU foam was fabricated following the conventional method using TDI, while MGPU foam was developed using a safer low isocyanate content (4-5%) prepolymer based on HDI and biocompatible foaming agents. Both the developed foams' physicochemical and biological characteristics were evaluated as per the following BS EN 13726 and ASTM D 3574-17. The obtained results revealed that MGPU foam showed 242.30 ± 90% higher free swell absorptive capacity (FSAC) and a lower moisture vapor transmission rate (MVTR) of 4393.33 ± 32.14 $g/m^2/day$ in comparison to GPPU foam. In addition, their structure properties relationship was obtained between pore size, density, crosslinking density, % porosity, and tensile strength. MGPU foam demonstrated higher cell viability in comparison to GPPU foam. All measurements indicated substantial differences in their attributes, whereas MGPU foam demonstrated the ability to handle considerable volumes of the fluid that can work as a medium- to high-level exudate handling substrate in the innovative advanced foam-based dressing development.

Sustainable Recovery of Valuable Metals from Jarosite Residue Using a Sulfation–Roasting–Leaching Process

Manorama Swain

Department of Metallurgical and Materials Engineering, Faculty of Technology and Engineering,
The Maharaja Sayajirao University of Baroda, Vadodara
**Email id: manoramaswain2010@rediffmail.com*

Abstract

Approximately 80% of the world's total zinc production is achieved through the conventional hydrometallurgical process known as the Roast-Leach-Electrolysis (RLE) process. This method generates jarosite as a solid crystalline residue, which is easily filterable but contains high concentrations of toxic elements such as lead, zinc, sulphur, cadmium, chromium, and copper. Due to these hazardous components, jarosite is universally recognized as an environmentally harmful material with significant risks to human health. Jarosite residue collected from HZL undergoes treatment to recover valuable metals. However, since jarosite is a highly stable matrix in which metals are present in an insoluble form, direct dissolution proves to be ineffective. To address this, a combined sulfation–roasting–leaching process was developed for selective and efficient metal recovery. Sulfuric acid roasting followed by water leaching enables the quantitative extraction of zinc, cadmium, and other minor base metals. The lead, concentrated in the residue, is then recovered through brine leaching using a solution of suitable composition. Characterization of the materials is performed using Atomic Absorption Spectroscopy (AAS) and X-ray Diffraction (XRD) analysis. The results indicate that after the second-stage brine leaching process, the recovery rates achieved are 98.58% for zinc, 99.99% for cadmium, 99.92% for lead, and 86.34% for iron.

Keywords: Jarosite, Metal Recovery, Hydrometallurgy, Sulfation, Roasting, Leaching

Micro-alloying and grain refinement of Mg-alloy using friction stir processing

[a]Kamal Kumar, [a]Gaurav Kumar Sharma

[a]Department of Mechanical Engineering, Punjab Engineering College (Deemed to be University), Chandigarh,
Email: kamaljangra@pec.edu.in

Abstract

In the quest to develop a biodegradable implant, magnesium and its alloys have emerged as a potential frontier due to their good strength, light weight, and inherent biodegradability. In order to adopt magnesium alloys for safe clinical use, their degradation rate must be maintained within biosafety limits. Alloying of Mg is always challenging due to the low solubility and non-uniform distribution of most alloying elements, resulting in heterogenous and coarse secondary phases. These phases act as potential sites for micro-galvanic cell set-up and thus accelerate the degradation of Mg alloy. Friction stir processing (FSP) can cause severe plastic deformation in magnesium (Mg) alloys to serve the dual purpose of micro-alloying and homogenous grain refinement to achieve higher mechanical strength and corrosion resistance. In present study, single-pass and multi-pass FSP has been utilised to reinforce the Zr powder in ZM21 Mg-alloy. The experiments demonstrated that multi-pass FSP is highly effective to achieve uniform distribution of Zr reinforcement in Mg-alloy with fine grains. Using three-passes of FSP, the grain size of Mg-alloy has reduced from 63 µm to 8 µm with homogeneous microstructure. Mg-alloy reinforced with Zr particles and refined microstructure after 3-pass FSP has shown significant improvement in mechanical properties as compared to pristine Mg-alloy samples.

Keywords: Multi-pass friction stir processing, Mg-alloy, Micro-alloying, refinement of microstructure

Strength and Fracture Analysis of Electroless Coated SiC Reinforced Hybrid GFRP

[a]Sarbjit Singh, [a]Parvesh Antil and [a]Dharmender Jangra

[a]Punjab Engineering College (Deemed to be University), Chandigarh, 160012, India.
College of Agricultural Engineering & Technology, CCS HAU Hisar, Haryana, 125004, India
Vivekananda Institute of Professional Studies - Technical Campus, 110034, New Delhi, India
Email: sarbjitsingh@pec.edu.in

Abstract

The SiC particles are well known for their excellent mechanical properties. However, the low surface energy and hydrophobicity result in hindrances for effective bonding with the polymer matrix. The weak interfaces due to inherent lack of chemical compatibility and poor interfacial bonding between SiC and the polymer matrix could limit the performance of composites. To overcome this problem, the electroless copper coating of SiC is performed, which improved bonding strength by improving wettability and adhesion with the matrix. The coating helped in enhancing the reinforcement-matrix interactions and reduced the particle agglomeration. The identification of copper phases within SiC is achieved through the application of X-ray particle diffraction (XRD) methodology. The face-centred cubic copper phase as per the Hanawalt method was characterized by positions as 2θ = 43.30, 50.48, and 74.16 as the most intense diffraction peaks. The incorporation of copper particulates through electroless coating enhanced interfacial bonding and improved resistance to fracture under loading conditions. The SiC coating also enhanced the composite's tensile and compressive strength by approximately 15% when compared to the uncoated SiC-reinforced composite. Fracture analysis conducted during tensile testing, as well as the bonding characteristics between the matrix and reinforcement, is investigated by field emission scanning electron microscopy (FESEM) coupled with energy dispersive spectroscopy.

Sustainable Strategies for Recycling and Recovery of Electrical Industrial Waste

Ankit Bhojani and Vandana Rao

Department of Metallurgical and Materials Engineering, The Maharaja Sayajirao University of Baroda, Vadodara, Gujarat
Email: vandana.j.rao-metallurgy@msubaroda.ac.in

Abstract

The rapid consumption in electrical and electronic equipment has resulted in the generation of significant amounts of electrical waste, posing technical challenges for material recovery and recycling. This paper focuses on the technical aspects of recycling and recovery processes, including collection, sorting, mechanical treatments, and advanced recovery techniques such as pyrometallurgical and hydrometallurgical methods. These processes are evaluated for their efficiency in material separation, metal recovery, and waste minimization. By addressing the technical challenges and advancements in these methodologies, this study highlights potential pathways for enhancing the recovery of valuable materials and reducing the environmental impact of electrical waste.

Keywords: Electrical waste, recycling, resource recovery, pyrometallurgical processes, hydrometallurgical techniques

Effect of Process Parameters and Heat Treatment on Structure and Mechanical Properties of Directed Energy Deposited Ti6242

Sita Choudhary[a], Prasanth Soundappan[b], Debtanay Das[a], Satyam Suwas[a]

[a]Department of Materials Engineering, Indian Institute of Science Bangalore-560012, INDIA
[b]Department of Design and Manufacturing, Indian Institute of Science Bangalore-560012, INDIA
Email: sitac@iisc.ac.in

Abstract

As printed Ti6242 has good strength due to non-equilibrium refined microstructure but ductility is very low (< 10%). Therefore, in this study, we aim to investigate the effect of post processing heat-treatment on mechanical properties of DED printed near-alpha Ti6242 alloy. Microstructural and structural characterization was done using Optical, SEM and XRD. X-ray computed tomography was done to analyze the porosity distribution in as-printed condition. Post-processing cyclic heat-treatment was designed. Mechanical properties were analyzed for both as printed and heat-treated condition by uniaxial tensile test. As printed condition resulted in high yield strength of about results in high yield strength of about 1350 MPa with the % elongation of about 5%. Post processing heat-treatment led to formation of equilibrium alpha and beta phases, leading to improvement in the ductility at the expense of strength. Cyclic heat-treatment results in the formation of globular alpha and increased lath thickness. This study shows that with the design of suitable heat-treatment mechanical properties of the printed parts can be improved.

Keywords: DED, Heat-treatment, Microstructure, Mechanical Properties

Development and characterization of functionally graded A6061-TiB2 composites using high shear mixing and centrifugal casting technique

[a]Nidhi Sindhu, [a]Sunil Manani, [a]R.K. Goyal, [a]Sreekumar Vadakke Madam

[a]Department of Metallurgical and Material Engineering, Malviya National Institute of Technology, Jaipur, India
Email: 2019rmt9158@mnit.ac.in

Abstract

Functionally graded metal matrix composites exhibit position-specific properties, making them highly suitable for structural applications such as cylinder liners and brake discs. The study presents the processing of functionally graded A6061 reinforced with 5 wt.% TiB2 using an in-situ chemical reaction route, followed by a vertical centrifugal casting technique. The development of composites involved two primary steps: (1) preparation of the composite melt using different liquid processing techniques- manual stirring (MS), continuous impeller (CI), and CI followed by high shear (HS) (2) casting of a hollow cylinder through centrifugal casting at varying rotational speeds (700, 1000, 1200, 1500, and 1800 rpm). The results revealed that TiB2 particles segregated towards the outer region of the cylindrical cast, leading to a 36% increase in hardness compared to the particle-less region and a 17% increase compared to the homogeneous composites. The lower coefficient of thermal expansion (CTE) and melting temperature in particle-concentrated regions, relative to gravity-cast composites, contributed to enhanced thermal stability. Quantitative analysis showed that the average size of TiB2 agglomerates was decreased from 23μm in MS to 9 μm in CI and further reduced to 3μm in HS-processed FG MMCs. High-resolution transmission electron microscope (HRTEM) confirmed that the individual TiB2 particles in HS-processed composites ranged from 5 to 20 nm. Furthermore, primary α-Al grain size was refined by 59% in HS, 33% in CI, and 19% in MS, compared to the base alloy. Bulk hardness demonstrated a notable increase in heat-treated HS composites showing a 34% increase, compared to 28% for CI and 24% for MS outer region, with compressive yield strength increased from 170 MPa to 185 MPa. The heat-treated HS-processed FG A6061-5 wt.% TiB2 composites (Particle-rich region) exhibited the highest tensile yield strength (259 MPa), ultimate tensile strength (372 MPa), and strain (3.7%), significantly surpassing the as-cast alloy and other composite variants. Additionally, wear resistance improved by 56% in heat-treated HS composites compared to the base alloy, outperforming CI (44%) and MS (38%).

Tailoring electrical and thermal properties of poly (ether-ketone) using Bamboo like-Carbon nanotubes: Prospects for EMI shielding

Mohini Tiwari[a] and R. K. Goyal[b]

[a] Centre for Nanotechnology, Indian Institute of Technology Roorkee, Roorkee-247667, India
[b] Department of Metallurgical and Materials Engineering, Malaviya National Institute of Technology Jaipur, Jaipur-302017, India
E-mail: m_tiwari@nt.iitr.ac.in, rkg.meta@mnit.ac.in

Abstract

The rapid evolution of modern-day technology has led to significant surge in electronics across military, telecommunication, aerospace and consumer sectors. The surge in electronics has also led to a novel pollution in form of electromagnetic interference (EMI), which not only results in malfunctioning of these devices and their catastrophic failure, but also causes several negative impacts on human health. Thus, it is imperative to develop advanced materials for effective EMI shielding.[1] However, the increase in complexity and miniaturization of these electronic devices require lightweight materials without compromising their electrical and thermal conductivity.[2,3] Herein, bamboo like-carbon nanotubes (CNT) reinforced poly(ether-ketone) (PEK) light weight nanocomposites were prepared using a planetary ball mill followed by conventional hot-pressing method (powder metallurgy route).[4] Various analytical techniques were used to characterize the nanocomposite. FE-SEM analysis revealed uniformly dispersed bamboo-like CNT across the PEK matrix. With increase in content of CNT, a ten orders of magnitude enhancement were observed in both DC and AC electrical conductivity, reaching ~10−3 S/cm and ~10−4 S/cm (at nearly all the frequencies), respectively for 1.95 vol.% of CNT. The obtained percolation threshold was as low as 1.3-1.95 vol.% CNT. A high dielectric constant (~60) was also observed for the nanocomposite (at 1 kHz) which is 20 times higher as compared to neat PEK. Thermogravimetric analysis showed an increase in thermal stability and char yield for the nanocomposites compared to PEK. The thermal conductivity and mechanical properties of the nanocomposites were also improved with reinforcement of CNT. These results suggest potential applications of the CNT/PEK nanocomposite as EMI shielding materials in aerospace, stealth technology and other anti-static applications.

Keywords: Polymer nanocomposites; Carbon Nanotubes; Powder metallurgy; Percolation threshold

Exploration of Natural Filler Materials in Brake Friction Composite: A Comprehensive Review

Mitali Gore[1], Ajit Bhosale[2] Mithul Naidu[3]

[1]Zeal College of Engineering and Research, Narhe, Pune, Maharashtra, India.
[2]Department of Mechanical Engineering, MKSSS's Cummins College of Engineering for Women, Pune 411052, India
[3]Department of Mechanical Engineering, Tolani Maritime Institute Induri, Pune, India.
Email- mitaligore19@gmail.com1, ajit.bhosale@cumminscollege.in2, mjn2979@gmail.com3

Abstract

The brake friction materials are more so, however, important in automotive technology aimed at improving the performance, safety, and comfort qualities of driving. The changed world of composite friction basically strives towards attaining profuse brakes' capability and environmental sustainability. They were historically composed of brake friction materials. Due to stringent environmental regulations and their known toxicological effects, there has been a general shift away from the use of these substances and in favor of substitutive eco-friendly methods. This transition is aided by the introduction of natural and synthetic supplements furnished with, and which may be used as substitutes for, renewable resources. The relationship between some of the principal ingredients-discussed above and advanced processes employed to modify them-is adequately understood for these materials to be developed effectively. The present review discusses filler materials used in brake friction composites with respect to the optimization of their thermal and mechanical properties. In this review, an in-depth discussion on the properties and compatibility, and processing approaches of natural and synthetic fillers are provided in light of their performance-enhancing potential. Furthermore, it will discuss the challenges concerning the sustainability of friction materials, including durability, cost, and scalability. The review outlines the critical research gaps while highlighting new ways of addressing these challenges. Thus, through the integration of advanced fillers, the automotive field has been undergoing a phase of life-on-the-edge development in achieving brake systems that are both high-performing and environmentally sustainable. These developments would herald a new phase in brake friction technologies that will be greener and more efficient in meeting the needs of contemporary automotive engineering.

Keywords: Brake friction materials, eco-friendly fillers, natural products, synthetic fillers, brake performance, friction composites.

Investigation of Wear Characteristics of Oxide-added Cast 7075 Aluminum Alloy

Devang Mahant[1,2], Daulat Kumar Sharma[1], Rahul Pandey[1,2] and Vandana Rao[2]

[1]Metallurgy Department, Government Engineering College, Sector 28, Gandhinagar.
[2]Metallurgical & Materials Engineering Department, FTE, Maharaja Sayajirao University of Baroda.
Email: devangmahant@gecg28.ac.in

Abstract

Aluminum 7075 alloy has excellent mechanical properties and exhibits good ductility, strength, toughness, and fatigue resistance. Apart from these properties, tribological property is enhanced because of the addition of oxide additives. In this study, the tribological properties of cast Al7075 with the addition of 2.5% zirconium oxide (Zirconia) and titanium oxide (Titania), produced in a resistance heating furnace followed by die casting, were investigated. The wear test is conducted using a pin-on-disc wear testing machine, as specified by ASTM G99. The comparison is based on two independent process variables: a fixed sliding distance of 1000 m for all samples and applied load variations from 10, 20, 30, and 50 N with 500, 700, and 1000 revolution speeds. Using a scanning electron microscope (SEM), the wear surface morphology of the samples was analysed, and the wear test results were compared. Further, it was found that oxides added samples showed less wear loss compared to as-cast Al7075 samples. The main abrasion mechanism for as-cast Al7075 samples is identified as ploughing and deep wear tracks, while for Al7075 samples with Zirconia and Titania addition, it is characterized by delamination and shallow wear marks.

Keywords: Cast Al7075, Zirconia (ZrO2), Titania (TiO2), Tribology, SEM.

Influence of Intercritical Temperature on Cryogenic Toughness of 7% Ni Steel

Gautam Mishra[a*], Sudipta Patra[a]

[a]Department of Metallurgical Engineering, Indian Institute of Technology (Banaras Hindu University), Varanasi, 221005, India
E-mail: gautammishra.rs.met21@iitbhu.ac.in

Abstract

In the current study, 7 wt.% Ní alloy steel was prepared, hot rolled, and heat treated according to popular quenching, lamellarization, and tempering treatments. The inter-critical lamellarization temperature was varied, and the microstructure-property correlation was evaluated at each stage of heat treatment to understand the metallurgical aspects. Optical and detailed electron microscopic techniques were used to characterize and quantify the microstructures. Mechanical responses under uniaxial and impact loading were also recorded for all the studied samples. Tempered martensite with blocky and lamellar morphology, along with retained austenite and ε-martensite, were observed in the microstructures after the above-mentioned heat treatment. The lamellarization at 700 °C leads to a more uniform distribution of alloying elements and, therefore, promotes the formation of finer retained austenite with uniform distribution, compared to the 650°C lamellarization temperature. The presence of lower matrix strain and uniformly distributed fine retained austenite provides the highest toughness with moderate strength in the 700°C samples. ε-martensite is expected to provide the necessary strength to balance the softening arising due to tempered martensite and retained austenite. Moreover, the uniformly distributed fine and filmy-shaped retained austenite provides thermal stability, and arrests crack propagation, enhancing toughness.

Optimization of Micro-Alloying and Composition on Strength and Toughness of 0.2%C-1.5Mn Steel

Prashant Kumar Singh[a], Gautam Mishra[a], J.K. Singh[a], Sudipta Patra[a]

[a] Indian Institute of Technology (BHU), Varanasi-221005, U.P.
Email: prashantkumarsingh.rs.met23@itbhu.ac.in

Abstract

Micro-alloyed element (V and Nb) containing steels were prepared with varying nitrogen level along with Ni and Mo identify the strengthening and toughness contribution of all the alloying elements. The study was conducted in three different process routes keeping in mind the industrial processing routes suitable for plate and coil production. As rolled, normalized and coiling are the three-processing route. The As rolled structure showed that 0.15V+0.03Nb steel can provide the highest grain refinement and yield strength but toughness in as rolled steels are comparatively lower than other route of processing. In case of Normalized steel, the strength reduces significantly but the toughness increases three times at -50℃. The coiling at 600℃ after 1000℃ holding suggests that both the yield strength and the toughness can significantly increase specially in Vanadium and nitrogen containing steels. Characterization techniques such as Optical Microscopy (OM), Scanning Electron Microscopy (SEM), Electron Back Scattered Diffraction (EBSD) and Transmission Electron Microscopy (TEM) have been used for further investigation. The interphase precipitation strengthening contributes highest in the coiling route during holding at 600℃. The increase of hardenability by Mo causes harder second phase formation which deteriorates the toughness values. Ni does not help in increasing the strength but may have an effect in toughness. The strengthening contribution was calculated for each steel and each route of processing. The processing microstructure property were correlated in light of grain size, precipitate formation and dissolution, second phase fraction, hardness and grain boundary data.

Keyword: Micro-alloyed steel, Vanadium, microstructure, Impact toughness, Yield strength.

High Temperature Oxidation Behaviour of Powder Forged IN718 Oxide Dispersion Strengthened (ODS) superalloy

S. D. Gaikwad[a], Vikram V. Dabhade[a], Gajanan P. Chaudhari[a], S.V. S Narayana Murty[b] and Sushant Manwatkar[b]

[a]Department of Metallurgical and Materials Engineering, Indian Institute of Technology Roorkee, Roorkee - 247667
[b]Vikram Sarabhai Space Centre (VSSC), Indian Space Research Organization (ISRO), Thiruvananthapuram - 695022
E-mail: vikram.dabhade@mt.iitr.ac.in

Abstract

The present investigation deals with the oxidation behaviour of IN718 and IN718 ODS (0.7 wt.% of yttria) superalloy processed by cryo-milling/mixing and powder forging. The oxidation behaviour of IN718 and IN718 ODS superalloy in as-forged (AF) and AF+aged conditions was investigated at 850 °C for 200 h. The study examined the oxidation kinetics of the oxide scale, surface morphology, and oxide phases through various characterization techniques, including mass gain measurement, scanning electron microscopy (SEM), energy dispersive spectroscopy (EDS), and X-ray diffraction (XRD). The oxidation behaviour of IN718 and IN718 ODS alloy was correlated with grain size, retained porosity, and the influence of precipitates (γ□, γ□, and oxide dispersoids). The oxide scale formed in AF IN718 alloy was a porous, thick layer of chromium oxide with an average thickness of 50 μm. In contrast, the AF+aged IN718 alloy exhibited a dense, compact, and continuous oxide scale. This scale consisted of duplex oxide layers, including an inner and an outer layer, with an average thickness of 6 μm. The outer layer was primarily enriched with oxides of Cr, Fe and Ni, while the inner layer predominantly contained Cr2O3. The IN718 ODS alloy, in both conditions (AF and AF+aged) exhibited an oxide scale that was dense, compact, and continuous, with an average thickness of less than 2 μm. The scale was primarily composed of chromium oxide. The oxide scale primarily consists of Cr2O3, along with a small amount of Cr, Ni, and Fe-riched spinel, as well as TiNbO4 oxides in both conditions.

Rice husk ash filled glass epoxy hybrids: A sustainable microwave absorbing material

V. S. Darekar, Mohammed Fahad Gauri and R. K. Goyal

Department of Metallurgical and Materials Engineering, Malaviya National Institute of Technology Jaipur, Jaipur-302017, India
Email:rkgoyal72@yahoo.co.in

Abstract

Rice Husk Ash(RHA) a value-added product recycled from bio-waste was utilized as reinforcement in a glass-epoxy(EP/GF) matrix to develop EP/GF/RHA hybrids, for microwave absorption.The hybrid composites with RHA loading 0, 5, 7.5 and 10 wt.% were fabricated using a simple and convenient hand layup technique. The electrical, mechanical, and microwave absorption properties of EP/GF/RHA hybrids were investigated. The developed hybrid composites are lightweight with a density in the range of 1.57-1.70 g/cm3. The addition of RHA slightly affected the electrical conductivity of the EP/GF composite. The EP/GF/RHA hybrid composites showed higher tensile strength than those of composites without RHA. The maximum tensile strength was obtained at 7.5 wt% RHA. The microwave absorption properties of EP/GF composites improved with the addition of RHA. The hybrid with 7.5 wt% RHA exhibited a maximum reflection loss (RLmax) of about -16.64 at 9.18 GHz. These results suggest that the prepared EP/GF/RHA hybrids are lightweight with better microwave absorption in the X-band and can be used as microwave absorbing material for defense applications.

Comprehensive Exploration of Zinc Oxide Nanoparticles: Unravelling the Intricate Intermolecular Properties through Advanced Characterization Techniques

[a*]Brajesh Kumar Ahirwar[a], Arvind Kumar[b]

[a]Ph.D. Scholar, bAssociate Professor
[a],[b]Department of Mechanical Engineering, Maulana Azad National Institute of Technology, Bhopal, MP- 462003
Email: ahirwarbrajeshkumar@gmail.com

Abstract

Zinc oxide (ZnO) nanoparticles have emerged as a versatile material due to their exceptional structural, optical, and surface properties, making them suitable for applications in electronics, catalysis, and biomedical sciences. This study presents an in-depth characterization of ZnO nanoparticles synthesized through a controlled process to ensure high purity, stability, and uniform morphology. Fourier Transform Infrared Spectroscopy (FTIR) confirms the presence of functional groups, while X-ray Diffraction (XRD) analysis identifies the crystalline structure and phase purity. Field Emission Scanning Electron Microscopy (FeSEM) and Transmission Electron Microscopy (TEM) provide insights into morphology, size, and nanoscale structural features. Energy Dispersive Spectroscopy (EDS) verifies elemental composition, ensuring minimal impurities. Raman spectroscopy further elucidates vibrational properties, supporting the structural integrity of ZnO. Brunauer–Emmett–Teller (BET) analysis determines the surface area and porosity, essential for catalytic and adsorption applications. Particle size distribution analysis highlights size uniformity, while zeta potential measurement assesses surface charge and colloidal stability. These extensive characterizations provide a holistic understanding of ZnO nanoparticles' physicochemical attributes, crucial for optimizing their synthesis and enhancing their applicability. The results contribute to the development of high-performance ZnO-based nanomaterials, fostering advancements in various nanotechnology-driven industries. This study serves as a benchmark for future research on ZnO nanoparticles.

Keyword: Zinc oxide nanoparticles, XRD, FTIR, TEM, Raman spectroscopy, BET analysis, Zeta potential

Electrochemical study of Transition Metal Substituted Strontium Titanate

Tithi Sen[a], Swati Chopra[a*], Amit Singh[a], Bablu Mordina[b] and Dibyendu Sekhar Bag[a]

[a]Polymers and Rubber Division, DMSRDE, G.T.Road, Kanpur-208013
[b] Nanoscience and Coating Division, DMSRDE, G.T.Road, Kanpur-208013
Email: swati.dmsrde@gov.in

Abstract

This work examined the electrochemical characteristics of strontium titanate replaced with metal cations of Zn, Cd, and Hg. Acrylic acid was used as the gelating agent in the sol-gel synthesis of the titanates. At about 700°C, metal-mixed oxides were proven to develop by thermogravimetric analysis (TGA), which was followed by a progressive weight loss as a result of partial oxygen release. The effects of substitution of Zn^{2+}, Cd^{2+}, and Hg^{2+} cations on structure, crystallographic distortions, grain size and electrochemical properties were examined. Microscopic and spectroscopic methods including X-ray diffraction (XRD), scanning electron microscopy (SEM), Fourier transform infrared (FTIR), cyclic voltammetry (CV) and galvanometric charge-discharge (GCD) were used to characterize the prepared titanates. Strontium titanate and its substituted forms were successfully formed, as evident from XRD data, with peak shifts indicating a nearly cubic crystal structure. SEM examination revealed changes in grain size and shape moderated by transition metal substitution with no visible agglomeration. FTIR spectra aligned with characteristic perovskite peaks. Using a three-electrode configuration, cyclic voltammograms collected at scan speeds between 5 and 100 mV s^{-1} within a voltage range of -0.3 V to +0.5 V confirmed the redox activeness of all the Sr-based substituted titatnates. The greatest improvement in specific capacity of 63.15 F/g at 0.6 A g-1 among the substituted titanates was observed in the case for Hg-doped strontium titanate.

Applications of Nanomaterials for Soft Robotics: A Review

Sachin Kumar Nikam[1], Sandeep Mahore[2], Shankar Kumar[3], Athar Khan[4], Yogesh Dewang[3*]

[a]Assistant Professor, Department of Mechanical Engineering, LNCT University, Bhopal, Madhya Pradesh, India
[2]Ph. D. Research Scholar, Department of Metallurgical and Materials Engineering, MNIT, Jaipur
[3]Professor, Department of Mechanical Engineering, Lakshmi Narain College of Technology, Bhopal, MP, India
[4] Student, Department of CSE-IOT, Lakshmi Narain College of Technology, Bhopal, Madhya Pradesh, India
[3] Associate Professor, Department of Mechanical Engineering, Lakshmi Narain College of Technology, Bhopal, Madhya Pradesh, India*
Email: dewang.yogesh3@gmailcom

Abstract

Soft robotics is an emerging field that leverages the mechanical compliance and adaptability of soft materials to create robots with capabilities akin to biological systems. The integration of nanomaterials has enabled significant advancements in soft robotics, improving their actuation, sensing, energy storage, and fabrication methods. This paper reviews recent progress in the applications of nanomaterials in soft robotics, focusing on their role in enhancing mechanical, electrical, and multifunctional properties. It was found that nanomaterials include the use of carbon-based nanomaterials, metal and metal oxide nanoparticles, and polymer-based nanocomposites, nanofillers etc. Future research in this field is expected to concentrate on creating highly sensitive nanomaterials that will aid in the creation of humanoid soft-robotics sensing systems and adding nanomaterials to hydrogels for soft robotics applications with unique properties.

Keywords: nanomaterials; nanoparticles; nanofillers; soft robotics; actuators.

Synergistic Photocatalytic Degradation of Textile Dye using Novel Polypyrrole- Zinc Oxide Nano composite System

Nandini V. Iyer [a, b], Hozefa Dhila [a], Abhishek R. Bhapkar [a], Jayant A. Kher [b], Shekhar D. Bhame [a*]

[a] *Materials Research Laboratory, Symbiosis Institute of Technology, Symbiosis International (Deemed University), Lavale, Pune-412115, India*

[b] *Department of Applied Sciences, COEP Technological University, Pune-411005, India*

Email: shekhar.bhame@sitpune.edu.in

Abstract

The current investigation involves the synthesis of Polypyrrole-Zinc Oxide (PPy-ZnO) nanocomposites and their application as photocatalyst in the degradation of Methylene Blue (MB). The nanocomposites were synthesised through an in-situ polymerisation method, employing ammonium persulphate as an oxidant and Dodecyl Benzene Sulphonic Acid (DBSA) as a dopant. Different weight percentages (0.05%, 0.1%, 0.2%, and 0.3%) of ZnO nanoparticles were utilised to prepare the PPy-ZnO nanocomposites. X-ray diffraction (XRD) studies revealed the amorphous nature of undoped PPy, while PPy-ZnO displayed peaks corresponding to ZnO, confirming the formation of nanocomposites. It also indicates the effective incorporation of ZnO nanoparticles into the PPy matrix. The FTIR analysis revealed vibrations of Zn-O and PPy ring, indicating significant interactions between the PPy network and ZnO. FE-SEM analysis showed densely packed particles with irregular shapes. The photocatalytic performance of the PPy-ZnO nanocomposites towards MB degradation was investigated by exposure to ultraviolet (UV) radiation. Various operational parameters, including exposure time, photocatalyst dosage, type of catalyst, adsorption studies, pH, and source of light were examined to understand the process of dye degradation. The highest removal of MB dye, reaching approximately 90.13 %, was observed without exposure to UV light, which was further enhanced in the presence of UV light. Two mechanisms were proposed: adsorption (in the absence of UV light) and photocatalytic degradation (in the presence of UV light). The maximum removal efficiency for MB dye was achieved at 0.2 g/L of 0.05 wt.% PPy-ZnO nanocomposite, with 5 mg/L MB concentration, which resulted in a removal efficiency of 99.6%. The scavenger analysis revealed that •O2□ radical was the primary reactive species responsible for dye degradation, while the MB removal followed pseudo-second-order kinetic model.

Keywords: Polypyrrole, zinc oxide, methylene blue, adsorption, photocatalytic degradation

Corrosion Resistance and wear analysis of AA7050 through TiO2/BN Reinforcements

Anil Chourasiya[a], [b]C. M. Krishna, [c]Madhusudan Baghel, [d]Amit Kumar

[a],[b]Department of Mechanical Engineering, Maulana Azad National Institute of Technology, Bhopal (M.P.)
[c]Key National Demonstration Center for Experiment Mechanical Engineering Education, Shandong University, Jinan 250061, PR China
[d]IES College of Technology, Bhopal (M.P.)
Email: anilcwarrior@gmail.com

Abstract

AA7050, a high-strength aluminum alloy widely used in aerospace and structural applications, is prone to corrosion and wear, limiting its long-term performance. This study investigates the enhancement of corrosion resistance and wear behavior of AA7050 through the incorporation of titanium dioxide (TiO2) and boron nitride (BN) reinforcements. The composite was synthesized using a stir casting method to ensure uniform dispersion of the reinforcements within the aluminum matrix. Electrochemical corrosion tests, including potentiodynamic polarization and electrochemical impedance spectroscopy (EIS), were conducted to assess the corrosion resistance of the developed composite in a chloride-rich environment. Additionally, wear performance was evaluated using a pin-on-disc under varying loads and sliding velocities. The results indicate a significant improvement in corrosion resistance due to the passive oxide layer formed by TiO2 and the lubrication effect of BN. Moreover, the reinforced composite exhibited lower wear rates and improved hardness compared to unreinforced AA7050. The synergistic effect of TiO2 and BN contributes to enhanced durability, making the developed composite a promising material for applications requiring high corrosion and wear resistance.

