ICFCM

2025 the 8th International Conference on Frontiers of Composite Materials

ICSMR

2025 the 9th International Conference on Smart Material Research

Tokyo, Japan
June 9-11, 2025

Conference Venue

東京理科大学
TOKYO UNIVERSITY OF SCIENCE

Morito Memorial Hall 森戸記念館

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Ramesh K. Agarwal, Washington University in St. Louis, USA

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CONFERENCE VENUE

Morito Memorial Hall
森戸記念館
Tokyo University of Science, Kagurazaka Campus

Address: 4-2-2 Kagurazaka, Shinjuku-ku, Tokyo

東京都新宿区神楽坂 4-2-2

https://www.tus.ac.jp/en/campus/kagurazaka.html

The Kagurazaka campus is located in the heart of Tokyo, making it convenient for commuting students but also providing easy access to the institutions and facilities students need to support their learning and research. The campus features a concentration of educational and research facilities and the rich university experiences available only to students in an urban setting.

In addition, this downtown campus offers opportunities to experience the connections between academics and the community, with sophisticated professional educational opportunities; collaboration among government, business, and academic organizations; and enhanced support functions for startup companies.

Note: The organizer doesn't provide free accommodation nor booking service. We suggest you to make early reservation!

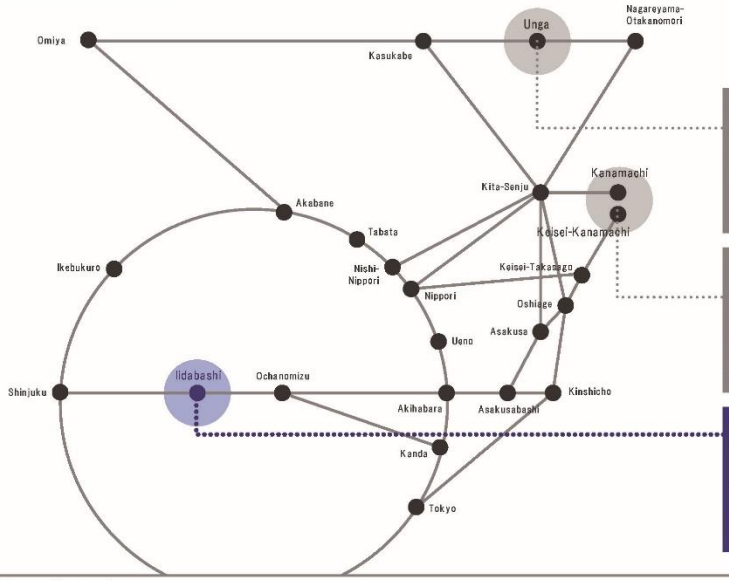
Tokyo University of Science

Kagurazaka Campus

1-3 Kagurazaka,Shinjuku-ku,Tokyo 162-8601

Located 3 minutes' walk from Iidabashi Station, accessible via the JR Sobu Line, the Tokyo Metro Yurakuchom, Tozai and Namboku Lines, and the Oedo Line.

ACCESS MAP



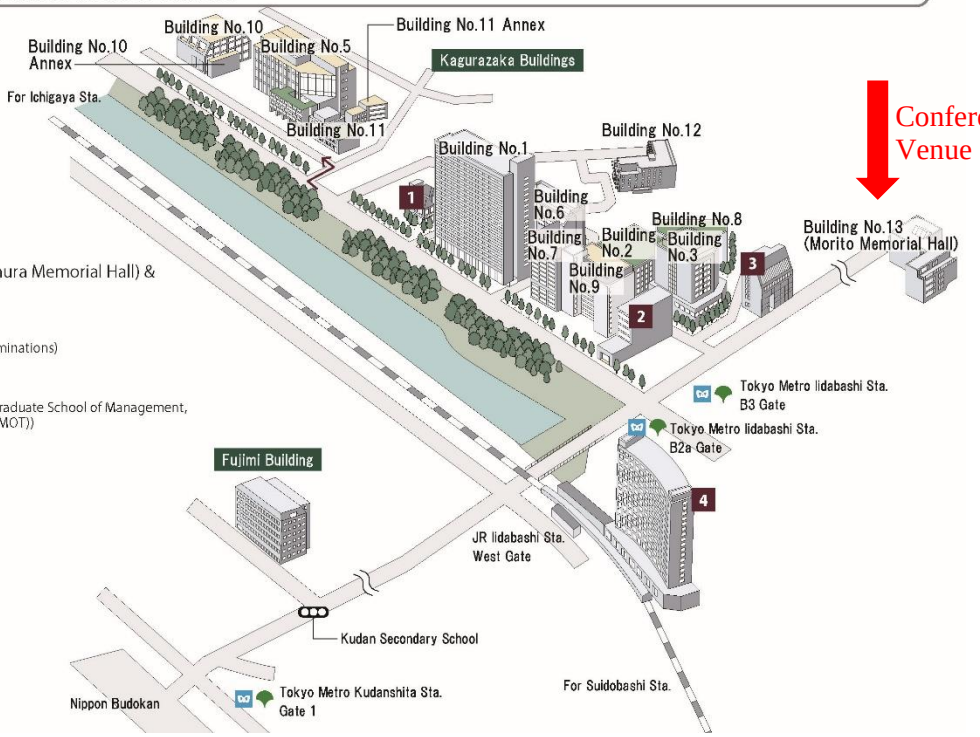
Noda Campus
2641 Yamazaki, Noda-shi, Chiba Prefecture 278-8510

Katsushika Campus
6-3-1 Niijuku, Katsushika-ku, Tokyo 125-8585

Kagurazaka Campus
1-3 Kagurazaka, Shinjuku-ku, Tokyo 162-8601

- **From Narita Airport**
  Take the JR Narita Express train to Tokyo Station. Transfer to the JR Yamanote Line / Keihin-Tohoku Line and take it to Akihabara Station. Transfer to the JR Sobu Line and take it to Iidabashi Station. Travel time: about 1 hour 30 minutes.
- **From Haneda Airport**
  Take the Tokyo Monorail Line to Hamamatsucho Station. Transfer to the JR Yamanote Line / Keihin-Tohoku Line and take it to Akihabara Station. Transfer to the JR Sobu Line and take it to Iidabashi Station. Travel time: about 45 minutes.
- **From Tokyo Station**
  Take the JR Chuo Line to Ochanomizu Station. Transfer to the JR Sobu Line and take it to Iidabashi Station. Travel time: about 10 minutes.
- **From Shinjuku Station**
  Take the JR Sobu Line to Iidabashi Station. Travel time: about 12 minutes.

CAMPUS MAP



1. The Museum of Science, TUS (Futamura Memorial Hall) & Mathematical Experience Plaza
2. Futaba Building
   (First floor: Center for University Entrance Examinations)
3. PORTA Kagurazaka 4th & 5th floors
   (Graduate School of Innovation Studies and Graduate School of Management, Department of Management of Technology (MOT))
4. CENTRAL PLAZA 2nd floor
   (TUS Open College)

GENERAL INFORMATION

Oral Presentation

1. Timing: a maximum of 15 minutes total, including speaking time and discussion. Please make sure your presentation is well timed. Please keep in mind that the program is full and that the speaker after you would like their allocated time available to them.
2. You can use USB flash drive (memory stick), make sure you scanned viruses in your own computer. Each speaker is required to meet her/his session chair in the corresponding session rooms 10 minutes before the session starts and copy the slide file(PPT or PDF) to the computer.
3. It is suggested that you email a copy of your presentation to your personal inbox as a backup. If for some reason the files can't be accessed from your flash drive, you will be able to download them to the computer from your email.
4. Please note that each session room will be equipped with a LCD projector, screen, point device, microphone, and a laptop with general presentation software such as Microsoft PowerPoint and Adobe Reader. Please make sure that your files are compatible and readable with our operation system by using commonly used fronts and symbols. If you plan to use your own computer, please try the connection and make sure it works before your presentation.
5. Videos: If your PowerPoint files contain video clips please make sure that they are well formatted and connected to the main files.

Poster Presentation

- Bring your high-resolution printed poster with you to the meeting (size must not exceed A1 [594mm×841mm]).
- Set up your printed poster at least one hour before your session start time on the day you are scheduled to present.
- Presenters must remove their printed posters immediately after the poster session.

Dress Code

Please attend the conference in formal attire.

Conference Photos

All the conference photos will be available for download through conference website within one week after the conference.

Accommodation

The conference organizer doesn't provide free accommodation or room reservation service. Participants should book rooms by themselves.

Safety Reminder: Secure Valuable Items at All Times

We remind you to secure your personal belongings at all times.
Please remember to:
* Wear your Conference Identification Badge at all times. Do not throw away Badge.
* If you are using a laptop computer, do not leave it unattended at any time.
* Keep your purse, wallet and other valuables with you at all times.
* The conference organizer will not be responsible for the loss or damage to any personal belongings.

SCHEDULE AT A GLANCE

June 9, 2025 | Monday Meeting Room 2, 2F, Morito Memorial Hall			
13:00-17:00	Participants Registration & Conference Kits Collection		
June 10, 2025 | Tuesday Morito Memorial Hall			**Room**
09:45-09:50	Opening Remarks	**Prof. Kazuo Umemura**, Tokyo University of Science, Japan	Meeting Room 1, 2F
09:50-10:30	Keynote Speech	"*Environmentally Responsible Biodegradable 'Green' Composites*" **Prof. Ramesh K. Agarwal**, Washington University in St. Louis, USA	
10:30-10:50	Group Photo & Coffee Break		
10:50-11:30	Keynote Speech	*"From Macroscopic Near-Infrared Spectroscopy to Microscopic Near-Infrared Microscopy"* **Prof. Kazuo Umemura**, Tokyo University of Science, Japan	Meeting Room 1, 2F
11:30-12:00	Invited Speech	*"Multiscale Modelling and Experimental Verification of Interactive Characteristics of Delamination Damage of Composite Laminates"* **Prof. Shuxin Li**, Wuhan University of Technology, China	
12:00-13:00	Lunch @ Meeting Rooms, 2F, Morito Memorial Hall		
13:00-15:15	Session 1	Biomedical Innovations: Smart Composites for Drug Delivery and Tissue Engineering	Forum 2, 1F
	Session 2	Surface Engineering and Coatings for Enhanced Composite Performance	Meeting Room 3, 2F
	Session 3	High-Temperature and Electromagnetic Functional Composites for Extreme Environments	Meeting Room 2, 2F
15:15-15:30	Coffee Break		
15:30-17:45	Session 4	Sustainable Composites and Advanced Manufacturing Techniques	Forum 2, 1F
	Session 5	Advanced Mechanical Performance and Numerical Modeling of Composite Structures	Meeting Room 3, 2F
15:30-16:30	Posters	Multifunctional Composites: Fabrication, Processing, and Smart Integration	Meeting Room 2, 2F
18:00-19:00	Dinner Banquet @ Churrasco Restaurant ALEGRIA Kagurazaka		
June 11, 2025 | Wednesday Tokyo University of Science			
11:30-12:30	Lab Visit Gathering Point @ Morito Memorial Hall		

KEYNOTE SPEAKER

June 10th | 09:50-10:30
Meeting Room 1, 2F
Zoom Link: https://us02web.zoom.us/j/89830328629

Prof. Ramesh K. Agarwal

Washington University in St. Louis, USA

Bio: Professor Ramesh K. Agarwal is the William Palm Professor of Engineering in the department of Mechanical Engineering and Materials Science at Washington University in St. Louis. From 1994 to 2001, he was the Sam Bloomfield Distinguished Professor and Executive Director of the National Institute for Aviation Research at Wichita State University in Kansas. From 1978 to 1994, he was the Program Director and McDonnell Douglas Fellow at McDonnell Douglas Research Laboratories in St. Louis. Dr. Agarwal received Ph.D in Aeronautical Sciences from Stanford University in 1975, M.S. in Aeronautical Engineering from the University of Minnesota in 1969 and B.S. in Mechanical Engineering from Indian Institute of Technology, Kharagpur, India in 1968. Over a period of forty years, Professor Agarwal has worked in various areas of Computational Science and Engineering - Computational Fluid Dynamics (CFD), Computational Materials Science and Manufacturing, Computational Electromagnetics (CEM), Neuro-Computing, Control Theory and Systems, and Multidisciplinary Design and Optimization. He is the author and coauthor of over 500 journal and refereed conference publications. He has given many plenary, keynote and invited lectures at various national and international conferences worldwide in over fifty countries. Professor Agarwal continues to serve on many academic, government, and industrial advisory committees. Dr. Agarwal is a Fellow eighteen societies including the Institute of Electrical and Electronics Engineers (IEEE), American Association for Advancement of Science (AAAS), American Institute of Aeronautics and Astronautics (AIAA), American Physical Society (APS), American Society of Mechanical Engineers (ASME), Royal Aeronautical Society, Chinese Society of Aeronautics and Astronautics (CSAA), Society of Manufacturing Engineers (SME) and American Society for Engineering Education (ASEE). He has received many prestigious honors and national/international awards from various professional societies and organizations for his research contributions.

