SEMINAR

Department of
Mechanical Engineering

Bioinspired Nanostructured Surfaces: Mechanics, Optics, and Multifunctionality

SPEAKER

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ABSTRACT

Biological nanostructures found in nature, such as moth eyes and lotus leaves, achieve remarkable optical and self-cleaning properties through their nanostructured surfaces. Translating these bioinspired designs into engineered materials offers a transformative opportunity to create surfaces that simultaneously exhibit antireflection, self-cleaning, dust mitigation, and mechanical durability, properties critical for applications in photonics, aerospace, and display technologies.

This seminar presents research on the design, fabrication, and characterization of subwavelength nanopillar arrays on silicon and sapphire substrates, inspired by the moth-eye structure. Fabricated using interference lithography and inductively coupled plasma reactive ion etching, these nanostructures are systematically studied to understand how pillar geometry governs mechanical behavior and optical transmission, while also providing wetting control and dust mitigation functionality.

A central focus of the seminar is the mechanical characterization of nanopillar arrays with different pillar aspect ratios. Mechanical modeling together with nanoindentation measurements reveal distinct deformation mechanisms as a function of aspect ratio on silicon nanopillar arrays. For sapphire nanopillar arrays, the influence of aspect ratio on optical and mechanical performance is investigated. High aspect ratio nanopillars broaden the antireflection bandwidth, but at the cost of reduced mechanical performance. Low aspect ratio nanopillars, by contrast, achieve comparable optical performance in the visible wavelength range while exhibiting hardness comparable to glass, demonstrating that mechanical robustness and optical functionality can be realized simultaneously. These findings provide new insights into the design of mechanically durable, multifunctional nanostructured surfaces.

The seminar will conclude with a discussion of future research directions, including multiphysics co-optimization of mechanical and optical performance, fabrication of monolithic nanostructured surfaces on hard ceramics, post-exposure mechanical reliability following extreme thermal cycling, and new opportunities for nanostructured surfaces in extreme-environment applications.

ABOUT THE SPEAKER

Mehmet Kepenekci is a Ph.D. candidate in Mechanical Engineering at The University of Texas at Austin, working in the Nanostructures & Nanomanufacturing Laboratory under the supervision of Prof. Chih-Hao Chang. He received his B.S. (2018) and M.S. (2021) degrees in Mechanical Engineering from Middle East Technical University in Ankara, Turkey. His research focuses on the fabrication and mechanical characterization of bioinspired nanostructures, with an emphasis on engineering mechanically robust multifunctional nanostructured surfaces. His current work examines how nanopillar geometry influences deformation mechanisms, hardness, scratch resistance, and optical performance of subwavelength nanopillar arrays on silicon and sapphire substrates.

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