Keywords: AA7050, TiO2/BN reinforcements, corrosion resistance, wear behavior, composite materials, electrochemical analysis

Effect of Incident Velocity on damage of layered targets in Ballistic Applications

Bhonsle Chetankumar, S V Nimje and A Kumaraswamy

Department of Mechanical Engineering, Defence Institute of Advance Technology (Deemed University), Pune, Maharashtra, India-411025
Email: sunil.nimje@diat.ac.in

Abstract

In the present research work, three-dimensional FE analyses have been carried out in order to evaluate the effect of incident velocity of preformed fragment on the damage characteristics of layered targets under impact scenario using explicit FE code LS-Dyna. This investigation is mainly focused on the effect of various impact parameters such as incident velocity (300 to 3000 m/s) and mass (1, 3 and 5g) of tungsten alloy fragments (cubical and spherical) impacting layered targets. Three target configurations such as a single-layer aluminium alloy (AA5083H116), a dual-layer ceramic-aluminium alloy (Alumina-AA5083H116), and a three-layer composite structure (Alumina-AA5083H116-UHMWPE/Dyneema) have been considered in the present analysis. Eight-noded hexahedral elements were employed to discretize the target plates as well as fragments. The Johnson-Cook (J-C) strength and damage models along with Gruneisen Equation of State are utilized to characterize material behaviour of Al alloys target and tungsten alloy fragments, while Johnson-Holmquist (J-H) material constitutive model is used for ceramic target. Furthermore, Chang-Chang Damage model is used for characterizing the material behaviour of FRP composites. The target volume erosion fraction (TVEF), projectile volume erosion fraction (PVEF), residual velocities, and crater damage have been computed from series of simulations. Furthermore, significant efforts have been put in order to indicate damage in terms of flow stress and strain rate. The results indicate that cubical fragments inflict greater damage compared to spherical. The introduction of a ceramic frontal layer enhances impact energy dispersion, reducing K.E transferred to the backing aluminium plate. The three-layered target configuration demonstrates superior resistance, effectively mitigating fragment penetration and reducing residual velocities along with change in flow stress compared to single- and dual-layer systems. These findings provide valuable insights into the damage capabilities of fragments against layered armour structures. In view of layered targets are recommended for improved damage resistance of target under high-velocity threats.

Keywords: Ballistic Impact, Layered Target, Impact Velocity, FRP composite.

Effect of Fragments shapes and materials on damage of layered Targets in Ballistic Applications

Kirit Gogineni[a], A Kumaraswamy[*a]; S V Nimje[a]

[a]*Department of Mechanical Engineering, Defence Institute of Advance Technology (Deemed University), Pune, Maharashtra, India-411025*
Email: akswamy@diat.ac.in

Abstract

This study investigates the impact of fragment shape with varied materials on the damage behaviour of layered targets in ballistic applications. Series of Numerical simulations have been carried out using LS-Dyna in order to simulate impact scenario with various ballistic parameters. Five fragment shapes such as sphere, cube, square pyramid, hexagonal pyramid, and right circular cone with two different materials- tungsten alloy and SS304 steel were considered. The material behaviour was characterized using J-C strength and damage models, along with Gruneisen Equation of State. An erosion algorithm was used in the explicit FE code LS-DYNA to remove undesirable elements. Eight-noded hexahedral elements were used to discretize the target plates/fragments. The different target configurations: a single-layer 3 mm RHA plate, a dual-layer 3+3 mm RHA system with a 1 mm air gap, and a three-layer RHA structure (3+3+3 mm RHA) with 1 mm air gaps between layers are considered in the present research work. Each fragment, with a mass of 5 g, was launched at normal incidence velocities ranging from 500 to 2000 m/s. Based on exhaustive numerical simulations, damages have been computed in terms of crater diameter, target eroded volume fraction (TVEF) for various target configurations. The results were compared with monolithic 9 mm RHA plate. Results indicate that cubical fragments cause greater damage compared to other shapes at similar velocities. The addition of an RHA layer improves impact energy dispersion, reducing residual velocity. The three-layered configuration exhibits superior resistance, effectively mitigating fragment penetration and minimizing residual velocities and TVEF compared to single- and dual-layer targets. Notably, 5 g cubical fragments at high velocities of 2000m/s induce the most significant damage. These findings provide valuable insights into the impact resistance of layered protective structures against high-velocity threats.

Keywords: Ballistic application, multi-layered target, rolled homogenous armor

Structural Design and Analysis of an Incline Impact Test Rig for Packaging Integrity Testing

Tejas Parbhane[a], Nihal Dhote[a], Nilesh Sakle[b], Murtaza Laila[b]

[a]Department of Mechanical Engineering, COEP Technological University, Pune-India
[b]Automotive Research Association of India, Pune-India
Email: parbhanets23.mech@coeptech.ac.in

Abstract

This study investigates the impact of fragment shape with varied materials on the damage behaviour of layered targets in ballistic applications. Series of Numerical simulations have been carried out using LS-Dyna in order to simulate impact scenario with various ballistic parameters. Five fragment shapes such as sphere, cube, square pyramid, hexagonal pyramid, and right circular cone with two different materials- tungsten alloy and SS304 steel were considered. The material behaviour was characterized using J-C strength and damage models, along with Gruneisen Equation of State. An erosion algorithm was used in the explicit FE code LS-DYNA to remove undesirable elements. Eight-noded hexahedral elements were used to discretize the target plates/fragments. The different target configurations: a single-layer 3 mm RHA plate, a dual-layer 3+3 mm RHA system with a 1 mm air gap, and a three-layer RHA structure (3+3+3 mm RHA) with 1 mm air gaps between layers are considered in the present research work. Each fragment, with a mass of 5 g, was launched at normal incidence velocities ranging from 500 to 2000 m/s. Based on exhaustive numerical simulations, damages have been computed in terms of crater diameter, target eroded volume fraction (TVEF) for various target configurations. The results were compared with monolithic 9 mm RHA plate. Results indicate that cubical fragments cause greater damage compared to other shapes at similar velocities. The addition of an RHA layer improves impact energy dispersion, reducing residual velocity. The three-layered configuration exhibits superior resistance, effectively mitigating fragment penetration and minimizing residual velocities and TVEF compared to single- and dual-layer targets. Notably, 5 g cubical fragments at high velocities of 2000m/s induce the most significant damage. These findings provide valuable insights into the impact resistance of layered protective structures against high-velocity threats.

Keywords: Ballistic application, multi-layered target, rolled homogenous armor

Machine Learning Perspective of Predictive Modelling for Additive Manufacturing

Jasvinder Singh

Department of Production and Industrial Engineering, Punjab Engineering College (Deemed to be University), Chandigarh-160012, India
Email: jasvinder.singh.iitd@gmail.com

Abstract

Additive Manufacturing (AM) has revolutionized fabrication in innumerable fields due to its salient features of complexity in geometries and customization of components. However, challenges in ensuring the quality and reliability of AM parts still exist due to inherent issues like component warping and suboptimal surface finish. The progression of digital and computational technologies has led to the extensive application of data-driven machine learning (ML) in additive manufacturing (AM) since it offers efficient quality assurance, process enhancement, and intricate system modelling techniques. This paper outlines the many stages of employing ML to support AM operations. The application of ML in predictive modelling for AM has been explored, emphasizing its potential to enhance product quality and optimize manufacturing processes. The paper has successively highlighted the integration of data-driven ML approaches, which has emerged as a promising solution. A comprehensive emphasis on predictive modelling techniques reveals the critical role of ML in highlighting the importance of understanding material characteristics, working conditions and process parameters. Various ML algorithms, including regression models and deep learning frameworks, are evaluated for their efficacy in predicting geometric deviations, mechanical properties like fatigue life, temperature profile, melt pool characteristics, optimization of process parameters, and real-time monitoring to minimize defects. It has been concluded that ML algorithm can effectively work out for better prediction of AM process. It has also been summated that modern machine learning algorithms can optimize process parameters and facilitate the analysis of in-process defect detection. In additive manufacturing processes, machine learning corroborates professionals in process planning, production planning, assessment, and product quality management.

Effect of Al on microstructure and Phase evolution of CoCrMnNiFeAlx high entropy alloy processed via mechanical alloying

Uday Pratap Singh Bais[a*], Alok Singh[a], Pradip Kumar Verma[a]

[a]Mechanical Engineering Department, Maulana Azad National Institute of Technology, Bhopal M.P. 462003, India
Email: udaypratapsinghbais@gmail.com

Abstract

In this study, an equiatomic combination of Co, Cr, Mn, Ni, and Fe was processed with varying Al content using the mechanical alloying (MA) route to fabricate $CoCrMnNiFeAl_x$ (x = 0, 0.1, 0.2, 0.3) high-entropy alloy powder after 40 hours of milling. The effect of Al content on the microstructure and phase composition after milling, as well as the observed changes in crystallite size, lattice strain, and lattice parameters of the mechanically alloyed samples, was investigated. X-ray diffraction (XRD) and scanning electron microscopy (SEM) were employed to characterize the microstructure and phase evolution during milling. This study provides insights into the role of Al in tailoring the microstructural characteristics and phase stability of $CoCrMnNiFeAl_x$ HEAs, which is critical for optimizing their mechanical and functional properties.

Keywords: High-entropy alloys, Mechanical alloying, Phase evolution, Lattice strain.

Effect of fragment mass on damage of hybrid targets in Ballistic Applications

Rishabh Subhash Almel[a], A Kumaraswamy[*a], S V Nimje[a]

[a]Department of Mechanical Engineering, Defence Institute of Advance Technology (Deemed University), Pune, Maharashtra, India-411025
Email: akswamy@diat.ac.in

Abstract

Present research deals with three-dimensional analysis to indicate effect of fragment mass on the damage of hybrid target using explicit FE code LS-Dyna. This work is mainly focused on the effect of various impact parameters such as mass of fragments (3,5,8 and 10g), obliquity (0 to 60°) and incident velocity (2000 m/s) of Tungsten Heavy Alloy fragments impacting on multilayered targets. The different targets configurations such as single layer Steel 4340, double layered (2mm Boron carbide + 3mm Steel 4340; 3mm Boron carbide + 4mm Steel 4340) and three layered (2mm Boron carbide + 3mm Steel 4340 + 4mm SS304) are considered for this work. The Johnson-Cook (J-C) strength and damage models along with Gruneisen Equation of State are employed to characterize material behavior of steel target and tungsten alloy fragments, while Johnson-Holmquist (J-H) material constitutive model is used for ceramic target. Eight-noded hexahedral elements were used to discretize the target plates/fragments. Furthermore, an erosion algorithm was used in the explicit FE code LS-DYNA to remove undesirable elements. Based on numerical simulations carried out, the results focused on the effects of cube and sphere-shaped fragments on different targets configurations, considering variations in mass and obliquity angles. The damage parameters considered are in terms of – target volume erosion fraction (TVEF), projectile volume erosion fraction (PVEF), residual velocities, residual K.E. and crater diameters. Furthermore, extensive measures have been undertaken to illustrate damage concerning flow stress and strain rate. The three-layered target setup showed excellent resistance, significantly decreasing fragment penetration and lowering residual velocities, as well as altering flow stress more effectively than single- and dual-layer target setups. The introduction of a ceramic frontal layer enhanced energy dispersion, reducing K.E transferred to the backing Steel plate. Furthermore, for a given target configuration the 10g fragment induced the most significant damage for both shapes. These results offer crucial understanding of the damage potential of fragments when striking layered armor structures. Consequently, layered targets are advised to enhance damage resistance against high-velocity threats.

Microstructural and mechanical behaviour of thermally aged Al6082/TiO2/SiC bimodal composite

Subodh Kumar[a*], Gajendra Dixit[a], Savita Dixit[b], Bhagwan Singh Lovevanshi[a], Pradip Kumar Verma[a], Amit Kumar[3]

[a]Department of Mechanical Engineering,
[b]Department of Chemistry, Maulana Azad National Institute of Technology, Bhopal, 462003 M. P. India
[3]Mechanical Engineering Department, IES College of Technology, Bhopal M.P. 462044, India
Email: ssubodh28@gmail.com

Abstract

In the present study, a novel bimodal hybrid composite of Al6082 reinforced with nano-sized TiO_2 and SiC particles were fabricated using the stir squeeze casting technique. The manufactured composite was heat-treated to enhance its mechanical and microstructural characteristics. The microstructural features were examined using a field emission scanning electron microscope attached to energy dispersive spectroscope. The strength and hardness of the heat-treated alloy and composite were assessed by mechanical testing. The heat-treated composite reinforced with 0.75 wt% TiO_2 and 2 wt% SiC exhibited the highest values of hardness, yield strength, and ultimate tensile strength of 116.2 HRB, 320 MPa and 386 MPa respectively.

Keywords: Al6082, Stir casting, Microstructure, Tensile strength, Hybrid composites

Analysis of corrosion behaviour and electrical conductivity of AA7075/HEAp composite

Pradip Kumar Verma[a*], Alok Singh[a], Uday Pratap Singh Bais[a], Subodh Kumar[a], Amit Kumar[b]

[a]Mechanical Engineering Department, Maulana Azad National Institute of Technology, Bhopal M.P. 462003, India
[b]Mechanical Engineering Department, IES College of Technology, Bhopal M.P. 462044, India
Email: pradipme203116011@gmail.com

Abstract

In the present study, the corrosion behaviour and electrical conductivity of aluminium matrix composites reinforced with high-entropy alloy particles are discussed. High-entropy alloy particles have emerged as a new type of reinforcement for aluminium composites due to their outstanding physical and mechanical properties. The composites were fabricated using stir casting coupled with an ultrasonic transducer. The weight loss method was used to study the corrosion behaviour of the developed metal matrix composites. Additionally, electrical conductivity measurements using the four-point probe method demonstrated that the composite retained good conductivity despite the presence of reinforcements. The balance between corrosion resistance and electrical conductivity was attributed to the synergistic effect of HEA particles, which acted as a barrier against localized corrosion while maintaining conductive pathways. The findings suggest that AA7075/HEAp composites have significant potential for aerospace and marine applications, where high strength, corrosion resistance, and electrical performance are crucial.

Keywords: High entropy alloy, Corrosion, Electrical conductivity, Metal matrix composite.

Tribological analysis of T6 heat-treated Al7075 composites reinforced with ceramic and sustainable particles

Bhagwan Singh Lovevanshi[*1], P. K. Sonia, Savita Dixit[b], Subodh Kumar[a]

[a]Department of Mechanical Engineering, MANIT Bhopal-462003, M.P., India
[b]Department of Chemistry, MANIT Bhopal-462003, M.P., India
Email: gsbhagwan1235@gmail.com

Abstract

This research paper investigates the tribological characteristics of Al7075 composite reinforced with SiC and cow dung ash (CDA) particles under T6 heat-treatment conditions. The combination of traditional reinforcement (SiC) with a non-traditional and sustainable substance (CDA) presents a novel approach to improving the base alloy's tribological properties. Two-stage stir-casting, equipped with an ultrasonic probe, was used to synthesize the hybrid composite. Optical microscopy and Vickers micro-hardness test was conducted to assess the microstructure and indentation resistance of composite. The optimum hardness result obtained was 174.41 HV, which indicates a 42.54% improvement over as-cast Al7075 for sample C3. Tribological analysis was performed on a dry-sliding condition with a pin-on-disc wear test set-up. The wear rate of samples was analyzed under varying normal load and sliding velocity. Morphology and surface roughness of worn-out surfaces were examined by FESEM with EDS and profilometer analysis. The results of this study not only contribute to the improvement of tribological properties but also offer a sustainable and eco-friendly reinforcement approach by incorporating CDA as a reinforcement.

Keywords: Heat-treatment, Cow dung ash, Tribological characteristics, Optical profilometer

Self-Healing and Shape-Memory Behaviour of Poly (Ethylene-co-Methacrylic Acid) / Thermoplastic Polyurethane Blend Materials

Shilpi Tiwari[a*] and Dibyendu Sekhar Bag[a]

[a]Defence Materials and Stores Research and Development Establishment
DMSRDE PO, Kanpur-208013, India
E-mail: tiwarishilpi8318@gmail.com

Abstract

Integrating shape memory and self-healing behaviour into a single material system has drawn more attention due to their potential use in various applications such as aerospace, armour and soft robotics. Herein, thermoplastic polyurethane (TPU) and Na-neutralized poly (ethylene-co-methacrylic acid) (Na-EMA) ionomer were blended to achieve good self-healing as well as shape memory properties. The developed blend materials having different composition of Na-EMA and TPU were characterized by various techniques. Thermo-reversible ionic interactions in EMA ionomers as well as hydrogen bonding between TPU and EMA ionomers provide good self-healing properties to the developed blend materials. In addition, the presence of both hard and soft segments in the constituents blend materials such as Na-EMA ionomers and TPU also delivered good shape memory properties to the blends. The healing efficiency and shape memory behaviour were improved by increasing the content of TPU in the blend. Optical microscope was employed to compare the healing of damaged area of the samples before and after the healing process. All blend samples showed self-healing behaviour but the blend sample comprised of 80 wt% Na-EMA ionomer and 20 wt% of TPU showed maximum healing efficiency (~94%) in tensile strength of the blend material. This blend composition also showed remarkable shape memory behaviour with a shape-fixing ratio and shape recovery ratio of ~97.0% and ~99.6 %, respectively. FTIR analysis confirmed the presence of hydrogen bonding and coordinated structures in the blends. The blend materials were thermally stable up to 285oC. Such novel blend materials having self-healing and shape memory behaviour may have potential applications such as armour, aerospace, and other applications.

Fabrication of Low-Temperature Co-Fired Ceramic (LTCC) Ring Resonators by Digital Light Processing (DLP) based 3D printing Technology

Lalita Bari, Jyoti Kondhalkar, Yash Tapkir , Swapnil Doke, Rajendra Panmand, Pravin Bailmare, Janardhan Rao Gadde, Vijaya Giramkar and Shany Joseph*

Centre for Materials for Electronics Technology, Panchawati, Off Pashan Road, Pune 411008
Email: shany@cmet.gov.in

Abstract

Low-Temperature Co-Fired Ceramic (LTCC) technology is widely used for fabricating multi-layer ceramic substrates, offering low signal loss, and high-frequency performance. It is a crucial technology in miniaturized and integrated electronic applications, particularly in aerospace, automotive, medical, and defense sectors. LTCC technology is a multi-layer ceramic process. In the conventional process, the LTCC ceramic green tapes are cut to the required size. Registration holes, via holes and cavities are then punched into the different tape layers. Via holes are filled, usually with silver or gold as per the requirement of product, and then thick film processing is used to print metallization patterns on tapes. Additive manufacturing (AM) provides an efficient alternative by enabling the layer-by-layer fabrication of complex 3D structures, reducing material waste, and overcoming geometric limitations. Among various AM techniques, Digital Light Processing (DLP) 3D printing has emerged as a promising method for fabricating LTCC components. DLP technology uses a projected light source to cure photopolymer-based suspensions, allowing the rapid fabrication of intricate designs with high resolution and precision. The group is involved in research studies on development of LTCC-based packages and devices using DLP 3D printing with an in-house formulated LTCC slurry composed of glass powder and ceramic. (1)Most RF and microwave LTCC components developed by printed transmission lines and micro strip, ring resonators can be fabricated and measured using standard processes. Tibor Rovensky et al. (2016), had demonstrated the fabrication of ring resonators using various LTCC materials, including DuPont 951, DuPont 9K7, and Murata LFC, and analyzed their dielectric properties. (2) using conventional LTCC process. A ring resonator is a closed-loop waveguide structure that supports resonance at specific frequencies due to constructive interference. These components are widely utilized in RF/microwave circuits and photonic applications for filtering, sensing, and frequency selection. The work reported here presents the design, fabrication, and development of LTCC-based microstrip ring resonators using DLP 3D printing with an in-house formulated LTCC slurry composed of glass powder and ceramic. To demonstrate the same, we have designed microstrip ring resonator, with the dimensions of 15 mm × 30 mm. The resonator is fabricated using DLP based 3D printing technology. The fabrication process involved converting the computer-aided design (CAD) model into a stereolithography (.STL) file, which was processed through slicing software to guide the DLP printing. The fabricated structures comprised of 40 to 45 layers, and after sintering, the material exhibited shrinkage of ~30–32% in the x- and y-axes and ~22–24% in the z-axis.

Microstructural Characterization and Phase Transformation Behaviour of Zr-1Nb Alloy during Thermo-Mechanical Processing

Swarup Acharya[a*], Adarsh Patel[a], S. Santra[a], S. Neogy[b], R.K. Chaube[a], K. Kapoor[a] and PP Bhattacharjee[3]

[a]Nuclear Fuel Complex, Hyderabad, India
[b]Bhabha Atomic Research Centre, Mumbai, India
[3]Indian Institute of Technology, Hyderabad, India
Email: sacharya@nfc.gov.in, swarupmet03@gmail.com

Abstract

Zirconium alloy-based components are preferred as structural material for thermal reactor applications owing to their low thermal neutron absorption cross-section, corrosion resistance, good mechanical properties in the operating range and formability. Reliable in-reactor performance of these structural materials under extremely harsh reactor environment of temperature, pressure and neutron fluence is largely governed by microstructural features like grain morphology, grain size distribution, crystallographic texture, nature and distribution of precipitates, etc. Several literatures highlighted on superior corrosion resistance in aqueous environment and lower in-reactor hydrogen uptake of Zr-1wt%Nb material. Thus, it is essential to establish the thermo-mechanical processing and phase transformation aspects of Zr-1%Nb tube during industrial scale production, in order to enhance the residency period of fuel assemblies and achieve higher burn-up in thermal nuclear reactors. In general, fabrication route of these Zr-1Nb seamless tube consists of vaccum arc melting followed by series of thermo-mechanical processing (TMP) steps which include hot extrusion, cold pilgering and vacuum annealing. The process steps used for the fabrication are aimed at obtaining required microstructure, property and dimensional tolerances. This paper brings out the microstructural characterization during thermo-mechanical processing on Zr-1%Nb material. Effect of hot deformation, cold working and heat treatment condition on microstructure, texture and phase transformation has been discussed. Detailed metallurgical characterization has been performed using optical microscopy, scanning electron microscopy, electron back scattered diffraction (EBSD), transmission electron microscopy (TEM), X-ray diffraction (XRD), to study microstructural features like grain morphology, grain size distribution, crystallographic texture, nature and distribution of precipitates etc. The optimization of vacuum annealing parameters was found to be essential in order to achieve fine second phase precipitates resulting improve corrosion properties. The dominance of radial basal texture, essential for improved performance against hydrogen related degradation, ensured through suitable cold pilgering schedule. The hydride orientation fraction in radial direction has also been estimated.

Effect of Angle of Obliquity on damage of layered Targets with varying thickness in Ballistic Applications

Saleha Haque[a], Adepu Kumaraswamy[a]

Department of Mechanical Engineering, Defence Institute of Advance Technology (Deemed University), Pune, Maharashtra, India-411025

Email: salehahaque3984@gmail.com, salehahaque3984@gmail.com, akswamy@diat.ac.in

Abstract

The present investigation provides a computational analysis of the influence of obliquity angle on the damage of multi-layered targets of variable thickness in ballistic applications, subjected to impacts with varying fragment variables. This investigation specifically examines the destruction induced by tungsten alloy fragments of different shapes (spherical and cubical) and masses (3g and 5g) impacting layered targets at velocities of 2000 m/s and 3000 m/s, with obliquity angles ranging from 0 to 60 degrees. The numerical analysis model is formulated using the Lagrangian technique, incorporating an erosion contact algorithm within LS-DYNA. Both the target and fragments have been discretized using eight-noded hexahedral elements. A mesh convergence study has determined best suitable mesh size of 0.3 mm for both the target and fragment models. This study analyses various target configurations with differing thicknesses, including single-layer targets of 2mm and 9mm thickness, double-layer targets with a 2mm+3mm thickness and an airgap, and triple-layer targets with a 2mm+3mm+4mm thickness and an airgap, using Ar-500 steel alloy. The destruction analysis considers major and minor crater diameters, target and projectile volume eroded fraction (TVEF, PVEF), fragment residual velocity, and fragment kinetic energy. The results will focus on the effects of cube and sphere-shaped fragments on targets, considering variations in mass, velocity, and obliquity angles. The triple-layer target configuration demonstrates the highest resistance to fragment penetration, significantly affecting residual velocities and TVEF in comparison to single-layer and double-layer targets. The outcomes of these simulations offer the guidelines for optimization of armor configurations, material selection and layering, design against various threats, angle of incidence consideration, mesh convergence and simulation accuracy and enhancing residual protection. Overall, the study's findings contribute valuable knowledge to the field of protective armor development, aiding in the creation of more effective and efficient armor systems that can withstand various ballistic threats.

Keywords: Multi-layered Targets, ballistic application, fragment kinetic energy

Tensile and thermal Properties of 3D Printed High-Performance ULTEM 1010 / Short Carbon Fibers Composites

[a]Sushant D. Sale, [a]V. M. Sreekumar, [a]R. K. Goyal

[a]Department of Metallurgical and Materials Engineering, Malaviya National Institute of Technology Jaipur, Jaipur-302017, India

Email: rkg.meta@mnit.ac.in, 2021rmt9083@mnit.ac.in

Abstract

ULTEM is a high-performance thermoplastic polymer with a semi-transparent appearance and excellent mechanical and thermal properties mainly used in aerospace applications. In this work, the filaments of neat and short carbon reinforced (SCF) ULTEM, used in fused deposition modeling (FDM), were made using ULTEM granules and SCF. To create the composite filament, they were subsequently sent to the twin screw extruder's hopper and then mixed in a chamber at high temperature. Heating chamber temperatures were maintained between 340°C to 370°C. The XRD of filaments confirms the addition of SCF in ULTEM. Optical images of polished filaments confirm the uniform distribution of SCF in the matrix. The neat and SCF-reinforced filament was used to fabricate the specimens using the FDM technique. The tensile properties of neat and ULTEM SCF 10 were investigated for ±45□ and 0□ raster angles (RA). Adding SCF to ULTEM reduces the tensile strength of the composite by nearly 22 %. The fractured tensile specimens examined using scanning electron microscopes (SEM). The coefficient of thermal expansion (CTE) study was also conducted for ±45□ and 0□ RA. It confirms the reduction in CTE value for ULTEM SCF 10 composite with 0□ raster angle. The above study helps to understand and fabricate neat and SCF-reinforced ULTEM composite via FDM for aerospace applications.

A Review of the Correlation between the Microstructure, Arc Modes, and Corrosion Behaviour of SS316L during Wire Arc Additive Manufacturing (WAAM)

[a]Manish Kumar Jindal, [b]Naveen Porwal, [c]Jinesh Kumar Jain, [d]Rajendra Kumar Goyal, [e]Yashwant Koli

[a, b, c, e] Department of Mechanical Engineering, MNIT Jaipur, Rajasthan – 302017

[d] Department of Metallurgical and Materials Engineering, MNIT Jaipur, Rajasthan – 302017

Abstract

Utilizing wire arc additive manufacturing (WAAM) in lieu of conventional casting for the fabrication of complex-shaped components enables the deployment of cost-effective technologies, contingent upon the geometry and volume of parts required. The characteristics of the WAAM components were elucidated by contrasting their microstructures with those of the as-cast and heat-treated cast components following the fabrication of the WAAM components using three different cooling dwell periods. The results indicated that the cast and WAAM components exhibited similar microstructures, comprising austenite and delta ferrite phases; however, due to delayed cooling during solidification, the cast components possessed coarser grains and less delta ferrite content. On the contrary, the highest corrosion resistance was achieved with WAAM components produced with a dwell duration of 120 seconds. During WAAM investigations on 316L stainless steel utilizing diverse arc modes and a consistent deposition rate, it was discussed the mechanisms and impacts of the arc mode on stability, structural integrity, microstructures, and mechanical characteristics of the manufacturing process. The findings demonstrate that the Speed Pulse and Speed Arc additive manufacturing techniques are comparatively stable, very efficient, and structurally sound. The tensile strength and hardness of a component generated by Speed Arc WAAM exceed those of a component produced by Speed Pulse WAAM. This study examines the impact of essential process variables, specifically welding current and travel speed, on the bead shape and microstructure of stainless steel deposits.

Keywords: Wire-Arc Additive Manufacturing (WAAM), microstructures, deposition rate, post heat treatment, solidification rate.

Development of Eco-Friendly Carry Bags Using TPS-PBAT with Nanofillers via Blown Extrusion Techniques

[a]Chandramani Batsh, [a]Atiqul Islam, [a]Sazzadur Rahman, [a]Vineet Aniya

[a]Polymer & Process Engineering Laboratory, Chemical Engineering & Process technology Department, CSIR-Indian Institute of Chemical Technology, Hyderabad, Telangana, India – 500007
Email: batshchandramani@gmail.com

Abstract

In pursuit of sustainable solutions to mitigate plastic pollution, we have developed biodegradable carry bags utilizing thermoplastic starch (TPS) and poly(butylene adipate-co-terephthalate) (PBAT) as primary components. The formulation incorporates nanofillers and green compostable plasticizers to enhance flexibility and processability. Reactive extrusion was employed for the preparation of pellets, followed by blown extrusion for the fabrication of carry bags and garbage bags. This composite material addresses the critical issue of single-use plastic waste by offering a biodegradable and compostable alternative. The nanofillers significantly improves the mechanical properties and barrier performance of the films, additionally providing plasticization and thermal stability that leads to enhancement in the overall durability of the bags. Characterization of the films was conducted to evaluate surface morphology, hydrophobicity, wettability, binding energies, and opacity. The developed bags exhibited superior tensile strength and elongation at break, reflecting enhanced durability for practical applications. Wettability studies confirmed the hydrophobic nature of the films, which is crucial for maintaining structural integrity under varying environmental conditions. Moreover, opacity measurements indicated optimal light penetration, making the material suitable for packaging purposes. This study aligns with global efforts to control pollution and manage waste by utilizing renewable, biodegradable materials that can seamlessly integrate into existing waste management frameworks. The successful development of TPS-PBAT nanocomposite carry bags presents a scalable, eco-friendly alternative to conventional plastic bags, contributing to reducing environmental impact and promoting circular economy practices.

An investigation into the effects of tempering heat treatment on mechanical characteristics of tool steel

Mansha Mohan[a], Lakshay Sharma[a], Krishna Kumar[a]

[a]Metallurgical and Materials Engineering, Malaviya National Institute of Technology Jaipur- 302017, Rajasthan, India
Email: kkumar.meta@mnit.ac.in

Abstract

High-carbon alloy steel also known as tool steel is well known for its high degree of hardness, compressive strength, and abrasion resistance, protecting wear out against hard particles. The present study examines the effect of tempering at various temperatures (150° C, 250° C, 350° C, 450° C, 550° C) of tool steel. Mechanical and microstructural behaviour was studied to obtain an optimum combination of elongation and tensile strength. Heat treatment cycle comprise of initially austenitization at 850° C followed with water quenching, thereafter tempering at various temperatures. The experimental findings reported an increase in hardness with decent elongation behaviour for 450° C, 550° C tempering temperature. Initially, the increase in tempering temperature increases the hardness but elongation is decreased. Presence of ferrite phase and carbide precipitate signifies brittle nature for 150° C, 250° C, 350° C. The decrease in hardness value at further tempering temperature of 450 C and 550 C can be incorporated due to presence of retained austenite and dissolution of carbide leading to more ductile behaviour.

Keywords: Heat treatment, Tool Steel, Mechanical Behaviour, Microstructure

Examination of the corrosion inhibition properties of plant extract on the corrosion of DSS2205 in an acidic environment

Swati Chaudhary, Siddharth Atal, Saurabh Kumar

Department of Chemical and Biochemical Engineering, RGIPT Jais
Email: vivekk@rgipt.ac.in, ddwivedi@rgipt.ac.in

Abstract

This study investigates the effectiveness of plant extract as a corrosion inhibitor for DSS2205 (Duplex Stainless Steel 2205) in a 15% hydrochloric acid (HCl) solution, a frequent scenario in well acidizing processes. The corrosion rate of DSS2205 was evaluated using Linear Polarization Resistance (LPR) and Electrochemical Impedance Spectroscopy (EIS) techniques. The experimental setup involved samples exposed to a 15% concentration of hydrochloric acid (Hcl), with and without the addition of a plant extract recognized for its corrosion-inhibiting properties. The results demonstrated a notable reduction in the corrosion rate in the presence of the plant extract, as confirmed by LPR and EIS measurements. Scanning Electron Microscopy (SEM) was employed to examine the surface morphology of both untreated and treated samples. The results demonstrated significant changes, showing that the treated samples exhibited improved resistance to corrosion. This study highlights the ability of natural plant extracts to function as effective corrosion inhibitors in harsh acidic conditions, offering a sustainable alternative for protecting DSS2205 in acidizing well applications.