Environmentally Responsible Biodegradable 'Green' Composites

Abstract: Most advanced composites currently available are made using non-degradable polymeric resins such as epoxies, esters, polyurethane, etc., and high strength and/or high stiffness fibers such as graphite, aramids, and glass, designed for long term durability. While they have desirable mechanical, thermal and chemical properties, they have two major disadvantages. First, the materials used are not sustainable; the high performance fibers (except glass) and resins are almost entirely derived from petroleum, and secondly these composites are non-degradable under normal environmental conditions. In recent years, the growing environmental concerns have pushed research in the area of bio-degradable green composites since they do not require petroleum (source of greenhouse gas emissions) and land-fills at the end of their lives. In green polymer composites, one of the two chemicals from which they are synthesized can be produced sustainably reducing their carbon footprint. For example, polyurethanes (PU) can now be produced using polyols from soybean oil, polyethylene terephthalate (PET) from ethylene glycol, and polybutylene succinate (PBS) from succinic acid. Use of renewable plant-based lignocellulosic fibers has been a natural choice for reinforcing (or filling) polymers to make them greener. Plenty of examples can be found where plant-based fibers are used for reinforcing non-degradable thermoplastic polymers such as PP, high, medium, and low density polyethylene (HDPE, MDPE, LDPE), nylons, polyvinylchloride (PVC), and polyesters as well as thermoset resins such as epoxies and esters to produce greener composites. Due to their good mechanical properties, longer plant-based fibers, extracted from the stems or leaves of plants such as abaca, bamboo, flax, henequen, hemp, jute, kenaf, pineapple, ramie, sisal, etc., are being evaluated as low cost alternative reinforcements to commonly used glass fibers to make composites. These fibers are annually renewable, as compared to wood which takes 20 – 25 years to grow before it can be cut and used. Significant research efforts are currently being spent in developing a new class of fully biodegradable or compostable green composites by combining natural fibers with biodegradable resins. Most of the current technology is still in the research and development stage. This presentation will review some of these developments and their current and potential applications, especially in construction and transportation sector.

KEYNOTE SPEAKER

June 10th | 10:50-11:30
Meeting Room 1, 2F

Prof. Kazuo Umemura

Tokyo University of Science, Japan

Bio: Dr. Kazuo Umemura is a full professor of Tokyo University of Science. His specialty is biophysics, especially, nanobioscience and nanobiotechnology. One of his recent interests is nanoscopic research of hybrids of biomolecules and carbon nanotubes (CNTs). Unique structures and physical/chemical properties of the hybrids are promising in biological applications such as nanobiosensors and drug delivery.

Dr. Umemura received his B.S. degree in Physics from Nagoya University. His M.S. and Ph.D. degrees were given from Tokyo Institute of Technology. After working at several institutes/universities as a researcher in Japan and in China, he became a professor of Tokyo University of Science. Kagurazaka campus of Tokyo University of Science is located at the center of Tokyo, so five subway/railway lines reach in front of the campus.

From Macroscopic Near-Infrared Spectroscopy to Microscopic Near-Infrared Microscopy

Abstract: Near-infrared (NIR) optical responses of nanocarbons such as single-walled carbon nanotubes (SWNTs) have been widely applied to various industrial applications. Biological applications using SWNT optical responses are also promising approaches because biomolecules normally do not have absorbance or photoluminescence (PL) in NIR ranges. It is easy to distinguish optical spectra of SWNTs from those of biomolecules in NIR area.

Using the unique optical responses, various biosensing techniques have been proposed. One of the excellent approaches is the proposal of glucose sensors by several independent research groups. Glucose oxidases were attached on mono-dispersed SWNT surfaces. Then, glucose solutions were injected to the SWNT aqueous suspensions. Reactions of the injected glucoses and glucose oxidases can be detected as changes of absorbance or PL spectra of SWNTs. SWNTs decorated with glucose oxidase molecules were recognized as a nano-size glucose sensor.

The biosensing techniques have been demonstrated with absorbance or PL spectra. In that case, SWNT suspensions were inserted in an optical corvette, and then, optical responses of SWNTs were macroscopically detected. Although SWNT devices were nano-size, measurements were macroscopically carried out.

Recently, microscopic detection of SWNT PL have been demonstrated by several challenging authors. Functionalized SWNTs were deposited on a coverslip, and then, individual SWNT molecules or aggregates of SWNTs were visualized by NIR optical microscopes. By this approach, optical responses of SWNTs could be detected under microscopic observations. In this talk, I will introduce both macroscopic and microscopic approaches to apply SWNTs to biosensing.

INVITED SPEAKER

Prof. Shuxin Li

June 10th | 11:30-12:00
Meeting Room 1, 2F

Wuhan University of Technology, China

Bio: Emeritus Prof. & Chief Scientist, Wuhan University of Technology. Fellow of Institution of Mechanical Engineers (FIMechE), Former Engineering Executive and Technical Authority at a leading international aeronautics company, Senior Visiting Research Fellow of University of Bristol. Over 35 years research and industrial experience in advanced engineering materials and structures. Scientific research focuses on basic science and technology combined with applications in aviation, automobile and transportation, energy, and ocean engineering. Extensive expertise on integration of material/ manufacturing/ design/ evaluation multidisciplinary research on composite structures and production of composite components. Research outputs have become industrial material specifications, manufacturing guidelines, structural design principles, certification procedures, in-service safety evaluation standards in the related engineering fields. Over 100 high-level scientific research papers published on international top journals in composites fields.

Multiscale Modelling and Experimental Verification of Interactive Characteristics of Delamination Damage of Composite Laminates

Abstract: Interlaminar fracture or delamination is one of the most damaging failure modes of fiber-reinforced composite laminates in engineering application such as aircraft components. Damage tolerance assessment for composite structures, such as the FAR 25 and CS-25 airworthiness regulations, are required to consider the interactions of different failure mechanisms during delamination initiation and propagation. In this study, multiscale cohesive zone model (CZM) based on the different physical deformation and damage mechanisms are developed to investigate the interactive characteristics between the microscale material damage mechanism ahead and the macroscale fiber bridging behind the delamination crack tip. Consequently, numerical simulations of the deformation and fracture damage features observed in the various delamination damage growth experiments are carried out and compared with the experimental results to validate the proposed multiscale modelling. The investigation indicated that the geometrical and stacking sequences dependent delamination fracture features such as R-curve effects commonly observed in the experimental results are attributed to the progressive development of the extrinsic toughening mechanisms associated with macroscale fiber bridging behind the delamination crack tip. The influence of the intrinsic mechanism associated with the microscope material damage mechanisms ahead of the delamination crack tip is insignificant. Therefore, it is possible to determine the intrinsic fracture toughness of the composite material by distinguishing and excluding the influence of the extrinsic toughening mechanism associated with macroscope fiber bridging observed in the testing. The progressive development of the macroscale fiber bridging is also attributed to the various delamination crack growth behavior under cyclic loading with different delamination length. The failure of Paris Law to correlate the delamination growth rate da/dN with various cyclic energy parameters such as maximum cyclic energy and cyclic energy range, as well as the R ratio effect, of the delamination damage growth can be attributed to the nonlinear deformation and damage characteristics induced by the extrinsic toughening mechanism associated with the macroscale fiber bridging. The classical Paris Law widely used for the fracture crack propagation of metallic materials must be modified based on the multiscale deformation and damage mechanisms associated with the delamination deformation and fracture crack growth of the composite material.

Session 1 - Biomedical Innovations: Smart Composites for Drug Delivery and Tissue Engineering

Chairperson: Kazuo Umemura, Tokyo University of Science, Japan

Time: 13:00-15:15, June 10th | **Room: Forum 2, 1F**

*Note: The schedule of each presentation is for reference only. Authors are required to attend the whole session, in case there may be some changes on conference day. Please join in the room 5-10 minutes earlier.

CM25-319-A

13:00-13:15

HydroWrap for T2DM-Related Fractures: A Smart H_2S-Delivery Controller Modulating Macrophage Senescence

Jing Wang
The Fourth Military Medical University, China

Abstract: Type 2 diabetes mellitus (T2DM) is closely associated with impaired fracture healing, largely due to a dysregulated bone microenvironment driven by macrophage senescence and its subsequent senescence cascaded effects. Reduced hydrogen sulfide (H_2S) levels have been identified as a key contributor to this pathology. To address this, we developed HydroWrap, a dual-responsive H_2S-delivery controller designed to target different stages of macrophage senescence, and promote fracture healing in T2DM.

CM25-365-A

13:15-13:30

FFT2 Multiscale Method for Modeling the Failure Behaviors of Fiber Reinforced Composites

Bing Wang
Harbin Institute of Technology, China

Abstract: We propose a novel FFT2 parallel multiscale computational method to predict the nonlinear behavior and failure of composite materials. Unlike traditional multiscale methods, the proposed approach reformulates the mechanical boundary value problem into Lippmann-Schwinger type integral equations at both the micro- and macro-scale, thereby leveraging the numerical efficiency of the fast Fourier transform (FFT) method at both scales. The application of generic (e.g. non-periodic) boundary conditions at the macro-scale is carried out by using the virtual boundary technique and buffer zones. In addition, the introduction of a clustering algorithm further improves the computational efficiency of the numerical method during the information transfer between scales. To ensure accurate damage prediction and mitigate spurious strain localization at both scales, suitable regularization techniques are employed. The proposed multiscale method is applied to investigate the transverse tension of unidirectional composite dog-bone specimens. After experimental verification, the method is applied to simulate 2D and 3D brittle fracture, elasto-plastic damage, and examples with non-uniform material orientation. The results demonstrate the robustness and adaptability of the clustering approach, which achieves up to 65.90-fold speedup and 81.62-fold reduction in memory usage compared to non-clustered multiscale methods, while maintaining a comparable level of accuracy.

CM25-401A

13:30-13:45

Layout Evaluation of the Effects of Metal-Organic Framework (ZIF-8) Nanoparticles as Carriers for PARPi (Olaparib) on Photothermal/ Photodynamic Therapy in Triple-Negative Breast Cancer Cells under Near-Infrared Light

Yu-Tung Yen, Shi-Chan Teng, Wen-Cheng Wang, Tzu-Hao Huang, Yi-Chun Chen, Ku-Fan Chen, Chia-Hua Lin
National Chi Nan University, Taiwan

Abstract: Triple-negative breast cancer (TNBC) is one of the most aggressive forms of breast cancer, posing a severe threat to women’s health and lives. In recent years, the incidence and mortality rates of TNBC have been on the rise, with tumour metastasis being the primary cause of death among TNBC patients. Due to the lack of effective targeted therapies against endocrine or HER2 pathways, there is an urgent need for new treatment options for TNBC patients. This study focuses on zeolitic imidazole frameworks (ZIFs) and poly (ADP-ribose) polymerase (PARP) inhibitors (Olaparib), exploring the unique properties of the metal-organic framework ZIF-8. We investigated the delivery of PARPi anti-cancer drugs to TNBC cells using ZIF-8 and evaluated their cytotoxicity. Additionally, we assessed the efficacy of photothermal therapy (PTT) and photodynamic therapy (PDT) based on ZIF-8 nanoparticles under near-infrared light, testing the synergistic effects of PTT and PDT. This helped us

understand the interactions between ZIF-8 nanoparticles, cancer treatment drugs, and TNBC cells. We synthesized multifunctional nanoparticles composed of ZIF-8 and encapsulated PARP inhibitor (Olaparib). As a subclass of metal-organic frameworks (MOFs), ZIF-8 is a novel crystalline porous material that can effectively control the pH-responsive release and delivery of drugs in biomedical applications. The results showed that ZIF-8@Olaparib achieved a drug release efficiency of 50-60% and exhibited excellent photothermal conversion and reactive oxygen species (ROS) generation efficiency under 808nm near-infrared irradiation. This led to irreversible damage to MDA-MB-436 cells at low concentrations. Our findings indicate that that integrating PTT and PDT effects into ZIF-8@Olaparib multifunctional nanoparticles provides a more effective cancer treatment method compared to traditional chemotherapy drugs. Moreover, ZIF-8@Olaparib combines the advantages of ZIF-8, demonstrating excellent biocompatibility and anti-tumour capabilities. It shows great potential for drug delivery in future clinical research on cancer treatment.

