DREXEL UNIVERSITY
Materials Science and Engineering
College of Engineering

Fall Seminar Series

Hybrid Micro/Nanomanufacturing of Functional Materials

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Wednesday, October 30, 2:00 p.m.
PISB 104

Recent developments in nanostructured materials have demonstrated myriad desirable properties ranging from photonic or plasmonic metamaterials to biomanipulative 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 three such strategies: (1) multiscale thermoplastic and thermoset forming for the generation of nanotextured and nanoporous architectures, (2) focused laser spike (FLaSk) excitation for the fabrication of nanoscale patterns through extreme thermal gradients, and (3) self-limited electrospray deposition (SLED) of hierarchically-structured coatings. Multiscale forming employs a combination of conventional dies and self-assembly to simultaneously impart macro/micro/nanoscale structure to a metallic, polymeric, or composite component. In FLaSk, nanoscale polymeric or metallic features are made in a localized region by simultaneously providing both the mobility and driving force for self-assembly. In SLED, specific manipulation of the electrostatic repulsion, hydrodynamic forces, and evaporation kinetics can be employed to conformally cover 3D architectures with hierarchical microcoatings of protective and functional materials. Further, combining these methods enables rapid deposition of templated microstructures. The critical feature of these processes is that they shift the burden of micro/nanoscale resolution from a costly or slow technique to a more scalable bottom-up method. In this way, barriers to integration with rapid production methods, such as thermal forming, roll-to-roll manufacturing, or spray coating are removed.

Jonathan Singer obtained his PhD (2013) from the Massachusetts Institute of Technology and MSc and BS (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 research manufacturing hierarchically-structured materials that incorporate the extraordinary properties of nanostructures into complex geometries. His research was most recently recognized through a 2018 3M Non-Tenured Faculty Award.