Keywords: Green corrosion inhibitor, acidizing wells, corrosion rate, plant extract, duplex stainless steel.

Development of Inhouse Inhibitor for the Application in Reduction of Corrosion in Storage of Ethanol Blended Petrol

[a]Saurabh Kumar, [a]Swati Chaudhary, [a]Siddharth Atal

[a]Department of Chemical and Biochemical Engineering, RGIPT Jais
**Email: ddwivedi@rgipt.ac.in*

Abstract

The aim of this study is to investigate the inhibition effect of waste oil based synthesized inhibitors on different steels such as carbon steel and stainless steel in ethanol blended fuel environment. The corrosion rates were obtained in different conditions through weight loss method and then corrosion rates were verified through electrochemical method. Fuel properties such as calorific value, fire point and flash point of blended fuel with inhibitors were also tested and compared with blended fuel without inhibitors. In this study, it is found that corrosion rate with inhibitors is much less as compared to corrosion rate without inhibitors due to formation of protective layer which prevent corrosion. The surface of the sample submersed in fuel blended solution with corrosion inhibitor are much smoother than other submersed samples. Therefore, results suggest that waste oil-based inhibitors mitigate the corrosion on steel and affirm that it has served as an effective corrosion inhibitor for steel in ethanol blended fuel environment.

Keywords: Ethanol blended fuel, Corrosion Inhibitor, waste cooking oil, Electrochemistry

Blister Resistive and Corrosion Resistive Additives for Zinc Primer

[a]Siddharth Atal, [a]Kuncha Swaraj, [a]Saurabh Kumar, [a]Swati Chaudhary, [a]Deepak Dwivedi

[a]Department of Chemical and Biochemical Engg., Rajiv Gandhi Institute of Petroleum Technology, Jais UP-229304
Email: siddhartha22ce@rgipt.ac.in

Abstract

The new primer formulation described in this invention offers remarkable protection against blister formation and corrosion caused by exposure to seawater. The novel primer has excellent protective qualities for metallic surfaces, especially in marine settings. It is made up of a carefully chosen blend of proprietary ingredients. The formulation offers a novel approach for increased asset longevity and lower maintenance costs by addressing the long-standing issues with blistering and seawater corrosion. The efficacy of the primer is attributed to its distinct molecular architecture, which creates a strong barrier against moisture infiltration and corrosive chemicals, resulting in improved durability and performance. This development, which has numerous applications in the offshore, coastal, and maritime infrastructure sectors, marks a substantial advancement in protective coating technology. By securing patent protection for the blister and seawater corrosion-resistant primer, the applicant hopes to promote sustainability and innovation in the field of material protection.

Keywords: Blister resistive, Corrosion-resistant, seawater, Primer

Plasmonic Coupling Effect of Annealed Gold Nanoarrays

Gaurav Pal Singh[a], Bodo Fuhrmann[a], Frank Syrowatka[a], Joerg Schilling[a], Neha Sardana[a]

[a]Department of Metallurgical and Materials Engg., Punjab Engineering College, Chandigarh 160012, India
Email: gaurav12294@gmail.com

Abstract

Electron beam lithography (EBL) is a highly accurate and flexible technique to produce a wide variety of nanostructures. However, it is an extremely expensive and slow process. Laser interference lithography (LIL) is a maskless and high throughput technique to fabricate periodic nanostructures. The drawback of LIL is that the ratio of the size of the individual nanostructure (d) to the period of the array (p) is limited (d/p ~ 0.5 for the setup used in the current article). Thereby, limiting its ability to create lattice plasmon resonances with a high quality factor (Q-factor). In the current article, we study the effect of thermal annealing on the Q-factor of the plasmonic resonances of gold nanodisk arrays fabricated by LIL and a lift off process. The nanodisk arrays with periods of 400 nm and 500 nm exhibited a plasmonic resonance in the visible and NIR regions, which was caused by the interaction of the single disk resonance and a (1 0) grating resonance. Annealing for a short duration lowered the d/p ratio from 0.5 to 0.4, and led to smoothening of the disk surfaces and growth of gold grains, resulting in lower ohmic and radiative losses from the gold disks and doubling of the Q-factor of the resonances from 3.6 to 7.8. Finite element method (FEM) simulations were used to monitor this improvement in material parameters. Annealing for a longer duration disintegrated the nanodisk into several smaller particles while maintaining the overall periodicity of the array. While the plasmonic resonances of the experimentally investigated fragmented disks were basically destroyed, simulation predict that for larger periods fragmented nanodisk arrays (keeping the d/p ~ 0.4) can exhibit extremely strong and sharp resonances whose Q-factor increases more than 58.4 times compared to the unfragmented discs. In addition, simulations show a massive enhancement of the local electric field and the creation of a multitude of hotspots between the fragmented particles, promising immense potential for surface enhanced Raman sensing.

Oxidation Fatigue Interaction Behaviour of CM247 DS LC alloy

Sharat Chandra[a], Rajesh Kumar Rai[a]

[a]Malaviya Institute of Technology Jaipur, Rajasthan 302017 India
Email: rajesh.meta@mnit.ac.in

Abstract

The performance of rotating blades in aero-engines is significantly impacted by environmental degradation, particularly oxidation, especially at the high operating temperatures. This degradation becomes especially critical when considering low cycle fatigue (LCF), a phenomenon driven by the cyclical thermal and mechanical stresses that occur during engine operation. This study explores how prior cyclic oxidation and temperature influence the LCF behavior of CM 247, a nickel-based superalloy commonly used in turbine blades. Both as received and pre-oxidized specimens were subjected to LCF tests at 750°C and 850°C for strain amplitudes of 0.5 %. The pre-oxidation process, intended to mimic the oxidation damage that occurs in service, involved thermal exposure at 850°C for 500 hours. This study shows that pre-oxidisation led to decrease in the LCF life of the alloy.

Strain Rate Sensitivity and Energy Absorption Characteristics of PU Foam under Effective Loading

V. Utikar[a], S. Nimje[a] and S. M. Mulla[b]

[a]Department of Mechanical Engg., Defence Institute of Advanced Technology (DIAT), DU, DRDO, Pune - 411025
[b]Fatigue and Material Centre of Excellence, Automotive Research Association of India (ARAI), Pune - 410501
Email: vutikar@gmail.com

Abstract

PU foam is widely recognised for its wonderful energy absorption potential, it also has always been an important material for the automotive and aerospace industries and, of course, impact protection applications. PU foam possesses a strain rate-dependent property, which affects how it deforms and dissipates energy under dynamic loading. Present research work deals with the investigation of the strain rate-dependent behaviour of PU foam using FE Analysis software LS-DYNA. The major emphasis of this work is on development and execution of the material models. An advanced level of the model incorporates advanced materials, namely MAT_CRUSHABLE_FOAM (MAT_063) and MAT_LOW_DENSITY_FOAM (MAT_057), and results are validated with experimental data available in literature. The effect of strain rate on stress-strain, energy absorption, and failure mechanisms of PU foam are studied in detail. It was observed from results that an increase in strain rate elevates peaks in stress levels. Results also illustrates that the energy absorption capacity increases due to the viscoelasticity of the foam. Furthermore, failure modes change from gradual densification at low strain rates to brittle-like collapse at higher strain rates. Above outputs will play vital role for accurate characterization of the materials under impact loading with high strain rate. Having shown to aid in the optimization of PU-based protective systems for safety and performance, this study now opens avenues for future work aimed at micro structural incorporation into material models to further enhance predictive accuracy and computational efficiency.

Keywords: PU Foam, MAT_057, MAT_063, FEA, LS-DYNA, Strain Rate

Monte-Carlo Simulation-Based Study of the Annealing Twinning of High Entropy Alloys and its Influence on Microstructure and Texture Evolution.

[a]Lalit Kaushik, [a]Shi-Hoon Choi

[a]Department of Metallurgical and Materials Engg., Indian Institute of Technology Jodhpur, Jodhpur-342030, India
Email: lalitkaushik@iitj.ac.in

Abstract

In the current study, an equiatomic CoCrFeMnNi high entropy alloy (HEA) was cold rolled to 80% reduction in thickness. Annealing experiments were performed at 700°C for time ranging between 5 minutes to 1 hour. Owing to the low stacking fault energy of the HEAs, profused annealing twins were observed during the recrystallization. The new orientations introduced due to annealing twinning led to texture weakening but didn't randomize the texture completely. The twin cluster near standard FCC texture component revealed the evolution of some selective orientations during the annealing. The annealing behavior was simulated by incorporating annealing twinning effects using the Monte-Carlo (MC) for better understanding of the underlying mechanism of texture evolution. Multiple generations of twins occurred right from the commencement of the annealing and continued till the full recrystallization was achieved.

Impact of particle velocity on HVOF coating properties: A state-of-the-art review

Atirek Gaur[a], Upender Pandel[a], Anup Kumar Keshri[b] and Swati Sharma[a]

[a]*Department of Metallurgical and Materials Engineering,*
Malaviya National Institute of Technology Jaipur, Jaipur-302017, India
[b]*Department of Metallurgical and Materials Engineering Indian Institute of Technology Patna, Bihta, Bihar, India, 801103*
Email: swati.meta@mnit.ac.in

Abstract

Thermal spray coatings enhance part performance by improving surface functionality and have been widely used in recent decades to resist wear, erosion, and corrosion. However, optimizing process parameters is essential for achieving high-performance coatings with superior mechanical and related properties. The well-adhered and dense coatings offered by HVOF generally depends on key process parameters like spray distance, powder feed rate, particle velocity and oxygen/fuel ratios. A comprehensive understanding of these key process variables helps to optimize the HVOF process parameters and the attain modified coating properties for specific applications. The present investigates the effect of increased gas flow rates, reduced powder feed rates, and spray distances on particle velocity and temperature. Previous studies suggest that the increased particle velocities characteristic of the HVOF process promote the formation of dense coatings. Particle velocity plays a crucial role in splat formation, inter-particle bonding, and phase transformations, all of which are pivotal for coating performance. Within the HVOF, the substantial kinetic energy of the particles allows them to deform in a plastic manner rather than in a molten state, fostering the development of compact, solid coatings. Although the particles remain in a plastic state, they experience considerable deformation upon impact, yielding a dense, pore-free coating with minimal oxygen incorporation. This review offers a detailed analysis (drawing on insights from recent research) of the impact of particle velocity under impression of different optimized process parameters on the microstructure of HVOF coatings. The effect of particle velocity on microstructural evolution of the splat particles in the coating, the coating density and consequently the obtained properties (mechanical and chemical) has been explored and a review of the same is presented in the present work.

Keywords: HVOF, Thermal Spray, Coatings, Particle Velocity, Microstructure, Phase Composition.

Study the effect of different annealing conditions on phase and microstructure evolution of CoCrFeNi-Ti high entropy alloy synthesized through mechanical alloying

[a]Apoorva Vashishtha, [a]Abhishek Tripathi and [a]Swati Sharma

[a]Department of Metallurgical and Materials Engineering, Malaviya National Institute of Technology Jaipur, Jaipur-302017, India
Email: 2021RMT9088@mnit.ac.in

Abstract

The study of high-entropy alloys is a relatively new field of materials science, and ongoing research seeks to further investigate and optimize their properties for numerous industrial and technological applications. Due to its high strength, ductility, and resistance to wear and corrosion, the base of CoCrFeNi with Ti has garnered interest for prospective engineering applications. Powder of nano-crystalline equiatomic TiCoCrFeNi high entropy alloy was synthesized through mechanical alloying route using a planetary mill, followed by annealing at 573, 773, and 973 K for 3 hours in Argon atmosphere. X-ray diffraction (XRD) confirmed the formation of a metastable nano-crystalline solid solution containing major FCC phase with a lattice parameter of 3.56 Å with a slight inclusion of BCC phase with a lattice parameter of 2.87 Å after 120 minutes of effective milling. As the milling progresses further, the XRD patterns indicate further solid solution formation containing FCC, BCC & Co-Ti rich Laves phase with a structure similar to a hexagonal close packed Co2Ti phase. This study revealed the significance of annealing conditions on the phase composition and microstructure of TiCoCrFeNi HEA. Different annealing temperatures resulted in distinct phase transformations and crystal structure modifications, which may substantially affect the mechanical properties and thermal stability of the alloy. Upon annealing at 973 K, this metastable supersaturated solid solution has been transformed into equilibrium phases, resulting in the formation of sigma phase (body centered tetragonal structure), considered a weak martensitic transformation, in which a high-temperature cubic phase transforms into a slightly tetragonal phase without mechanical stress or deformation. X-ray diffraction (XRD) analysis was performed on both the ball-milled and heat-treated samples to identify the phases present and determine the evolution of crystal structures under various annealing temperatures. Using a high-resolution scanning electron microscope (SEM) equipped with energy-dispersive spectroscopy (EDS) unit, we were able to examine the changes in chemical composition caused by varying milling durations. Thermodynamic calculations were performed using the CALPHAD method and thermo-calc software to complement the experimental observations and enhance our understanding of the thermodynamics of the system. A brief discussion on thermodynamic parameters of CoCrFeNiTi high entropy alloy for alloy formation, phase evolution and HEA forming ability clearly elucidate that the formation of the stable solid solution phases is possible for the investigated multi-component CoCrFeNiTi system according to the stability criteria. The combination of experimental and computational techniques provided a comprehension of the microstructural changes in CoCrFeNiTi HEA under different annealing conditions.

Keywords: High entropy alloy, Mechanical alloying, Microstructure, Sigma phase, Annealing conditions

LiH-Polymer Composite Shield for Enhanced Radiation Protection in Space Applications

[a]Kavita Lalwani, [a]Sreedevi V V

[a]*Department of Physics, Malaviya National Institute of Technology Jaipur, India*
Email: kavita.phy@mnit.ac.in

Abstract

Radiation shielding is a critical challenge for long-duration space missions due to the harmful effects of cosmic rays and solar energetic particles [1]. This study explores a novel composite shielding material composed of lithium hydride (LiH) and a polymer matrix for enhanced radiation protection in space applications. LiH is known for its high hydrogen content and excellent neutron attenuation properties, while the polymer matrix provides structural integrity, flexibility, and additional radiation absorption [2]. The combination aims to achieve an optimal balance between mass efficiency, mechanical strength, and radiation shielding performance. OLTARIS simulations [3] and its comparison with experimental studies are employed to evaluate the shielding effectiveness against galactic cosmic rays (GCRs) [4] and secondary radiation. Results on dose equivalent, particle flux and LET (Linear Energy transfer) suggest that the LiH-polymer composite exhibits superior shielding capabilities compared to conventional materials such as aluminum, making it a promising candidate for space habitats and spacecraft protection.

Keywords: Space radiation environment, GCR, LiH, Polymer composites, OLTARIS

PEEK Composites: A Promising Structural Material for Space Radiation Protection

Sreedevi V V[a], Kavita Lalwani[a], Rajendra Kumar Goyal[b]

[a] *Department of Physics, Malaviya National Institute of Technology Jaipur, India*
[b] *Department of Metallurgical and Materials Engineering, Malaviya National Institute of Technology Jaipur, India*

Abstract

Space radiation, composed of high-energy ionizing particles, presents a significant challenge for deep space exploration. Polymer-based composite materials have gained interest due to their lightweight properties and excellent radiation attenuation capabilities. This study evaluates the shielding effectiveness of a Polyether Ether Ketone (PEEK)-Zinc Oxide (ZnO) composite [2] with boron nitride in a Free Space Galactic Cosmic Ray (GCR) environment [3] using HZETRN simulations [4]. ZnO, known for its excellent proton absorption properties, is embedded in the PEEK matrix, while an additional layer of boron nitride is incorporated to enhance neutron shielding. Dose equivalent results indicate that the PEEK-ZnO composite achieves greater dose reduction compared to conventional materials like aluminum. Additionally, optimizing shield thickness and ZnO composition enhances radiation protection. Further, the particle-wise dose equivalent and radiation flux in the tissue for PEEK-ZnO composites are analyzed to assess each particle's contribution to radiation, aiding in the identification of the most effective space radiation shielding.

Keywords: Space radiation environment, GCR, PEEK, Al, BN, HZETRN

Correlating Structural and Mechanical Properties of (MoNbTaW)N films as a Function of Deposition Temperature

[a]Sai Kumar Katta, [a]Venkata Girish Kotnur

[a]School of Engineering Sciences and Technology, University of Hyderabad, Prof. CR Rao Road, Gachibowli, Hyderabad-500046, Telangana, India.
Email: vgk@uohyd.ac.in

Abstract

This study investigates the relationship between the structural and mechanical properties of (MoNbTaW)N films deposited on Si (100) substrates via direct current magnetron sputtering (DCMS), with deposition temperatures ranging from ambient to 500oC. Surface morphology, crystal structure, bonding characteristics and mechanical properties were studied using scanning electron microscopy (SEM), atomic force microscopy (AFM), X-ray diffraction (XRD), X-ray photoelectron spectroscopy (XPS) and nanoindentation. SEM and AFM analysis reveals a fine-grained microstructure that becomes more refined with increasing deposition temperature, with feature size distributed around 5-6 nm at 500oC. Film thickness decreases from 690 nm to 610 nm due to elevated deposition temperature. XRD results confirm a NaCl-type face-centred cubic (FCC) crystal structure across all films, with a significant change in preferred orientation from (111) to (200) as the deposition temperature increases. XPS indicates a metal-nitrogen (Me-N) bond formation, evidenced through shifts in binding energy. Nanoindentation measurements show that all the films exhibited hardness in the range of 26-27 GPa, while, the film modulus increased from 300 GPa to 340 GPa, as the deposition temperature increased to 500 C. These findings provide insights into the temperature-dependent evolution of (MoNbTaW)N films, offering valuable guidance for optimizing their structural and mechanical performance in advanced applications.

Keywords: Multiprinciple element nitride, Deposition temperature, Hardness and modulus, Metal-nitrogen bonding

Stability behaviour and thermophysical characteristics of nano-particles integrated to improve the performance of refrigeration systems- A review

Md Jamil Akhtar[a], S.P.S. Rajput[b]

[a]Research Scholar, Department of Mechanical Engg., M.A.N.I.T., Bhopal
[b]Professor, Department of Mechanical Engg., M.A.N.I.T., Bhopal
Email: jamil8492@gmail.com

Abstract

In present days, there has been a revival of interest in enhancing the thermal properties of base fluids for thermal engineering applications. Research has shown that incorporating nanoparticles into conventional fluids significantly improves their thermophysical properties and overall system efficiency. Consequently, numerous studies have explored the integration of nanofluids in refrigeration systems, demonstrating their potential to enhance cooling performance. This paper provides a comprehensive review of nanofluid implementation in refrigeration systems, covering preparation methods, variations in thermophysical properties, stability challenges, and performance impacts. Additionally, it examines the limitations and practical feasibility of nanoparticle integration. Studies indicate that nanoparticles in lubricants and refrigerants enhance heat transfer, with greater concentrations yielding more pronounced improvements. However, increased viscosity at higher concentrations can negatively affect fluid flow and efficiency. Despite these challenges, enhanced thermal conductivity contributes to system optimization by improving heat exchange and reducing energy consumption. Research highlights that nanoparticle doping decreases compressor power input while increasing cooling capacity, leading to substantial performance gains. However, factors such as stability, dispersion, agglomeration, and sedimentation must be addressed to ensure sustained improvements. Nanoparticle integration in refrigeration systems holds great promise, yet challenges such as high costs, potential toxicity, erosion effects, and clogging risks must be resolved. Addressing these issues through continued research will enable the widespread adoption of nanofluids, positioning them as a transformative solution in refrigeration engineering.

Keywords: Nanofluid Stability, Performance, Refrigeration system, Nano-refrigerant, Thermophysical properties

Influence of Novel Thermomechanical Processing on Microstructure, Mechanical Properties, and Tribological Behaviour of Ti-6Al-4V Alloy

[a]Sandeep Mahore, [a]Swati Sharma and [a]Abhishek Tripathi

[a]Department of Metallurgical and Materials Engineering, Malaviya National Institute of Technology Jaipur, Jaipur-302017, India

Email: abhishek.meta@mnit.ac.in

Abstract

This study investigates the effects of a novel thermomechanical processing approach on Ti-6Al-4V specimens, focusing on microstructural evolution, mechanical properties, and tribological performance. Initially, the alloy was homogenized at 1070°C for 75 minutes, followed by water quenching, and then hot-rolled at 750°C with reductions from 10% to 40%. The variation in rolling reductions and cooling rates resulted in distinct microstructural characteristics and hardness variations. In the β-phase region Ti-6Al-4V undergoes complete transformation into the β-phase, where fast cooling forms an α□ martensitic microstructure, increasing strength and hardness. Conversely, thermomechanical processing in the α+β phase range (700–980°C) produces a bimodal microstructure with fine equiaxed α grains in a transformed β matrix. Controlled cooling refines the α+β lamellar structure, enhancing hardness. Tribological tests assessed friction and wear resistance, revealing that higher rolling reductions improved hardness and reduced material loss. The wear mechanism varied based on microstructure, shifting from adhesive wear in coarser structures to abrasive wear in finer, harder structures.

Keywords: Titanium Alloy, Thermomechanical Processing, Tribological Behaviour, Mechanical Properties and Microstructure.

N-Acryloyl phenylalanine and their anti-inflammatory potential on Lipopolysaccharide-induced raw 264.7 macrophages; Systemic inflammation on a rat model

[a]Divya Pareek, [a]Sukanya Patra, [a]Gurmeet Singh, [a]Rajlaxmi Pradhan, [a]Taniya Das and [a]Pradip Paik

[a]School of Biomedical Engineering, Indian Institute of Technology Varanasi, Uttar Pradesh, 221005, India
Email: divyapareek.rs.bme19@itbhu.ac.in, paik.bme@iitbhu.ac.in

Abstract

Systemic inflammation can lead to single or multi-organ failure, and suitable medicine is needed for the survival of severe patients. Existing anti-inflammatory components possess adverse biological side effects and demand new therapeutics. Polymeric nanoparticles based on amino acids could be the best solution due to their Cytocompatibility and Immune reactivity. In this work, we have synthesised amino acid-based polymeric nanoparticles (Phe NPs) of size 20-30 nm using N-acryloyl chloride and N-Acryloyal phenylalanine methyl ester. The biological and immune response of Phe NPs was found to be commanding, which has been proved using immune cells (RAW 264.7 macrophages). In vitro study revealed that Phe NPs (~98%) can easily be uptake by the immune cells and could influence their signalling pathways, potentially leading to the reduction of inflammation followed by improving the immune responses. In silico molecular docking revealed that Phe NPs could potentially interact with proinflammatory cytokines such as IL-6, NF-κβ, TNF-α, COX2, and IL-1β. The NPs also show a similar type of binding as IBF, making strong evidence of its immune properties in controlling systemic inflammation. LPS-stimulated Raw macrophages were used in vitro, and LPS-induced rat models were used to check the anti-inflammatory responses of Phe NPs. The anti-inflammatory response of Phe NPs was checked by RT PCR analysis using different doses with the inflamed markers TNF-α, IL-6 and VEGF. Finally, rats are sacrificed, and systemic organs (Brain, liver, kidney, spleen, lung and heart) are acquired by taking their organ weight and real-time images. The collected organs went for full H&E histological analysis. Their histological analysis evaluated the severity of inflammation and response of Phe NPs with different dosages on specific organs. Overall, it has been concluded that amino acid-based nanomaterial has a huge scope to control systemic inflammation. Further, clinical research could be conducted to determine the results of these unique polymeric nanoparticles.

Advancing Sustainable Construction Materials through Investigation of Fly Ash Blended Cement Mortar Properties

Soumyaranjan Panda[a], Kunal M. Shelote[a], Mohammed Ziya Ul Hassan[a], Ashish Kumar Dash[b], and Supratic Gupta[a]

[a]Department of Civil Engineering, Indian Institute of Technology Delhi, New Delhi-110016 India
[b]Department of Civil Engineering, National Institute of Technology Andhra Pradesh, West Godavari-534101, India
Email: srpanda.ce@gmail.com

Abstract

The construction industry is actively exploring sustainable materials to address environmental concerns and reduce the carbon footprint associated with conventional practices. Mortar plays a vital role in construction providing stability and durability to buildings. However, cement production has environmental limitations, such as high carbon dioxide emissions and energy consumption. The annual growth rate of cement production, which increases by 2.5%, exacerbates these environmental issues. Fly ash, a byproduct of coal combustion, offers numerous benefits, including reducing cement usage, improving sustainability, and promoting eco-friendly construction practices. Hence, this study includes a comprehensive investigation of fresh and hardened cement mortar characteristics blended with fly ash. Here, mortar mix designs were prepared with a w/c ratio of 0.33, 0.4, 0.48, and 0.7 with an increment in fly ash proportion 0%, 15%, 25%, and 35% based on the efficiency (K-factor) theory. Several test methods were employed to evaluate the rheology, mechanical, and durability properties of the fly ash-blended mortar. Compressive strength tests confirmed the mechanical performance, while water permeability and rapid chloride penetration tests provided detailed insights into durability. An enhancement in slump value is reported till 25% of fly ash inclusion with a constant admixture dosage. Similarly, a rheological study shows that the yield stress and viscosity of the mortar decreased as the fly ash material increased up to 25%; further, increasing fly ash shows the reverse effect. The mechanical and durability tests provide better outcomes, suggesting a blend of fly ash in mortar is advantageous.

Carbonation and Permeation properties of normal concrete, self-compacting concrete and mortar with the effective usage of Fly ash, Marble powder and Stone dust

[a]Md Marghoobul Haque, [a]Pramendra Kumar and [a]Supratic Gupta

[a]Department of Civil Engineering, Indian Institute of Technology Delhi, New Delhi-110016, India
Email: cez228417@iitd.ac.in

Abstract

The construction industry is responsible for huge emissions of CO2 leading to the rise in global warming. One of the ways to reduce CO2 emissions is by minimizing the usage of cement in the construction industry. Various waste materials like fly ash, marble powder, stone dust can be used as an alternative to cement and aggregate respectively to promote sustainability in the construction industry. This study focuses on the effective usage of the abovementioned waste materials in the manufacturing of concrete. Due to increasing global warming, the carbonation of concrete is a matter of huge concern. Carbonation reduces the alkalinity of concrete and can lead to serious durability issues like corrosion. In this regard, carbonation of all 22 mixes (comprising of normal vibrated concrete, self-compacting concrete and self-compacting mortar) with an effective w/c ratio of 0.49 and 0.54 have been performed. Three different curing conditions are considered for the mixes before placing them into carbonation chamber (CO2 concentration = 4 ± 5%, Temperature = 20 ± 3°c and Relative Humidity=60%). Additional to the carbonation, various other strength and durability tests like compressive strength, RCPT, water permeability and penetration test (T25) have been performed to understand the permeation behaviour of concrete and mortar specimens.

Influence of Heat Treatments on Mechanical Properties of LPBF Ti-6Al-4V/Ti-6Al-2Sn-4Zr-2Mo Bimetals

Akhilesh Goyal[a*], Bhallamudi Ravi[b], and Shyamprasad Karagadde[a]

[a]Department of Mechanical engineering, Indian Institute of Technology Bombay, Mumbai, India
[b]National Institute of Technology Karnataka, Surathkal, India
Email: akhileshgoyal93@gmail.com

Abstract

This study investigates the mechanical properties of additively manufactured Ti-6Al-4V and Ti-6Al-2Sn-4Zr-2Mo (Ti-6242) bimetallic joints fabricated using laser powder bed fusion (LPBF). Ti-6Al-4V is known for its balanced mechanical properties but limited high-temperature stability, whereas Ti-6242 maintains strength at elevated temperatures. The aim of combining these alloys is to leverage the cost-effectiveness of Ti-6Al-4V with the high-temperature performance of Ti-6242 for aerospace and energy applications. The rapid cooling associated with LPBF results in acicular martensitic structures and sharp compositional gradients that necessitate post-heat treatments to stabilize microstructures, alleviate residual stresses and improve mechanical properties. Cuboidal bimetallic specimens were produced and subsequently subjected to heat treatment cycles below the β-transus temperature. Microstructural characterization of the as-printed (ASP) and heat-treated samples was performed using optical and scanning electron microscopy as well as electron diffraction spectroscopy. The specimens were tested in tensile loading along the bimetallic interfaces. The α-phase segregation at the interface for different heat treatment cycles was correlated to the tensile behavior of bimetallic specimens. Heat treatment at 975°C for 24 hours led to homogenization of alloying elements and removed the distinct interface zone. This further led to reduced strain incompatibility between both alloys and balanced tensile properties were achieved with improved ductility of the bimetal.

A Comprehensive Review on methods for Predicting Shrinkage in Recycled Concrete Aggregate

Moorvi, Supratik Gupta

Department of Civil Engineering, Indian Institute of Technology Delhi, New Delhi-110016, India
Email: cez228423@iitd.ac.in

Abstract

Sustainability concerns are important these days since natural resources are being used much more quickly to produce products like concrete. Every year, our nation produces enormous amounts of construction trash. This trash pollutes the environment and needs a significant amount of land for disposal. There is a lot of research being done to find alternatives for cement, sand, and coarse aggregate in concrete that won't compromise the strength of the structure. The present study undertakes a thorough examination of the effects associated with the integration of recycled aggregates (RA), derived from construction and demolition waste, on the shrinkage behaviour of concrete. The paper employs a systematic methodology that encompasses the identification, appraisal, selection, and synthesis of pertinent literature to elucidate the diverse factors that impact the utilization of RA. The factors that need to be considered in this study encompass the extent to which natural aggregates can be substituted with RA, the characteristics and source of the RA, the methodology employed in the mixing process, the conditions under which the curing takes place, and the incorporation of chemical admixtures and additives. This study investigates the correlation between various influencing factors and the phenomenon of concrete shrinkage. The results indicate that current prediction models commonly exhibit a tendency to overestimate the shrinkage strain of concrete when incorporating RA. This implies that the aforementioned models may not be entirely appropriate for accurately predicting the shrinkage behaviour of concrete containing RA.

An Ultra-Fast and Facile Fabrication of Turbostratic Holey Graphene and its Electrochemical Behaviour

[a]Niranjan Pandit, [a]Saurav Keshri, [a]Anup Kumar Keshri

[a]Plasma Spray Coating Laboratory, Dept. of Metallurgical and Materials Engg., Indian Institute of Technology Patna
Email: niranjan_2221mm03@iitp.ac.in

Abstract

Scalable production of turbostratic holey graphene (tHG) with high energy density and power density is essential but challenging for flexible and compact supercapacitors. Herein, we demonstrate an efficient, rapid, cost-effective and kilogram-scale method for fabricating the twisted multilayer holey graphene using an atmospheric plasma spray. The twisting of graphene layers reduces electronic interactions between them, increasing the spacing between layers and consequently enhancing the graphene's effective specific surface area. The fabricated tHG electrode exhibits the highest specific capacitance of ~250 F g-1 at 0.5 A g-1, an energy density of 28.54 Wh kg-1 and a power density of 280 W kg-1 in the three-electrode system. Furthermore, the electrode exhibits outstanding electrochemical stability, retaining about 94% of its capacitance after 10,000 cycles. These characteristics position the tHG as an auspicious material for next-generation high-performance supercapacitors.

Keywords: Holey graphene; Turbostratic graphene; Electrodes; Supercapacitor; Plasma spray

Synergistic effect of Al2O3 and MoS2 on the corrosion behaviour of plasma sprayed aluminium matrix composite coating

[a]Saurav Keshri, [a]Niranjan Pandit, [a]Anup Kumar Keshri

[a]Plasma Spray Coating Laboratory, Department of Metallurgical and Materials Engineering,
Indian Institute of Technology Patna – 801106
Email: saurav_2221mm012@iitp.ac.in

Abstract

In this study, the incorporation of alumina (Al2O3) and molybdenum disulfide (MoS2) in Aluminium (Al) was successfully fabricated through shroud plasma spray. This strategic incorporation of MoS2 and Al2O3 effectively fills voids, leading to a remarkable reduction in inherent porosity within the aluminium coating, achieving an impressive ~76.54 % reduction. These composite coatings exhibited outstanding hydrophobicity (contact angle ~119°), signifying remarkable water repellency and anti-corrosion properties compared to bare aluminium (contact angle ~81.7°). During the electrochemical corrosion test, the corrosion rates (CR) of Al coating (CR = 9.14 mpy) was notably around 23 times higher compared to MoS2 and Al2O3 reinforced aluminium composite coating (CR = 0.372 mpy) in a 3.5 wt % NaCl electrolyte. The subsequent post-corrosion analysis further confirmed the composite coating's efficiency in mitigating the impact of corrosive salts, underlining the effectiveness of the hybrid coating in combating corrosion attacks. A corrosion behaviour prediction model was established based on computational and experimental data.