CM25-320-A

13:45-14:00

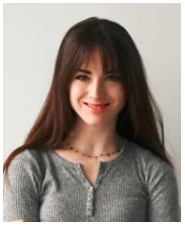
Sustained Therapeutic Effects of Self-Assembled Hyaluronic Acid Nanoparticles Loaded with α-Ketoglutarate in Various Osteoarthritis Stages

Xinli Wang, Xinyu Wang, Pengfei Han, Pengrui Bao, Yanchen Li, Yafei Feng
The Fourth Military Medical University, China

Abstract: Osteoarthritis (OA) is a prevalent degenerative disease characterized by irreversible destruction of articular cartilage, for which no current drugs are known to modify its progression. While intra-articular (IA) injections of hyaluronic acid (HA) offer temporary relief, their effectiveness and long-term benefits are debated. Alpha-ketoglutarate (αKG) has potential chondroprotective properties, but its use is limited by a short half-life and poor cartilage-targeting efficiency. Here, we developed self-assembled HA-αKG nanoparticles (NPs) to combine the benefits of both HA and αKG, showing stability, bioavailability, and sustained pH-responsive release in the knee joint. In both early and advanced OA stages in mice, HA, αKG, and HA-αKG NPs could relieve pain, enhance mobility, and reduce cartilage damage, with HA-αKG NPs demonstrating the best efficacy. Mechanistically, αKG not only promotes cartilage matrix synthesis but also inhibits degradation by activating the PERK-ATF4 signaling pathway to reduce endoplasmic reticulum stress (ERS) in chondrocytes. This study highlights the therapeutic potential of HA-αKG NPs for treating various OA stages, with efficient and sustained effects, suggesting rapid clinical adoption and high acceptability among clinicians and patients.

CM25-362-A

14:00-14:15



Sustainable Conductive Composites: Biodegradable Breakthroughs in Printed Electronics & Biomedical Applications

Sandra Lepak-Kuc, Aleksandra Kądziela
Warsaw University of Technology, Poland

Abstract: The rapid expansion of the electronics industry has raised critical environmental concerns, including electronic waste accumulation, the use of toxic materials, and the ecological footprint of conventional manufacturing processes. Addressing these challenges requires the development of sustainable, biodegradable electronic materials that can replace traditional, non-recyclable components while maintaining high performance. This is particularly crucial in disposable biomedical applications, where transient electronics must combine functionality with environmental responsibility.

CM25-420

14:15-14:30

Luminescent Metal-Ceramic Phosphor Composite

Lien-Hui Kan, Chen-Yu Wu, Huei-Fen Chen, **Horng-Yi Chang**
National Taiwan Ocean University, Taiwan

Abstract: When solar energy irradiates conductive metal surfaces, it is primarily converted into heat due to the generation of eddy currents on the metal surface. However, combining metals with inorganic ceramic long-persistent phosphors enables the storage and reuse of solar energy. In this study, a chemical precipitation method was employed to coat nickel precursors onto $SrAl_2O_4:Eu^{2+},Dy^{3+}$ (SAO) ceramic phosphors, which emit a broad green spectrum at 520 nm under 440 nm excitation. A uniform nickel shell was successfully deposited on the surface of the phosphor particles, with only a slight decrease in photoluminescence intensity. The formation of a complete shell layer was confirmed through EDS elemental mapping analysis. Advanced oxidation heat treatment effectively produced a NiO shell and enhanced the structural integrity of $SrAl_2O_4$. Subsequent reduction heat treatment converted the NiO into a

metallic nickel shell. This metallic layer improved the wettability and interfacial bonding between SAO and nickel backbone, providing increased resistance to mechanical stress. Due to the larger surface area of the foamed nickel structure, the resulting porous phosphor composite demonstrated superior luminescent performance compared to traditional phosphor-metal castings. This innovative phosphor-metal composite shows great potential for novel lighting applications in the metal and lighting industry.

CM25-364-A

14:30-14:45

In-Situ Identification of Mechanical Properties of Component Materials in Ceramic Matrix Composites using Model Order Reduction and Bayesian Method

Bo Gao
Harbin Institute of Technology, China

Abstract: A novel method is proposed for identifying the mechanical properties of in-situ component materials in ceramic matrix composites using macro-mechanical test data. First, the computational efficiency of meso-mechanical modeling with damage behavior is enhanced through the model order reduction method. Next, sensitivity analysis is integrated into the Bayesian network to reduce the number of simultaneously identified parameters, mitigating the ill-posedness of the inverse problem. The method is validated through numerical and experimental case studies. In the numerical case with 5% Gaussian noise, the maximum parameter identification error is 6%, while the strength prediction error is only 2%. For the experimental case, the stress-strain curve derived from the identified parameters agrees well with empirical data, exhibiting a mere 2% error in strength prediction. To our surprise, the maximum deviation of properties between the identified results and reference literature values reaches 50%, underscoring the critical importance of in-situ property identification for accurate characterization.

CM25-322-A

14:45-15:00

Breaking the Cocoon into Steel: A Breakthrough in Clinical Use of Biodegradable Silk Fibroin-Based Cannulated Screws for Fracture Fixation

Wei Cao, Tianji Wang, Geng Xiang, Keyin Liu, Tiger H Tao, Wei Lei and **Yafei Feng**
The Fourth Military Medical University, China

Abstract: Biodegradable materials offer significant advantages, including the avoidance of secondary surgical interventions, reduction of stress-shielding effects, enhanced mechanical adaptability, and elimination of imaging artifacts. Leveraging the programmable degradation properties of silk fibroin, we refined the fabrication process to design a novel silk fibroin-based biodegradable implant. This study aimed to evaluate the safety and feasibility of these implants for stable fracture fixation in weight-bearing areas, using both sheep models and human patients.

CM25-327

15:00-15:15

Enhancement of Bambusa Blumeana Fiber-Reinforced Concrete’s Structural Performance Through Alkali-Silane Treatment

Melvin Dayao, **Dean Robin De Leon** and Jeremiah Millare
Mapua University, Philippines

Abstract: Bamboo fibers, sustainable and renewable resources, have gained significant interest as a reinforcement material in concrete. However, the hydrophilic nature of bamboo fibers limits their compatibility with the concrete matrix. To improve the interfacial bonding and mechanical properties of bamboo fibers, an alkali-silane treatment was employed to modify the fiber surface. This study investigated the effects of alkali-silane treatment, with varying silane concentrations, on the chemical composition, thermal stability, surface morphology, and mechanical properties of bamboo fibers. Treated and untreated fibers were incorporated into concrete composites and subjected to mechanical tests, which include splitting tensile strength, flexural strength, and compressive strength tests. FTIR spectra, TGA curves, and SEM micrographs identified that the alkali-silane treatment with a 5% NaOH and 10% KH570 (3-Methacryloxy-propyltrimethoxy-silane) solution was most effective in improving fiber properties and concrete composite performance. The treated fiber-reinforced concrete composites exhibited significantly-improved splitting tensile strength, flexural strength, and compressive strength compared to untreated fiber-reinforced and non-reinforced concrete. These findings demonstrate the potential of alkali-silane-treated bamboo fibers as a promising reinforcement material for sustainable concrete composites.

Best Presentation Award & Session Group Photo

Session 2 - Surface Engineering and Coatings for Enhanced Composite Performance

Chairperson: Moosa Salim Al Kharusi, Sultan Qaboos University, Oman

Time: 13:00-15:15, June 10th | **Room: Meeting Room 3, 2F**

*Note: The schedule of each presentation is for reference only. Authors are required to attend the whole session, in case there may be some changes on conference day. Please join in the room 5-10 minutes earlier.

CM25-316-A

13:00-13:15

Surface Micro-Nano-Structure Optimization of C/C Composites and Its Brazing to Copper

Binyao Cao, Qiang Song, Xiaoshuang Wang
Northwestern Polytechnical University, China

Abstract: Carbon/Carbon(C/C) composites often experience high residual thermal stresses and embrittlement risks when brazed to metals, particularly near the interface on the C/C side. This study employed a two-step approach—electrophoretic deposition followed by chemical vapor deposition—to introduce porous graphene-optimized SiC nanowhiskers at the joining surface of C/C composites, aiming to address interfacial issues in the joining of C/C with Cu. The results demonstrated that the prefabricated structure significantly enhanced the wettability of the AgCuTi metal filler on the C/C surface. Additionally, the formation of gradient structure and refinement of plastic Ag matrix induced by the micro-nano prefabricated layer helped to reduce the residual thermal stress at the interface Furthermore, the prefabricated layer prevented excessive penetration of the metal filler into the C/C side, thereby mitigating structural damage to the carbon matrix. The modified C/C-Cu joints exhibited an average shear strength of approximately 56.2 MPa, representing a 78.4% improvement over the original joints. This simple and efficient interfacial modification method is an important guideline for resisting interfacial damage when brazing composites to metal with active fillers.

CM25-357

13:15-13:30

Nano-Titanium Dioxide Coatings for Enhanced Performance of Pantograph Support Insulators in Electric Railway Systems

Norrawit Tonmitr, Amnart Suksri, Warayut Kampeerawat, Nakaret Kano, Methus Suwannaruang, Sora-at Tanusilp
Khon Kaen University, Thailand

Abstract: Pantograph support insulators are critical for maintaining reliable power transmission in electric railway systems. However, conventional porcelain insulators suffer from contamination buildup, leading to leakage currents and flashover risks. This study investigates nano-titanium dioxide (TiO_2) coatings to enhance porcelain insulator performance. X-ray diffraction (XRD) analysis confirmed the transformation of P25 TiO_2 into the rutile phase at 1240°C, improving durability and electrical properties. Energy-dispersive X-ray spectroscopy (EDX) verified uniform TiO_2 distribution, while field emission scanning electron microscopy (FE-SEM) revealed a smooth glaze layer. Electrical testing demonstrated a 52.11% reduction in leakage current for nano-TiO_2-coated insulators under 11 kV conditions, attributed to enhanced hydrophobicity and photocatalytic self-cleaning. These results highlight the feasibility of integrating nano-TiO_2 coatings into insulator manufacturing for reduced maintenance and improved reliability.

CM25-307-A

13:30-13:45

Layered Composites Made of Polymer Derived Sioc/Zrb_2 Reinforced by Zro_2/Sio_2 Fibers with Simultaneous Microwave Absorption and Thermal Insulation

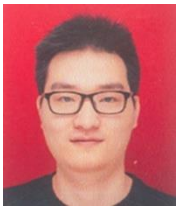
Yumeng Deng, Yujun Jia and Hejun Li
Northwestern Polytechnical University, China

Abstract: To simultaneously improve the microwave absorption and thermal insulation properties of the ceramic materials for stealth high speed vehicles, layered composites made of polymer derived SiOC/ZrB_2 reinforced by ZrO_2/SiO_2 fibers were reported in this work. The composites possess a continuous multilayer structure, which was fabricated via the precursor impregnation assisted by hot press curing and pyrolysis using the transparent ZrO_2/SiO_2 fibers and polymer derived SiOC and nano ZrB_2. The layered

composites show an effective absorption band (EAB) of 4.2 GHz at a thickness of 2.9 mm and the minimum reflection loss of -59.34 dB. The exceptional electromagnetic (EM) wave attenuation capability is ascribed to the impedance matching as well as massive EM wave loss caused by the multilayers in which the nano ZrB2 provides interfacial polarization and electrical conduction loss. With a design of the multi-curvature arch structure, a remarkable reduction of radar cross-sectional can be achieved. Besides, the layered composites exhibit good oxidation resistance and thermal insulation when exposed to the dynamic heating environment, demonstrating the potential application in harsh environments used for multifunctional electromagnetic absorbing materials.

CM25-360-A

13:45-14:00



Residual Mechanical Properties of Bio-Inspired Carbon-Based Composites with Multilayer Toughened Shell-Pearl Structure

Ruicong Chen
Northwestern Polytechnical University, China

Abstract: Shells are natural composites with outstanding mechanical properties, achieved through a combination of calcium carbonate flakes and organic layers arrangements. Here, inspired by the layered structure of shell pearl, we report a $C_f/(PyC/SiC)_n$ composites with high residual strength and good anti-ablation properties prepared via one-step chemical vapor infiltration method. The layered biomimetic structure increased the sliding resistance induced by the clamping stress to promote cracks deflection at multi-layer interface, where multiple crack initiation at a PyC weak layer followed by crack deflection in a SiC tough layer. The flexural strength of as-prepared $C_f/(PyC/SiC)_5$ composite was significantly improved about 55.7 % in comparation to C_f/PyC/SiC composite. After ablation, the flexural strength of $C_f/(PyC/SiC)_5$ composite degraded by only 11.2 %, while that of C_f/PyC/SiC composite reduced about 32.4 %. This work is expected to provide insights for the preparation of high-performance carbon-based composites, with promising applications as thermal protection materials in aerodynamic heating environments.

