MECHANICAL & INDUSTRIAL ENGINEERING COLLOQUIUM: ME 794 002

Jonathan P. Singer
Assistant Professor
Department of Mechanical and Aerospace Engineering,
Rutgers University
Email: jonathan.singer@rutgers.edu

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"Scalable Micro/Nanomanufacturing of Complex Architectures through Hybrid Lithography"

Abstract

Recent developments in nanostructured materials have demonstrated myriad desirable properties ranging from superior optical trapping to antimicrobial surfaces. To bring these properties from the lab to the commercial space will require innovative nanomanufacturing strategies focused on scalable and cost-effective techniques. My lab, the Hybrid Micro/Nanomanufacturing Laboratory, applies the manipulation of fundamental driving forces to this challenge through combinations of top-down and bottom-up techniques for new hybrid lithographic strategies. In this seminar, I will highlight two such strategies: (1) sacrificial template nanoimprint for the generation of nanotextured surfaces and surface nanocomposites and (2) focused laser excitation for the fabrication of nanoscale patterns through extreme thermal gradients. The critical feature of these processes is that they shift the burden of nanoscale resolution from a costly or slow technique to a more scalable method bottom-up method. In this way, barriers to integration with rapid production methods, such as roll-to-roll and thermoplastic forming, are removed. Sacrificial nanoimprint utilizes rapid nanowire growth on micromold structures to simultaneously impart macro/micro/nanoscale structure to a metallic or polymeric component. This technique represents the first industrially-compatible thermoforming paradigm for adding the benefits of nanostructures to, for example, medical implants. Likewise, through extreme gradient patterning, nanoscale features with spatial control are made possible by unlocking intrinsic wetting-based morphologies in a parallelizable platform. Achieving spatial control over both the structure and function of a multiscale material will enable enhanced optical and biomanipulation properties and "smart" materials behaviors, such as tunable metamaterials and actuatable microrobotics.

About the Speaker:

Jonathan Singer obtained his PhD (2013) from the Massachusetts Institute of Technology and MSc and BE (2008) from the University of Pennsylvania, all in Materials Science and Engineering. His undergraduate and masters research was in hydrogen storage for fuel cell vehicles. The latter study was conducted in collaboration with General Motors Company and pursued light metal hydrides as a chemisorption solution for cyclable and efficient hydrogen storage and generation. His doctoral studies at MIT focused on the development of hybrid laser direct write methods, most significantly, the use of highly focused lasers to provide the driving force for 2D and 3D self-assembly with applications in phoXonic metamaterials. After receiving his PhD, he worked as a postdoctoral research associate in Yale University's Department of Chemical and Environmental Engineering. Here, he investigated methods for the nanoimprint of photovoltaic materials and bulk metallic glass alloys, focusing on approaches that would simultaneously push the maximum aspect ratio, resolution, and 3D compatibility of the patterned features. He is currently an Assistant Professor in the Department of Mechanical and Aerospace Engineering at Rutgers University, where he continues to develop methods for the generation of hierarchically structured materials to incorporate the extraordinary properties of nanostructures into complex geometries.

For More Information Contact: Prof. Eon Soo Lee, eonsoo.lee@njit.edu