Keywords: Aluminium matrix composite; Hydrophobicity; Corrosion; MoS2; Al2O3.

Bake-Hardening (BH) Response of DP590 and FB590 Hot-RolledSteels Subjected to Various Pre-Strain Levels and Baking Conditions

Saish Gulab Kumbhar

COEP Technological University, Pune

Abstract

This study investigates the bake-hardening (BH) response of DP590 and FB590 hot-rolled steels subjected to various pre-strain levels and baking conditions. Tensile samples were prepared and tested according to ASTM E8 standards. Pre-straining was applied at 1%, 2.5%, and 5%, followed by baking at 140°C, 170°C, and 200°C for 20 minutes each. The bake-hardening response was evaluated through tensile testing to determine the increase in yield strength due to the interaction of dislocations with carbon atoms during the baking process. Results indicate a positive correlation between increasing pre-strain and bake-hardening magnitude, with higher baking temperatures enhancing the BH effect. DP590 exhibited a more pronounced bake-hardening response compared to FB590, attributed to differences in microstructural characteristics. The findings provide insights into the material behavior under different forming and baking conditions, contributing to optimized processing strategies for automotive and structural applications where improved strength and formability are desired.

Tribological Investigation of Fiber Orientation Effect on the Wear Performance of Bamboo Fiber and Recycled Glass Fiber Epoxy Hybrid Composite

[a*]Deepa Ahirwar, [a]Rajesh Purohit, [b]Savita Dixit, [a]Subodh Kumar, [a]Bhagwan Singh Lovevanshi

[a]Department of Mechanical Engineering, Maulana Azad National Institute of Technology Bhopal 462003
[b]Department of Chemistry, Maulana Azad National Institute of Technology Bhopal 462003
Email: deepa.ahirwar25@gmail.com

Abstract

This study investigates the influence of fiber orientation on the tribological behavior of random short bamboo and recycled glass fiber epoxy hybrid composites under dry-sliding conditions using pin-on-disk testing. The effects of load, sliding speed, and reinforcement weight, along with fiber orientation, were analyzed. Samples with parallel and perpendicular fiber orientations were tested to evaluate wear rates. The Taguchi method was employed to optimize experimental parameters and minimize wear. Results indicated that, in most cases, the perpendicular (across) fiber orientation exhibited a higher wear rate compared to the parallel orientation. The minimum wear loss of 0.015 mg was recorded for a sample reinforced solely with recycled glass fiber at a sliding speed of 50 RPM and a load of 5N. Among all compositions, the lowest wear losses observed were 0.015 mg overall and 0.016 mg for hybrid compositions. Morphological characterization using scanning electron microscopy (SEM) provided insights into the wear mechanisms of the composite surfaces.

Keywords: Fibre orientation, Hybrid Polymer Composite, Bamboo Fibre, Recycled Glass Fibre, Dry Sliding Wear, Polymer Composite Tribology

Influence of Dispersion Routes on the Multifunctional Properties of LLDPE/CNF Nanocomposites

Vaibhav Jain[a], S Wazid Ali[a], Mangala Joshi[a]

[a] Department of Textile Technology, Indian Institute of Technology, New Delhi, Hauz Khas, 110016

Abstract

The dispersion of carbon nanofibers (CNFs) in polymer matrices plays a critical role in enhancing the multifunctional properties of nanocomposites. This study investigates the effect of two different dispersion routes-solvent mixing and melt mixing using a twin-screw extruder—on the electrical, thermal, and structural properties of linear low-density polyethylene (LLDPE)/CNF nanocomposites. Nanocomposites were fabricated by incorporating CNFs into LLDPE through solvent-assisted dispersion in p-xylene followed by compression molding, and melt mixing via a twin-screw extruder. Morphological analysis using field emission scanning electron microscopy (FESEM) and X-ray diffraction (XRD) confirmed differences in CNF dispersion quality between the two routes. Electrical characterization, including volume resistivity and dielectric property analysis, revealed that solution-mixed nanocomposites exhibited superior conductivity and lower percolation threshold due to better CNF dispersion. Differential scanning calorimetry (DSC) was used to study thermal transitions, while thermal conductivity measurements indicated enhanced heat dissipation in solvent-mixed samples. Additionally, melt flow index (MFI) analysis provided insights into the processability of the composites. This study highlights the crucial influence of dispersion techniques on tailoring the multifunctional performance of LLDPE/CNF nanocomposites, making them promising candidates for applications in EMI shielding, thermal management, and flexible electronic devices.

Keywords: LLDPE, Carbon Nanofibers, Solution Mixing, Melt Mixing, Electrical Conductivity, Thermal Conductivity, Volume Resistivity, Dielectric Properties

Development of Smart Biodegradable Mulch Film for Sustainable Agriculture

Atiqul Islam[a], Chandramani Batsh[a], Sazzadur Rahman[a], Vineet Aniya[b]

[a]Research Scholar, CSIR-Indian Institute of Chemical Technology, India
[b]Senior Scientist, CSIR-Indian Institute of Chemical Technology, India
Email: chemist.atiqul@gmail.com

Abstract

Conventional polyethylene-based mulch films, widely used in agriculture, pose significant environmental challenges due to their non-biodegradable nature, leading to soil contamination and microplastic accumulation. To address these issues, this study focuses on the development of an eco-friendly, biodegradable mulch film using a blend of poly(butylene adipate-co-terephthalate) (PBAT), thermoplastic starch (TPS), and naturally derived nanofillers. The blend was prepared using a twin-screw extruder, ensuring optimal dispersion and uniformity. The proposed mulch film offers dual benefits: self-degradation in the soil environment and nutrient supplementation upon degradation. Polysaccharides derived from natural sources were incorporated to enhance the biodegradability of the film, while nanofillers provided improved mechanical and barrier properties, making the film suitable for agricultural applications. To further enhance soil fertility, nutrient-enriched components were integrated into the formulation, allowing the film to act as a slow-release fertilizer upon decomposition. Preliminary results demonstrate the potential of the developed film to maintain soil health and agricultural productivity while significantly reducing environmental impact. This innovative approach not only replaces conventional plastic-based mulch films but also supports sustainable agricultural practices by closing the nutrient loop and improving soil quality.

Scalability and Cost-Effectiveness of Machine Learning in Solar Air Heater Applications

Jailal Prabhakar Patel[a] and J L Bhagoria[b]

[a]Research Scholar, Mechanical Engineering Department, MANIT Bhopal, (M.P.) India.
[b]Professor Mechanical Engineering Department, MANIT Bhopal, (M.P.) India.
Email: jai.ptl@hotmail.com

Abstract

With the rapid advancement of machine learning technology, regression analysis has become a crucial tool for extracting patterns from large datasets to enable accurate predictions. Data prediction plays a significant role in various domains, including weather forecasting, medical diagnosis, financial forecasting, and renewable energy applications. Among them, solar air heaters (SAHs) are widely used for energy-efficient heating in various industrial and residential applications. However, the performance of SAHs is influenced by multiple factors such as ambient temperature, solar radiation, and airflow rate, making accurate prediction and optimization a challenging task. This study focuses on three widely used machine learning algorithms—BP neural network, extreme learning machine, and support vector machine—to predict and optimize the thermal performance of SAHs. By comparing the performance of individual models and their integrated versions in regression tasks, the advantages, limitations, and cost-effectiveness of each approach are analysed. Furthermore, simulation experiments on four different datasets, including solar air heater performance data, are conducted to validate the efficiency and feasibility of these algorithms. The results demonstrate that integrating multiple machine learning models enhances predictive accuracy while maintaining a balance between performance and computational cost, making it a viable approach for improving SAH efficiency and broader regression-based applications.

Keywords: Machine Learning Regression, Solar Air Heater Optimization, Predictive Modelling, Energy Efficiency, Cost-Effective Forecasting

Impact and Post-Impact Damage Assessment of Hybrid Basalt Fiber Composites Reinforced with Flax, Hemp, and Glass Fibers via Hand Layup

[a]Adarsh Chaurasiya; [a]R S Rana

[a]Department of Mechanical Engineering, Maulana Azad National Institute of Technology, Bhopal MP

Abstract

Ternary hybrid epoxy composites reinforced with basalt (B), flax (F), hemp (H), and glass (G) fibers in textile form - namely FHB, GHB, and GFB-were fabricated and investigated. The reinforcement volume fraction was maintained between 21–23% for all samples. Additionally, laminates composed solely of basalt, hemp, and flax fibers were prepared for comparison. The mechanical performance of hybrid laminates was found to be intermediate, with basalt fiber-reinforced laminates exhibiting superior properties, while flax and hemp fiber laminates displayed lower performance. In terms of impact behavior, GHB emerged as the weakest hybrid laminate, whereas FHB slightly outperformed GFB. Increased stiffness was observed in all hybrid composites compared to flax and hemp fiber laminates. A morphological study of fractured surfaces using SEM revealed variations in fracture mechanisms among flax, hemp, and hybrid FHB laminates. Post-impact flexural tests, monitored through acoustic emission analysis, indicated that FHB hybrids were more prone to delamination. However, they demonstrated better resistance to impact damage than the other hybrid configurations.

Keywords: Hybrid, Polymer–matrix composites (PMCs), Impact behaviour, Acoustic emission, Basalt fibres

Development of CoCrFeNiSi0.5 Multi Component Alloy Surface Coating on Plain Carbon Steel Through a Novel In-situ Weld Surface Alloying Approach

[a]A.V. Sreenu, [a]G.P.S.S.Ganesh, [a]G. Shivani

[a]Department of Metallurgical and Materials Engg., Rajiv Gandhi University of Knowledge Technologies-Nuzvid,AP
Email: sreeiitm09@rguktn.ac.in

Abstract

Si addition to the low strength CoCrFeNi medium entropy alloy system proved to be advantageous in increasing the strength, hardness, wear, erosion and oxidation resistance. Increase of lattice distortion, precipitation of hard silicides and lowering of stacking fault energy with increase of Si were attributed for the enhanced mechanical properties. Development of such Multi Component Alloy (MCA) coatings on plain carbon steel engineering components will enhance the service life in hostile environments. However, the existing MPEA coating techniques requires alloyed powders and cost intensive vacuum based and/or laser-based processing techniques. In the present research a novel single step (Synthesis + Fabrication) processing approach was developed for the deposition of CoCrFeNiSi0.5 MPEA alloy on low carbon steel (LCS) substrate through cost effective Gas Tungsten Arc Welding (GTAW) using metal powder cored wire consumable. SS304 metallic sheet with 0.05mm thickness was used to prepare hallow tubes of 5 mm diameter and 50 mm length which were subsequently filled with Co, Cr, Ni and Si elemental powder mixture without Fe powder input since the LCS dilution from GTAW will be served as a source of Fe. A well bonded cladding (≈ 2 mm thickness) without defects, was obtained at 140A weld current, 16V arc voltage, 80 mm/min weld speed and 1.18 KJ/mm. The MCA cladding is free from the defects and consists of good interfacial bonding and representing a dendritic morphology along with planar growth near to the fusion boundary. A Ni-Si rich phase is present at the inter- dendritic region and CoCrFe rich FCC phase is present in the dendritic region which is evident from the EDS point analysis and elemental mapping. The XRD analysis also confirms the Ni-Si rich (Cr3Ni5Si2) phase and the FCC phase. The micro hardness survey across the interface has shown a steep increase in the hardness from 183 HV0.5 in the LCS substrate to 418 HV0.5 in the cladding. The proposed approach is proved to be effective in achieving the aimed MCA bulk coatings without vacuum / laser-based techniques and need only elemental powders.

Micro Electro Discharge Drilling Machine: Precision Machining for Micro-Scale Applications

Saurabh Jain[a], Sudhanshu Kumar[a], M K Pradhan[b]

[a]*Department of Mechanical Engineering, Maulana Azad National Institute of Technology, Bhopal, MP*
[b]*Department of Mechanical Engineering, National Institute of Technology, Raipur, CG*

Abstract

Micro Electro Discharge Drilling (Micro-EDD) is an advanced machining technique used for precision micro-hole fabrication in hard-to-machine materials. This non-contact process utilizes controlled electrical discharges between a tool electrode and the workpiece, submerged in a dielectric medium, to remove material through thermal erosion. Unlike conventional drilling, Micro-EDD enables the machining of high-strength alloys, ceramics, and composites with minimal mechanical stress, making it highly suitable for aerospace, biomedical, and microelectronics applications. The performance of Micro-EDD depends on key process parameters such as discharge energy, pulse duration, gap voltage, and tool electrode material. Optimizing these factors enhances drilling accuracy, reduces taper formation, and improves surface finish. Recent advancements, including the use of high-frequency pulsed power supplies, nano-dielectric fluids, and adaptive control systems, have significantly improved process efficiency and machining resolution. Despite its advantages, challenges such as electrode wear, thermal damage, and limited material removal rates persist. Ongoing research focuses on developing hybrid techniques, integrating ultrasonic vibrations, laser assistance, and optimized dielectric compositions to enhance productivity and precision. The adoption of artificial intelligence and machine learning for real-time process monitoring is further refining the control of spark characteristics and machining stability. This paper provides a comprehensive overview of Micro-EDD, highlighting its working principles, influential parameters, recent advancements, and prospects. With continuous innovations, Micro-EDD is poised to play a crucial role in next-generation micro-manufacturing, offering unparalleled accuracy and flexibility in machining complex geometries.

Keywords: Micro Electro Discharge Drilling (Micro-EDD), Precision Machining, Thermal Erosion, Dielectric Medium, Electrode Wear.

Improvement of Stretch Flangeability of Boron Steel by Interrupted Loading

[a]Rajababoo Kumar, [a]Aman Mohtta, [b]Murugaiyan Amirthalingam, [b]Uday Chakkingal

[a]Department of Metallurgical and Materials Engineering
[b]Indian Institute of Technology Madras, Chennai 600 036
Email: mm21d064@smail.iitm.ac.in

Abstract

The need for lighter, stronger, and more cost-effective materials in the automotive industry is a key driver of modern steel development. This can be achieved by selecting suitable materials and utilizing thinner gauge sheets. Advanced high-strength steel (AHSS) remains a crucial structural material in the automotive industry as they have good combination of strength and ductility. Boron-added steel are used for making hot formed components with a final microstructure that is nearly completely martensitic after hot forming fooled by die quenching. However, some preforming at room temperature may be required and this requires good formability. Formability is measured using the Hole Expansion Test (HET). In this test, a 90×90 mm sheet with a central hole of 10 mm is placed on a conical punch. As the punch expands the hole, the ratio of the change in the hole diameter to the initial diameter is known as the Hole Expansion Ratio (HER). The formability increases with an increase in the HER. The present studies have shown that interrupted loading can improve the HER of boron steel. The pause in loading allows the material to redistribute stresses, enhancing its ability to expand without cracking. The stretch-flangeability of boron steel, which is its resistance to edge failure during flanging operations, can be improved through interrupted loading.

Structure-Property Co-relation with Hydride Orientation in Zircaloy-4 Seamless Clad and Zirconium Lined Zircaloy-4 Duplex Clad for Water Cooled Reactors

Swarup Acharya[a,b], S. Santra[a], A. Agarwal[a], A. Yadava, R.K. Chaube[a], K. Kapoora and P.P. Bhattacharjee[b]

[a]Nuclear Fuel Complex, Hyderabad-500062, India
[b]Indian Institute of Technology Hyderabad, Kandi, Hyderabad, India
E-mail: ms23resch14005@iith.ac.in, sacharya@nfc.gov.in

Abstract

Low solubility of hydrogen in Zirconium alloys both at room temperature and operating conditions leads to precipitation of brittle hydrides, introducing various modes of degradation mechanisms. Thermo-mechanical processing adopted during fabrication of the cladding material plays major role with respect to microstructure, texture and second phase precipitation, thereby influences in-reactor degradation aspect. In the present study, it has been attempted to bring out the effect of hot deformation and cold working schedule on hydride orientations in conventional Zircaloy-4 cladding material. Basal pole textures have been estimated at different stages of clad tube fabrication using X-ray diffraction (XRD). Hydride orientation fraction (Fn) has been estimated on artificially hydrogen charged specimens. The observation in hydride orientation fraction has been co-related with texture and Q-factor maintained during pilgering operation employed for tube fabrication. Role of hydride orientation on transverse and longitudinal ductility has been studied in Zircaloy-4 clad material. Detail microstructural characterization has been performed on the as fabricated Zircaloy-4 clad using electron back scattered diffraction (EBSD) and transmission electron microscopy (TEM). In order to achieve high burn-up, development of low tin zirconium lined (Zr-0.3Sn) Zircaloy-4 duplex clad was attempted through co-extrusion followed by co-pilgering route. However, construction of duplex clad is having inherent issue of two variant of zirconium alloys with different workability, introducing variation in microstructure and texture. This paper includes microstructure-texture characterization of low tin zirconium lined (Zr-0.3Sn) Zircaloy-4 duplex clad. Possible variation in hydride orientation across clad cross-section, consisting of two variant of zirconium alloys has also been discussed in this paper.

Study of Rheology, Durability and Strength of Self-Compacting Mortar with Optimized Fly Ash Dosage

Anu Bala[a], Kunal M. Shelote[a], Supratic Gupta[b],

[a]Department of Civil Engg., University Institute of Engg. and Technology (UIET), M. D. University Rohtak, India.
[b]Department of Civil Engineering, Indian Institute of Technology (IIT) Delhi, Hauz Khas, Delhi 110 016, India.
Email: anujangra.iitd@gmail.com

Abstract

In the present study, the rheology, durability, and compressive strength (CS) of self-compacting mortar (SCM) have been studied. A total of eight mix designs were studied with four effective water-cement ratios (w/c) (0.43, 0.49, 0.55, and 0.70) and two levels (OPT1 and OPT2) of fly ash dosage. OPT1 was kept as 25% for each effective w/c, whereas OPT2 was taken as 30%, 35%, 40%, and 45%, corresponding to effective w/c 0.43, 0.49, 0.55, and 0.70, respectively. The rheology of SCM was assessed using slump flow and v-funnel flow following EFNARC limits, whereas, the durability of SCM was investigated using a rapid chloride penetration test (RCPT) and water permeability test. The experimental study showed that the addition of high-volume fly ash has a significant effect on the rheology, durability, and CS of SCM. At ambient conditions, the highest value of CS was obtained 49.3 MPa for SCM with effective w/c of 0.43 and fly ash dosage OPT1 at 28 days of curing. An increase in effective w/c has increased the porosity of SCM, causing decrement in CS and durability. CS of SCM was evaluated at elevated temperatures up to 600ºC during post-fire conditions in an electric furnace. Explosive spalling has occurred at 600ºC for SCM having effective w/c 0.43 and 0.49. At elevated temperatures, CS has marginally improved at 400ºC due to secondary hydration reaction for all the mix designs.

Keywords: self-compacting mortar, fly ash, rheology, mechanical strength, durability, elevated temperature.

Development of Aluminium Alloy Anode Material and a Prototype Aluminium-Air Battery

[a]Utkarsh Bhadauria, [a]Anand Madhav, [a]Rajesh K. Khatirkar, [a]Amrut V. Agasti

[a]Department of Metallurgical and Materials Engg., Visvesvaraya National Institute of Technology Nagpur, India
Email: utkarsh.bhadauria.0205@gmail.com

Abstract

This research focuses on developing an Aluminium-Air (Al-Air) battery prototype by improving the performance of the aluminium alloy anode in a potassium hydroxide (KOH) electrolyte. Al-Air batteries offer high energy density and a lightweight design, making them a promising alternative to lithium-ion batteries. However, their widespread adoption is hindered by rapid anode corrosion and excessive hydrogen gas evolution, which reduce efficiency and safety. This study examines the effects of three electrolyte additives—glycerol, barium acetate, and urea on mitigating these challenges to enhance battery performance and durability. In alkaline environments like KOH, aluminium reacts with oxygen to generate electricity but also undergoes unwanted corrosion, leading to hydrogen evolution that destabilises the battery. The selected additives address this issue by modifying electrolyte behaviour or forming protective layers on the anode surface. Glycerol increases electrolyte viscosity, slowing ion movement and reducing hydrogen generation. Barium acetate promotes passivation, limiting direct electrolyte contact and minimising corrosion. Urea blocks active sites on the aluminium surface, further suppressing hydrogen evolution. The impact of these additives was evaluated through weight loss and hydrogen evolution tests, revealing that all three improve battery stability to varying degrees. Among them, glycerol and barium acetate demonstrated the most significant reductions in both corrosion and hydrogen release. These findings provide deeper insight into aluminium alloy behaviour in alkaline electrolytes, highlighting the critical role of electrolyte composition in Al-Air battery development. By optimising electrolyte formulations, this research contributes to the advancement of efficient and scalable Al-Air batteries, offering a sustainable alternative for electric vehicle applications.

Direct Energy Deposition-Based Composite Fabrication

[a]Mohit Sharma and [a]Amit Choudhary

[a]*Department of Mechanical and Industrial Engineering, Indian Institute of Technology-Roorkee*
Roorkee, Uttarakhand, 247667, India
Email: mohit_s1@me.iitr.ac.in

Abstract

The increasing demand for advanced engineering materials has driven the development of metal matrix composites (MMCs) with superior mechanical, thermal, and functional properties. This study explores a sustainable and efficient approach for fabricating MMCs using Wire Arc Additive Manufacturing (WAAM). The WAAM process, recognized for its high material utilization, energy efficiency, and suitability for medium-to-large-scale components, is adapted to integrate ceramic reinforcements into a metallic matrix. This research focuses on incorporating tungsten carbide (WC) particles into a steel matrix through a WAAM system equipped with a controlled powder feeder. Systematic investigations were conducted to examine the influence of WAAM process parameters on the microstructural evolution and mechanical properties of the fabricated MMCs. This work highlights the potential of WAAM-fabricated MMCs for demanding applications in aerospace, automotive, and marine industries, contributing to the advancement of environmentally responsible and economically viable manufacturing solutions for next-generation composite materials.

Keywords: Metal matrix composites, Additive manufacturing, Sustainability

Mechanical performance of 3D printed high-performance polymer

Krishna Kumar[1*], Sumodh Kumar[2], and Mrityunjay Doddamani[1]

[1]*Department of Mechanical Engineering, Indian Institute of Technology Jodhpur, 342027, Rajasthan, India.*
[2]*School of Mechanical and Materials Engineering, Indian Institute of Technology Mandi, 175005,*
Himachal Pradesh, India
kkgarg2000@gmail.com

Abstract

The current work presents 3D printing of ultra-high glass transition, thermally stable, and mechanically strong, high-performance polymer (HPP), exploring its potential for the applications in high-temperature environments. Enhancing structural performance of the 3D printed HPP through an innovative approach is the novelty of this work, contributing to the realm of material science and 3D printing community. Initially, the filament is prepared through extrusion process for samples printing. The 3D printed HPP revealed outstanding tensile modulus of 2690 MPa and the tensile strength of 46.50 MPa, which further boosted to 2760 MPa and 75.30 MPa (61.93% □), respectively, due to annealing. A comparative study revealed a remarkable performance of the annealed HPP compared to regular and HPPs. Finally, two different hinges, integrative and compliant hinges used in the space systems, are 3D printed with the HPP and presented for demonstration. The results underscore the promise of 3D printed HPP for various high-temperature applications.

Study the effect of biochar on the dielectric properties of polyolefins

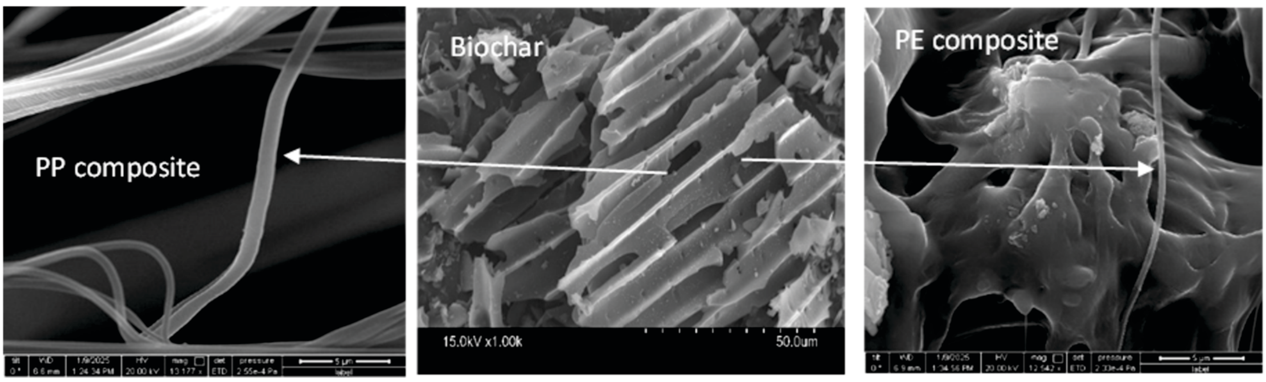
[a]Moumita Naskar and Ankita Deb

[a]Central Power Research Institute, Regional Testing Laboratory, Kolkata 700091, India
E-mail: moumita@cpri.in

Abstract

Biochar produced by thermal cracking of coconut coir (CC) in a limited oxygen atmosphere was successfully used as a doping agent for polyolefin. Scanning Electron Microscopy (SEM) image established the fibrous structure of CC. Polyolefins predominantly polyethylene (PE) and polypropylene (PP) possess high dielectric properties due to nonpolar hydrocarbon based molecular structure. Thermal stability of PE is not satisfactory. PP is not suitable for many uses due to poor dielectric constant and mechanical properties. Introduction of CC could improve thermal stability, tensile & elongation, volume resistivity and break down voltage depending on the amount added. The morphology of the prepared PE and PP composites were studied under SEM. Volume resistivity (VR) was evaluated at 30 ˚C, 60 ˚C and 90 ˚C for the prepared PE, PP compositions to check the safety, efficiency, and reliability aspect at extreme service temperature and activation energy (Ea) was calculated from Arrhenius equation for all the composites. However, challenges related to compatibility, dispersion, and processing need to be addressed for successful commercialization. With continued research and development, biochar-filled polyethylene composites have the potential to become a more sustainable and cost-effective alternative to conventional polymer materials for high voltage insulation applications.

Keywords: Biochar; Polyolefins; Electron Microscopy; thermal stability; Volume resistivity; activation energy



Poster Presentations

Development of Antifouling Chitosan/PEO Membranes

Rohini Verma[a], Chetna Verma[a], Bhuvanesh Gupta[a], Samrat Mukhopadhyay[a]

[a]Bioengineering Laboratory, Department of Textile and Fibre Engineering, Indian Institute of Technology, New Delhi- 110016, India.
E-mail: rohini.verma347@gmail.com

Abstract

Chitosan is a natural macromolecule used extensively in various industries such as food packaging, chemicals, pharmaceuticals, medical, and agricultural applications. There are a number of features that make it an attractive option to use in biomedical applications, such as biocompatibility, biodegradability, non-immunogenicity, and antibacterial properties. Chitosan-based hydrogels, membranes, sponges, or fibres as wound dressing candidates are already available with remarkable results, but these materials have tendency to adhere on wound surfaces which requires mechanical debridement. Additionally, chitosan membranes lack adequate mechanical and antifouling properties, which limits its application in healthcare. In this study, chitosan/polyethylene oxide (PEO) membranes were prepared by solution casting method. PEO was added into the chitosan solution in varying concentrations from 10% to 35%. These blended membranes were characterized using FT-IR, AFM, EDX, contact angle, tensile testing, and bacterial adherence to examine the effect of PEO with increased concentration. It has been found that the increase in PEO concentration increases the flexibility of membranes, while at the same time, bacterial adhesion to membrane surface is compromised. The contact angle and crystallinity of membranes decreased gradually with the increase in PEO concentration. Contact angle(θ) decreased from 90°±2 to 75°±2 which states that the membranes became more hydrophilic with the addition of PEO. Membranes are being evaluated for the drug immobilization and subsequent release in the medium.

Development and Characterization of Periodate oxidized Cotton Fabric for Human Healthcare System

Nirmal Rathore[a], Chetna Verma[b], Jyoti Chaudhary[a], Bhuvanesh Gupta[b]

[a]Department of Chemistry, MLS University, Udaipur, Rajasthan, 313001, India
[b]Bioengineering Laboratory, Indian Institute of Technology, Delhi, 110016, India
Email: rjnirmal80@gmail.com

Abstract

Functional textile materials are improved textiles that have shown promise in biomedical applications, feminine hygiene products, wound dressings, and healthcare applications. Cotton stands out among these fabrics because of its advantageous qualities, which include breathability, high absorbency, eco-friendliness, and tactile comfort, which make it appropriate for direct contact with human skin and tissues. Adding antimicrobial treatments to haemostatic materials is becoming more and more important as worries about microbial infections continue.

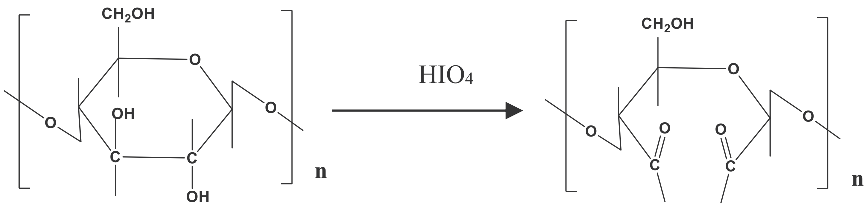


Fig. a) Cotton fabric b) Oxidized cotton fabric

In the current study, periodic acid is used to oxidize the cotton fabric to produce aldehyde group at C-2 and C-3 positions of glucose molecule in polymeric chain of cotton and this was confirmed using FT-IR spectroscopy method. Further, effect of reaction time, temperature and periodic acid concentration were examined and as a result it was found that with increase in reaction time, temperature and periodic acid concentration the amount of aldehyde concentration is also increased. The aldehyde content was determined using a UV-Vis analytical method with 2,4-dinitrophenylhydrazine.

Keywords: Dialdehyde cotton, bio composite, drug delivery, UV-visible, FT-IR.

Development of Anti-Bacterial Polylactic Acid Film for Biomedical Applications

Megha Yadav[a], Chetna Verma[b], Jyoti Chaudhary[a], Bhuvanesh Gupta[b]

[a]Department of Chemistry, MLS University, Udaipur, Rajasthan, 313001, India
[b]Bioengineering Laboratory, Indian Institute of Technology, Delhi, 110016, India
Email: meghani2301@gmail.com

Abstract

Polylactic acid (PLA) is a thermoplastic, compostable, biodegradable and biocompatible polymer derived from renewable resources such as corn, sugar beet etc. and has application in biomedical field. Because of its anti-microbial property, PLA and its composites are currently used in medical implants, tissue engineering, orthopaedic devices, and drug delivery systems.

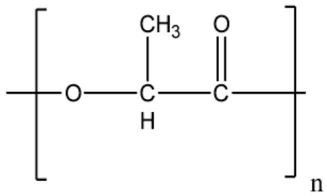


Fig. Polylactic Acid

In current study, the infection-resistant surface was created by employing Polylactic acid (PLA) as the base material. Functional property of PLA was enhanced using alkaline hydrolysis process. The functional groups generated on its surface are used to bind bioactive agents making it antimicrobial in nature. The physicochemical properties of the PLA surface were characterized using FTIR and contact angle.

Keywords: Polylactic acid, Functional PLA, Antimicrobial, Biomedical Applications.

Development and Characterization of Sodium Alginate-based Membranes for Wound Healing System

Pooja Badsara[a], Chetna Verma[b], Jyoti Chaudhary[a], Bhuvanesh Gupta[b]

[a]Department of Chemistry, MLS University, Udaipur, Rajasthan, 313001, India
[b]Bioengineering Laboratory, Indian Institute of Technology, Delhi, 110016, India
Email: poojabadsara1994@gmail.com

Abstract

Biopolymers are naturally occurring polymers that are emerging as a great alternative due to their multifunctional properties, such as biocompatibility and biodegradability. Sodium Alginate (SA) is an anionic biopolymer with these properties and show excellent haemostatic and rapid wound healing behaviour, which makes it suitable for different biomedical applications. Carboxymethyl cellulose (CMC) is also an anionic biopolymer with high absorption capacity, flexibility, and the ability to promote angiogenesis, making it ideal for biomedical approach.