CM25-349-A

14:00-14:15

Bio-Inspired FeS_2 Quantum Dot/TiO_2 Mesh Evaporator for Seawater Desalination and Organic Pollutant Removal

Xi Zhang, Yanyan Song
Northeastern University, China

Abstract: Constructing easily operable and cost-effective solar-driven catalysts for seawater desalination and organic pollutant degradation is crucial for water purification. Pyrite (FeS_2) quantum dots (QDs), with a narrow bandgap (0.95 eV) and a high light absorption coefficient (>10^5 cm^{-1}), exhibit excellent light-harvesting capabilities. As an efficient heterogeneous photo-Fenton catalyst, the Fe(II) sites (≡Fe(II)) of FeS_2 QDs can activate the decomposition of H_2O_2 to generate reactive oxygen species (ROS) for the degradation of pollutants in water. However, the charge transfer rate of the ≡Fe(III)/Fe(II) redox cycle is considered as the limiting step in H_2O_2 activation during heterogeneous Fenton reactions. To address the issue, integrating photocatalysis with interfacial Fenton reactions offers an economical and efficient strategy, where photocatalysis synergistically enhances charge transfer within the ≡Fe(III)/Fe(II) cycle. Water striders are aquatic insects that inhabit the surfaces of ponds, rivers, and open oceans. To survive on the water surface for extended periods, their legs have evolved hierarchical, directionally structured microsetae with helical nanogrooves, which play a crucial role in providing strong water-repellent support. Inspired by the exquisite structure, this work developed a TiO_2 mesh modified with FeS_2 QDs, integrating a photocatalytic-Fenton cascade process with solar-driven interfacial distillation. A simple drop-coating method is employed to make the four corners hydrophobic, creating a biomimetic, water strider-inspired seawater purifier that simultaneously produces clean distilled water and removes organic pollutants and pathogens rapidly. The unique hierarchical micro/nano structures of the hydrophobic regions provide strong buoyancy, ensuring the stable flotation of the FeS_2 QD/TiO_2 mesh. Benefiting from the porous and flexible nature of the Ti mesh, the FeS_2 QD/TiO_2 composite exhibits excellent mass transfer performance, facilitating efficient vapor escape and salt crystallization dissolution. Under sunlight, this system enables continuous and stable evaporation, desalination, and pollutant degradation.

CM25-413A

14:15-14:30

Thermodynamics Formation of Oxides in Aluminum-Deoxidized Maraging Steel and Their Effects on Toughness

Chao Wang
Northwestern Polytechnical University, China

Abstract: Maraging steels are the ultrahigh-strength steels containing very low-carbon content, which require the strict control on impurity elements to ensure superior strength and toughness. In present work, the influence of oxygen content on the microstructure and mechanical performance of maraging steel prepared by laser powder bed fusion (L-PBF) was investigated using vacuum induction gas atomization (VIGA) powder with 0.034 wt% oxygen and plasma rotating electrode process (PREP) powder with 0.016wt% oxygen. A model was also developed to describe nucleation, diffusion growth, and collision aggregation of oxides in the solidification of melt pool during L-PBF process. The PREP deposit contains more and finer nano-scale Al_2O_3 inclusions, averaging 37 ± 11 nm in size with a number density of $7.6\times10^{18}/m^3$, compared to 59 ± 28 nm and $6.5\times10^{18}/m^3$ in the VIGA deposit. This difference is attributed to the lower oxygen content in PREP, which increases the nucleation driving force and promotes explosive nucleation. The PREP specimens exhibit the higher impact toughness than the VIGA specimens, with values of 138 J at 23 ° C and 65 J at -196 ° C, respectively, resulting in the increase by 53.3% at 23 ° C and 47.8% at -196 ° C, primarily due to the finer oxide inclusions.

CM25-403

14:30-14:45

Evaluation of a Fiberglass Patching Kit for Repairing Cracked Steel Plates Via the PZT-SLDV Lamb Wave Technique

Nikta Amiri, Lingyu Lucy Yu
Alfred University, USA

Abstract: This study investigates the effectiveness of a commercially available two-part fiberglass patching kit for repairing steel plates with cracks of varying sizes. The kit, produced by DuraPower Product Inc., includes a fiberglass patch, resin, and an activator, which serve as the adhesive for the repair. Four steel plates were tested: one without a crack and three with small (5 mm), medium (13 mm), and large (20 mm) cracks machined at the center. The repair process involved applying a fiberglass patch to each plate, and Non-Destructive Evaluation (NDE) using PZT-SLDV Lamb waves employed to assess the repaired specimens. The NDE results showed that the patching material significantly influenced wave energy transmission, with wave energy being more confined within the patch on the repaired surfaces. The study demonstrated that the repair process was effective in restoring the structural integrity of plates with varying crack sizes, successfully addressing defects of different lengths, and achieving good adhesion with minimal air bubble formation. This research provides valuable insights into the real-world applicability of the patching kit for repairing cracked steel surfaces.

CM25-414A

14:45-15:00

Microstructure and Mechanical Properties of Sc/Zr Modified 1460 Al–Li Alloy Fabricated by Laser Powder Bed Fusion

Siyu Zhang
Northwestern Polytechnical University, China

Abstract: The preparation of Al–Li alloy by laser powder bed fusion (LPBF) technology, especially Al–Li alloy with high Li content, is of great significance for lightweight of aerospace equipment. However, the significant susceptibility of Al–Li alloys to hot cracking during the process limits their advancement. This study starts from the two aspects of process control and composition modification, to achieve the production of crack-free and high-quality 1460 Al–Li alloys. Crack-free 1460 specimens can only be prepared at extremely low scanning velocity. The process window is markedly expanded by Sc/Zr modification. The heterogeneous nucleation of Al3(Li,Sc,Zr) results in significant grain refinement and effectively suppresses crack initiation and propagation. The unique bimodal heterogeneous microstructure endows the alloy with notable mechanical properties. After the addition of 0.6Sc-0.3Zr, the ultimate tensile strength (UTS), yield strength (YS), and elongation (δ) of 1460 alloy are increased by 104%, 158%, and 43.9%, respectively. The strength-plasticity synergism is primarily attributed to grain refinement strengthening, precipitation strengthening, and hetero-deformation induced strain hardening resulting from its unique bimodal heterogeneous

microstructure. The UTS and YS of 1.2Sc-0.6Zr modified 1460 alloy increased by 156% and 279%, respectively. However, this further increase in the Sc/Zr content significantly deteriorates the plasticity of the alloy. This work establishes a foundation for advancing the use of Al–Li alloys in high-performance, lightweight, and complex aerospace structures.

CM25-417A

15:00-15:15

Microstructure Evolution and Mechanical Properties of Tungsten Alloy Prepared by Laser Directed Energy Deposition

Zhiwei Hao
Northwestern Polytechnical University, China

Abstract: Tungsten heavy alloys (WHAs) are widely applied across military, medical, and other advanced industries. Laser-directed energy deposition (LDED) is an innovative approach to fabricate WHAs with intricate microstructures. This study explored the manufacturing processes and forming characteristics of three distinct tungsten alloy compositions to elucidate the microstructural formation mechanisms and performance evolution of WHAs prepared by LDED. Electron backscatter diffraction analysis revealed the occurrence of heterogeneous nucleation and dendritic precipitation in supersaturated solid phases across different alloy compositions. By applying the drag force equation derived from the two-phase flow theory, the Gaussian energy distribution inherent to the LDED process, and the low flowability of WHAs, this study reveals the microstructural layering mechanisms within LDED-produced samples. Through process optimization, 90W samples that exhibited an ultimate tensile strength of 1093 MPa and elongation of 16.8% were obtained. In situ mechanical testing revealed that the reduced elongation of the WHAs produced by LDED is due to their unique fracture mechanism driven by the interconnection of cracks between fractured tungsten particles. However, by incorporating smaller W particles and optimizing the gap ratio, the stress concentration can be effectively mitigated and crack propagation can be curtailed, thereby significantly enhancing elongation.

Best Presentation Award & Session Group Photo

Session 3 - High-Temperature and Electromagnetic Functional Composites for Extreme Environments

Chairperson: Shuxin Li, Wuhan University of Technology, China

Time: 13:00-15:15, June 10th | **Room: Meeting Room 2, 2F**

*Note: The schedule of each presentation is for reference only. Authors are required to attend the whole session, in case there may be some changes on conference day. Please join in the room 5-10 minutes earlier.

CM25-311-A

13:00-13:15

An Ultra-Broadband Electromagnetic Wave Absorbing ZrB_2-Based Ceramic Composite

Mengyu Dai, Yujun Jia
Northwestern Polytechnical University, China

Abstract: Broadband electromagnetic wave (EMW) absorbing ceramic materials are highly required for the thermal parts of aerocraft. As members of ultra-high temperature ceramics, ZrB_2-based ceramics have great potential for applications in more extreme environments relative to the currently used silicon-based and oxide-based ceramics. However, ZrB_2 is not among the traditional EMW absorbing material candidates due to its high conductivity, which induces the strong reflection of EMW due to the impedance mismatch with free space. Herein, ZrB_2-based ceramic with a bionic microstructure inspired by peacock barbules is proposed. Boron nitride nanotubes acting as polarization centers inside the ZrB_2-based material cause massive EMW dissipation. The ceramic shows an ultra-broadband absorption of 9.6 GHz (lower than −10 dB from 8.4 to 18 GHz), almost covering the entire X and Ku bands, superior to the reported ceramics. The polarization centers successfully turn the ZrB_2-based ceramic from EMW reflecting material to an excellent EMW absorbing material by the bionic barbule interspersed microstructure. The simulated metamaterial of the ceramic achieves an ultra-broad absorption (lower than −15 dB) in the range of 2-40 GHz. This work provides valuable insights for the development of broadband absorption material for high-temperature environments.

CM25-312-A

13:15-13:30

Achieving Broadband Electromagnetic Absorption at a Wide Temperature Range up to 1273 K by Metamaterial Design on Polymer-Derived SiC-CNT@BN Ceramic Composites

Bin Ren, Yunjun Jia
Northwestern Polytechnical University, China

Abstract: High-temperature broadband electromagnetic wave (EMW) absorption has emerged as a forefront challenge of EMW functional materials for harsh environment applications such as aerodynamically heated parts of stealth aircraft and aero engines. Polymer-derived SiC ceramic (PDC-SiC) is expected to become a potential EMW absorbing material in high temperatures because of its favorable oxidation resistance and tunable dielectric performance depending on pyrolysis temperature. Unfortunately, when utilized alone as absorbing materials, the PDC-SiC is usually fabricated at low temperatures to satisfy the impedance-matching requirements for EMW absorption, which induces an issue of inadequate loss capacity within the ceramics. To address this challenge, an innovative strategy is proposed for broadband absorption at high temperatures. This strategy involves introducing boron nitride-coated carbon nanotube (CNT@BN) as the absorber and combining periodic structure design to fabricate SiC-CNT@BN metamaterials, which have a frustum pyramid shape. The experimental results reveal that SiC-CNT@BN metamaterials exhibit excellent absorption performance even under a high-temperature environment of 1273 K, in which the effective absorption bandwidth (EAB) (below 10 dB) can achieve 15.52 GHz, almost covering the whole S, C, X, and Ku bands. Moreover, the CST simulation results show that the SiC-CNT@BN metamaterials have an impressive EAB of 34.62 GHz and the average absorption intensity is remarkably high with a value of 21.07 dB (<99 % absorption) in the frequency range of 2–40 GHz. The exciting EMW attenuation capability is ascribed to favorable impedance matching, enhanced conduction loss abilities, and multiple polarization loss at high temperatures. This work provides valuable insights for the development of broadband-absorbing material in high-temperature harsh environments.

CM25-314-A

13:30-13:45

Gradient Structure Design and Ablation Resistance of C/C-HfC-SiC Composite Leading Edge

Wei Li, Xiaohong Shi
Northwestern Polytechnical University, China

Abstract: The development of lightweight materials capable of retaining high strength at temperatures above 2000 °C is essential for the thermal protection of aerospace vehicles. Carbon/carbon (C/C) composites are attractive candidates due to their low density, excellent thermostability, and thermal shock resistance, but their susceptibility to oxidation limits their applications. Modification of C/C composites with ultrahigh-temperature ceramics improves ablation resistance but reduces thermal conductivity. Most reports on the ablation resistance of C/C composites are on disc samples, but they are generally machined to components such as sharp leading edges in the practical environment. The ablation behavior of the components is extremely relevant to their shapes. Here, we designed a novel C/C-HfC-SiC composite leading edge with a gradient structure according to the simulated temperature distribution. Gradient-structured composites were obtained by precursor infiltration pyrolysis (PIP) combined with chemical vapor infiltration. From the top (high-temperature region) to the bottom (low-temperature region) of the leading edge, the content of the modified element (HfC-SiC) decreases, while the PyC content increases. The resulting sharp leading edge exhibits low density (1.85 g/cm3), high thermal conductivity, and superior ablation resistance. Compared to conventional modified C/C composites with uniformly distributed HfC-SiC, a 237 °C reduction in the surface response temperature during ablation is observed, attributed to a 423% increase in thermal conductivity at the bottom of the gradient-modified leading edge. Additionally, at temperatures exceeding 2300 °C for 120 s, a linear recession rate of 3.31 μm/s is achieved. At a density only 6% higher than that of C/C composites, the linear recession rate is reduced by 84%. The excellent ablation resistance results from the synergistic effect of various regions of the sharp leading edge. The top of the composites resists high temperatures and airflow, while the bottom dissipates heat effectively. This study presents a novel approach for improving the ablation resistance of C/C composite leading edges, and the developed composites with gradient ceramic structures are highly promising ultrahigh-temperature thermal protection applications.

