

Mechanics of Functional Interfaces: From Bioinspired Surfaces to Durable, Data-Driven Materials

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ABSTRACT

The performance and reliability of functional materials are often governed not by the bulk material alone, but by the mechanics and evolution of their interfaces. This seminar presents a research program centered on establishing quantitative relationships between material structure, processing, interfacial behavior, mechanical response, environmental degradation, and functional performance. The research trajectory spans bioinspired surfaces and biological mechanics, functional coatings, interfacial fracture, durability, and automated experimentation. Early work on bioinspired surface architectures demonstrated how geometry, chemistry, and wettability can be used to control liquid and gas transport. These principles motivated a broader investigation of functional interfaces in which mechanical integrity and interfacial behavior are treated as coupled design variables. Particular emphasis will be placed on the mechanics of ice–surface interfaces. Conventional measures of ice adhesion do not necessarily capture the force required to remove ice from large-area surfaces. Interfacial fracture measurements reveal a complementary design parameter—interfacial toughness—that can govern the propagation of failure and enable scale-independent ice release. By combining materials design, mechanical characterization, and interfacial fracture mechanics, this work establishes relationships between low interfacial toughness, mechanical robustness, and functional performance.

The seminar will further discuss durable and self-deicing surfaces, environmental degradation, robotic materials preparation, and automated experimental systems. Together, these efforts motivate a broader approach in which fundamental mechanics, materials processing, advanced characterization, automation, and data-driven methods are integrated to accelerate the discovery and development of functional materials. Building on this foundation, the proposed research program at IISc will focus on four interconnected directions: fundamental mechanics of materials and interfaces, automated experimental discovery, scalable functional materials, and durability under realistic environments. Opportunities for interdisciplinary research, along with plans for teaching and mentoring in experimental mechanics, mechanics of materials, materials characterization, fracture, tribology, computational methods, and automated materials experimentation, will also be discussed.

ABOUT THE SPEAKER

Dr. Dev Gurera is a Senior Postdoctoral Research Fellow at the University of Michigan, USA, and an alumnus of IIT Ropar, with a Ph.D. and M.S. in Mechanical Engineering from The Ohio State University, USA. His research lies at the intersection of experimental mechanics, materials and interfaces, functional coatings, advanced manufacturing, and automated and data-driven experimentation. His research focuses on understanding how material structure, processing, interfacial mechanics, and environmental exposure govern functional performance, failure, and durability. His work has spanned bioinspired surfaces and biological mechanics, water harvesting, adhesion and interfacial fracture, anti-icing and de-icing materials, durable coatings, tribology, robotic experimentation, and automated materials research. He has contributed to multidisciplinary research programs supported by DARPA, the U.S. Navy/ONR, Honda, and Ford, and has experience developing and commissioning substantial experimental research infrastructure.



7th October 2026, 04.00 PM, Online Seminar,

Teams Meeting ID: 433 339 805 962 828

Passcode: Ls2Qd6Uc

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