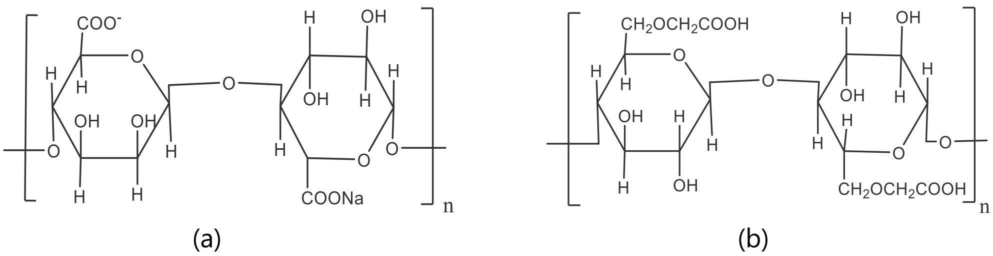


Fig. Chemical structure of (a) Sodium Alginate (b) Carboxymethyl Cellulose

The present work focuses on developing SA-CMC blend membranes by varying CMC content using solution-casting method. The structure and morphology of the membranes were characterized by FTIR and SEM analytical techniques and swelling studies. These membranes may be used for biomedical applications in human healthcare due to their biocompatibility and liquid absorption capacity.

Keywords: Sodium Alginate, Carboxymethyl Cellulose, Biocompatibility, Wound healing.

Development and Characterization of Polyvinyl Alcohol Nanocomposite Membranes for Drinking Water Disinfection

Chesta Mehta[a], ChetnaVerma[b], Jyoti Chaudhary[a], Bhuvanesh Gupta[b]

[a]Department of Chemistry, MLS University, Udaipur, Rajasthan-313001, India
[b] Department of Textile and Fibre Engg., Indian Institute of Technology, New Delhi-110016, India
Email: chestakmehta@gmail.com

Abstract

Drinking water containing pathogenic bacteria and microbes can lead to a number of ailments. Therefore, there is an urgent need to develop new technology and better antibacterial materials for water treatment and filtration. The Indian population typically drinks untreated water, which contains significant concentrations of salmonella, E. coli, and pseudomonas species that cause diseases like typhoid and stomach ailments. By developing a water treatment material based on polymeric membranes, the issue of microbial contamination can be resolved.

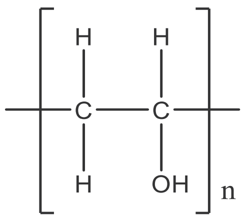


Fig. Chemical Structure of Polyvinyl Alcohol

In this work, polyvinyl alcohol nanocomposite membranes were prepared by solvent casting approach. The crosslinking of the membranes with boric acid crosslinker improved the dimensional stability. A series of metallic nanoparticles were used to develop nanocomposite membranes. The structural investigation of these membranes was carried out by using UV-Vis, TEM, XRD, and FTIR. The antibacterial potential of the membranes was studied using the disk diffusion and colony count methods. The most interesting aspect is that these membranes exhibit along-term antimicrobial nature. These results demonstrated that bioactive membrane is appropriate as an antimicrobial material for disinfection of water.

Mechanical Characterization and Biodegradability Analysis of Bio Composite Material Fabricated by Using Fine Waste Wood Carbonated Powder

Pankaj Sharma[*a], Kunal Sharma[b] and Vikas Sharma[c]

[a]*Department of Mechanical Engineering, Jagannath University, Jaipur, India*
[b]*Department of Mechanical Engineering, Vivekananda Global University, Jaipur, India*
[c]*Department of Engineering, Maxbrain Technologies, Jaipur, India*
Email: pankaj.sharma@jagannathuniversity.org

Abstract

The purpose of this research is to examine the mechanical and biodegradable properties of bio composites that are composed of epoxy resin and wood waste powder in carbonated form. A local wood carpentry shop in Jaipur provided the wood powder, which was then ground into fine powder using a ball milling process at JNIT University. The carbonation process of the fine wood powder was performed at VGU university at a temperature of 500°C. The composite characteristics were evaluated by integrating wood powder into epoxy resin at different weight percentages (0% to 15%). The strength and durability of the composites were assessed through a series of mechanical evaluations, including tensile, flexural, and impact tests. The dispersion and bonding of wood powder inside the epoxy matrix were investigated by conducting a microstructural examination of the cracked specimens. Controlled degrading studies were used to assess the biodegradability of the composites and determine their environmental impact. As per the findings, there is a balance between mechanical performance and biodegradability, with certain weight percentages of wood powder possessing ideal characteristics. The optimal composite was discovered through the use of the VIKOR technique in a Multi-Criteria Decision-Making (MCDM) approach. The resilience of the chosen optimal composite was verified through a sensitivity analysis. This study highlights the possibility of using horticulture waste as a sustainable reinforcing material in polymer composites, which is a beneficial waste management option that is environmentally friendly.

Investigating the Optical Properties of Eu (III) Complexes with Asymmetric Ligand Coordination

[a]Ritu Langyan

[a]Department of Chemistry, Kurukshetra University, Kurukshetra, Haryana-136119
Email: ritu.langyan@gmail.com

Abstract

Lanthanide complexes are widely used in display devices due to their brilliant emission in the visible region. Scholars are continuously working to develop the new complexes with high luminescence and quantum yield. Among lanthanides, Eu(III) ion gain considerable attention due to its red-emission in visible region. Although this ion, similar to other lanthanides, has low absorption coefficient, but coordination of this ion with a strong absorbing ligand can overcome this disadvantage. In this context, two bright-red emitting Eu(III) complexes were synthesized with diethylmalonate, 1,10-phenanthroline and 2,2′-bipyridine using solution precipitation methods. The characterization of complexes was carried out with FTIR, UV-vis, and PL spectra. Under UV excitation, the complexes showed emission peaks at ~585, 595, 616 and 650 nm, both in solution and powder state. The brilliant red emission delivered by the complexes was due to dominant peak at 616 nm. The prepared complexes might be efficiently used as red emitters in display devices.

Keywords: Europium complexes; Red luminescence; Co-ligands.

Development of Flexible CZTS Based Thin Film Solar Cell

Shruti Jain[a], Mayank K Singh[a], Ujjwal Sahua, Swarali Deshpande[a], Chaitanya Joshi[a] and Amrut A[a]

[a]Metallurgical and Materials Engg., Visvesvaraya National Institute of Technology, Nagpur
Email: amrutagasti@mme.vnit.ac.in

Abstract

Thin film solar cell has its limitation due to its constituent elements' availability constraints and their toxic nature. Second-generation of CZTS thin film solar cell have distinct advantages such as use of earth abundant elements, band gap of 1.4-1.5 eV which fits perfectly for a solar spectrum and high absorption coefficient. Even with such advantages, CZTS suffers with low carrier lifetime and low recombination time that seek for scope of improvement. This improvement can be achieved by having cationic replacements to zinc and tin provided the structure is either kesterite or stannite. The fabrication of CZTS-based thin-film solar cells involves electrodeposition of CZT on Mo-foil, Mo-coated glass and stainless steel substrates using precursor metal salt electrolyte under constant potential, followed by sulfurization in a tube furnace under inert gas at 500–600°C to prepare an absorber layer of CZTS. A ZnS buffer layer is deposited via chemical bath deposition, and Al-doped ZnO along with Ag layers are added using sputtering. Structural, morphological, and compositional characterizations of individual layers are conducted using XRD, Raman, and SEM techniques. Solar cells are then fabricated and evaluated for performance. Finally, flexible solar cells are utilized to develop prototype window curtains, showcasing their potential for practical applications.

Keywords: Thin film solar cell, CZTS based, deposition techniques, smart material, flexible device

Transforming Super Napier Grass into High-Capacitance Carbon for Energy Storage

Nikita Lote[a*], Dilip Peshwe[a], Abhay Deshmukh[b]

[a] Department of Materials & Metallurgical Engineering, VNIT, Nagpur, India
[b] Rashtrasant Tukadoji Maharaj Nagpur University, Nagpur, India
E-mail: nikitalote1996@gmail.com

Abstract

The researchers are getting attracted towards agriculture waste in energy field as it is low cost, sustainable, and easily available apart from its good properties which contribute to high energy supercapacitors. Super Napier grass is in boom for its agricultural use as it grows faster, has high nutrients, reduces soil erosion and increases soil fertility. As this grass grows faster it was necessary to study it for supercapacitor properties as well. This grass is a lignocellulosic biomass as it contains 36.34% cellulose, 34.12% hemicellulose and 30.40% lignin. Due to these contents the biomass has good properties for a durable supercapacitor. The carbon from Super Napier grass was procured from pyrolysis at 300 in a muffled furnace then graphitization was achieved in an inert atmosphere at 900. The carbon was used in a three electrode setup with 1M H2SO4 electrolyte. The electrode was tested for electrochemical characterization where it displayed an impressive specific capacitance of 123F/g at 0.25A/g current density. Moreover it also maintained 100.4% of its initial capacitance after undergoing 1368 cycles at 5A/g current density highlighting its strong potential for using it in an energy storage device supercapacitor.

Keywords: Biomass derived carbon, Super Napier Grass, Supercapacitors, Energy Storage device.

Surface Characteristics and Tribological Performance of Severely Surface Deformed AISI 304L Stainless Steel

[a]Mohit Tiwari*, [a]Nilesh K. Kumbhar, [a]Shubham Parihar, [a]Santosh S. Hosmani**

[a]Department of Metallurgical Engineering and Materials Science,
Indian Institute of Technology Indore, Indore 453552, India
Email: mt2302105020@iiti.ac.in, sshosmani@iiti.ac.in

Abstract

Severe surface deformation techniques have emerged as effective methods for enhancing surface characteristics, mechanical integrity, and performance in engineering materials. Among these, Surface Mechanical Attrition Treatment (SMAT) stands out as an innovative process that induces nanostructured surfaces, significantly improving properties such as wear resistance, corrosion resistance, and overall mechanical behaviour. In this study, SMAT was applied to AISI 304L with varying process parameters such as ball velocities (~5, ~7, and ~10 m/s), ball diameters (5, 8, and 10 mm), and surface coverage levels (100 to 2000%) to promote deformation-induced martensite (DIM) formation through severe plastic deformation. Results showed that colliding balls velocities contributed more to hardness than ball diameter, and surface roughness decreased with extended SMAT durations. The maximum average surface hardness (392.07 ± 22.11 HV100) was achieved with a 7 m/s ball velocity and a 5 mm ball size, while the maximum average surface roughness (1.59 ± 0.38 μm) occurred at the highest ball velocity (~10 m/s) and largest ball size (10 mm). X-ray Diffraction (XRD) analysis revealed that the maximum DIM (~45%) was obtained with a 5 mm ball diameter and 10 m/s velocity, making this the optimum condition for wear studies. Subsequently, a comparative dry rotary wear study was then conducted on the optimized SMAT-processed and untreated AISI 304L samples at room temperature (RT), 150°C, 300°C, and 450°C sliding over a 1000 m sliding distance. Coefficient of friction stabilized faster at lower temperatures (RT, 150°C) while the opposite trend was observed at higher temperatures. Wear resistance improved for SMAT-treated samples, at all conditions. Scanning electron microscopy analysis of wear tracks revealed brittle material removal at lower temperatures due to increased wear debris, whereas at higher temperatures, a protective ductile layer formed, reducing wear. The highest wear rate (~5.63 × 10-3 mm3/m) was observed for the untreated specimen at RT, which decreased with increasing temperature. At 450°C, the wear rate for the untreated specimen reduced by ~54%. In contrast, the lowest wear rate (~2.01 × 10-3 mm3/m) was recorded for the SMAT-treated specimen, showing a ~52% reduction from its initial condition at RT. Overall, SMAT notably improved the surface characteristics of AISI 304L by promoting DIM formation, enhancing wear resistance across different temperature conditions.

Keywords: Surface Mechanical Attrition Treatment, Deformation Induced Martensite, Microhardness, High Temperature Wear.

Effects of Modelling of Interfacial Energy Between FCC and HCP Phase on the Stacking Fault Energy Calculations in Fe-Mn Alloy System

[a]Soumya Ranjan Behera, [a]Soumya Shouvik and [a]Prakash G. Ranaware

[a]Metallurgical and Materials Engineering, NIT Rourkela,
Email: 123mm0654@nitrkl.ac.in, 123mm0646@nitrkl.ac.in.

Abstract

A subregular solution thermodynamic model was used to estimate the stacking fault energy (SFE) in Fe–Mn alloy system. One of the barriers and uncertainties about the estimation of SFE using this model is related to the interfacial energy between γ (FCC) and ε (HCP) phase. This limitation is due to the lack of experimental data on the interfacial energy. Most of the researcher used interfacial energy value as a constant value in their models. In this work we modelled interfacial energy as a parabolic function of addition of chemical Gibbs free energy and magnetic Gibbs free energy. We started with experimental values of SFE from the literature on Fe-Mn system and using these values we estimated interfacial energy using subregular solution thermodynamic model. A parabolic fit of type y=ax2+bx+c was then obtained between addition of chemical Gibbs free energy and magnetic Gibbs free energy and interfacial energy. Thus, the interfacial energy was indirectly correlated with the composition of the alloy. Thermodynamic model was employed to estimate SFE using this new model of interfacial energy and validated with experimental data available in the literature. SFE values estimated by this modified model are very close to the experimental values as compare to models used by other researchers. Modified model was used to investigate effect of various parameters such as composition, temperature and grain size on the SFE of Fe-Mn alloy system. Modified model was also used to determine SFE at the martensitic start temperature (Ms) for Fe-Mn alloys. This in turn used to determine driving force as well as upper limit for austenite to ε-martensite transformation in Fe-Mn alloys.

Influence of pellet basicity on properties of iron ore pellets using lime as flux and bentonite as binder

Lakshya Sharma, Divij Jain, Mukul Joshi and Krishna Kumar

Department of Metallurgical and Materials Engineering, Malaviya National Institute of Technology Jaipur, Jaipur-302017, India
Email: 2023umt1434@mnit.ac.in, 2023umt1437@mnit.ac.in, 2023umt1410@mnit.ac.in, kkumar.meta@meta.ac.in

Abstract

Iron ore pellets are major iron-bearing material for iron making units. Acid pellets are commonly used but they offer poor metallurgical properties like strength and poor high-temperature properties. So nowadays more attention is towards developing fluxed pellets to improve the behavior and properties of iron ore pellets. The use of fluxed pellets offers enormous advantages over the traditional practice of using acid pellets in a combination of sinter and lump ore. Fluxed pellets are preferred as iron-bearing material in iron making units because they satisfy the quality requirement precisely. Flux type and amount play a vital role in deciding metallurgical properties at all stages from green ball formation to induration. Flux addition not only improves physical and other metallurgical properties but also makes iron making process more economical by reducing the coke rate and improving the productivity of iron making units. Trials have been carried out to understand the effect of variation of basicity on different physical and metallurgical properties of iron ore pellets by gradually increasing the basicity from 0.09 to 1.04 using lime as flux and bentonite as the binder. Lime is hardly used in iron ore pelletization because of its adverse effect on bentonite and its tendency to form cracks in pellets. CaO affects the properties of bentonite at the beginning but at higher basicity, the CaO forms Ca(OH)2 which acts as a binding agent and improve green ball properties. Pellets with varying basicity are tested for green, dry, and fired pellet properties Pellet with basicity in range of 0.27 to 0.48 shows optimum green and fired pellet properties.

Keywords: Pelletization, Slag Basicity, Binder

Utilisation of Bagasse Ash and Rice Straw in fabrication of Eco-Friendly bricks

Devesh Singh[a], Gabender Singh[b], Divyanshi Sharma[3]

[a],[b],[3]Department of Civil Engineering, Dayalbagh Educational Institute, Agra, INDIA
Email: deveshsingh2104152@dei.ac.in, gabendersingh047@gmail.com, divanshi.sharma@dei.ac.in

Abstract

The construction industry is a major contributor to environmental degradation due to excessive cement consumption and carbon emissions. In response to this challenge, this study explores the development of Sustainable Bricks (Agro Bricks) by incorporating bagasse ash and rice straw as partial replacements for cement. The objective is to assess the feasibility of these agricultural waste materials in improving the sustainability and performance of bricks. This study explores Sustainable Bricks (Title Bricks) by partially replacing cement with bagasse ash (5/10/15/20%) and rice straw (2/4/8/10%). A total of 40 brick samples were fabricated using two Mold types to assess strength, durability, and structural integrity. Tests showed compressive strength of 4.5–7.0 MPa, making them suitable for non-load-bearing applications. Water absorption remained within 10–15%, ensuring durability. Results indicate the feasibility of agricultural waste in sustainable construction, reducing cement dependency. Future research will focus on optimizing mix proportions and large-scale applications.

In-Situ Monitoring and Control of Plasma Plume in Direct Energy Deposition of Stainless Steel 316L

[a]M. Singh, [a]Ravi K R
[a]Department of Metallurgical and Materials Engineering, Indian Institute of Technology Jodhpur, Jodhpur- 342037, India
Email: singh.110@iitj.ac.in

Abstract

In-situ monitoring and control of plasma plume behavior during direct energy deposition (DED) of stainless steel 316L (SS316L) are essential for understanding process dynamics and achieving precision in additive manufacturing (AM). Plasma plume characteristics significantly influence process stability, clad quality, and real-time control of melt pool geometry. This study investigates plasma plume variations during the DED process at different input parameters—laser power, scan speed, and powder feed rate—and correlates them with optical emission spectroscopy (OES) signals and melt pool characteristics. SS316L clads were fabricated using laser powers ranging from 400W to 2000W, with varying scan speeds and powder feed rates. Plasma plume area and intensity were measured using a CMOS camera and OES analysis, while melt pool temperatures were assessed with two-color pyrometers for recoil pressure analysis. Clad morphology was examined using a Leica metallurgical microscope in bright-field mode. Integration of multi-sensor data and melt pool geometry measurements provided a comprehensive understanding of plasma plume behavior during SS316L deposition.
The study observed that at 400W laser power, limited plasma plume area and intensity resulted in insufficient melting and bonding. Increasing laser power transitioned the process into conduction mode, enhancing energy transfer and uniform melting. In the 1200W–1600W range, a transitional phase emerged, marking the shift from conduction-dominated melting to an intense transitional state. Beyond this range, the process transitioned into keyhole mode, characterized by deep penetration and high recoil pressures, significantly affecting clad morphology. This study advances prior research by bridging the gap between material evaporation effects and plasma plume behavior during mode transitions. By correlating plasma plume characteristics—height, intensity, and recoil pressure—with clad deposition modes, the findings establish critical insights into material evaporation. Additionally, an OES intensity-based closed-loop control system was developed to optimize plasma plume transitions during the DED process, enabling precise control and improved uniformity in SS316L AM.

Comparative analysis of wear resistance: continuously cooled c arbide-free bainitic steel vs. hardox-450 martensitic steel

[a]K David Shalem Carey, [a]Shetti Swamy and [a]SK Md Hasan

[a]Department of Metallurgical and Materials Engineering, Indian Institute of Technology Jodhpur, India-342030.
Email: m23mte004@iitj.ac.in

Abstract

The ongoing demand for wear-resistant steel continues to grow as various abrasive environments require increasingly durable materials. This study presents a comparative analysis of the wear behavior of a newly developed continuously cooled low-alloy carbide-free bainitic (CFB) steel and a commercially available wear-resistant martensitic steel, Hardox-450 (HDX-450). The CFB steel, designed with a low-carbon and low-alloy composition, was subjected to a heat treatment schedule involving homogenization at 1100°C followed by air cooling to obtain a carbide-free bainitic microstructure. The CFB steel exhibited a microstructure consisting of acicular bainitic ferrite laths with retained austenite films, while HDX-450 displayed a tempered martensitic structure. Both the steels were subjected to ball-on-disc dry sliding wear tests at the ambient conditions. The microstructures, mechanical properties, and wear performance of both steels were investigated using X-ray diffraction (XRD), scanning electron microscopy (SEM), hardness testing, tensile testing, and surface profilometry analysis. CFB steel demonstrated superior mechanical properties, including higher hardness (~516 HV) and ultimate tensile strength (~1970 MPa) compared to HDX-450 (~480 HV, ~1600 MPa). The CFB steel demonstrated lower volume loss and specific wear rate compared to HDX-450. Worn surface morphology revealed delamination, and cracking in HDX-450, while CFB steel exhibited smoother worn surfaces with parallel grooves and limited delamination. X-ray diffraction analysis confirmed the strain-induced transformation of retained austenite (γ_R) to martensite in the CFB steel during wear testing, contributing to its enhanced wear resistance through the TRIP (Transformation Induced Plasticity) effect. Dislocation density estimations using the modified Williamson-Hall method showed a higher increase in dislocation density for the CFB steel as compared to HDX-450 after wear testing, further explaining its superior wear resistance. The study highlights the potential of the newly developed CFB steel as a cost-effective and as an alternative to wear-resistant HDX-450 for the applications involving abrasive wear.

Oblique Angle Deposition of Ga_2O_3 Thin Films by e-beam Evaporation for Self-Cleaning Window Layers in Silicon Solar Cells

Nishtha Veluri[1], Vishakha Sharma[1], Anupam Sharma[b], Nilanjan Halder[*a]

[a]Department of Physics, Manipal University Jaipur, Jaipur 303007, Rajasthan, India
[b]School of Physics, SMVD University, Katra 182320, Jammu and Kashmir, India
Email: nilanjan.halder@jaipur.manipal.edu

Abstract

Deposited dust particles are a major hindrance to the power efficiency of solar cells. The problem of reduced transparency in dusty panels can be mitigated by covering the silicon photovoltaic (PV) panels with a hydrophilic coating (window layer) of high wettability and transparency, allowing the light to pass through, while facilitating water spreading. High bandgap materials ZnO, TiO2, SnO2, etc. have been explored as hydrophilic layers, but poor electrical transport, optical losses, and bandgap value often limit their effectiveness as window layers in high-efficiency solar cells. In this study, we have investigated the hydrophilicity of e-beam-deposited Ga2O3 thin film on Silicon wafers for its possible use as a window layer in silicon solar cells. Ga2O3 thin film was deposited on Si substrates, by e-beam evaporation of Ga2O3 pellets in a vacuum chamber, with a base pressure of 4 x10-6 mbar at three different angles of 0°, 10°, and 20°. The oblique angle deposition of the material was performed to increase the surface roughness of the thin film, due to a phenomenon called the "shadowing effect" where the depositing particles are partially blocked by previously deposited material, leading to the formation of nanostructured film with increased surface irregularities. We observed that the contact angle i.e. the angle between a solid surface and water droplet, of the thin film decreases with the increasing surface roughness of the Ga2O3 film, indicating an enhancement in wettability of the films for efficient anti-dust performance. Physical techniques like X-ray diffraction (XRD), field emission scanning electron microscopy (FESEM), Raman Spectroscopy, and photoluminescence spectroscopy (PL) were used to characterize the grown films. The bandgap of the deposited films was found to lie between 4.4-3.9 eV, ensuring the effective use of Ga2O3 as a transparent coating over the solar cells. Thus, considering the challenges posed by dusty solar panels, and their ecological and economic impact, the exploration of Ga2O3 as a hydrophilic self-cleaning window layer on solar PV cells presents a highly promising future option.

In-Situ Temperature Monitoring and Process Control in Additive Manufacturing of Inconel 718 with Optical Emission spectroscopy

Manoj J, Mohit Singh, and Ravi. K.R

Department of Metallurgical and Materials Engineering, Indian Institute of Technology Jodhpur, Jodhpur-342037, India
Email: manoj.1@iitj.ac.in

Abstract

Inconel 718, a nickel-based superalloy, is extensively utilized in the aerospace, automotive, and power industries due to its ability to maintain mechanical properties at elevated temperatures. As modern aerospace designs become increasingly complex, Additive Manufacturing (AM) has emerged as an optimal method for fabricating intricate Inconel 718 geometries. However, the AM process involves numerous parameters—such as laser power, scan speed, powder feed rate, and spot diameter—that significantly influence the final part quality. Therefore, acquiring process data is essential for ensuring precise control over part integrity. In-situ process monitoring, particularly temperature tracking, plays a critical role in quality assurance, as temperature data provides valuable insights into cooling rates, melt pool behavior, and evaporation dynamics. Conventional temperature measurement tools, including thermocouples, pyrometers, and thermal cameras, encounter hardware limitations when exposed to extreme temperatures, especially near or beyond 3000°C, where Inconel 718 approaches its boiling point, and evaporation effects become prominent. While numerical modeling serves as a powerful approach to simulate melt pool dynamics and temperature fields, these models require experimental validation. To address this challenge, Optical Emission Spectroscopy (OES) has emerged as a promising experimental technique for high-temperature AM processes. By analyzing plasma emission across various wavelengths, OES enables real-time temperature measurement throughout the AM process, providing critical insights into temperature distribution and clad quality. This information is crucial for validating numerical models and further advancing high-temperature AM techniques. The average intensity of the prominent Fe peak at 520.79 nm was recorded at approximately 14,000 units, corresponding to a pyrometer reading of 3000°C. However, due to hardware limitations, the pyrometer was unable to measure temperatures beyond this threshold. To overcome this, the intensity ratio between 540.86 nm and 526.33 nm was analyzed across various process parameters and powder feed rates. The temperatures predicted from this spectral analysis were compared with both experimental measurements and numerical simulations, showing strong agreement. The numerical model successfully captured the thermal cycles and melt pool dimensions, closely agreeing with experimental data. The temperature measured from pyrometer was increasing with increasing laser power and a decreasing trend was observed for increasing scan speed. The OES sensor data showed a strong correlation between laser power and intensity values, indicating that higher laser powers led to increased metal vaporization and plasma formation. Optical Emission Spectroscopy (OES) proved to be a valuable alternative for high-temperature monitoring, enabling accurate temperature predictions through intensity ratio analysis. The numerical model successfully replicated the thermal behavior and melt pool characteristics, reinforcing its reliability for process optimization. These findings contribute to advancing high-temperature process monitoring techniques and improving predictive modeling accuracy in metal additive manufacturing.

Sugar cane bagasse ash as cement replacement on properties of mortars

Mahima Prasad[a], Devdutta Ghosh[b], Divyanshi Sharma[a]

[a]Undergraduate Student,Department of Civil Engineering, Dayalbagh Educational Institute Agra 282005
[b]Heritage and Special Structures, CSIR-CBRI, Roorkee
E-mail: mahimap291@gmail.com, debdutta@cbri.res.in, architectdivyanshi@gmail.com

Abstract

This study examines how the characteristics of mortars are affected when sugarcane bagasse ash (SCBA) is used in part in place of cement. After being treated to increase its pozzolanic activity, SCBA—a by-product of the sugar industry—was added to cement mortars at different replacement levels (e.g., 5%, 10%, and 15% by weight). The workability, setting time, compressive strength, and durability of the mortars were examined and contrasted with a control mix. The results showed that while greater replacement levels resulted in a slight decrease in strength, adding SCBA up to 10% increased compressive strength because of the enhanced pozzolanic response. Workability was marginally impacted, necessitating modifications to the water-to-cement ratio. Tests of durability showed that mortars treated with SCBA had decreased water permeability and enhanced resistance to sulfate assault. By lowering cement use and reusing industrial waste, these results demonstrate SCBA's potential as an environmentally friendly supplemental cementitious material (SCM) that supports sustainable building methods. To optimize SCBA processing's advantages in real-world applications, more study on its long-term performance is advised.

Reduced Graphene Oxide Production by Silicon Thin Film Deposition using Ionized Physical Vapor Deposition

Rimlee Saikia[a,b,*] , Bharat Kakati[b] and Manoj Kr Mahanta[3]

[a]Dept of Physics, Gauhati University, Guwahati, India-781014
[b]Dept. of Energy Engineering, Assam Science and Technology University, Guwahati, India-781013
[3]Department of Physics, Pragjyotish College, Guwahati, India-781009
Email: rsaikia424@gmail.com

Abstract

This work reports the effective reduction of graphene oxide (GO) films synthesized via a modified Hummers' method. To realize the potential of graphene for large-scale applications, the reduction of GO films is essential. Conventional reduction methods for producing reduced graphene oxide (rGO) include thermal, chemical, and plasma processes. Herein, we present a novel approach using ionized physical vapor deposition (iPVD) of a silicon thin film onto the GO film at a working pressure of 5.5×10^{-3} mbar using Argon as the process gas. X-ray diffraction (XRD) and Raman spectroscopy confirm the reduction of the GO film, evidenced by an increased ID/IG ratio for the rGO compared to the GO film. Current-voltage (I-V) characterization further demonstrates improved conductivity in the rGO. This iPVD-based approach offers a highly efficient technique for rGO production, promising significant potential for flexible electronics and energy storage applications.

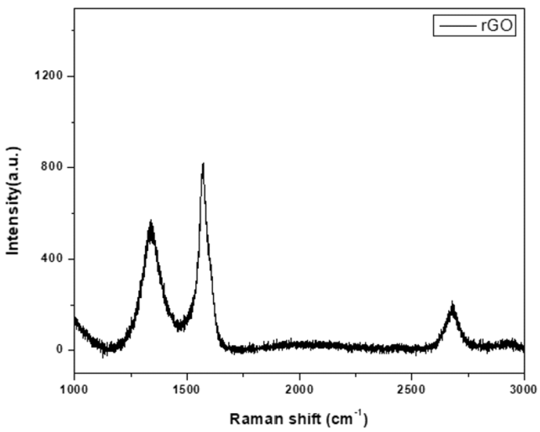


Fig : Raman shift for rGO with ID/IG =1.23

Activated charcoal and foam residue-incorporated open-cell polyurethane foam: Effect on the sound absorption, flame retardancy and mechanical properties

Rohit Bagal, Nikhil Uttam, T. Umasankar Patro

Department of Metallurgical and Materials Engineering, Defence Institute of Advanced Technology Pune, Maharashtra-411025, India

Email: rohit.srfmate24@research.diat.ac.in, umasankarp@diat.ac.in

Abstract

Rapid urbanization and transportation growth have made noise pollution a major global concern, affecting health, work efficiency, and quality of life. In this context, polyurethane (PU) foam offers an effective solution due to its lightweight, open-cell, excellent acoustic properties. However, PU foam is highly flammable, thus limiting its application in several areas. Moreover, their acoustic properties can further be improved by using fillers. The present work deals with the incorporation of two fillers: (a) activated charcoal (AC) and (b) rigid PU foam residue powder (RPUF), a cold storage industry waste into flexible PU foam in the weight ratios of 5–15% relative to polyol weight. The pore size increased with an increase in the filler content from 38 μm to 65 μm for RPUF and from 38 μm to 71 μm for AC filler. A 5 wt% filler improved tensile properties of PU foam, but concentrations >5 wt% led to deterioration of properties, likely due to poor dispersion. Tensile strength increased by ~70% with 5 wt% AC, ~42% with 5 wt% PUFP, and ~15% with 5 wt% mixture of fillers. This composite PU foam achieved a sound absorption coefficient of ~0.44 with AC filler. The incorporation of fillers improved the flame retardancy (~26%) of PU foam by promoting char formation.

Current Trends and Emerging Technologies for Piezoelectric Materials in Biomedical Applications

Shashi Ranjan Pathak[a], Nidhi Bisla[b], Anup Malik[a]

[a]Department of Mechanical Engineering, Malaviya National Institute of Technology Jaipur, Rajasthan, India
[b]Jindal Global Business School, OP Jindal Global University, Sonipat, Haryana, India
Email: shashirpathak@gmail.com

Abstract

Piezoelectric materials are a class of smart materials that change in size when an electric field is applied to them. These materials can be employed in biosensors, smart implantable devices, tissue engineering, and energy harvesting systems. The Purpose of this review is to get an insight into which piezoelectric materials are used in biomedical applications. This review explores the fundamental principles of piezoelectricity, classification of piezoelectric materials, and timeline of piezoelectric materials in biomedical devices. Furthermore, the review discusses recent applications of piezoelectric materials in image sensing, therapeutic and self-powered implants. Challenges such as biointegration, stability, and miniaturization were critically analyzed. The outcomes of this review are the potential of piezoelectric materials in the development of biomedical devices, their use in targeted drug delivery, piezoelectric actuators, and sensors. It also provides insights into the future developments and directions in the field of piezoelectric biomedical devices and their improved efficiency and precision.