CM25-318-A

13:45-14:00

Ablation Resistant Behavior of Ultra-High Temperature Ceramic Modified C/C Composites in Extreme Thermal Environments

Menglin Zhang, Qiangang Fu
Northwestern Polytechnical University, China

Abstract: Carbon/Carbon (C/C) composites are widely used in aerospace applications due to the low density, high specific strength, and excellent high-temperature mechanical properties. Advanced materials that function in the most extreme environments - Ultra high Temperature Ceramics (UHTCs). UHTCs have extremely high melting point, mechanical strength, high temperature stability. The excellent performance of UHTCs modified C/C composites in extreme high-temperature environments is fascinating, despite the inevitable analytical difficulties by the complex ceramic characteristics and modified structure. By combining numerical simulation and experiments, the service performance of MeC-SiC (Me: Hf, Zr, Ti, Ta, Nb, W) modified C/C composites under oxyacetylene ablation was investigated. Based on the thermal protection characteristics of various composites, C/C-HfC-ZrC-TaC-SiC composites with continuous ceramic-rich layer was designed and prepared by reactive melt infiltration for protecting fibers and improving ablation resistance. The promotion of reactive melt infiltration by $TaSi_2$ enhances the flexural strength of composites, and the severe reaction caused by excessive content could also exacerbate fibers damage. HZT441 composites exhibits the best flexural strength (195.27 MPa). The results showed that HZT441 (HfC:ZrC:TaC=4:4:1) sample after 80 s oxyacetylene ablation (4.2 MW/m^2), exhibited the lowest mass and linear growth rate of 0.10 mg/s and 1.02 μm/s. The effective inhibition of oxygen invasion and carbon fibers damage, benefits from the dense self-derived oxide layer including $(Hf,Zr)_6Ta_2O_{17}$, $(Hf,Zr)O_2$ and SiO_2. Based on the chemical non-equilibrium model, the maximum temperature of oxyacetylene flame combustion is 3250 K, the maximum velocity of the flame is 18.01 m/s, in the core flame flow region for the sustained high-temperature section, the flow field in this region is the

most stable, the temperature decreases slowly, transiting the core flame flow region, the distance along the direction of the centre line increases the temperature decreases sharply. Based on the approximate modeling of the modified composites, finite element analysis showed that the modified approach of reactive melt infiltration followed by a unique ceramic-rich layer constituting the integration of the matrix-coating reduces the temperature of the carbon fibers during the ablation process, which alleviates the material damage due to insufficient temperature resistance of the material. Under thermal loading, the surface stress distribution was mainly dominated by compressive stress, which mitigated the damage between the matrix and fibers. In this work, the mechanism of oxyacetylene assessment environment and thermal loading is clarified to provide theoretical support for the ablation temperature response of UHTCs modified C/C composites.

CM25-324-A

14:00-14:15

Ablation Resistance and Mechanical Properties of C/C-HfC-SiC Composites with a Bulletproof-Like Layer

Zhiqiang Liu, Yujun Jia, Qiangang Fu
Northwestern Polytechnical University, China

Abstract: With the rapid development of hypersonic aircraft, the demand for higher speeds, higher temperatures and stronger erosion has become increasingly urgent. Due to excellent properties such as low density, high specific and excellent high-temperature mechanical properties, carbon/carbon (C/C) composites have been regarded as great application prospects in thermal protection materials. However, the oxidation of C/C composites in an aerobic environment above 370 ℃ limits the application. Ceramics with high melting points and erosion resistance are often used to improve the service life of C/C composites. In this work, two structural designs based on the arapaima fish scale structure enhance the performance of composites. A double-layer SiC/PyC coating was deposited to modify C/C-HfC-SiC composites by chemical vapor deposition. Introducing the PyC layer reduces the porosity and roughness of composites. The composites with arapaima fish scale structure showed good flexural and ultra-temperature particle erosion resistance. By introducing the PyC layer, the samples showed higher flexural strength of 220 MPa, which was 40.13% higher than that of without. Ar-O_2-Al_2O_3 plasma ablation system was used to evaluate the anti-particle erosion performance of composites in a high-temperature and oxygen-rich environment. After ablation for 40 s, the linear ablation rates decreased from 5.95 μm/s to -4.6 μm/s. This study provides new ideas to develop C/C composites with improved ablation-resistant and mechanical properties.

CM25-334-A

14:15-14:30

A New Strategy to Improve the Ablation Resistance of C/C-ZrC-SiC Composites by Using Mesophase-Pitch-Based Carbon Fibers as Heat Transfer Channels

Yuanxiao Zhao, Hejun Li
Northwestern Polytechnical University, China

Abstract: Currently, C/C-ZrC-SiC composites prepared using the precursor impregnation pyrolysis (PIP) process still suffer from insufficient thermal conductivity of the components, leading to excessive surface heat accumulation. In this paper, CF_{MP}/C-ZrC-SiC-2450°C composites were prepared with mesophase-pitch-based carbon fiber (CF_{MP}) as reinforcing fiber. Thanks to the highly oriented graphite microcrystalline structure and larger phonon mean free path of CF_{MP}, as well as the partially axially aligned CF_{MP} parallel to the ablation direction in the X(Y)Z plane, the thermal conductivity of CF_{MP}/C-ZrC-SiC-2450°C composites along the X(Y)Z plane is higher than that of the XY plane, effectively reducing the surface temperature. Subsequently, the crystallinity of the graphite structure in CF_{MP} was enhanced again by increasing the heat treatment temperature, and finally CF_{MP}/C-ZrC-SiC-3000°C composites with excellent ablation resistance were obtained, corresponding to linear and mass ablation rates of 0.412 μm/s and 1.081 mg/s, respectively. The above results indicate that the highly crystalline CF_{MP}/C thermally conductive skeleton plays a key role in reducing the ablation surface temperature and protecting ZrC-SiC ceramics from oxyacetylene flame ablation, which lays a solid foundation for the subsequent development of high-performance ablation-resistant C/C composites.

CM25-348-A

14:30-14:45

Design and Microstructure Evolution of the Area-Tailored Coating on C/C Composites for Ultra-High Thermal Protection

Jiaqi Hou, Jiaping Zhang
Northwestern Polytechnical University, China

Abstract: Carbon fiber-reinforced carbon matrix (C/C) composites are considered as potential materials for extreme environments owing to their low density and good mechanical strength even at 2500 °C in an inert atmosphere. However, it is necessary to provide the C/C composites with a suitable thermal protection coating for the external structure owing to their oxidation sensitivity over about 450°C. Besides, the thermal and aerodynamic loads on different areas of thermal structural components applied in extreme environments vary greatly, which can lead to the cracking or failure of protective coatings made for C/C composites due to mismatched thermal response. To solve the problem, we propose an innovative strategy to design an area-tailored protective coating by simulating the service environment of thermal-structural components. The components of area-tailored coating were selected according to oxyacetylene flame environment where the component helpful to resist high-temperature gas scouring was enriched in the central area and the adjacent area was set component with similar thermal expansion coefficients to C/C composites to relieve mismatch thermal response. After ablation, compared to normal coating, area-tailored coating coated on C/C composites showed good cyclic ablation resistance due to relieved thermal response mismatch of the coating in different regions, with a decreasing of thickness and mass loss rates by 140% and 103%, respectively. The results indicate that our proposed innovative strategy of area-tailored protective coating has a positive effect on high-temperature ablation resistance, which may provide new strategy and inspiration for the design and preparation of coatings for C/C composites thermal structural components applied in extreme environments.

CM25-332-A

14:45-15:00

The Integrated Design of Yb_2SiO_5-$Yb_2Si_2O_7$/$Yb_3Al_5O_{12}$ Environmental Barrier/Thermal Barrier Coatings on the Surface of C/C Composites

Fan Jiao, Shouyang Zhang, Xiaohong Shi
Northwestern Polytechnical University, China

Abstract: Carbon/carbon (C/C) composites, as important candidate materials for hot-end components in aero-turbine engines, have become a research focus in the industry due to their unique advantages of low density, low coefficient of thermal expansion, and the enhancement of mechanical properties with increasing temperature. However, the high oxidation sensitivity of C/C composites limits their use in high-temperature environments containing oxygen and water vapor. To address this issue, environmental barrier coatings (EBCs) are often deposited on their surfaces. The composition of these coatings (including $Yb_2Si_2O_7$, Yb_2SiO_5, and $Yb_3Al_5O_{12}$, among others) and their structural design (such as multilayer coatings, gradient coatings, and self-healing coatings) are current research hotspots. Currently, the primary method for controlling the composition and structure of coatings is through empirical design based on experiments, which significantly increases the economic and time costs of engineering projects. Extensive research has shown that the composition and structure of coatings are determined by both the direction of thermodynamically controlled chemical reactions and the pathways of kinetically controlled chemical reactions. Therefore, the proactive design of coating composition and structure based on thermodynamics and kinetics is crucial for improving the high temperature water-oxygen corrosion resistance of C/C composites. Based on this, this work takes the composition and structure design of a multi-component coating of Yb_2SiO_5-$Yb_2Si_2O_7$/$Yb_3Al_5O_{12}$ as an example. first, the thermodynamic conditions for generating the target phases are determined through the classic Gibbs free energy model calculation. Subsequently, the kinetics behavior for forming the target coating structure is actively controlled by introducing oxygen vacancies. Finally, an integrated environmental barrier/thermal barrier coating was successfully fabricated, consisting of an outer $Yb_3Al_5O_{12}$ thermal barrier layer and an inner Yb_2SiO_5-$Yb_2Si_2O_7$ environmental barrier layer, both layers being integrated in fabrication. The C/C composites coated with this coating were tested for high-temperature water-oxygen corrosion (at a temperature of 1500 ºC, in a water-oxygen coupled corrosion environment of 90 vol.% H_2O and 10 vol.% O_2 with an O_2 flow rate of 100 ml/min), and the coated C/C composites maintained a stable macrostructure after

100 hours of service. The microstructure evolution during the service process indicates that the $Yb_3Al_5O_{12}$-containing thermal barrier layer with higher high-temperature stability inhibits the decomposition of $Yb_2Si_2O_7$ in the environmental barrier layer, and the well-matched thermal expansion coefficients among the various phases are the main reasons for the long-term stable service of the coating in the high temperature water-oxygen corrosion environment.

CM25-335-A

15:00-15:15

Effect of Porous Pre-Coating on the Phase Composition and Oxidation Protective Performance of Sic Coating by Gaseous Silicon Inffltration

Huilun Shi, Qiangang Fu, Bing Liu, Liu Fei
Northwestern Polytechnical University, China

Abstract: The extensive application of carbon/carbon (C/C) composites in ultra-high temperature environments necessitates the development and support of advanced anti-oxidation coating technologies. Though gaseous silicon infiltration (GSI), as a mild and efficient method for preparing silicon-based ceramic coatings on C/C composites, has stirred up worldwide interest, it is still a big challenge to control the phase composition and microstructure of the coatings. Herein, by adjusting the carbon content of the pre-coating via using four kinds of resin (phenolic resin (PF), boron-modified phenolic resin (BPF), cashew shell oil-modified phenolic resin (PCF), epoxy-modified phenolic resin (EPN)), the permeability and reaction degree between gas-phase Si and resin carbon were controlled effectively. A pre-coating with higher porosity and more residual carbon can provide a larger specific surface area and sufficient carbon source, which is conducive to the permeation and reaction of Si. The results show that the lower the residual carbon content in the pre-coating, the larger its specific surface area, resulting in a deeper penetration of Si. Once the residual carbon content is too low, it will lead to insufficient carbon sources and excessive free Si in the GSI coating, which has a negative effect on the oxidation performance of the coatings. This study, for the first time, demonstrates the strategy for improving the oxidation protective performance of SiC coating by controlling porous pre-coating, which opens up a novel avenue for regulating the GSI process.The coating prepared with EPN resin, which has 53 % residual carbon content, exhibits the best oxidation protection performance for C/C. Compared to conventional PCF-GSI coating, EPN-GSI coating has a 40 % reduction in mass loss after oxidation at 1500℃ for 110 h.

Best Presentation Award & Session Group Photo

Session 4 - Sustainable Composites and Advanced Manufacturing Techniques

Chairperson: Bing Wang, Harbin Institute of Technology, China

Time: 15:30-17:45, June 10th | **Room: Forum 2, 1F**

*Note: The schedule of each presentation is for reference only. Authors are required to attend the whole session, in case there may be some changes on conference day. Please join in the room 5-10 minutes earlier.

