Scalable Nanofabrication of Functional Architectures through Hybrid Lithography

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In order to advance patterning capabilities for future applications, innovative lithographic strategies that focus on scalable and cost-effective techniques must be developed. To address this challenge, a growing number of alternative patterning methods to conventional photolithography for the fabrication of complex structures have emerged, all of which possess certain advantages and disadvantages, generally in the form of tradeoffs between speed and control. My research has focused on developing hybrid lithographic nanofabrication techniques to overcome the limitations of individual techniques—specifically, the development of processes to enable the scalable fabrication of previously impossible architectures.

In my doctoral work in the lab of Edwin Thomas at MIT, I designed techniques that combine large area patterning methods (*i.e.* interference lithography and self-assembly) with 3D laser direct write and that can simultaneously exploit emerging developments in enhanced resolution. This research has resulted in hybrid techniques that have enabled (i) the single-shot fabrication of plasmonic resonators, (ii) the local fill-fraction control of complex periodic and quasiperiodic photonic and phononic architectures with deliberate defects, and (iii) the use of thermocapillary forces for the controlled dewetting of polymer thin films and alignment of block copolymer networks for applications in affordable pattern transfer. In my current role as postdoctoral associate in the lab of Chinedum Osuji at Yale, I have continued work on hybrid methods with an increasing focus on functional materials, such as fluorescent, plasmonic, and semiconducting nanoparticles and conjugated polymeric systems, with applications in, for example, organic-inorganic bulk heterojunction photovoltaics. These materials are difficult to deliberately pattern through conventional means, so my work pursues large-scale alternative methods including (i) magnetic field alignment of nanowires, (ii) high-aspect ratio nanoimprint with metallic glass molds, and (iii) durotaxis-directed electrospray of polymers and nanoparticles.

Moving forward, I will continue to couple experiments and simulations in the full cycle of process-to-device development to create new strategies for patterning that incorporate materials with functionalities in their molecular and supermolecular structures into the final complex architectures that are compatible with high-throughput fabrication processes.

Selected Manuscripts

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