A Review on Industrial Applications of Piezoelectric Materials

Shashi Ranjan Pathak[a], Nidhi Bisla[b], Anup Malik[a]

[a]Department of Mechanical Engineering, Malaviya National Institute of Technology Jaipur, Rajasthan, India
[b]Jindal Global Business School, OP Jindal Global University, Sonipat
Email: shashirpathak@gmail.com

Abstract

The ability of piezoelectric materials to convert mechanical energy into electricity and vice versa aims to be used in various applications in different industries. This enables the use of such devices to measure physical properties such as pressure, velocity, and temperature. Piezoelectric materials are widely used to store energy because they have the ability to generate electricity from mechanical vibration. The purpose of this paper lies in its capabilities and understanding of these materials and their various applications in different sectors. Sensors, actuators, and energy harvesters are just a few of the many piezoelectric devices. Improved behavior and sensitivity, robustness of systems, mechanical vibration, and electrical output are the main advantages of piezoelectric materials. This review tries to explain working of piezoelectric materials and their applications in a concise and systematic way

Modelling of Interfacial Energy as Function of Thermodynamic Driving Force for Austenite to Epsilon Martensite Phase Transition to Estimate Stacking Fault Energy for Fe-Mn-C Alloy System

Soumya Ranjan Behera[a], Soumya Shouvik[a] and Prakash G. Ranaware[b]

[a]UG Student, Metallurgical and Materials Engineering, NIT Rourkela,
[b]Assistant Professor, Metallurgical and Materials Engineering, NIT Rourkela,
Email: 123mm0654@nitrkl.ac.in, ranawarepg@nitrkl.ac.in

Abstract

One of the barriers and uncertainties about the determination of the stacking fault energy (SFE) for Fe-Mn-C alloy system from thermodynamic model is related to the interfacial energy between austenite (FCC) and epsilon-martensite (HCP) phase. Researcher used ab initio calculations to determine this interfacial energy, however, the values obtained were not accurate for prediction of SFE by thermodynamic model. Recently some researcher proposed this interfacial energy as a parabolic function of thermodynamic driving force for austenite to martensite phase transformation. They considered thermodynamic driving force as addition of chemical Gibbs free energy and magnetic Gibbs free energy. However, this relation had not adjusted well and do not produce SFE values close to the experimental results of SFE obtained by other researchers for entire range of Mn and Carbon content of Fe-Mn-C alloy system. In this work we modelled interfacial energy as a parabolic function of addition of chemical Gibbs free energy, magnetic Gibbs free energy, excess Gibbs free energy due to grain size and strain energy produced during phase transformation. Thus a total thermodynamic driving force for phase transformation is considered. We started with experimental values of SFE from the literature on Fe-Mn-C system and using these values we estimated interfacial energy using subregular solution thermodynamic model. A parabolic fit of type y=ax2+bx+c was then obtained between total thermodynamic driving force and interfacial energy. Thermodynamic model was employed to estimate SFE using this new model of interfacial energy and validated with experimental data available in the literature on Fe-Mn-C alloy system. SFE values estimated by this modified model are very close to the experimental values as compare to models used by other researchers. Modified model was used to investigate effect of various parameters such as composition, temperature and grain size on the SFE of Fe-Mn-C alloy system.

Effect of Post-Processing Heat Treatment on Microstructural Evolution and Mechanical Properties of Additively Manufactured (LPBF) Inconel 625

T M Shreyas[a], Ravi Ranjan Kumar[b] and S V S Narayana Murty[b]

[a]Indian Institute of Space Science and Technology, Thiruvananthapuram, India - 695 547
[b]Materials & Manufacturing Entity, Liquid Propulsion Systems Centre, Thiruvananthapuram, India - 695 547
Email: tmshreyas01@gmail.com

Abstract

Inconel 625 (IN625) is a solid-solution strengthened nickel-based superalloy renowned for its exceptional high-temperature strength, oxidation resistance, and corrosion resistance. These properties make IN625 highly suitable for aerospace, marine, and nuclear applications. The advancement of additive manufacturing (AM), particularly Laser Powder Bed Fusion (LPBF), has enabled the fabrication of complex geometries, addressing the challenges associated with machining IN625. However, the rapid cooling rates and thermal gradients inherent in LPBF processing often lead to high residual stresses and anisotropic microstructures, which can significantly affect the alloy's mechanical performance. This study examines the effects of various post-heat treatment processes on the microstructure and mechanical properties of LPBF-fabricated IN625. Heat treatments were performed, including stress relieving, stress relieving followed by annealing (SR + Annealing), and solution annealing at different temperatures. Mechanical properties were evaluated through room-temperature tensile testing to assess the material's behavior under different heat treatment conditions. The results indicate that stress relieving with annealing at 982°C reduces residual stresses and refines the microstructure, promoting directionality and columnar grain growth. This leads to increased ductility and a reduction in strength due to the partial annihilation of dislocations. In contrast, solution annealing at 1177°C results in a fully recrystallized, equiaxed grain structure, effectively transforming the as-built microstructure into a homogeneous morphology. This significantly enhances ductility by completely eliminating dislocation density from the as-built state. These findings provide valuable insights into optimizing post-heat treatment parameters to tailor the microstructure and mechanical performance of LPBF-fabricated IN625 for advanced engineering applications.

Keywords: IN625, LPBF, Heat Treatment, Microstructural Evolution

Wheat Straw Burning: Causes, Environmental Challenges, and its Sustainable Use in Soil Improvement

Neha[a], Shashwat Prasad[b], Randeep[c]

[a],[b],[c]Department of Civil Engineering, Dayalbagh Educational Institute (Deemed to be University), Agra, India, 282005
Email: workingneha01@gmail.com

Abstract

This study examines the causes and environmental consequences of wheat straw burning, with a specific focus on the generation, accumulation, and impact of wheat straw ash (WSA) on soil properties. The indiscriminate deposition of WSA in agricultural fields reduces soil permeability, disrupts infiltration capacity, and increases surface runoff, leading to limited groundwater recharge. Additionally, WSA alters soil aeration, hampers microbial activity, and accelerates nutrient depletion, significantly affecting soil fertility and crop productivity. The high calcium oxide (CaO) content in WSA further raises soil alkalinity, making it unsuitable for certain crops and contributing to soil compaction and erosion susceptibility. Despite these environmental concerns, farmers continue to burn wheat straw due to economic constraints, rapid land clearance requirements, and a lack of effective residue management solutions. However, this study explores an alternative approach by utilizing wheat straw ash (WSA) for soil improvement, particularly in plastic soils. These soils exhibit high water retention, poor drainage, and significant shrink-swell behaviour, leading to reduced permeability and structural instability. The incorporation of WSA, rich in silica (SiO_2) and calcium oxide (CaO), enhances soil properties by reducing plasticity, improving compaction efficiency, and increasing load-bearing capacity. Laboratory investigations including Standard Proctor compaction, unconfined compressive strength (UCS), and indirect tensile strength tests, demonstrate that WSA, when incorporated in optimal proportions, significant changes have been observed in compaction parameters and strength of plastics soil. These findings suggest that WSA can serve as a sustainable alternative to conventional soil stabilization materials, providing a cost-effective and environmentally responsible solution for improving soil properties. By mitigating the adverse effects of wheat straw burning and repurposing WSA for agriculture and infrastructure projects, this research promotes sustainable residue management practices while addressing critical soil degradation challenges.

Keywords: Wheat straw ash, plastic soil, OMC, MDD, UCS, tensile strength, agricultural residue management, soil improvement, sustainability.

Optimizing Strength and Sustainability: Investigating Lc3 for Enhanced Rammed Earth Construction

Anshuman Singh Tomar*, Sonu Yadav*, Nipun Dixit*, Randeep*

**Department of Civil Engineering, Dayalbagh Educational Institute (Deemed to be University), Agra, India*
Email: anshumant558@gmail.com

Abstract

Rammed earth is an ancient construction technique that has been widely used for thousands of years due to its availability, cost-effectiveness, and thermal efficiency. In recent years, there has been a resurgence of interest in rammed earth construction as part of sustainable and eco-friendly building practices. However, a key limitation of traditional rammed earth structures is their relatively low strength and susceptibility to moisture-related deterioration. To overcome these challenges, this study investigates the incorporation of Limestone Calcined Clay Cement (LC3) as a stabilizer to enhance the mechanical properties, durability, and environmental performance of rammed earth. LC3 is a low-carbon binder composed of limestone, calcined clay, and cement, which has gained attention for its reduced carbon footprint compared to conventional Portland cement. This study examines the effectiveness of LC3 in improving compressive strength, material homogeneity, and moisture resistance in stabilized rammed-earth blocks. Experimental results reveal that the inclusion of LC3 refines the pore structure, leading to a denser and more durable composition. Ultrasonic Pulse Velocity (USPV) tests confirm an increase in material density and uniformity, which enhances structural integrity and resistance to environmental degradation. The findings suggest that LC3 not only enhances mechanical performance but also aligns with the principles of sustainable construction by minimizing carbon emissions and utilizing locally available materials. As a result, LC3-stabilized rammed earth presents a viable, eco-friendly alternative for modern construction, particularly in regions where sustainable and low-carbon materials are a priority. This study contributes to the growing body of research on green building technologies, demonstrating that the integration of LC3 can effectively address the limitations of traditional rammed earth while maintaining its sustainability benefits.

Keywords: Rammed earth, LC3, Compressive strength, USPV, Water absorption, sustainability.

Sustainable Concrete Using Recycled Coarse Aggregate: A Path Toward Eco-Efficient Construction

Puneet Agrawal [a], Krishma Yadav [b]

[a],[b]Department of Civil Engineering, Dayalbagh Educational Institute (Deemed to be University), Agra, India, 282005
E-mail: punagra2001@gmail.com

Abstract

This study evaluates the mechanical and durability performance of Recycled Coarse Aggregate (RCA)-incorporated concrete at replacement levels of 0%, 50%, and 100%. Key parameters such as compressive strength, flexural behaviour, water absorption, and long-term durability were analyzed to assess its suitability for structural applications. The increasing depletion of natural aggregates and the rising volume of construction and demolition (C&D) waste have created an urgent need for sustainable alternatives in the construction industry. The continued reliance on virgin aggregates is environmentally unsustainable, leading to resource depletion and excessive waste generation. RCA presents a viable solution, aligning with circular economy principles by reducing construction waste and promoting resource conservation. The results indicate that while RCA exhibits higher porosity and water absorption than natural aggregates, optimized mix designs incorporating supplementary cementitious materials (SCMs) significantly enhance its mechanical strength and durability. This research provides a framework for integrating RCA into structural concrete, offering a viable alternative for large-scale sustainable construction. By demonstrating RCA's potential to replace natural aggregates without compromising structural integrity, this study reinforces the role of RCA in achieving low-carbon construction, aligning with global sustainability goals and green building standards.

Keywords: Recycled Coarse Aggregate (RCA), sustainable construction, circular economy, eco-efficient concrete, green building materials, durability, flexural strength, compressive strength, resource conservation.

Pull-Out Performance of Headed Rebars Embedded in Plain Cement Concrete and Steel Fiber Reinforced Concrete

Diksha Gola[1], R. Siva Chidambaram[2], Tarun Kumar Moka[3], Lokesh S[4]

[a]Department of Civil Engineering, Dayalbagh Educational Institute, Agra, India
[2],[3],[4]Structural Engineering Division, CSIR- Central Building Research Institute, Roorkee, India
E-mail: dikshagola2003@gmail.com, lokesh.cbri21a@acsir.res.in

Abstract

The use of headed rebars has emerged as a practical alternative to conventional hooked bars, offering superior anchorage efficiency and reducing steel congestion in reinforced concrete structures. This study investigates the pull-out behavior and bond strength of headed rebars embedded in Plain Cement Concrete (PCC) and Steel Fiber Reinforced Concrete (SFRC). A total of 16 specimens were tested under tensile loading with variation in head profiles. The key parameters like ultimate bond strength, peak load capacity, and failure mechanisms are analyzed. The experimental results conclude that SFRC significantly enhances the bond strength and pull-out resistance of headed rebars due to improved crack control and stress distribution provided by steel fibers. The headed rebars embedded in SFRC exhibited up to 67% higher load-carrying capacity compared to those in PCC. Among the tested profiles, the hooked headed bars demonstrated better anchorage performance under tensile loading due to their combined mechanical interlock and head confinement. This study highlights the use of headed rebars and SFRC in the beam-column joint region for superior anchorage and ductility.

Rice husk ash as filler in epoxy: Contribution to microwave absorption performance

Mohammed Fahad Gauri, V. S. Darekar and R. K. Goyal

Department of Metallurgical and Materials Engineering
Malaviya National Institute of Technology Jaipur, Jaipur-302017, India
Email: rkgoyal72@yahoo.co.in

Abstract

In the present work, Rice Husk Ash (RHA) an agricultural waste-derived product was utilized as reinforcementin epoxy (EP) matrix to develop EP/RHA composites for microwave absorption. The composites, with RHA content of 0, 10, 20, and 30 wt%, were fabricated. The study primarily focused on the microwave absorption and thermal properties of these composite materials. The resulting composites exhibited a density in the range of 1.18 to 1.34 g/cm^3. The thermal conductivity of RHA-incorporated composites slightly increased with increasing RHA content. The incorporation of RHA significantly improved the microwave absorption characteristics. Highest reflection loss (RLmax)of -22.57 dB was found at 8.45 GHz. This performance suggests that EP/RHA composite materials are suitable for defense applications, offering efficient microwave absorption in the X-band frequency range. Additionally, the use of RHA enhanced the sustainability of the composites by repurposing agricultural waste. This aligns with global trends towards eco-friendly materials. These findings underscore the potential of EP/RHA composites as lightweight and efficient microwave absorption, with future research needed to explore additional properties and applications.

Evaluation of GFRP Bars in Reinforced Concrete Columns: A Step Towards Durable Construction

Devesh Singh[a], Prashant Singh[b], Devesh Jaysawal[3], Divyanshi Sharma[4]

[a,b,3,4]Department of Civil Engineering, Dayalbagh Educational Institute, Agra, INDIA
Email: deveshsingh2104152@dei.ac.in, prashantsingh2104174@dei.ac.in,
deveshjaysawal@dei.ac.in , divyanshi.sharma@dei.ac.in

Abstract

This work concerns the study of the structural performance of Glass Fiber Reinforced Polymer (GFRP) bars intended as an alternative to conventional steel reinforcement in concrete columns subjected to axial compression. Steel bars have been widely used, but they are susceptible to corrosion, causing a nuisance in terms of longevity. GFRP bars will then be targeted to study their expected benefits. Two sets of columns were designed and compared with respect to strength, load capacity, failure modes, and stiffness; one was reinforced by steel, and the other by GFRP bars. Steel-reinforced columns were noted to be the stronger but were relegated to a slow decay due to rust. On the contrary, GFRP-reinforced columns were shown to demonstrate good corrosion resistance and thus are more applicable in aggressive environmental conditions. This study highlights the structural performance of GFRP bars in reinforced concrete columns, demonstrating their viability as an alternative reinforcement material. As the use of GFRP bars continues to grow in modern-day construction, GFRP is fast shaping up as a sustainable and durable alternative for the infrastructure of the coming years.

Phase and microstructure evolution of high entropy alloy processed via mechanical alloying

Uday Pratap Singh Bais[a*], Alok Singh[a], Pradip Kumar Verma[a]

[a]Mechanical Engineering Department, Maulana Azad National Institute of Technology, Bhopal M.P. 462003, India
Email: udaypratapsinghbais@gmail.com

Abstract

High-entropy alloys (HEAs) have garnered significant attention due to their unique structural and mechanical properties. Mechanical alloying (MA), a high-energy ball milling process, is widely used to synthesize HEAs with tailored microstructures. This study investigates the phase and microstructure evolution of HEAs processed via MA, focusing on the formation of solid solutions, grain refinement, and metastable phase transformations. The severe plastic deformation during MA promotes atomic-level mixing, leading to the dissolution of elemental powders and the formation of nanocrystalline or amorphous phases. Extended milling times often stabilize single-phase FCC, BCC, or dual-phase structures, depending on alloy composition and thermodynamic parameters. The high defect density induced by MA, including dislocations and stacking faults, influences the subsequent phase transformations and mechanical behavior. Additionally, oxidation and contamination from process control agents (PCAs) may introduce secondary phases, altering the final microstructure. This study provides insights into the mechanisms governing phase stability and microstructural changes in mechanically alloyed HEAs, paving the way for their application in advanced structural and functional materials.

Keywords: High-entropy alloys, Mechanical alloying, Phase evolution, Powder metallurgy

Utilisation of Bagasse Ash and Rice Straw in fabrication of Eco-Friendly bricks

Diksha Gola, Mahima Prasad, Devesh Singh, Santprakash Rajne, Gabender Singh, Divyanshi Sharma

Department of Civil Engineering, Dayalbagh Educational Institute, Agra, INDIA
Email: dikshagola2003@gmail.com, divanshi.sharma@dei.ac.in

Abstract

The construction industry is a major contributor to environmental degradation due to excessive cement consumption and carbon emissions. In response to this challenge, this study explores the development of Sustainable Bricks (Agro-Bricks) by incorporating bagasse ash and rice straw as partial replacements for cement. The objective is to assess the feasibility of these agricultural waste materials in improving the sustainability and performance of bricks. This study explores Sustainable Bricks (Title Bricks) by partially replacing cement with bagasse ash (5/10/15/20%) and rice straw (2/4/8/10%). A total of 40 brick samples were fabricated using two Mold types to assess strength, durability, and structural integrity. Tests showed compressive strength of 4.5–7.0 MPa, making them suitable for non-load-bearing applications. Water absorption remained within 10–15%, ensuring durability. Results indicate the feasibility of agricultural waste in sustainable construction, reducing cement dependency. Future research will focus on optimizing mix proportions and large-scale applications.

EMI shielding effectiveness of high-performance polymer-based composites

M. Darwhekar [a], D. Pitale[a], H. Pawar [a], R. D. Gadve [a,b]

[a] *Department of Metallurgy and Materials Engineering, COEP Technological University, Shivaji Nagar, Pune, Maharashtra, India.*

[b] *Department of Metallurgical and Materials Engineering, Malaviya National Institute of Technology, Jaipur, Rajasthan, India.*

Email: darwhekarmm22.meta@coeptech.ac.in, rdg.meta@coeptech.ac.in

Abstract

With the uprise of Industry 4.0, and advances in the electronic and information technology, use of electromagnetic radiations has grown exponentially. This leads to electromagnetic pollution posing as a threat to the devices as well as human health. Hence, shielding of these electromagnetic interferences becomes essential. Traditionally used metals and conductive materials have certain limitations considering their heavy weight, poor corrosion resistance and high cost. Conductive polymer composites have been a prominent research focus as they overcome the limitations posed by prior materials. High performance polymers possess more advanced properties when compared to engineering polymers. Thus, using these polymers can significantly improve the properties of the conductive composites. This study provides a detailed review of materials that use high performance polymers for effective electromagnetic interference shielding, summarising the key-findings from various experimental studies and theoretical analyses over the course of time along with fabrication and characterization techniques. Furthermore, potential areas for future research and applications have been discussed.

Study on microwave absorption properties of high performance polymer composites

P. Nagure [a], T. Govardhan [a], M. G. Kulthe [a]

[a] Department of Metallurgy and Materials Engineering, COEP Technological University, Shivaji Nagar, Pune, Maharashtra, India.
Email: nagurepr22.meta@coeptech.ac.in, mgk.meta@coeptech.ac.in

Abstract

Microwave absorption is a critical research area with applications in stealth technology and wireless communications. Microwave absorption materials are essential for mitigating EMI, ensuring device functionality and reducing electromagnetic pollution. The absorption efficiency of materials depends on their electrical and magnetic properties, quantified by complex permittivity (ε) and permeability (μ). Reflection loss (RL) is a key metric, optimized through impedance matching to minimize wave reflection and maximize energy dissipation. High-performance polymers have emerged as promising candidates due to their lightweight nature, thermal stability, and dielectric properties. These polymers offer unique advantages, including ease of processing, chemical resistance, and the potential for structural flexibility, making them suitable for a wide range of applications. This study explores the use of high-performance polymers for microwave absorption, focusing on their dielectric and magnetic properties that contribute to efficient electromagnetic wave absorption and blocking. The mechanisms of microwave absorption, such as dielectric relaxation and magnetic resonance, are analysed to understand the interaction between electromagnetic waves and polymer composites. The impact of polymer matrix composition, structural morphology, and processing techniques on absorption efficiency is also investigated. This work aims to provide a comprehensive overview of the current advancements in microwave absorption using high-performance polymers and nanomaterials as fillers.

Modification of the shape memory polymer composites hybridized with functionalized graphene nanoplatelets: enhancement of mechanical, thermomechanical and thermogravimetric properties

Ritesh Gupta, Mukul Joshi and Krishna Kumar

Department of Metallurgical and Materials Engineering, Malaviya National Institute of Technology Jaipur, Jaipur-302017, India

Email: kkumar.meta@mnit.ac.in

Abstract

Ameliorating the mechanical and thermomechanical properties of the shape memory polymers (SMPs) make them an important class of materials for new-age applications ranging from aerospace, electronics, and marine. To show the more recent attempts proof-of-concept in designing the SMPs with higher mechanical and thermomechanical properties, herein we had designed the multiscale shape memory hybrid composites (SMHCs) having known composition of functionalized graphene nanoplatelets (fGNPs) through dispersing the fGNPs uniformly using ultrasonication in shape memory epoxy polymer. Subsequently, hybrid composites were prepared through impregnation of carbon fiber in the fGNP ~ epoxy solution. Mechanical and thermomechanical characterizations were performed to evaluate the effect of the fGNPs within the SMHC. Significant improvement in the mechanical and thermomechanical properties were achieved in the SMHC with amine functionalized fGNP compared with the carboxy functionalized fGNP and non-functionalized epoxy polymer. Compared with the unmodified carbon fiber reinforced polymer composites, SMHC with 0.4 and 0.6 wt% amine fGNP improved by 19.7% and 33.2%, whereas 5.9% and 17.4% by carboxyl fGNP. Morphological study indicated the improvement of wettability of carbon fiber and interfacial bonding between the fiber and matrix. The recovery of the modified polymer composites into the original shape primarily occurred due to the gradual release of internal energy harnessed in the frozen and active phase of the polymer network. Due to the incorporation of nanofillers, the molecular kinetic energy of the reversible active phase increases, which intensifies the micro-Brownian motion. Thereby, the recovery stage was achieved due to the return of the frozen phase to the disoriented entropy condition. The addition of nanoparticles increases the crosslinking, which in turn increases the volume of the frozen phase. Hence, higher volume of frozen phase would hamper the recovery of the samples in its original shape, resulting in the lower shape fixity. However, the shape memory parameters of shape fixity and shape recovery evaluated with the heat activation bending did not degrade significantly and remained ~95 ± 2% and ~96 ± 1%, respectively.

Tribometry analysis of Ni-P-Graphene oxide/Carbon nano tubes composite coatings prepared by electroless deposition process

Krishna Kumar, Premlata Rao, Divij Jain, Upender Pandel

Department of Metallurgical and Materials Engineering, Malaviya National Institute of Technology Jaipur – 302017, India
Email - kkumar.meta@mnit.ac.in

Abstract

Ni-P coatings with or without graphene oxide (GO) and carbon nano tubes (CNT) were deposited over mild steel substrate by electroless deposition process. The morphology, hardness and wear behavior are co-related to understand the response of nanoparticles (GO and CNT) addition into the Ni-P coatings. With nanoparticle addition morphology is found to be smooth and compacted. The hardness of CNT incorporated Ni-P coatings was found higher than that of GO incorporated Ni-P coatings which shows that the hardness is highly susceptible to the size and the dispersion of nanoparticles. The nanosized CNT led to even dispersion and the particle size of evenly dispersed CNT was found 327.01 nm whereas it was found 538.71 nm for GO, which eventually contributing for excellent wear properties because even dispersion of nanoparticles promotes the finer and smoother surface morphology. Further, the wear depth with time is found to be lower for Ni-P-CNT composite coatings due to tubular structure of CNT, which favors the continuous reinforcement network into the Ni-P matrix and strengthen it. The coefficient of friction is also lower for CNT incorporated Ni-P coatings because of the higher load transfer capability and resistance to wear, than GO containing Ni-P coating. Moreover, the wear rate is calculated from the mass loss and found to be minimum for CNT incorporated Ni-P coatings.

Keywords: Graphene oxide, Carbon nano tubes, electroless process, wear resistance, hardness.

Fabrication and Characterization of Highly Efficient Blue Organic Light Emitting Diode (OLEDs) Using TADF Emitters

Mohd Ayan Anwar[1, 2], Ramesh Babu Yathirajula[1], Franco Mayanglambam[1]

[1]Department of Physics, Gurukula Kangri (Deemed to be University), Haridwar 249404, Uttarakhand, India
[2]Centre for Nanotechnology, Indian Institute of Technology Guwahati, Guwahati 781039, Assam, India.
Email: 1050ayan@gmail.com

Abstract

Organic Light Emitting Diodes (OLEDs) utilizing Thermally Activated Delayed Fluorescence (TADF) emitters are promising candidates for next-generation display and lighting technologies due to their potential for high efficiency and extended operational lifetimes. However, achieving stable and high-efficiency blue emission remains a major challenge. This study investigates the fabrication and characterization of blue OLEDs incorporating TCzTrz as the emissive material. Unlike conventional solution-processed techniques, precise thermal evaporation was employed to achieve uniform film morphology, controlled molecular orientation, and enhanced charge transport critical factors for improving device performance. To investigate the optical properties, UV-Vis absorption and photoluminescence (PL) spectroscopy were performed, confirming a prominent blue PL emission. validating the suitability of TCzTrz for OLED applications. The fabricated OLEDs were further analyzed through electroluminescence (EL) spectroscopy and current-voltage-luminance (I-V-L) measurements, demonstrating optimized charge balance and improved emission stability. The results highlight that strategic layer engineering and tailored deposition techniques significantly enhance efficiency and extend device longevity. These findings provide critical insights into advanced material processing strategies for next-generation OLED technologies, paving the way for their seamless integration into high-performance optoelectronic applications.

Keywords: Blue OLEDs, TCzTrz, TADF, Thermal Evaporation, Photoluminescence, Electroluminescence

Self-Repairing Flexible Pavements

[a]Manu Partap Singh and [a]Praveen Aggarwal

[a]Department of Civil Engineering, NIT Kurukshetra, Haryana,136119, India
Email: 323102408@nitkkr.ac

Abstract

Self- repairing properties are relatively new in the realm of materials research. Something doesn't need to be replaced when it can repair itself. Product lifetime is an important factor that should be maximized, especially while constructing roadways. Although practically everyone is happy when new roads open since they can reduce commuting times by several minutes, nobody wants to fix them. As roads deteriorate, governments are unable to keep up with the essential repairs. This situation is costing everyone a great deal of money. Through extended lifespan and reduced maintenance requirements, the incorporation of self heal technology into road design holds the potential to revolutionize the processes involved in building and maintaining roadways. In addition to minimizing traffic disruption from road maintenance procedures, lowering CO2 emitted during process, and provide safe transportation, Self- repairing asphalt will prevent asphalt pavements from ageing prematurely. This will minimize amount of natural resources required in maintenance of roads. In addition to their potential benefits for the environment, Self- repairing materials also hold the promise of drastically reducing global road network maintenance expenses. The asphalt pavement design can utilize three main Self- repairing techniques: induction heating, rejuvenation, and nanoparticles. This Document explores each of the three options and projects future developments in Self- repairing asphalt technology.

Performance and Durability Assessment of Full-Depth Reclamation Mixes with Cement and Chemical Stabilizers

Sanjeev Kumar and Praveen Aggarwal

Department of Civil Engineering, NIT Kurukshetra
Email: 323102402@nitkkr.ac.in

Abstract

Full Depth Reclamation (FDR) is a sustainable pavement rehabilitation and maintenance technique that reclaims existing road materials to construct a stabilized base layer. The present study focuses on the sustainable use of Reclaimed Pavement Material (RPM), which includes reclaimed asphalt pavement (RAP), reclaimed base, reclaimed subbase, and subgrade courses in FDR by optimizing cement content and chemical stabilizer to improve the pavement performance in terms of strength and durability. Unlike previous research, it also considers the influence of subgrade conditions on FDR performance. A detailed experimental program was performed to evaluate the FDR mixtures engineering behavior. The test includes gradation analysis, specific gravity, aggregate impact value, liquid and plastic limit, Proctor test, unconfined compressive strength (UCS), California bearing ratio (CBR), flexural test, and durability tests. Laboratory-prepared FDR mixes, composed of 100% RPM, were tested with varying cement content and chemical stabilizer to assess their impact on engineering properties. The findings show that using a chemical stabilizer improves strength and durability, which makes FDR a viable option for pavement rehabilitation. From the obtained data, it can be concluded that the FDR mix containing 4.5% cement and 4.0% chemical stabilizer provides optimal strength and durability.

Enhancing the Performance of Stone Mastic Asphalt Using Fiber Reinforcement

Rohit Narayan[a], Manpreet Singh[b] and Babita Saini[a]

[a]Department of Civil Engineering, NIT Kurukshetra
[b]Department of Civil Engineering, TIET
Email: 323402403@nitkkr.ac.in

Abstract

Stone mastic asphalt (SMA) is a robust and durable paving material known for its superior resistance to deformation and cracking. This abstract explores the innovative incorporation of various Fibers into SMA formulations to enhance performance characteristics. Different types of Fibers, cellulose Fiber, glass Fiber, and coconut Fiber, are evaluated for their impact on the mechanical properties and overall durability of SMA. The study highlights how each Fiber type contributes to improved tensile strength, reduced rutting potential, and enhanced fatigue resistance. Laboratory tests demonstrate that cellulose Fibers offer excellent moisture resistance, while glass Fibers significantly bolster the asphalt matrix's structural integrity. Coconut Fibers, on the other hand, provide a sustainable alternative with promising performance benefits. This research underscores the potential of Fiber-reinforced SMA in paving applications, suggesting that tailored Fiber combinations can significantly optimize the performance of asphalt mixtures, leading to longer-lasting and more resilient road surfaces that can withstand varying environmental conditions and traffic loads. The integration of fibrous materials within Stone Mastic Asphalt (SMA) markedly elevates its mechanical characteristics, whereby glass Fiber demonstrates superior stability (8.7 Kn) alongside minimal deformation (2.8 mm). This investigation substantiates that Fiber-reinforced SMA enhances durability, mitigates rutting susceptibility, and promotes sustainability, thereby contributing to the longevity of pavement structures.

Key words: Stone Mastic Asphalt, Fibers, Stability, Flow, Performance, Sustainability

Comparative Analysis of Metallurgical and Mechanical properties of Gas Tungsten Arc and Laser Beam welded joints of Incoloy 800HT

Gurinder Singh[a], Jagmohan Datt Sharma[b], Sandeep Singh Sandhu[c]

[a],[b]Punjab Engineering College, Chandigarh, India,
[c]Focus College, BC, Canada
Email: gurindersingh.phd19meta@pec.edu.in

Abstract

The Iron-based superalloy Incoloy 800HT has garnered significant attention in the realm of advanced materials, primarily owing to its remarkable strength, corrosion resistance, and oxidation resistance, particularly in extreme temperature environments. These attributes position it as a promising candidate material for applications in fourth-generation nuclear power plants and high-temperature gas-cooled nuclear reactors. In this paper metallurgical, mechanical and microhardness characteristics of butt welds were compared using gas tungsten arc welded (GTAW) utilizing IN82 as a filler wire and laser beam welded (LBW) joints of 6 mm thick plate of Incoloy 800HT superalloy. The GTAW joints were produced using established parameters: a current of 130 A, voltage of 12 V and argon shielding flow rate of 15 l/min. For LBW, optimal parameters were applied, including a laser power 5 kW, scanning speed of 1 m/min and argon shielding flow rate of 15 l/min. Microstructural analysis revealed variable dendritic and cellular morphologies in GTAW weld metals, with lower precipitation of γ' and γ'' phases compared to LBW weld joints. The findings revealed a fusion zone with a wineglass shape, slightly wider on the top. The fusion zone contained elongated columnar dendrites alongside fine equiaxed dendrites. A notable phase transformation occurred due to the high cooling rate characteristic of laser welding. Near the Laves phases, an irregular and planar distribution of dislocations linked to subgrain boundaries was observed. Tensile tests showed GTAW joints failing at the BM with UTS of 624 MPa, while LBW weld failed at the weld joint. As-welded GTAW joints demonstrated higher impact toughness, while LBW welds had impact toughness close to the BM. The microhardness of LBW joints improved due to fast cooling and solidification, resulting in very fine columnar-dendritic grains. This comprehensive investigation contributes to a deeper understanding of the weldability and performance characteristics of Incoloy 800HT in critical high temperature applications.