CM25-412A

15:30-15:45

Simultaneously Enhancing Strength and Toughness of Heat-Treated Near β Titanium Alloy Fabricated by Laser-Directed Energy Deposition

Hanlin Ding
Northwestern Polytechnical University, China

Abstract: In order to achieve strength-plasticity matching and improve the fracture toughness of near β titanium alloy Ti55531 fabricated by laser-directed energy deposition (LDED), the heat-treated microstructure and the corresponding tensile properties and fracture toughness were investigated. Microstructure evolution during heat treatment and deformation behavior during mechanical testing were analyzed. The results showed that the primary β grains were approximately equiaxed with weak texture in LDED-built Ti55531. After subcritical solution and single/double aging (SS-SA and SS-DA) treatment, the continuous grain boundary α phases appeared, and the intercrystalline α phase was very fine. These make the strength high and the elongation and fracture toughness very poor because the cracks easily initiate and propagate along grain boundaries. In contrast, the treatment of supercritical β annealing and aging (SBA-A and SBCA-A) presented the Widmanstätten grain boundaries and zigzag grain boundaries in LDED-built Ti55531, respectively. Because these grain boundaries can effectively inhibit crack propagation, the elongation and fracture toughness were significantly improved. Especially for SBA-A treatment, it presents the optimal strength-plasticity matching with a or the strength of 1045±12 MPa and elongation of 12.0±1.2 % and excellent fracture toughness of 81.7±1.1 MPa • $m^{1/2}$.

CM25-305

15:45-16:00

Enhancing Antimicrobial and Irradiation-Shielding Properties of Poly(Butylene Succinate) Composites with Nanolignin for Active Biodegradable Packaging Applications

Wanwitoo Wanmolee, Bongkot Hararak, Wasawat Kraithong, Charinee Winotapun
King Mongkut's University of Technology North Bangkok (KMUTNB), Thailand

Abstract: This study investigated the incorporation of lignin nanoparticles derived from black liquor (S-BLNAce) into polybutylene succinate (PBS) to enhance the antimicrobial and irradiation-shielding properties of PBS composite films for packaging applications. Black liquor, a by-product of paper industry, was utilized to produce nanolignin through acetone fractionation and anti-solvent precipitation techniques. PBS composite films with varying S-BLNAce concentrations (0.5–2.0%wt) were fabricated via blow-molding and evaluated for mechanical, irradiation-shielding, and antimicrobial properties. The addition of S-BLNAce nanolignin improved the tensile strength and modulus of PBS, particularly at lower concentrations, while slightly reducing elongation at break. Films with higher nanolignin content exhibited enhanced irradiation shielding, especially in the UV-A and UV-B regions, and demonstrated significant antibacterial activity against *Escherichia coli* and *Staphylococcus aureus*. These findings highlight the potential of nanolignin as a bio-based additive for developing high-performance, sustainable packaging materials, aligning with circular economy and sustainability goals.

CM25-328-A

16:00-16:15

Sustainable Flame Retardant Treatment of Nonwoven PLA/Flax: Effect of Thermal Compression on Flame Retardancy Performance

Salma Sabir, Fabienne Samyn, Valérie Gaucher, Sophie Duquesne
Centrale Lille Institut, France

Abstract: The increasing demand for eco-friendly materials highlights the need for durable flame retardant treatments in polylactic acid (PLA) and flax composites. Our study examined commingled nonwoven PLA/flax composites treated with an eco-friendly flame retardant derived from phytic acid and urea. These fire-retarded

nonwovens underwent thermal compression to create a solid thermoplastic composite. The primary objective of this work was to evaluate the flame retardancy performance and to assess how thermal compression affects the flame retardant properties of the final composite. Using ^{31}P NMR, we demonstrated that the phosphorylation process of the substrate with the flame retardant occurred exclusively in the flax fibers. The results showed a 28% and 23% reduction in peak heat release rate before and after thermal compression, respectively. Mechanical properties were assessed in tensile mode, revealing slight impairments; Young's modulus remained at 2.9 GPa, and the ultimate tensile strength was reduced by approximately 50%, likely due to a decrease in molecular weight, as demonstrated by CES analysis. Furthermore, Raman spectroscopy indicated a reduction in the degree of graphitization, which plays a significant role in the formation of a condensed barrier during combustion.

CM25-419A

16:15-16:30

Achieving Superior Strength-ductility Synergy in Laser Powder Bed Fusion of AlSi10Mg by In-situ High-speed Scanning Remelting

Wenzhe Yang
Northwestern Polytechnical University, China

Abstract: Laser powder bed fusion (LPBF) is an additive manufacturing technique that has shown promise for fabricating components with intricate structures. AlSi10Mg alloys have been effectively utilized in automotive, aeronautical, and aerospace fields due to the high specific strength, prominent corrosion/oxidation resistance and excellent processing performance. However, the limited strength and ductility of LPBF-processed AlSi10Mg alloys often fail to satisfy the demanding requirements of complex and challenging service environments, thus limiting their broader engineering applications. This study addresses this limitation by introducing an innovative in-situ high-speed scanning remelting (HSSR) technique that enhances the microstructure of LPBF-processed AlSi10Mg. This approach led to a more uniform grain size and distribution, effectively constraining the softer columnar grains with harder equiaxed grains, and increased the density of grain boundaries. These microstructural improvements collectively resulted in an exceptional synergy between strength and ductility. The alloy achieved superior comprehensive mechanical properties, with a tensile strength of 496.1 $\pm$ 5.8 MPa and an elongation to fracture of 21.4 $\pm$ 0.9%, representing a notable advancement in this field. The HSSR technique presents a novel practical approach to in-situ microstructural control and mechanical property enhancement in LPBF-processed alloys, opening new pathways for their application in demanding engineering contexts and offering significant potential for future applications.

CM25-371

16:30-16:45

Fabrication and Characterization of NaOH-Treated Nito (Lygodium circinnatum) Fiber-Reinforced Composite

Erica Trisha T. Aranas, Juan Carlos H. Sayurin, Carlo S. Emolaga and **Jeremiah C. Millare**
Mapua University, Philippines

Abstract: This study explores the potential of Lygodium circinatum (commonly known as Nito vine), an underutilized natural fiber in polymer composites, as reinforcement in epoxy-based polymer composites. With the growing shift toward sustainable alternatives to synthetic fibers, Nito fiber presents an eco-friendly and cost-effective option. Sodium hydroxide (NaOH) treatment was applied to modify the fiber surface, and its effects on the fiber – matrix interaction, thermal stability, and mechanical performance were evaluated. FTIR analysis confirmed the successful reduction of non-cellulosic components such as hemicellulose in the treated fibers. SEM micrographs revealed enhanced interfacial bonding between the NaOH-treated fibers and the epoxy matrix, with reduced signs of debonding. Thermogravimetric analysis indicated improved thermal stability in composites containing treated fibers, as reflected by a higher degradation temperature. Mechanical properties such as tensile and flexural strength and modulus, as well as impact resistance, however, did not exhibit significant improvements, which might also be affected by the variability in the natural fibers and the hand lay-up method. These findings emphasize both the promise of Nito fiber as a viable natural reinforcement and the importance of consistent processing methods in composite fabrication. Overall, this work supports the favorable transition toward natural fibers in composite applications, particularly where thermal performance is prioritized.

CM25-351-A

16:45-17:00

Model Construction of Heat Source and Numerical Simulation of Temperature Field in Wood Rotational Friction Welding

Liang ZHAO, Hui JIN
Southeast University, China

Abstract: Wood friction welding is a new type of connection method that achieves effective wood bonding through friction heat generation. In order to analyze the melting and solidification of thermoplastic materials in wood during the welding process, this paper derives a welding heat source model that considers both the frictional heat generation in the shoulder and side areas of the wood dowel, based on the process parameters of wood rotational friction welding. The calculation results of the heat source model are used as boundary conditions, taking into account the heat dissipation caused by heat conduction and convection. The partial differential equation of heat conduction considering anisotropic heat transfer in wood was solved, and the temperature field inside the wood during the welding process was obtained. After comparing with existing experimental results and verifying the accuracy of the calculation results, further research was conducted on the effects of the insertion direction of the wood dowel, the speed of the wood dowel, the aperture ratio of pre- drilled holes to the wood dowel, and the insertion speed of the wood dowel on the temperature field distribution of the heat source.

CM25-408A

17:00-17:15

Crystal Orientation Dependence and Crack Initiation Mechanism for Fatigue and Dwell Fatigue of Ti60 Titanium Alloy

Boning Wang, Weidong Zeng, Runchen Jia, Jianwei Xu
Northwestern Polytechnical University, China

Abstract: Near-α Ti60 alloys have been successfully applied to aero-engine blades because of their excellent high-temperature properties and good room-temperature fatigue strength. However, an accurate understanding of fatigue crack initiation at the microscopic scale remains a major challenge in engineering, mainly stemming from the inherent sensitivity of the crack initiation process to the microstructure. Therefore, a study of the fatigue life and its dwell sensitivity was carried out for Ti60 alloys with different microtexture intensities. It was found that microstructures significantly reduced the dwell sensitivity and led to larger crack initiation planes, and that these failure characteristics favoured several key microconfigurations, all of which were related to basal slip in the [0001] orientation domains. Meanwhile, the similarities and differences between fatigue and dwell fatigue in terms of crack initiation mechanisms are elucidated, and the process from slip formation to crack initiation is understood in conjunction with the in situ. This study reveals the characteristics and mechanisms of different microtexture fatigue and dwell fatigue nucleation, which provides an important theoretical basis for the elimination of crack-initiation sensitive structures and the optimisation of thermal processing parameters and reduction of the sensitivity to dwell in titanium alloys.

CM25-370

17:15-17:30

Effect of Infill Percentage and Pattern Variations on the Compressive Strength and Material Properties of 3D Printed HDPE Materials

M.S.M. Al-Kharusi, Mohammed S. Al Owiemri
Sultan Qaboos University, Oman

Abstract: This study examines how infill percentage and infill pattern affect the compressive strength of 3D-printed High-Density Polyethylene (HDPE) parts using Fused Deposition Modeling (FDM). Specimens were printed with infill densities of 15%, 30%, 60%, and 100% across three patterns: honeycomb, grid, and triangular. Compression tests followed ASTM D695 standards. Results show that compressive strength increases significantly with higher infill percentages, with fully solid (100%) samples reaching up to 43.35 MPa. Among patterns, the honeycomb design consistently outperformed grid and triangular structures due to its efficient stress distribution. At lower infill percentages, pattern choice had a stronger impact, while at higher densities, the infill percentage became the dominant factor. These findings offer practical guidelines for optimizing strength and efficiency in applications such as aerospace, automotive, and healthcare.

CM25-411A

17:30-17:45

Laser Powder Bed Fusion of Sic Particle-Reinforced Pre-Alloyed Tib_2/Alsi10mg Composite with High-Strength and High-Stiffness

Mingji Dang
Northwestern Polytechnical University, China

Abstract: Recently, laser powder bed fusion (LPBF) of particle-reinforced aluminum matrix composites (PAMCs) with high-strength and high-stiffness have attracted extensive attention in aviation and aerospace. However, performance improvement of single or dual PAMCs using traditional mechanical mixing method is still limited. Therefore, this study innovatively employed pre-alloyed ~6.5 wt.% TiB_2/AlSi10Mg composite as the matrix and mechanically mixed SiC particles with different contents (5 vol.% and 10 vol.%) to fabricate dual PAMCs with high particles content through LPBF. The results indicated that the 5 vol.% SiC+TiB_2/AlSi10Mg composite revealed relatively weak agglomeration effect of SiC particle and highest relative density (~99.1%), thus exhibiting optimal processability. Using this composition material as the research object, it was found that the microstructure maintains the basic features of pre-alloyed TiB_2/AlSi10Mg composite except for the slight grain coarsening. However, SiC particles react with α-Al matrix and Al_3Ti. Then Al_4C_3 and TiC enhancement phase were formed, and micron-sized Si particles precipitated within the Al cells surrounded by the eutectic Al-Si. More importantly, due to novel preparation method of dual PAMCs powder, simultaneous enhancement in ultimate tensile strength (~554.0 MPa), yield strength (~376.0 MPa), and elastic modulus (~97.4 GPa) was achieved. Total particle content (~14.0 wt.%) and tensile property were higher than those of reported other PAMCs processed by LPBF. Finally, expect for the fracture characteristics inherent to the pre-alloyed TiB_2/AlSi10Mg composite, new fracture mechanism for the tearing of SiC particles was exhibited. This work provides new insights into the preparation of high-strength and high-stiffness PAMCs processed by LPBF.

Best Presentation Award & Session Group Photo

Session 5 - Advanced Mechanical Performance and Numerical Modeling of Composite Structures

Chairperson: Subhajit Mondal, National Institute of Technology Rourkela, India

Time: 15:30-17:30, June 10th | **Room: Meeting Room 3, 2F**

*Note: The schedule of each presentation is for reference only. Authors are required to attend the whole session, in case there may be some changes on conference day. Please join in the room 5-10 minutes earlier.