Keywords: Incoloy 800HT, LBW, SEM analysis, Mechanical Properties, Microhardness

Exploring the Microstructure and Corrosion Resistance of HAP/TiO_2 Coatings on Ti-6Al-4V Alloy

Sheetal Meena[a], Niraj Bala[a] and Sushil Kumar Kansal[b]

[a]Department of Mechanical Engineering, National Institute of Technical Teachers Training and Research, Sector 26, Chandigarh 160019, India
[b]Department of Chemical Engineering, Dr. S. S. Bhatnagar University Institute of Chemical Engineering and Technology, Punjab University, Chandigarh, India.
Email: sheetalmeena8@gmail.com, nirajbala@nitttrchd.ac.in

Abstract

The Ti-6Al-4V alloy is commonly used in artificial hip and knee joints due to its strong biocompatibility and specific strength, but it faces challenges with corrosion over time. This study is aimed to enhance the alloy's resistance to corrosion and biocompatibility by applying hydroxyapatite (HAP) and Titanium dioxide (TiO2) based coatings using plasma arc spray technology. The coatings were examined for morphology and microstructure through SEM and XRD analysis. In-vitro corrosion test was performed using Potentiostat by immersing the samples in simulated body fluid (Ringer solution) at body temperature for 24 hours. The corrosion tests indicated high corrosion resistance of coated specimens as compared to uncoated Ti-6Al-4V alloy. The composite coating demonstrated superior biochemical stability in corrosive environments in comparison to pure hydroxyapatite, making it a promising choice for bone implant applications. The hydroxyapatite in the coating promotes osteointegration and when combined with TiO2, enhances the material's performance for medical purposes.

Keywords: Ti-6Al-4V, corrosion resistance, HAP, TiO2, coatings

A review on Ultra-High-Performance Concrete: Utilisation and Limitations in Road Infrastructure

Nadeem Khan[a], D M Rathva[b], Pankaj Goel[a] and Rakesh Kumar[a]

[a]Central Road Research Institute, New Delhi, INDIA
[b]The Maharaja Sayajirao University of Baroda, INDIA
Email: khann0682@gmail.com

Abstract

Ultra-High-Performance Concrete (UHPC) has emerged as a transformative material in the construction industry due to its superior mechanical properties, durability, and versatility. Unlike conventional concrete, UHPC does not contain coarse aggregates but instead incorporates refined quartz sand (≤0.6 mm) to enhance its structural integrity. Its composition primarily consists of high-quality Portland cement, supplementary cementitious materials such as fly ash, silica fume (0.2 µm), ground granulated blast furnace slag (GGBFS), and lime powder. additionally of steel fibers (0.2–0.3 mm in diameter, 12.7–16 mm in length) are incorporated for the improvement in tensile strength, ductility, and crack resistance of the matrix. Furthermore, nanometric materials like graphene oxide (3–5 µm plates, 0.3–2 nm thickness) and others it enhances the material's mechanical and durability properties at the nanoscale. The incorporation of a high-performance superplasticizer, particularly polycarboxylate-based (PCs), ensures superior workability while maintaining cohesiveness. UHPC requires advanced curing techniques beyond conventional methods to achieve its full potential. Its exceptional durability and strength make it an ideal material for infrastructure applications, particularly in the construction, repair, and rehabilitation of concrete highways, bridge decks, and pavement structures and high-rise buildings. Despite its numerous advantages, challenges such as high production costs, specialized material requirements, highly qualified person or technicians and complex construction methodologies hinder its widespread adoption. This review paper provides an in-depth analysis of the development, challenges, applications potential, economic feasibility, and limitations of UHPC in highway infrastructure.

Performance Evaluation of Bituminous Concrete with RAP and Low-Viscosity Binder

[a]Amit Kumar and [a]Praveen Aggarwal

[a]Civil Engineering Department, National Institute of Technology, Kurukshetra, Haryana, 136119, India
Email: i.amitkumar.001@gmail.com

Abstract

This study investigates the performance of bituminous concrete incorporating varying percentages of recycled asphalt pavement (RAP) material and modified with a low-viscosity binder. Laboratory tests were conducted to evaluate the resulting mixtures. The research methodology involves the preparation of hot mix asphalt (HMA) mixtures incorporating RAP at levels of 25%, 50%, 75%, and 100%, in conjunction with a low-viscosity binder. The performance characteristics of the mixtures were evaluated through a series of standard laboratory tests, including the Marshall test, the Indirect Tensile Strength (ITS) test, and the Tensile Strength Ratio (TSR) test. This study sought to evaluate the influence of reclaimed asphalt pavement (RAP) content and low-viscosity binder on key pavement performance parameters, with a focus on rutting resistance and moisture susceptibility. The findings revealed that incorporating RAP and a low-viscosity binder significantly influenced the mixture's rutting resistance and moisture susceptibility. The findings highlight the potential of using RAP and low-viscosity binders for sustainable road construction. This approach can contribute to reduced construction costs and minimized environmental impact. Further research is recommended to determine the optimal RAP content and binder selection for specific traffic and environmental conditions.

Keywords: Reclaimed Asphalt Pavement, RAP, Low-viscosity binder, Bituminous concrete, Sustainable construction

Effect of Gradation on Full-Depth Reclaimed Pavement Performance

Manoj Yadav and Praveen Aggarwal

Department of Civil Engineering, National institute of technology, Kurukshetra, Haryana -136119, India
Email: my314231@gmail.com

Abstract

This study on recycling old pavement components, full-depth reclamation (FDR) is a sustainable pavement restoration technique that reduces costs and environmental impact. Full-depth reclamation (FDR) is a viable pavement restoration approach that significantly improves the performance of pavement component parts while reducing costs and damaging the environment. Gradation can affect the water content and permeability of the FDR mix Proper gradation facilitates ease of compaction and ensures a dense and cohesive mixture. The effect of different gradations on UCS and durability examined by laboratory testing. Studies suggest that appropriate gradation improves strength and durability, but poorly graded materials don't. The aim of research to select the most appropriate gradation for better FDR pavement performance in terms of UCS and durability.

Keywords: Full-depth reclamation (FDR), recycled pavement materials, gradation effects, strength characteristics, durability, performance evaluation.

A Study on the Effects on Tribological Properties of Al-SiCp Nanocomposites

Vishesh Katariya, A.K. Pradhan

Department of Metallurgy and Materials Engineering,
Malaviya National Institute of Technology Jaipur 302017, INDIA
Email: Vishesh251@gmail.com

Abstract

In the present study the tribological properties of Al-SiCp Nanocomposites containing varying quantities of SiCp nano-particles is evaluated under dry sliding conditions. Micro Si-C powder purchased from the market is converted into nano powder using high energy ball milling for 20 hours.The nano-size of the prepared powder is confirmed form scanning electron microscopic study. Then after using stir casting technique, three nano-composites are prepared containing different amounts of SiCp (0.1%, 1%, 5%). The density of the nanocomposite increased with the increase in the content of SiCp due to the higher density of silicon carbide as compared to pure aluminum. A comparison of experimental results with theoretical values revealed that the nanocomposites prepared in this work are dense. The micro-hardness of the nanocomposites is found to increase with the increasing content of SiCp. Coefficient of thermal expansion of the Al matrix decreased slightly with the addition SiCp. DSC analysis showed a decrease in crystallinity of the 5 wt.% SiCp nanocomposite compared to pure the aluminum.

Optimization of Geocell Dimensions for Square Footings Resting on Clayey Soil

Jyoti Kumari and Jitendra Singh Yadav

Civil Engineering Department, National Institute of Technology, Kurukshetra, Haryana, 136119, India
Email: 323102405@nitkkr.ac.in

Abstract

The optimization of geocell dimensions for square footings resting on clayey soil using numerical modelling focuses on analyzing the effects of varying geocell parameters, such as size, shape, height, and position, on the foundation's performance. Geocells are commonly used to enhance the load-bearing capacity and reduce settlement in weak soils. In this study, numerical simulations are performed to investigate how changes in geocell dimensions affect the behavior of square footings. The geocell configurations analyzed include variations in cell size, shape, height (depth of geocell reinforcement), and placement (position relative to the footing and soil surface). By employing finite element analysis (FEA) and other computational methods, the research examines key parameters such as settlement, bearing capacity, and load distribution under different geocell designs. The numerical modelling allows for the systematic variation of geocell dimensions while accounting for the specific properties of clayey soil, including cohesion and friction angle. Results indicate that optimal geocell configurations can lead to substantial improvements in footing performance, reducing settlement and enhancing load-carrying capacity. The study provides valuable insights into the selection of geocell dimensions for foundations on clayey soils, offering a cost-effective and efficient method for foundation optimization in soft soil conditions.

Keywords: Geocells · Shape of geocells · Footing · Friction angle · PLAXIS3D

A review on quaternary blending of supplementary cementitious compounds as a partial replacement of cement in paving grade concrete

Ashwani Saini[a], Romeil Sagwal[b], Prathuri Sumanth[c]

[a] Research Intern, CRRI, New Delhi-110025, India;
[b] Senior Scientist, Rigid Pavement Division, CRRI, New Delhi-110025, India;
[c] Research Intern, CRRI, New Delhi-110025, India;
Email: ash8217219@gmail.com, prathurisumanth1999@gmail.com

Abstract

The increasing environmental concern related with carbon emission during the manufacturing of cement and the need for sustainable construction practices, researchers have focused on reducing the reliance on Ordinary Portland Cement (OPC) by using supplementary cementitious materials (SCMs). Nowadays, many concrete mixes incorporate different cementitious materials, which offer benefits such as the ability to replace some cement while maintaining its properties. This review paper focuses on the partial replacement of OPC with these SCMs, which include Silica Fume (SF), Fly Ash (FA) and Ground Granulated Blast Furnace Slag (GGBFS) in concrete. Cement can be partially replaced with one, two and three SCMs forming binary, ternary and quaternary blended concrete respectively. They serve various purposes such as enhancing durability, reducing permeability, improving flowability, decreasing alkali reactivity and upgrading the overall hardened properties of concrete through pozzolanic activity. The usage of supplementary cementlike compounds which consist of fly ash, silica fumes, and GGBFS in paving-grade concrete mixes, can provide technical and environmental benefits. Furthermore, the quaternary blending of paving-grade concrete has not been extensively studied, leaving room for further research and literature development.

Novel 2D Hematene (HM) based hybrid material Co3O4@HM for photo Sensing for Industrial Applications

Bhuneshwar Paswan[a*], Sumit Kumar Choudhary[a], Ujjwal Singh[b], Ravi P. Srivastava[a], Pranay Ranjan[a*], Devendra Singh Negi[a*],

[a] *Department of Metallurgical and Materials engineering, Indian Institute of Technology Jodhpur, Rajasthan – 342030, India*
[b] *Department of Electrical Engineering, Indian Institute of Technology Jodhpur, Rajasthan – 342030, India*
Email: p23mt0004@iitj.ac.in

Abstract

Two-dimensional (2D) Hematene (HM), derived from hematite through liquid-phase exfoliation, exhibits a reduced bandgap of approximately 1.1 eV for monolayers, compared to 1.9-2.2 eV in bulk hematite. This reduction in bandgap, attributed to quantum confinement effects, leads to enhanced charge transfer properties crucial for photo sensing. The high surface-to-volume ratio of HM nanosheets provides efficient interaction with target molecules, making it an ideal platform for photo sensing applications. The Co3O4 is an antiferromagnet p-type semiconductor with favourable band gap (1.48–2.19 eV) and high resistance to corrosion and oxidation2. Cobalt oxide, known for its excellent catalytic properties, enhances the overall photosensitivity of the hybrid material. The Co3O4@HM hybrid material leverages the synergistic effects of cobalt oxide and Hematene. The integration of Co3O4 with Hematene creates additional active sites for light absorption and charge separation, resulting in improved photocurrent generation and faster response times. Furthermore, the Co3O4@HM hybrid demonstrates enhanced stability and selectivity towards light of various wavelength. The development of Co3O4@HM opens new avenues for designing high-performance photosensors for industrial applications. Future research will focus on optimizing the synthesis process and investigating the long-term stability of this hybrid material for various industrial applications.

Synthesis of AlCoCrFeMg High-Entropy Alloy via Powder Metallurgy Route

[a]R K Saini, [a]U Pandel, [a]Vijay N Nadakuduru

[a]Department of Metallurgical and Materials Engineering
Malaviya National Institute of Technology Jaipur, Jaipur-302017, India
Email: 2020rmt9589@mnit.ac.in, vijay.meta@mnit.ac.in

Abstract

High-entropy alloys (HEAs) are gaining popularity in materials research due to their distinct microstructures and improved mechanical, thermal, and tribological properties. Among these, the AlCoCrFeMg HEA is notable for its promising combinations of lightweight and high-strength properties. The AlCoCrFeMg high-entropy alloy (HEA) was fabricated through the powder metallurgy route, ensuring a uniform microstructure and enhanced densification. The resulting AlCoCrFeMg HEA demonstrated exceptional hardness, high-temperature stability, and corrosion resistance, attributed to the synergistic effects of multi-principal elements and solid solution strengthening. Microstructural analysis revealed a homogeneous phase distribution with minimal porosity, contributing to the superior mechanical behaviour. These characteristics position the AlCoCrFeMg HEA as a promising candidate for applications in the aerospace, automotive, and energy sectors.

Keywords: Powder Metallurgy. High Entropy Alloys, Lightweight.

Effect of macro encapsulated PCM in building envelope: Experimental analysis

[a]Khushi Kumari, [a]Nand Kumar, [a]Himanshu Pratap, [a]Mohd. Sharique Ahmad

[a]Department of Civil Engineering, Dayalbagh Educational Institute Agra, Uttar Pradesh, 282005, India
Email: rskhushiofficial21@gmail.com

Abstract

Building sector is responsible for approximately 40% of global carbon dioxide emission. Accordingly, any measures for reducing building energy consumption would substantially benefit sustainable development. Recent studies focus on innovative techniques to enhance performance, with a growing emphasis on phase change materials (PCMs). PCMs can store and release heat during phase transitions, making them a promising solution for improving insulation, especially in roofs and external walls. This study evaluates and compares the thermal performance of two prototype cubicles; one is the control sample and other is integrated with macroencapsulated HS-29 PCM in a real tropical environment. Experimental studies were conducted to analyze the thermal behaviour and thermal decomposition of PCM using differential scanning calorimeter (DSC) and thermo gravimetric analysis (TGA). The surface temperature of the walls is analysed using K-type thermocouples and thermal gun. Additionally, computational modelling through software simulation is also performed to evaluate the influence of walls and ceiling with PCM in the whole energy balance of a building. The findings indicate that the encapsulated PCM significantly improves thermal behaviour, energy efficiency, and indoor comfort in concrete structures, highlighting its potential for advancing energy-efficient building practices. This study contributes essential insights into the application of PCMs in construction, supporting further innovations in sustainable building technologies.

Comparative Analysis of Various Parameters for production of High Quality Graphene by Shear Exfoliation

[a]Supriya Kodali, [a]Raj Kishora Dash

Advanced Material and NEMS Lab
[a]School of Engineering Sciences and Technology, University of Hyderabad, Hyderabad-500046
Email: rajkishoradash@uohyd.ac.in

Abstract

2D nanomaterials like Graphene has emerged as a potential material for sensors, printed electronic devices, nanocomposites, and several applications due to its excellent electrical, chemical, and physical properties. Among all the synthesis processes, Liquid-phase exfoliation (LPE) is one of the key methods for producing graphene in large quantities without utilizing any toxic chemicals. Further, commercial grade large quantities of graphene can also be produced, which is the main challenge in this area. In this study we have demonstrated different parameters like Surface tension, Temperature & Dialysis effecting to successfully obtain graphene from the graphite sheets through high-shear mixing under high-shear turbulent flow conditions. Finally a comparison study on these parameters will be presented to show their effect on quality of synthesized graphene mainly focusing on the underlying mechanism involved in this process to obtain good quality graphene.

Utilization of Marble Dust Powder as Partial Cement Replacement and the Inclusion of Moss Concrete for Sustainable Construction

[a]Rohit Kumar, [a]Raj Singh and [a]Krishma Yadav

[a]Department of Civil Engineering, Dayalbagh Educational Institute (Deemed to be University), Agra, India, 282005
Email: rajsingh2104179@dei.ac.in

Abstract

Concrete, a pivotal construction material, has been under scrutiny for its environmental footprint due to cement production. This research investigates innovative approaches to sustainable concrete by partially replacing cement with marble dust powder (MDP) and incorporating moss-covered concrete. Marble dust, a by-product of marble processing, was evaluated in varying proportions 0%, 3%, 6%, 9%, and 12% for its effects on the mechanical properties of M20-grade concrete. The inclusion of moss aimed to enhance thermal insulation and air purification. Compressive strength tests revealed that 12% MDP replacement achieved the highest strength (24.17 MPa at 28 days), attributed to the pozzolanic reactivity of marble dust. Additionally, moss-covered concrete demonstrated potential in reducing the urban heat island effect and sequestering air pollutants such as SO_2 and NO_2. Cost analysis indicated an 18.5% reduction in material costs at 12% MDP replacement. This dual approach to sustainable construction presents an eco-friendly alternative to conventional concrete, offering improved mechanical properties, environmental benefits, and economic viability.

Keywords: Marble Dust Powder, Moss Concrete, Sustainable Construction, Compressive Strength, Eco-friendly Materials

A review on synthesis and properties of bulk consolidated Al-Mg/Al-Mg-Li alloys

[a]D. Das, [a]U. Pandel, [a]Vijay N. Nadakuduru

[a]Department of Metallurgical and Materials Engineering
Malaviya National Institute of Technology Jaipur, Jaipur-302017, India
Email: dd7880543@gmail.com , vijay.meta@mnit.ac.in

Abstract

The thermo-mechanical treatment and processing methods that have influenced the synthesis of bulk consolidated Al-Mg/Al-Mg-Li alloys are studied in this literature. In order to develop the alloys, the primary processing methods□casting or powder metallurgy□are discussed. The impact of thermomechanical treatments on the microstructural characteristics that contribute to the enhanced mechanical properties of Al-Mg/Al-Mg-Li alloys are identified and focused. From the elemental distribution maps of the as-cast and hot-isostatic-pressed (HIP) alloys, it was shown that the as-cast alloy exhibits a clear enrichment of Mg at the grain-boundaries. Conversely, the HIPed alloy had a homogeneous distribution of Mg. Specifically, the impact of thermo-mechanical treatment on the microstructure and mechanical properties of the third generation Al-Mg-Li alloy (Li<2wt%), 01420 or 01421, known as lightest Al-Li-based alloy in comparison with other competitive alloys such as Al-Cu-Li (2020, 2090), Al-Mg-Cu-Li (8090, 8091); are highlighted. Al3Li (δ□) is a fundamental intermetallic phase that strengthens the Al-Mg-Li alloy, while equilibrium phase like Al2MgLi (S1), Al3Mg2 (β), and AlLi (δ) have adverse effects on mechanical properties. Alloy 01420 has extremely poor formability, particularly cold-formability. Their good strength parameters are accompanied by limited ductility due to the presence of equilibrium phase precipitates at the grain-boundaries and the localization of the plastic deformation due to particle shearing of δ□. The majority of high-performance Al-Li alloys have the ability to harden by aging. During aging, the finely distributed δ□ phases in the matrix are responsible for the high strength.

Keywords: Powder metallurgy route, Hot-isostatic-pressing, Intermetallic phase, Thermo-mechanical treatment, Aging

Synthesis and Characterization of CaV2O6-glass composite for ultra low temperature co-fired ceramic (ULTCC) technology

Rajendra Panmand[*a], Rushikesh Dhamale[b], Varsha Pawane[a], Jyoti Kondhalkar, Vijaya Giramkar[a], Shany Joseph[a]

[a] *Electronics Packaging Group, Centre for Materials for Electronics Technology (C-MET), Panchawati Off Pashan Road, Pune, Maharashtra 411008, India.*

[b]*Department of Physics, Fergusson College (Autonomous), Savitribai Phule Pune University, Pune- 411004, India*

Email: rajendra@cmet.gov.in

Abstract

Low Temperature Co-Fired Ceramic (LTCC) technology is for manufacturing the multilayer circuits from ceramic substrates. LTCC device consists of multiple dielectric layers, screen-printed low-loss conductors, embedded baluns, resistors & capacitors and via holes for interconnecting the multiple layers. The LTCC is Herein, we synthesized Ultra-low-temperature Co-firing ceramics (ULTCC) based on calcium metavanadate (CaV_2O_6) ceramic using the conventional solid-state reaction route. The synthesized material is characterized by advanced techniques to know about the phase purity, crystal structure and microstructural characteristics using X-ray diffraction (XRD), Raman spectroscopy, and Field Emission Scanning Electron Microscopy (FE-SEM). The analysis revealed that the pure phase monoclinic CaV2O6 is obtained. The CaV_2O_6 -glass-ceramic has been prepared by adding glass in CaV_2O_6 with different weight ratios. The ceramic-glass powder was compacted into pellets and sintered at a temperature of 670oC. Furthermore, CaV_2O_6 -glass ceramics has been tested for microwave dielectric properties. For the ratio 70:30, the dielectric constant and Qf oblation εr = 11.1, Q X f = 9800 GHz. The overall results suggest that the CaV_2O_6 -glass ceramics could be promising materials for Ultra-low-temperature-cofired ceramic packaging technology.

Study of aging behavior of Al-4.5%Cu alloy synthesized via powder metallurgy route

[a]Shrawan K Bairwa, [a]Brij Mohan Mundotiya, [a]Vijay N Nadakuduru

[a]Department of Metallurgical and Materials Engineering, Malaviya National Institute of Technology Jaipur, Jaipur-302017, India
Email: 2022rmt9080@mnit.ac.in, vijay.meta@mnit.ac.in

Abstract

Duralumin is a type of non-ferrous alloy that is used mostly in industries, aircraft construction, discovered in 1906. Duralumin has qualities including mildness, high ductility, and corrosion resistance. This research sought to understand the mechanical characteristics of duralumin produced by powder metallurgy process and also check the aging behavior. The application of the artificial aging process can enhance the duralumin's mechanical qualities. Duralumin is aged artificially by being heated to a temperature of 500 °C for one hour, quenched, and then aged at 180 °C for eight hours. Both optical microscopy and field emission scanning electron microscopy (FE-SEM) were used to examine the sample morphology. The mechanical characteristics of duralumin were determined using Archimedes' principle and Vickers' micro hardness test, whilst the phase identification of duralumin was determined using X-ray diffraction (XRD). Duralumin's morphology during the aging process revealed a precipitate with circular grains. The maximum average hardness, 99.77 HV, was obtained.

Keywords: Duralumin; mechanical alloying; compaction; sintering; artificial aging

Resistance Spot Welding of SS304 Stainless Steel

[a]P Goyal, P Bairwa, [a]R K Saini, [a]Vijay N Nadakuduru

[a]Department of Metallurgical and Materials Engineering, Malaviya National Institute of Technology Jaipur, Jaipur-302017, India

Email: 2021umt1636@mnit.ac.in, vijay.meta@mnit.ac.in

Abstract

Resistance spot welding (RSW) is a crucial joining process for stainless steel, significantly influencing its mechanical properties. This study investigates the effects of varying weld parameters on the hardness, microstructure, and tensile strength of SS304. Samples were prepared with varying heat input and varying weld time. Hardness distribution across the weld cross-section and microstructural changes will be analyzed, along with tensile strength variations. Additionally, X-ray diffraction (XRD) has been performed on pure SS 304. It is anticipated that the weld nugget will exhibit increased hardness due to grain refinement, the heat-affected zone (HAZ) will show microstructural variations and tensile strength will vary with heat input. These findings will contribute to optimizing RSW parameters for Ss304.

Keywords: Resistance spot welding, Characterization, Mechanical Properties

Evaluation of Bituminous Mix Performance Using RAP and Low-Viscosity Binder

[a]Amit Kumar and [a]Praveen Aggarwal

[a]*Civil Engineering Department, National Institute of Technology, Kurukshetra, Haryana, 136119, India*
Email: 323102403@nitkkr.ac.in

Abstract

In this study, a bituminous mix modified with different percentages of recycled asphalt pavement (RAP) material and low-viscosity binder is investigated. The resulting mixtures were tested in the laboratory. The research method consists of making of mix design for the control mix and RAP-modified mixtures based on the optimum binder content (OBC) of the control mix. Then the mixtures of hot mix asphalt (HMA) made with the addition of low viscosity binder and RAP at 25%, 50%, 75%, and 100% levels. The mixtures were evaluated based on their performance characteristics through a set of standard laboratory tests such as the Marshall test, the Indirect Tensile Strength (ITS) test, and the Tensile Strength Ratio (TSR) test. As a focus on rutting resistance and moisture susceptibility, this study is motivated to investigate the effect of RAP content and low viscosity binder on these pavement performance parameters. According to the findings, the use of RAP and a low-viscosity binder had a significant effect on the mixture's rutting resistance and moisture susceptibility, showing improvement in rutting resistance and moisture susceptibility as the RAP content increased, but the improvement was less significant for moisture susceptibility. The results indicate that RAP and low-viscosity binders can be used for sustainable construction of roads. This method can lower the construction cost and also mitigate the impact on the environment. There is a need for further research to identify an optimum RAP and binder type for particular traffic and environmental situations.

Keywords: RAP, Reclaimed Asphalt Pavement, Low-viscosity binder, Bituminous mix, Sustainable construction

Thermo-Physical Studies of Mg-doped Bi2Te3 Thin Films by Varying Doping Concentrations for Improved Thermoelectric Performance Via Thermal Evaporation

Saicharan Dharavath[a], **R.K.Dash** [a*]

[a]Advanced Materials and NMES Lab, School of Engineering Sciences and Technology, University of Hyderabad, Hyderabad, Telangana,500046, India.
Email: rajkishoradash@uohyd.ac.in

Abstract

Bi2Te3-based thermoelectric materials are highly promising candidates for applications at low and room temperatures. In this study, we initially prepared magnesium-doped Bi2Te3 thin films with a thickness of 800 nm, with 10 wt% magnesium. These films were synthesized through thermal evaporation, resulting in significant changes to their structural and thermophysical properties. Furthermore, we examined the impact of dopant concentration on thermophysical behaviour by varying the magnesium doping levels to 5 wt% and 20 wt%. Structural analysis confirmed the presence of a rhombohedral crystal structure with an R-3m space group typical of the Bi2Te3 phase. Notably, we found that crystallinity improved with higher annealing temperatures. Energy-dispersive X-ray spectroscopy (EDX) and surface mapping verified the uniform distribution of constituent elements. We observed enhancements in the Seebeck coefficient and electrical conductivity, which are influenced by grain size and density with doping concentration. The Seebeck coefficient increased by 120μV/K, attributed to the energy filtering effect at small grain boundaries. In contrast, the electrical conductivity exhibited a non-monotonous trend as film thickness and dopant content increased. Ultimately, the film exhibiting minimal strain and dislocation density achieved a maximum room temperature power factor of 11.54 mW/m-K^2. This study demonstrates that thermal evaporation is an effective method for synthesizing magnesium-doped Bi2Te3 thin films.

Predicting the Tribological Properties of Surface Coatings by Optimized Machine Learning Approaches

[a]Aman Kumar, [a]Akash Kumar, [a]Manas Ranade, and [a]Suresh Bandi

[a]Department of Metallurgical and Materials Engineering, Malaviya National Institute of Technology Jaipur, Jaipur-302017, India.
Email: 2021umt1796@mnit.ac.in

Abstract

Surface coatings are commonly applied to enhance substrate properties, such as wear resistance, hardness, and oxidation resistance. Particularly for wear resistance, the coefficient of friction (COF) is a critical parameter that prescribes the resistance of a surface-coated material against the sliding motion. The Higher COF correlates to an increased wear rate. Hence the prediction of COF can qualitatively predict the tribological behavior of the coating. In general, the COF is experimentally calculated by the traditional methods of ball-on-disc and pin-on-disc. Reducing the experimental intensity and time consumption is always desirable, which can be efficiently achieved by machine leaning (ML) based predictive approaches. In this study, we propose a machine learning (ML)-based approach to predict the COF for surface coatings, leveraging a suite of regression models, including linear regression, decision trees, random forests, and support vector regression. The study focuses on two distinct coating systems: MoS2-Zr coatings deposited on hardened steel and FeCoCrNiAlN high-entropy alloy coatings on stainless steel substrates. Despite the limited dataset, the Optuna library for hyperparameter optimization across a comprehensive parameter space, helped to achieve the cross-validated R^2 scores of 0.89 for MoS2-Zr coatings and 0.80 for high-entropy alloy coatings. This demonstrates the efficacy of ML models in accurately predicting COF, even with constrained data. These findings highlight the potential of ML as a robust alternative to traditional experimental methods for COF and further wear rate predictions offering significant savings in time and resources while maintaining high predictive accuracy.

A review on recent approaches for microplastic removal for sustainable development

[a]Nishi Gandha, [a]Gaurav Manik

[a]Department of Polymer and Process Engineering, Indian Institute of Roorkee, Roorkee, Uttarakhand, India 247667.
Email: nishi_g@pe.iitr.ac.in, gaurav.manik@pe.iitr.ac.in

Abstract

Microplastics (MPs) have emerged as a pervasive environmental pollutant, posing a far-reaching impact to aquatic ecosystem and human health. This critical issue necessitates the emergent development of advanced materials for effective remediation. This has motivated many global, universities to start addressing microplastic pollution through a range of initiatives and research efforts. However, there is still a lack of integrated strategies that combine waste management, public awareness, and technological innovation to tackle plastic pollution comprehensively. Current methods such as mechanical filtration, chemical method and membrane technology for addressing microplastic pollution exhibit several significant limitations including generation of secondary wastes or use of toxic chemicals which can further complicate environmental management. A promising sustainable approach is the use of organic waste based activated bio-charcoal sourced from bamboo, sugarcane, rice straw and others as rapidly renewable resource that may help mitigate the health risks and align with broader environmental goals. Suitable elemental functionalisation of such novel sorbent for specific adsorbates can be a promising candidate for adsorbing different sizes and chemically different MPs from contaminated water. By leveraging on their unique properties like high surface area, porosity and cost-effectiveness of activated charcoal, a sustainable alternative solution may emerge. We review development of such adsorbent materials material with optimized activation and elemental functionalization, which may demonstrate superior performance in trapping range of microplastics compared to existing materials.

Keywords: Microplastics, Functionalisation, Activated charcoal, Sustainable, Adsorption

A Comparative Study of Thermal and Mechanical Processing of SS304L Steel

[a]Ranveer Singh, [a]Swati Sharma

[a]Department of Metallurgical and Materials Engineering
Malaviya National Institute of Technology Jaipur, Jaipur-302017, India
Email: ranveernitb.16@gmail.com

Abstract

In the present study, the effect of heat treatment and reversible cyclic plastic deformation (RCPD) on microstructure and mechanical properties of stainless steel 304L (SS304L) has been examined. The RCPD demonstrated a significant reduction in the grain size as well as formation of deformation-induced twins, without any observable phase transformation in the SS304L specimens. An isothermal annealing of as-received specimens at 950 0C (1223 K) for varying annealing durations exhibited the formation of recrystallized equiaxed austenitic microstructure. It was also observed that the grain size and the twin width increased simultaneously with annealing time, wherein the grain size increased linearly, whereas the increment in the twin width was parabolic in nature. The density of deformation twins decreased with increasing annealing time, which was attributed to the variation in the stacking fault energy (SFE) with temperature and duration of annealing treatment. The average hardness values decreased with increasing annealing time, and this trend was correlated with the increasing grain sizes and, simultaneously, decreasing amount of twin density.

Hydrothermally deposited MoS¬2 coatings on Mild steel substrates

[a]Lalit Chitoshiya, [a]Kavita Kumari, [a]Manisha Meena, and [a]Suresh Bandi

*[a]Department of Metallurgical and Materials Engineering,
Malaviya National Institute of Technology Jaipur, Jaipur-302017, India.
Email: 2021umt1889@mnit.ac.in*

Abstract

Self-lubricant coatings are crucial for various automotive applications in reducing the friction and wear between two surfaces. The coating on the surface separates the two wearing surfaces by acting as a third body and facilitating lubricant films. MoS2 is one of the well-known self-lubricating coating materials. This focuses on exploring a facile way of depositing MoS2 coatings on the mild steel substrate. In this view, the hydrothermal route was chosen where the precursors of molybdenum and sulfur are taken along with the distilled water in an autoclave where the substrate was also placed for in-situ deposition of coatings. The sealed autoclave was kept for the reaction at 160°C – 220 °C for 12-24 h in a hot air oven. The resulting coatings were characterized using scanning electron microscopy (SEM), X-ray diffraction (XRD), and tribological testing to evaluate surface morphology, phase & structure, and wear behavior.