CM25-303

15:30-15:45

Effect of Notch Shape & Size on the Mechanical Performance of Woven GFRP Laminate: A Numerical Investigation

Deepti Ranjan Mohapatra, Suryamani Behera, **Subhajit Mondal**
National Institute of Technology Rourkela, India

Abstract: Due to their ability to impart transverse stiffness, glass fibre-reinforced polymer (GFRP) composite materials have increasingly been used in different sectors, especially the woven type. Assembly of such materials in many configurations requires drilling a hole, thus creating a material discontinuity in that component. The failure strength and mode of failure significantly depend on the shape of such notches. The analysis of the effect of notch shapes and sizes is of utmost importance from a design point of view. In this investigation, the numerical model of woven GFRP laminates with various shaped notches is developed and subjected to a displacement-controlled quasi-static tensile test. The size of the notches is also varied to study its effect on the laminate's Bearing Strength (BS). The effect of three shapes, constituting a circle, a square, and a diamond, is evaluated for different ply orientation angles on their failure pattern is identified.

CM25-310-A

15:45-16:00

Constructing a "Brick and Mortar" Structure to Synchronously Strengthen the Mechanical and Tribological Properties of Fabric Laminated Composites by Isocyanate Functionalized Carbon Fiber Powders

Jifeng Yan, Jie Fei, Lehua Qi
Northwestern Polytechnical University, China

Abstract: Fabric laminated composites with excellent mechanical strength and brake stability are now developed as promising wet friction materials. However, facing the serious challenge of persistent operation under harsh conditions, abrasive resistance and interlaminar bonding properties of laminated composites require further improvement urgently. Herein, the methylene diphenyl diisocyanate (MDI) was chemically grafted onto the carbon fiber powder (CFP) surface via oil bath for surface functionalization. Subsequently, fabric laminated composites modified with functionalized CFP (CFP-MDI) were fabricated by sedimentation to construct a "brick and mortar" structure. As a result, the comprehensive performance of laminated composites presented an effective promotion with the introduction of CFP-MDI as mortar. In particular, benefiting from the conspicuous synergistic effect between CFP and MDI, the interlaminar shear strength of modified laminated composites was increased by 17.93%, and the wear rate decreased by 38.18% from 7.91×10^{-14} $m^3(N \cdot m)^{-1}$ to 4.89×10^{-14} $m^3(N \cdot m)^{-1}$, demonstrating excellent ability to efficiently suppress crack and local damage propagation. This work provides a new strategy to achieve the integrated construction of toughening interlamination and wear-resistant coating, which is conducive to the large-scale application of fabric laminated composites in the friction transmission braking field.

CM25-352-A

16:00-16:15

Numerical Study of Ballistic Performance in Annealed and Silica-Coated Kevlar Based Hybrid Soft Armors

Umavarun veeturi, Swati Neogi
IIT Kharagpur, India

Abstract: Among various synthetic fibers Kevlar fibers exhibit superior strength, durability, resistance to chemical, and environmental degradation for ballistic protection. Their prolonged exposure to sunlight or ultraviolet and thermal radiation during firefighting or other on-field activities may degrade the ballistic resistance. This

reduction in ballistic resistance stems from weakening of yarn material properties. To improve the lifetime of Kevlar 129 through external treatments, this study employed a two-stage approach. First, plain weave Kevlar 129 fabric (DuPont, USA) was annealed at 210°C for 8 hours. Then, to explore property retention, a 10 wt% of nano-silica particles were coated, followed by annealing under the same conditions. Scanning electron micrographs and elemental analysis confirm the presence of silica coating on Kevlar fabric (Fig. a). Yarn pull-out (Fig. c) and tensile test experiments revealed that annealing at higher temperatures lead to deterioration of mechanical properties but improvement of frictional properties. A higher inter-yarn friction is observed due to increased surface roughness in silica coated fabrics as shown by the AFM topographic images in Fig (b). Subsequently, 3D-FEM simulations (ABAQUS/CAE) were performed using the experimental parameters to predict the ballistic performance. For comparison of the ballistic performance multi-layered woven armor panel was constructed: (i) *eight* layered untreated fabric (pristine), (ii) panel composed of *four* pristine and *four* silica-coated, (iii) panel composed of *four* pristine and *four* coated-annealed at 210°C and (iv) panel composed of four pristine and annealed at 210°C and 350 °C individually. The residual velocity of the projectile was evaluated with a full metal jacket bullet of 9 mm x19 mm dimensions having a mass of 7.45 g. All the simulations were performed considering procedures outlined in the National Institute of Justice (NIJ) protocol, with an impact velocity of 400 m/s. Due to negligible change in the mechanical properties of the yarn material for the type (iii) fabric hybrid panel, the performance was found to be better as compared to annealed armor panel. On the other hand, for the same construction, inter yarn friction was observed to be enhanced due to the increase in the surface roughness due to coating between the yarns. It is also predicted that Type (iv) panels would exhibit reduced ballistic performance, consistent with the observed decrease in yarn material properties. As depicted in Fig. (d), silica coating enhances the ballistic resistance of the fabric. Notably, the hybrid panel exhibited superior performance in terms of the residual velocity and ballistic limit. These findings suggest the potential of silica nanostructure-interfaced Kevlar hybrid fabric panels for impact-resistant applications. Current investigations indicate that while yarn mechanical properties significantly influence fabric performance, inter-yarn frictional forces contribute to performance enhancement. A detailed numerical investigation, correlated with experimental findings, is presented.

CM25-304

16:15-16:30

An XFEM-based Analysis on the Effect of Pre-Existing Crack on the Woven GFRP with Central Side Edge Notch

Deepti Ranjan Mohapatra, Suryamani Behera, Subhajit Mondal
National Institute of Technology Rourkela, India

Abstract: Woven glass fibre-reinforced polymer composite materials are widely used in different sectors, replacing traditional construction materials with their advantages in lightweight construction, high strength-to-weight ratio, etc., and especially their ability to impart transverse stiffness to the structure. The objective of the current investigation is to introduce a side edge notch to the laminate and study the failure pattern. The effect of crack length on the failure pattern and strength of the laminate is also studied here using the extended Finite Element Method (XFEM). Maximum stress criteria based on bilinear traction separation law are utilised for crack initiation, and critical energy release criteria are used for crack opening and propagation. The results show the effectiveness of XFEM in capturing failure patterns in the laminate for all the considered cases.

CM25-315

16:30-16:45

The Application of a Hybrid Damage Modeling and Simulation Methodology to Composite Laminate Residual Strength Predictions

Gang Qi, Heng (Hannah) Liu, Il Yong Kim, Diane Wowk
The National Research Council Canada

Abstract: A reliable hybrid modeling and simulation methodology is developed to predict the progressive damage evolution and ultimate strength in multidirectional fiber-reinforced polymer (FRP) composite laminates. The integrated modeling approach combines continuum damage modeling (CDM), the extended finite element method (X-FEM), and the cohesive zone modeling (CZM) technique, to capture fiber breakage, polymer matrix major cracking, composite ply interlaminar delamination, and the interactions of these failure modes. The Schapery theory is incorporated into the finite

element model to accurately simulate the pre-peak nonlinearity of the load-bearing response caused by matrix micro-cracking. Multidirectional composite laminates with open-hole tension (OHT), open-hole compression (OHC), filled-hole tension (FHT), and filled-hole compression (FHC) configurations are examined as case studies. It is demonstrated that this hybrid modeling framework and methodology can effectively and efficiently capture the complex composite damage progression and properly predict the residual strengths of damaged composite laminates.

CM25-306-A

16:45-17:00

Optimisation of Structural Parameters of a 3D Woven UHMWPE-Epoxy Composite for Better Mechanical Properties

Vikas Verma, Abhijit Majumdar
IIT Delhi, India

Abstract: The mechanical properties of 3D fabric composites depend upon their material properties, structural parameters of preform and reinforcement-matrix interface. Parameters such as type of 3D fabric structure (orthogonal and angle interlock), stuffer-to-binder ratio (S:B), binding step, and binding depth significantly influence the mechanical properties of 3D fabric as well as their composites. While stuffer yarn arranged in the longitudinal direction provides bulk and uniaxial strength, binder yarns oriented in ‘Z’ direction ensure structural integrity. By optimising these parameters, equivalent mechanical strength can be achieved with lesser amount of reinforcement. Hence it can offer cost effectiveness by reducing the amount of reinforcement material for the desired properties of a 3D fabric composite. The objective of this research is to optimise the S:B ratio and binding step in a 3D orthogonal fabric. Ultra-high Molecular Weight Polyethylene (UHMWPE) yarn (1350 denier) is used as a stuffer and filler, whereas the same yarn of finer linear density (400 denier) is used as a binder. The S:B ratios of 1:1 and 4:1 are used with the binding step of one, two and three, and the number of layers of filler is five. Thus six 3D woven fabrics preforms having areal density of 760-820 g/m^2 are produced. Epoxy resin is used as the matrix, and composites are manufactured using the compression moulding technique. Tensile, 3-point bending and in-plane shear properties of composites are evaluated. The results reveal that a high S:B ratio, along with a higher binding step, leads to higher tensile strength. A higher binding step results in higher bending strength and in-plane shear strength. On the other hand, a lower S:B is beneficial for the bending and in-plane shear properties. The findings of this research will pave the way for designing better 3D woven composites.

CM25-308-A

17:00-17:15

Mechanical Properties and Friction Vibration Behavior of Silicone Rubber Powders Modified Carbon Fiber-reinforced Resin Composites

Zhaoxi Gou, Jie Fei, Hejun Li
Northwestern Polytechnical University, China

Abstract: Carbon fiber-reinforced resin composites (CFRCs) are widely used in aerospace, automotive manufacturing, and braking systems. However, the thermosetting resins and hard fillers in CFRCs have low toughness, which can lead to strong vibration behavior during continuous friction processes. This can result in structural instability of the system and even affect the safety and stability of mechanical equipment. This work proposed a method for co-blending modification of CFRCs with silicone rubber powders (SRP) to mitigate friction-induced vibrations. By comparing the mechanical properties, tribological property, and friction vibration behavior, the effect mechanism of SRP modification on CFRCs performance was investigated. The results demonstrated that SRP-modified CFRCs exhibited excellent damping property. SRP-modified CFRCs exhibited a 58.1% increase in the average loss factor. The "sea-island structure" matrix system formed by SRP exhibited a 51.4% improvement in impact strength. SRP modification improves the stability of the coefficient of friction and reduces fatigue wear for CFRCs. Benefiting from excellent damping and vibration reduction properties as well as stable interfacial contact characteristics, moderately SRP-modified CFRCs (containing 10 wt.% SRP) exhibit the lowest vibration levels and wear rates. Compared to unmodified CFRCs, the CFRCs modified with 10 wt.% SRP achieved a 35.5% decrease in the average amplitude of friction-induced vibration and a 29% reduction in wear rate. It is worth noting that the wear rate follows a similar trend with the vibration level of CFRCs since avoiding unexpected vibration during the friction

process is beneficial for reducing the wear rate. This work provides both theoretical and practical foundations for designing and developing CFRCs with high damping, low wear, and low vibration characteristic.

CM25-353-A

17:15-17:30

Accelerated Environmental Aging of Soft Thermoplastic Laminates and Its Impact on Ballistic Performance: Microstructural Study

Rohan M Jadhav, Swati Neogi
IIT Kharagpur, India

Abstract: Soft laminates and thermoplastic composites are at the cusp of being fully integrated into the soft armor industry. Polymeric fibers and composites made by UHMWPE and polypropylene are increasingly used in the armor industry. Despite increased use, effects of environmental factors on the long-term performance of thermoplastics is not well known. This study focuses on accelerated hygrothermal aging of UHMWPE soft laminates at elevated temperature and humidity (85° C-85%RH) and its effects on the ballistic performance of the constituent soft armor to artificially simulate field/storage conditions. The microstructural properties of the aged UHWMPE laminate were used as a correlating parameter to observe their influence on mechanical and ballistic properties as a means to create a non-destructive (NDE) testing method for soft armors. Molecular weight change of the soft laminate post aging was chosen as micro-property of choice which showed significant impact on the mechanical property dependence. Aging experiments were carried out in an environmental chamber and property measurements were made using viscometry and universal testing machine. To conclude, numerical simulation of the ballistic event was performed in LS-Dyna to observe the effect of altered mechanical properties on the ballistic performance. The depth of the backface trauma of the panels were observed to increase, indicating a sharper penetration of the projectile and a lower energy spread diameter indicating poor mechanical performance. The results of the ballistic simulation are in good agreement with the decreasing micro-property of the laminate material. Mechanical properties, namely elongation at break was found to be most affected by the aging of the material owing to molecular weight reduction. The correlation between the associated properties can be used as a guiding tool to identify the ballistic performance of a stored/in field use armor and assess the armor beforehand.

Best Presentation Award & Session Group Photo

Posters:
Multifunctional Composites: Fabrication, Processing, and Smart Integration

Time: 15:30-16:30, June 10th | **Room: Meeting Room 2, 2F**

*Note: Please paste poster on the wall at least 10 minutes before the session starts. Please take it away after the session, otherwise conference team will dispose the posters.

CM25-301-A Multiferroic Composite Materials Obtained by Various Sintering Methods

Dariusz Bochenek, Dagmara Brzezinska, Przemysław Niemiec, Artur Chrobak, Grzegorz Ziółkowski
University of Silesia, Poland

Abstract: The paper presents the influence of the sintering method on the functional properties of a multiferroic composite material based on a PZT type material ($Pb_{0.94}Ba_{0.06}(Zr_{0.52}Ti_{0.48})_{0.983}Cr_{0.006}Mn_{0.011}O_3$) and a NZF ferrite material ($Ni_{0.64}Zn_{0.36}Fe_2O_4$). The results of experimental tests of the PZT-NZF composite for the proportions of 90% PZT and 10% NZF components obtained by three sintering methods, i.e., free sintering (FS), i.e., pressureless method, hot pressing (HP) and spark plasma sintering (SPS), were presented. The tests showed that at room temperature, the composite obtained had good magnetic, as well as ferroelectric and dielectric properties for all sintering methods. The highest permittivity values are shown by the composite made by the free sintering method (620/9480 at room temperature and *T*C temperature, respectively). In contrast, the lowest values are shown by the composite made by the SPS method (605/6720 at room temperature and *T*C temperature, respectively). In the case of magnetic tests, the composite obtained by the SPS method shows the highest magnetization values (4.87 Am^2/kg). However, the composite made by the HP method has intermediate dielectric and ferroelectric parameter values compared to the other composites. The studies that were conducted have shown that all methods of sintering the multiferroic PZT-NZF composite allow for the obtaining of favorable performance parameters suitable for use in micromechanical applications.

CM25-358-A Fluid Infiltration: An Innovative Post-Processing Enhancing Technique for Binder Jetting

Zhijie Huang
Huazhong University of Science and Technology, China

Abstract: Binder jetting technology is gaining attention as a promising additive manufacturing method for achieving low-cost mass production. However, the manufacturing principles of powder bed result in green samples characterized by high porosity. While traditional infiltration post-processing techniques can address this issue to some extent, the processing time is long and the infiltration effect is poor. To overcome these challenges, a novel post-processing method has been proposed: fluid infiltration, for which a quantitative characterization method and quantitative metrics (infiltration degree & infiltration uniformity) based on machine vision have been proposed. The influence of different parameters on the infiltration effect was systematically analyzed by Taguchi analysis, with the infiltration of 316L stainless steel nanopowder. The most influential factor in the infiltration degree was the infiltration flow rate, and the least influential factor was the infiltration time. For infiltration uniformity, these two were infiltration flow rate and particle concentration, respectively. It is also pointed out that the different effects of parameters on the infiltration effect are due to the change in the pressure difference between the inside and outside of the sample. The second-phase strengthening of the samples by this technique was verified using nano-SiO_2 infiltration of hydroxyapatite (HA) samples. After infiltration, the problem that HA samples could not be sintered at normal pressure was solved. Sintered HA samples reached a compressive strength of 2.01 ± 0.09 MPa and a compressive modulus of 233.59 ± 8.94 Mpa, reaching the application standard of trabecular bone. The infiltration of SiO_2 facilitated the transformation of HA to α-tricalcium phosphate without generating a silicate phase. This study lays the groundwork for further exploration of fluid infiltration, opening new avenues for research and applications within the binder jetting field, thereby contributing to advancements and innovations in this technology.

CM25-309 White-beam X-ray Sectional Topography of Anthracene Single Crystals Grown by Physical Vapor Transport Technique

Sadaharu JO, Kentaro Kajiwara and Hitoshi Yoshikawa
Aichi Gakuin University, Japan

Abstract: White-beam X-ray sectional topography enabled the successful evaluation of the quality of anthracene single crystals grown by the physical vapor transport technique; however, such single crystals exhibited a thin plateletlike configuration and their quality is difficult to evaluate in the cross-sectional direction. The experimental results showed that the anthracene single crystals grown by the physical vapor transport technique maintained their high quality; however, they tended to have widespread hollows inside owing to their specific configuration.

CM25-350-A Effect of Nitric Acid Treatments on the Interfacial Bonding between Recycled Carbon Fiber and Polyamid-6

Hyo Kyoung Kang, Daeup Kim
Korea Institute of Industrial Technology, Republic of Korea

Abstract: In this study, carbon fibers recovered from waste carbon composites were subjected to chemical desizing, surface treatment, and resizing for the purpose of upcycling, and the changes in mechanical and chemical properties of carbon fibers and mechanisms of oxygen functional group according to surface treatment conditions were identified.

CM25-302-A Ferroelectromagnetic Composites Based on PLZT and Ferrite Material

Dagmara Brzezińska, Dariusz Bochenek, Artur Chrobak
University of Silesia, Poland

Abstract: The work presents the technology of ferroelectric-ferromagnetic ceramic composites obtained from PLZT powder (the chemical formula $Pb_{0.98}La_{0.02}(Zr_{0.90}Ti_{0.10})_{0.995}O_3$) and ferrite powder ($Ni_{0.64}Zn_{0.36}Fe_2O_4$), as well as the results of X-ray powder-diffraction data (XRD) measurement, microstructure, dielectric, ferroelectric, and magnetic properties of the composite samples. The ferroelectric-ferromagnetic composite (P-F) was obtained by mixing and synthesizing 90% of PLZT and 10% of ferrite powders. The XRD test of the P-F composite shows a two-phase structure derived from the PLZT component (firm peaks) and the ferrite component (weak peaks). The symmetry of PLZT was identified as a rhombohedral ferroelectric phase, while the ferrite was identified as a spinel structure. Scanning electron microscope (SEM) microstructure analysis of the P-F ceramic composites showed that refined grains of the PLZT component surrounded large ferrite grains. At room temperature, P-F composites exhibit both ferroelectric and ferromagnetic properties. The P-F composite samples have lower values of the maximum permittivity at the Curie temperature and a higher dielectric loss compared to the PLZT ceramics; however, they retain good multiferroic properties.

CM25-359-A Bimaterial Additive Manufacturing of Copper and Ceramic Based on Material Extrusion

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Abstract: Beam-based additive manufacturing has challenges in fabricating pure copper due to high reflectivity. Material extrusion additive manufacturing (MEAM) avoids these issues with low costs, making it suitable to fabricate complex structures in pure copper. In addition, MEAM is quite suitable for multi-material additive manufacturing. Central composite face-centered (CCF) design and central composite design (CCD) are used to analyze and optimize process parameters for densification. The measured porosity at the optimized printing (printing temperature = 177 ◦C, air gap = − 0.05 mm, layer thickness = 0.3 mm) and sintering parameters (sintering temperature = 1045 ◦C, holding time = 4 h) is in good agreement with the predicted values. Air gap and sintering temperature have the greatest influence on the porosity, and other parameters within a certain range of on-demand adjustments do not have a significant effect. The ultimate tensile strength and elongation of the sintered samples under the optimal parameters

are 153.9 ± 6.1 MPa and 31.36 ± 3.24%, respectively. No printing defects are found at the fracture and the elongation is good, showing the effectiveness of the parameter optimization. Co-firing of pure copper and ceramics doped with low melting point components can be achieved by controlling the powder loading rate and sintering parameters. Higher sintering temperatures are used to provide better electrical properties for pure copper compared to conventional low-temperature co-firing. MEAM enables more than just a simple combination of bi-materials, it can further realize complex circuits or even multi-layer three-dimensional electrical connections, which demonstrates a great potential for application.

CM25-421A Smart Functional Ceramics Based on Rare-Earth Doped $BiFeO_3$

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Abstract: Smart materials that simultaneously exhibit electric and magnetic ordering open exciting possibilities for multifunctional technologies. In this study, $BiFeO_3$ ceramics doped with neodymium (Nd^{3+}) and dysprosium (Dy^{3+}) were synthesized via a solid-state method and pressureless sintering. Structural investigations confirmed a stable rhombohedral phase (R3c), with minor secondary phases detected. Microstructural and compositional analyses (SEM/EDS) verified good homogeneity and reproducibility. The rare-earth doping significantly altered the magnetic response of $BiFeO_3$ by disrupting its native spin cycloid, thus enhancing its magnetoelectric potential. These modifications demonstrate the feasibility of fine-tuning ferroic interactions in oxide ceramics, which is highly relevant for the development of advanced smart systems such as sensors, actuators, and memory devices operating at or above room temperature.

CM25-347 Comparison of a Hybrid Pipe Design for Replacement of New and Corroded Steel Pipes Subjected to Transverse Impacts

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Abstract: This study examines the performance of hybrid steel-GFRP pipes compared to steel pipes, with a focus on bonding properties and the occurrence of internal corrosion. Some pipes were worn screw-shaped to mimic the effects of corrosion. The hybrid material was manufactured from two steel pipes reinforced with GFRP, bonded with polyester resin and 10% styrene to reduce viscosity and prevent bubble formation. Distortion problems during the manufacture of the specimens are addressed. Results indicate greater deformation in the worn pipes than in the steel-only specimens, whereas the hybrid material showed no significant difference between the two types. The hybrid material supported higher loads in some probes, but only two hybrid probes failed. Strain gauges measured the deformations, and the composite material's behavior was examined under a microscope. The hybrid material presented a lower flexural modulus and greater compliance to cracking. Despite the performance of the proposed hybrid material not being able to stand up to steel's superior mechanical properties, the study offers useful insights and recommendations for future research, backed by stress-strain graphs.

CM25-422A Fabrication and Characterization of Functional Oxide Ceramics for Smart Material Applications

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Abstract: Layered oxide ceramics that combine ferroelectric and dielectric functionalities are key candidates in the development of next-generation smart materials. In this study, $Bi_{5-x}Ho_xTi_3FeO_{15}$ ceramics ($x = 0 - 0.1$), belonging to the Aurivillius family, were synthesized via the conventional solid-state method. The effect of holmium doping on crystal structure, microstructure, and dielectric properties was comprehensively

investigated. XRD analysis confirmed the formation of a single-phase orthorhombic structure (Fmm2) for all compositions, with no secondary phases detected, indicating full incorporation of Ho3+ into the Bi-site. SEM micrographs revealed the typical layered morphology of Aurivillius phases and showed that increasing Ho content leads to a significant grain size reduction. Dielectric measurements in the frequency range of 20 Hz – 1 MHz and temperature range of 25 – 550° C demonstrated relaxor-like behavior, frequency dispersion of permittivity, and a strong temperature dependence of dielectric losses. The ability to tailor dielectric response and microstructure via rare-earth doping highlights the potential of $Bi_{5-x}Ho_xTi_3FeO_{15}$ ceramics for integration in smart systems such as sensors, actuators, and energy storage components.

CM25-426A Theoretical Simulation of Acousto-Optic Effects on Optical Fiber Modes

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Abstract: This study presents a comprehensive simulation-based investigation of acousto-optic interactions in optical fibers, focusing on the modulation of guided modes induced by elastic waves. Using COMSOL Multiphysics, we model and analyze the photoelastic effect resulting from transverse and longitudinal acoustic excitations, and its impact on the electric field distribution in weakly guiding step-index optical fibers.
The fiber model consists of a cylindrical core – cladding structure, with radii of 2.5 μm and 25 μm, and refractive indices of 1.45 and 1.44, respectively. Three simulation scenarios are compared: a baseline control group without acoustic modulation, acoustic excitation along the X-axis (perpendicular to the optical axis), and excitation along the Z-axis (parallel to light propagation). The simulation framework integrates the Solid Mechanics and Electromagnetic Waves (Frequency Domain) modules. Acoustic strain fields are generated through harmonic boundary displacements, and the resulting stress distributions are translated into refractive index modulations via the photoelastic relationship $\Delta n = -\frac{1}{2} n^3 p \varepsilon$.
Simulation results show that mode analysis is essential for initializing physically consistent electromagnetic fields in the optical domain. In the absence of acoustic excitation, the optical field gradually attenuates along the Z-axis. When modulated by acoustic waves, both transverse and longitudinal cases exhibit stronger and more uniform electric field profiles. Particularly, Z-axis modulation yields a more periodic Δn distribution and results in a more stable light intensity profile compared to X-axis modulation, where stress asymmetry leads to less uniformity.
Our results further indicate that the interaction is strongest near the core – cladding interface, where acoustic-induced refractive index gradients are most significant. The study confirms that GHzfrequency acoustic modulation can reinforce light confinement, suppress attenuation, and dynamically reshape mode profiles within the fiber.
In conclusion, this work establishes a unified theoretical framework to model and quantify acoustooptic interactions in step-index fibers. The findings highlight the direction-dependent nature of acoustic coupling and offer valuable insights for designing tunable optical devices such as modulators, filters, and distributed sensors. The presented methodology provides a foundation for future experimental validation and functional fiber-optic device development.