Synthesis, Characterization, and Solubility Studies of Novel Polybenzimidazopyrrones for Polymer Electrolyte Membranes for Fuel Cell.

[a]Navin P. Chikhaliya* and [a]Sanjay K. Parmar

*[a]Department of Chemistry, Sardar Patel University, Vallabh Vidyanagar-388120, Gujarat-388120, India
Email: navin.chikhaliya@spuvvn.edu*

Abstract

A series of novel polybenzimidazopyrrones (PBIP) were synthesized through the polycondensation of pyridine-bridged aromatic tetraamines, specifically 4,4'-(4-(5-fluoro-2-methylphenyl)pyridine-2,6-diyl)bis(benzene-1,2-diamine) and 4,4'-(4-(3-fluoro-4-methylphenyl)pyridine-2,6-diyl)bis(benzene-1,2-diamine), with various aromatic dicarboxylic acids. The resulting monomers were characterized using Infrared Spectroscopy, ^{1}H-NMR Spectroscopy, and Thermogravimetric Analysis. Experimental findings demonstrated that the synthesized PBIP polymers exhibit good solubility in strong organic solvents such as N-methyl-2-pyrrolidinone (NMP), N,N-dimethylformamide (DMF), and N,N-dimethylacetamide (DMAC).

Keywords: Fuel cell, Polymer Electrolyte membranes, Tetraamine, Polybenzimidazopyrrones

Development of an AI-powered Hematene Sensor for Exhaled Nitric Oxide Detection in Asthma Monitoring

Ujjwal Singh[a], Sumit Kumar Choudhary[c], Akanksha Dwivedi[b], Bhuneshwar Paswan[c], Pranay Ranjan[c], Devendra Singh Negi[c], Ajay Agarwal[a]

[a] Department of Electrical Engineering, IIT Jodhpur, Rajasthan – 342030, India
[b] Department of Computer Science Engineering, IIT Jodhpur, Rajasthan – 342030
[c] Department of Metallurgical and Materials engineering, IIT Jodhpur, Rajasthan – 342030, India
Email: p22ee011@iitj.ac.in

Abstract

Asthma, a chronic respiratory condition affecting millions worldwide, requires continuous monitoring for effective management. This paper presents the development of an AI-driven hematene sensor for the detection of exhaled nitric oxide (eNO) in asthma patients. Nitric oxide is a key biomarker for airway inflammation, and its accurate detection is vital for asthma diagnosis and management. We propose a convolutional neural network (CNN) classifier to process and analyze sensor data for precise gas mixture classification, inspired by similar approaches in machine learning-based gas detection. The sensor integrates advanced machine learning (ML) techniques to enhance accuracy by compensating for environmental variables and cross-sensitivities. In this study, hematene thin films were synthesized via a chemical-assisted method and characterized using FESEM, XRD, FTIR, AFM, and Raman spectroscopy. Nitric oxide (NO) gas sensing performance was evaluated using a static gas testing system. The sensor exhibited excellent performance at 150°C, with an 89.9% response to NO gas and low responses to interfering gases. It detected NO gases in the 20-2000 ppb range, with sensitivities of 38.6 kΩ/ppb (20-400 ppb) and 2.6 kΩ/ppb (401-2000 ppb). The sensor demonstrated good repeatability, selectivity, rapid response and recovery times. This non-invasive approach offers a promising solution for asthma management, enabling early intervention and reducing healthcare costs. By combining hematene's unique properties with AI-driven analytics, this approach paves the way for the next generation of medical devices for respiratory health monitoring.

Role of Powder Morphology on A-Phase Content in Plasma Sprayed Alumina Coatings

[a]Santosh Kumar*, [a]Chintham Satish, [a]Anup Kumar Keshri

[a]Plasma Spray Coating Laboratory, Department of Metallurgical and Materials Engineering
Indian Institute of Technology Patna – 801106
Email: santosh_2321mm09@iitp.ac.in

Abstract

Despite various studies addressing the retention of α phase in thermal sprayed alumina coatings, a noticeable research gap persists regarding the impact of feedstock morphology on phase retention and properties. In this work, we explored this simple way to enhance the retention of the α phase and studied its impact on mechanical and dielectric properties. To achieve this, we deposited alumina powders with two different morphologies (such as angular and spherical) with similar particle size using plasma spraying. After deposition, we quantified the retention of α phase present in the coatings using the Rietveld refinement method. From this analysis, we noticed that spherical morphology (SM) powder exhibited the highest percentage of α phase retention (82.81%) as compared to angular morphology (AM) powder (48.8%). In turn, SM-coating demonstrated superior mechanical properties, with improvements in hardness, elastic modulus and fracture toughness of 21.9 % 13.7 % and 25 % respectively, compared to AM-coating. This improved mechanical properties in SM-coating is attributed to high α phase retention, synergistic effect of both fully melted (FM) and partial melted (PM) regions of coating microstructure which hindered the crack propagation. Furthermore, the SM-coating exhibited superior dielectric properties, with a dielectric strength 9.9 % higher than the AM-coating. This dielectric performance is ascribed to high retained α phase and generation of discontinuous crack due to presence of PM regions in the SM-coating. These findings suggest the impact of feedstock powder morphology on coating performance and offer avenues for optimizing coating processes in diverse technological fields.

Keywords: Powder morphology; Plasma spray; Al2O3 coatings; α-phase; Dielectric properties

Enhancing Sustainability in Titanium Alloys: Ti407 as a Greener Alternative to Ti-6Al-4V

[a]Abhishek Arora, [a]Jaiveer Singh

[a]Indian Institute of Technology Jodhpur, Rajasthan
Email ID: p24mt0001@iitj.ac.in

Abstract

Ti-6Al-4V (Ti64) is widely recognized for its exceptional combination of strength and ductility, making it one of the most commonly used titanium alloys. High manufacturing costs related to high-temperature forming and subsequent machining are a drawback of Ti-6Al-4V despite its attractive properties. Ti407, a recently developed α+β titanium alloy by TIMET, offers a balanced combination of moderate room temperature strength, excellent formability, and enhanced ductility. The primary alloying elements in Ti407 include 0.85% Al, 4% V, 0.25% Fe, 0.15% O, and 0.25% Si (wt%). The lower aluminium content in Ti407 is believed to facilitate dislocation movement, thereby delaying crack initiation and propagation. Its ability to accommodate significantly more deformation before failure (than Ti64) will provide opportunities for improved impact energy absorption performance, while also improving machinability and formability, which could contribute to reduced manufacturing costs. Recent research has indicated that Ti407 exhibits significantly lower flow stress during forming and extends tool life by over 50%. Crystallographic texture analysis of deformed specimens suggests that Ti407 is more susceptible to texturing and shows greater grain elongation and rotation under applied stress than Ti64. Also, Ti-407 is easier to recycle due to low aluminium content which is present heavily in Ti-6Al-4V. Furthermore, its lower beta transformation temperature could contribute to cost savings in manufacturing processes. However, the deformation characteristics of this alloy are not yet fully understood, necessitating further investigation in comparison to Ti64 as a benchmark.

Material Characterization and Comparison in SLM-Fabricated Specimens vs Cast Structured Specimens

Kanta Chaudhary[a] and Niraj Bala[b]

[a]Government Polytechnic College Sikar, Rajasthan, India
[b]National Institute of Technical Teachers Training and Research, Sector 26, Chandigarh 160019, India
Email: chaudharykanta21@gmail.com

Abstract

This study investigates the impact of titanium dioxide and chromium oxide coatings on 17-4 PH stainless steel components, comparing samples produced through additive manufacturing and traditional manufacturing methods. SEM analysis was performed to evaluate the impact of coating on the performance of 17-4 PH stainless steel components. Results showed that the hardness of parts produced via additive manufacturing was lower than those of their conventional counterparts. The use of titanium dioxide and chromium oxide coatings significantly improved these properties in both instances. The study also examined the microstructure and wear behavior of titanium dioxide and chromium oxide coatings on precipitation hardening martensitic stainless steel (17-4PH), which is widely used in the oil and gas industries. Scanning electron microscopy (SEM) and energy dispersive spectroscopy (EDS) were used to analyze the microstructure and wear mechanisms. The wear resistance of 17-4 PH stainless steel underwent precipitation hardening for strength enhancement. The wear tests were performed using a pin-on-disc tribometer fitted with pins with different coatings. The wear resistance exhibited considerable variation attributed to the differing coatings on the pins. The study provides insights into optimizing stainless steel components for enhanced durability in harsh environments.

Keywords: 17-4 PH Stainless Steel, Conventional Manufacturing, Additive Manufacturing, Coatings, Microstructure analysis, Mechanical properties

Synthesis and Characterisation of Non-Equiatomic High-Entropy Alloy $Al_{0.2}Co_{1.5}Cr_xFeNi_{1.5}Ti$ Fabricated by Mechanical Alloying and Spark Plasma Sintering: Impact of Varying Chromium Content on Corrosion Resistance, Wear Resistance, Hardness, and Phase Evolution

Khushi Khandal, Avinish Khandelwal, Vidushi Makhija, Apoorva Vashishtha and Swati Sharma

Department of Metallurgical and Materials Engg., Malaviya National Institute of Technology Jaipur-302017
Email: swati.meta@mnit.ac.in

Abstract

The High-entropy alloys (HEAs) represent a novel class of materials that harness high configurational entropy, sluggish diffusion, severe lattice distortion, and the cocktail effect to achieve superior mechanical and functional properties. In this study, a non-equiatomic HEA with the nominal composition $Al_{0.2}Co_{1.5}Cr_xFeNi_{1.5}Ti$ (with x = 0.2, 0.4, 0.6, 0.8, and 1) was synthesized to explore the effect of varying chromium content on phase evolution, corrosion resistance, wear resistance, and hardness. Elemental powders were weighed and blended according to the specified stoichiometry and subsequently dry-milled in a planetary ball mill at 300 rpm with a ball-to-powder ratio of 10:1. Toluene was used as a process controlling agent to minimize cold welding and agglomeration. The as-milled powders were characterized using X-ray diffraction (XRD) (analyzed via X'Pert HighScore software), transmission electron microscopy (TEM), and CALPHAD calculations to elucidate phase formation and stability. The milled powders were then consolidated into bulk samples via spark plasma sintering (SPS) under a vacuum atmosphere. The SPS process involved heating from room temperature to 550 °C at 100 °C/min (with a 15-minute hold), followed by further heating to 1000 °C at 100 °C/min and then to 1150 °C at 20 °C/min with a final 20-minute hold at 1150 °C under 30 MPa, before cooling to room temperature. Post-sintering, density measurements (using the Archimedes method), XRD, scanning electron microscopy (SEM), corrosion tests, hardness (Vickers), and wear tests were performed to assess the consolidated alloy. The results reveal that chromium variation significantly influences phase formation and the resultant properties. An optimum Cr content promotes the development of a stable solid solution with refined microstructures, which in turn enhances corrosion and wear resistance as well as hardness and the localised corrosion was attributed to the formation of Co2Ti - type laves phase in non equiatomic HEA. The wear resistance of investigated HEA was found to be more than two conventional steels in certain conditions for (x=1). These improvements indicate the potential for tailoring the alloy for advanced high-temperature and structural applications. The enhanced performance of the optimized HEA makes it a promising candidate for high-temperature structural components, aerospace and automotive parts, marine applications, and advanced coating technologies where resistance to extreme conditions is critical.
Keywords: High entropy alloy, Mechanical alloying, Spark plasma sintering, Non-equiatomic, Phase evolution, Corrosion resistance, Wear resistance, Hardness.

Biopolymer based thin film for Wound Healing Application

[a]Hanana Abdul Majeed, [a]Chandramani Batsh, [a]Vineet Aniya

[a]Polymer and Process Engineering laboratory, Chemical Engineering & Process Technology Department, CSIR-Indian Institute of Chemical Technology, Hyderabad, India, 500007

Email: hanana0am@gmail.com

Abstract

Biopolymer-based patches, particularly those incorporating chitosan and its derivatives, have emerged as promising materials for wound healing applications. Chitosan, a natural polysaccharide derived from chitin, offers unique biocompatibility, biodegradability, antimicrobial properties, and the ability to promote cell growth, making it an ideal candidate for wound dressings. These chitosan-based patches create a protective barrier, maintain a moist environment, and facilitate faster healing by promoting tissue regeneration. Additionally, the incorporation of bioactive agents, nanoparticles, and growth factors into these films enhances their healing potential, making them ideal candidates for advanced biomedical applications such as hydrogels, nanofibers, and scaffolds. They will also highlight recent advancements and prospects in developing smart and multifunctional biopolymer films for improved wound management. In vitro cell culture studies demonstrate the cytocompatibility and bioactivity of chitosan-based patches, highlighting their ability to promote the growth of fibroblasts, keratinocytes, and endothelial cells, which are integral to wound healing. This review discusses the various formulations of chitosan-based patches, the mechanisms through which they facilitate wound healing, and their potential for clinical application. With the increasing need for effective wound management strategies, these biopolymer-based patches represent a significant advancement in modern wound care technology.

Pulse Laser-Synthesized Au@S,O GCN (Graphitic Carbon Nitride) Nanostructures for Enhanced dark & Visible Light-Driven Supercapacitor Applications

Ayele Ossa Leka[a], Pankaj Bhujbal'Sahil Saini,[a], Prathmesh Kadam,[b,] [a]Pratik Patil,[a], and Devnath Dhirhe[*]

[a]Advanced Laser Laboratory, Department of Applied Physics, Defence Institute of Advanced Technology, Pune, 411025, India. ;
[b]Savitrivai Phule Pune University, Pune Department of Physics
ayeleleka@gmail.com

Abstract

This study investigates the potential of graphitic carbon nitride (GCN) as an advanced electrode material for supercapacitor applications. Using a pulse laser synthesis technique, we developed Au-decorated sulfur and oxygen-co-doped GCN (Au-S, O-GCN) nanostructures. The synthesized material was characterized through various analytical techniques, confirming its amorphous and FCC crystal structures. FESEM and EDAX mapping verified the uniform incorporation of Au nanoparticles into the S, O-GCN matrix. The resulting Au-S, O-GCN, exhibits a high specific surface area, Extended Uv-visible absorption, excellent electrical conductivity due to AuNPs, and enhanced charge storage capability via localized surface plasmon resonance effects. These performances highlight the potential of Au-S, O-GCN as a promising electrode material for next-generation energy storage devices driven by visible light.

Influence of Increased Pozzolanic and Non-Pozzolanic Fines on the Volumetric Behavior of Mortar Under Various Curing Conditions

Pramendra Kumar, Md Marghoobul Haque, and Supratic Gupta

Department of Civil Engineering, Indian Institute of Technology Delhi, New Delhi-110016, India
Email: cez198632@iitd.ac.in

Abstract

Moisture diffusion in concrete is responsible for the movement of water in exposed concrete constructions. As a result, the moisture content of concrete fluctuates due to both time and space, and the moisture concentration of concrete is varying. The shrinkage occurs as a result of this moisture variation. Therefore, the current research investigates the effect of curing conditions, age, and mineral additives on the shrinkage of SCC mortar. The external non-conventional material studied is 35% fly ash, stone dust, and marble powder, whereas the curing conditions were fully immersed in water, lime, and 55% humidity with a 27°C-temperature chamber. The exposure time was kept different, and 4 different cases are studied. The mortar mix design prepared is based on the cementing efficiency of the material in order to achieve equal 28 days strength. The SCC mortar with a common base tried to be studied for shrinkage to properly investigate the effect of materials. The results reported that the stone dust has shown maximum shrinkage and swelling effect as compared to other materials irrespective of mineral admixture and curing condition. The 35% fly ash incorporated mortar resulted in more resistance to shrinkage as compared to other materials. The water and lime curing both showed swelling, whereas the other condition reported shrinkage of mortar.

Keywords: SCC Mortar, Shrinkage, Lime Curing, pozzolanic mineral admixture, non-pozzolanic mineral admixture

Design of Metal-Ceramic in-situ Interpenetrating Phase Composite (IPC) architecture for high toughness parts

[a]Jatin Kumar, [a]Yatheshth Bhandari, [a]Ujjawal Vyas, [a]Sreekumar VM

[a]Department of Metallurgical and Materials Engineering, MNIT Jaipur
Email: sreekumar.meta@mnit.ac.in

Abstract

Most modern toughening concepts for ceramics are based on the incorporation of a second phase into the ceramic matrix. The basic elements in the design of such composite structures are the choice of the toughening constituent, the microstructural scale and the architecture of the composite. The three dimensional interpenetrating phase composites (IPCs), whose architecture consists of a continuous matrix network penetrated by a continuous reinforcement network, can yield truly remarkable properties owing to their stability against microstructural coarsening and enhanced fracture resistance. The most common way of producing IPCs is infiltration of liquid metal into a porous ceramic perform However, channelling and improper filling of the pores create porosities often. In-situ IPCs can rectify most of the existing problems. In in-situ IPCs, the ceramic and metal networks are generated by certain thermodynamically feasible reactions. Reactively formed matrices and reinforcements of in situ composites are completely different from the starting reagents, they are thermodynamically compatible and are often arranged as interpenetrating networks. In situ processing of interpenetrating phase composites allows synthesizing significantly wide range of compositions. The starting reagents can be volatile oxides (SiO_2, TiO_2 etc) and metallic elements like Al, Mg, Ti, Cu etc. The thermite reaction between volatile oxides and metallic elements generates networks of Al_2O_3, $MgAl_2O_4$ interpenetrated with Al-Si, Al-Mg_2Si, TiAl alloy composites. In-situ IPCs show remarkable properties of toughened ceramics. The in-situ formation of ceramic phase induces a better metal-ceramic bonding with a perfect interface. They offer some distinctive mechanical and physical behaviours relative to the traditional Metal Matrix Composites (MMCs), such as high modulus, low coefficient of thermal expansion, low thermal mismatching between matrix and reinforcement, good thermal and electrical conductivities, advanced damage tolerance and wear resistance. The material can be tailored to a conductive ceramic material in an Al, Cu matrices. Simultaneously, the physical properties of the individual ceramics can be preserved. The research was focussed on the development of in-situ Al-Al_2O_3 IPCs using volatile oxide sources and their physical and mechanical property responses at various conditions.

$MoSe_2$ nanosheets as a cathode material for Gel Polymer Electrolyte based Zinc-air battery

[a]Sanjay Yadav, [a]Rajnish Dhiman

[a]Department of Physics, Malaviya National Institute of Technology Jaipur, Jaipur, India
Email: rajnish.phy@mnit.ac.in

Abstract

Transition metal dichalcogenides (TMDs) have gained attention of researchers due to the electrical and optoelectronic applications, hydrogen evolution, oxygen reduction reaction (ORR) and oxygen evolution (OER) capabilities. The MoSe2 is a two-dimensional layered TMD material, if synthesized in the forms possessing a high specific surface area, large number of edge sites, selenium vacancies etc. could have high electrochemical activity that can enhance the ORR and OER catalytic activity. Zn air batteries (ZABs) are the energy storage devices which use the phenomena of ORR and OER during the discharge and charge cycles of the device. Herein, the MoSe2 is synthesized in sheet like structures by a facile hydrothermal route using sodium molybdate and selenium metal powder as Mo and Se precursors at a temperature of 200ºC and are investigated as cathode material for ZABs. The battery devices fabricated using MoSe2 as air cathodes, Zn as anode and gel polymer electrolyte demonstrate an open circuit potential of 1.28 V and displayed a cycle life of 510 cycles (20 min per cycle) at a discharge current density of 5 $mAcm^{-2}$ and a cut off voltage of 1.0 V. The demonstrated high energy density, rate performance, and cycling stability establishes $MoSe_2$ as a potential electrocatalyst material for applications in Zn-air batteries.

Automation in the Process Route of Making Zirconium Alloy Ingots

[a]Ashutosh Shivhare*, [a]Sunil Goyal, [a]J. V. Rajkumar and [a]G. N. Ganesha

[a]Nuclear Fuel Complex, Kota project, Rawatbhata-323303, India
**Email: akshiv@nfc.gov.in*

Abstract

Zirconium alloys are deployed extensively in the thermal reactor due to their very low neutron absorption cross section, a desired nuclear property for thermal reactors. Zircaloy-4 is the candidate material for manufacturing Fuel bundle of Indian Pressurized heavy Water Reactors (IPHWRs). Manufacturing of Zircaloy-4 Ingots starts with compaction of reactor grade Zirconium Sponge (Hafnium free) along with alloying elements in Hydraulic press to form a cylindrical briquette of 135 mm length. Multiple briquettes are tag welded under vacuum in Electron Beam welding Unit to form a long cylindrical rod which is used as consumable electrode in Vacuum Arc Re-melting (VAR) furnaces to produce Zircaloy Ingots. The material is melted two times in VAR furnace to get homogeneous Zircaloy-4 Ingots with low volatile impurities of Diameter 350 mm and 3000 mm long.

Traditionally, these operations are carried out manually. At NFC Kota, several process improvements are carried out introducing innovative automations to improve the consistency of product, reliability, work place safety leading to overall productivity. The complete process of producing the Zircaloy-4 Ingot includes feeding of alloying elements and zirconium sponge in the press die cavity, precise weighing of Zr-sponge and the alloying elements, very strict control of operation parameters during EBW welding and melting in VAR furnace. This paper briefly describes various process improvements that have been carried out and the results obtained. With the above improvements around 200MT of Zircaloy4 Ingots has been produced, qualifying the stringent requirement of chemical composition and non-destructive testing.

Keywords: Zircaloy-4, Vacuum Arc Re-melting and Process Automation

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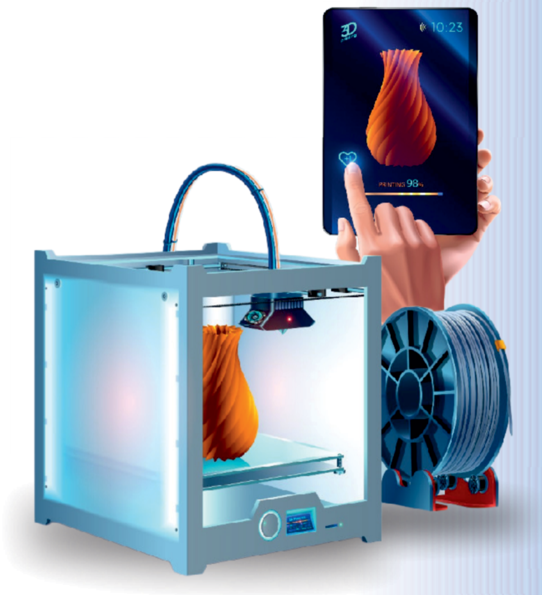

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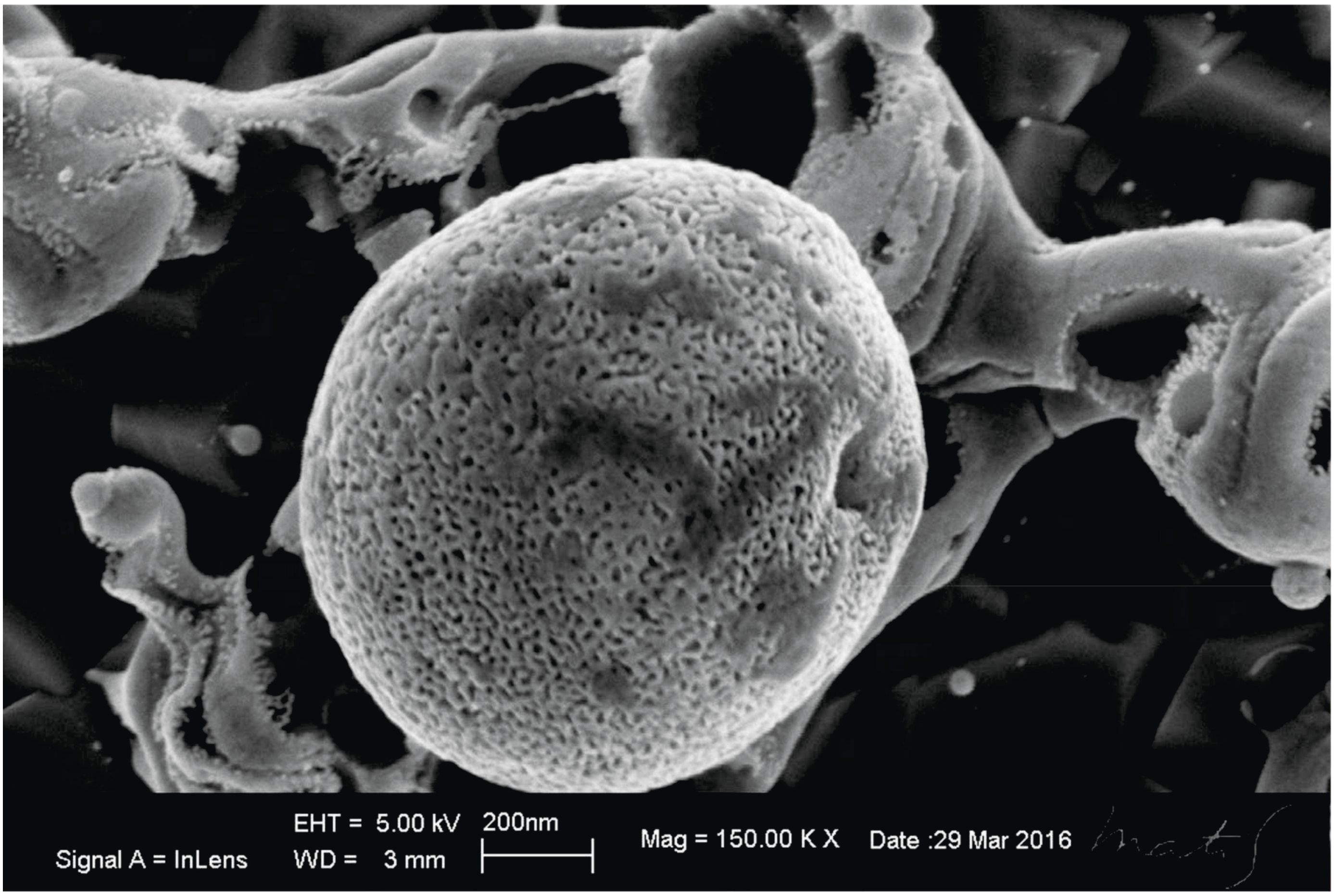

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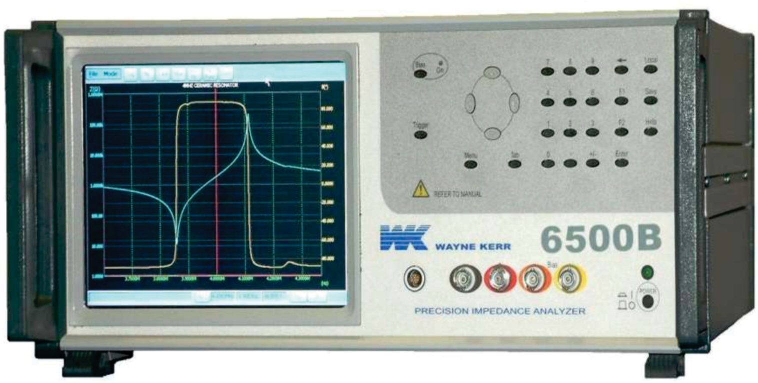

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- **Keyboard and mouse control with Pen drive option for data storage**

Accessories / options available:

High & Low Temperature Setup: LN2 to ambient / 500degC, Ambient to 250degC, Ambient to 500degC, Ambient to 1000degC and above, (custom built furnaces also available)
Cryo Industries of America, U.S Products: CCR's, Cryostats, Cryocooler, Electromagnets and Microscopy Workstations for temperature ranges 2K ~ 325K / 800K, 4K ~ 325K / 800K, 10K ~ 325K / 800K
Sample holders suitable for use with temperature controller furnaces: Solids & Liquids Sample holders, Di-electric Sample holder, Low temperature sample holders for LN2 to Ambient etc.
Software: For control, view, recording in tabular / excel form, graphical representation; Plot of Parameters vs Frequency / DC bias / AC level / Temperature and Data-Fitting software,

Wayne Kerr Electronics

Wayne Kerr Electronics Pvt. Ltd.,

410, KM Trade Tower, Hotel Radisson Building
Sector - 14, Kaushambi, Ghaziabad, UP - 201010
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Mob. No: 8800544566/9910339018 E-mail : sales@waynekerr.co.in

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अनुप्रयोग
APPLICATIONS

परमाणु उत्पाद
NUCLEAR PRODUCTS

राष्ट्र की सेवा में परमाणु
एन एफ सी
NFC
ATOMS IN THE SERVICE OF THE NATION

तट्यूबलर उत्पाद
TUBULAR PRODUCTS

नाभिकीय ईंधन सम्मिश्र NUCLEAR FUEL COMPLEX

परमाणु ऊर्जा विभाग की एक इकाई A Unit of Department of Atomic Energy, भारत सरकार Govt. of India
(आई.एस.ओ.9001, 14001 & 45001 संगठन ISO 9001, 14001 & 45001 Organization)

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Ph.: +91-40- 2712 1239 / 2718 4224, Fax: +91-40- 2712 1209 E-mail: marketing@nfc.gov.in




MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR
Department of Metallurgical and Materials Engineering

About the Institute

MNIT Jaipur was established in 1963 by the Government of India. On June 26, 2002, it earned the status of a National Institute of Technology (NIT) and became a Deemed University. MNIT Jaipur stands 43rd in NIRF ranking (2024) in the Engineering category.

- UG & PG admission occurs through CSAB, CCMT & CCMN.

Total Sponsored project: 590+ | **Total journal Publications: 8150+**

About the Department

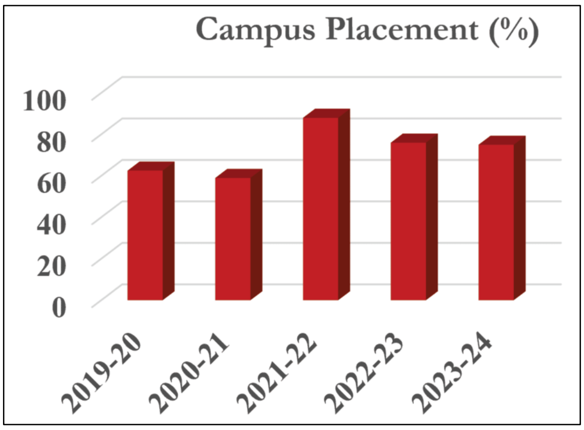
- **Established in 1965**
- **Offers B. Tech, M. Tech, Ph.D.**
- **Faculty: 16**

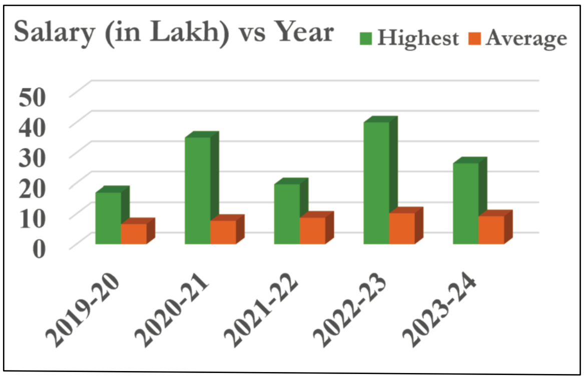
Achievements in last 5 years:

- **Total funding: > 620 lakhs**
- **Journal Publications: >120**
- **UG & Research labs: 20**
- **Patent filed/ granted : 20**
- **3-4 students secure top 100 AIR in GATE**

Research Labs: High-temperature XRD, DSC, UTM (Instron 8862), Advanced Composite, Mineral Processing, Foundry, Welding, Powder Metallurgy, Surface Engineering etc.

Collaborations with: IITs, NITs, CSIR lab, and other industries.





Prestigious Fellowship

- DAAD WISE Fellowship
- PMRF for Ph.D.
- IASc-INSA-NASI
- Ministry of Tribal Affairs India
- OPJEMS Scholarship

खान मंत्रालय MINISTRY OF MINES | इस्पात मंत्रालय MINISTRY OF STEEL | विज्ञान एवं प्रौद्योगिकी मंत्रालय MINISTRY OF SCIENCE AND TECHNOLOGY | इसरो isro | DRDO | BARC | SERB INDIA

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