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Synthesizing Functional Biomimetic Nanotextures Using Block Copolymer Self-Assembly

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In Nature, hierarchical, micro- and nanoscale textures assemble in a variety of biological systems, in turn producing emergent functional properties such as broadband antireflection, superhydrophobicity, and structural color. Inspired by these biological solutions, materials scientists have endeavored for decades to mimic these nanotextures in other materials. Our approach at the Center for Functional Nanomaterials (CFN) uses block copolymer thin films that robustly self-assemble into regular, uniform patterns across arbitrarily large areas but with features in the tens of nanometers length scale. I will describe how we combine block copolymer self-assembly with traditional thin film processing like metallization or plasma etching to synthesize biomimetic nanotextured surfaces in silicon and glass. Selecting the appropriate block copolymers and tuning the thin film processing techniques allows us to tailor the size and shape of the nanotexture features. For instance, wafer-scale arrays of conical nanotextures (~50 nm period) can be synthesized which resemble the textures on the surfaces of moth's eyes. By acting as an effective medium with a tunable refractive index gradient in the visible light regime, these nanotextured surfaces display broadband, omnidirectional antireflection that improves solar cell efficiency[1] and renders glass "invisible"[2]. Furthermore, by leveraging the versatility of this block copolymer based nanotexture synthesis, CFN users have also demonstrated that these nanotextures offer an ideal testbed for studying size and shape effects on superhydrophobicity in biomimetic structures [3,4]. Recently, the zeta potential of these superhydrophobic conical nanotextured surfaces have been measured as part of ongoing collaborative work with CFN users, which has implications for energy conversion and molecular separations [5]. Finally, I will describe our efforts to expand the capabilities of block copolymer self-assembly in order to synthesize other bioinspired structures that emulate functional properties of biological systems. In particular, blending block copolymers with very small homopolymers of the same type as each block dramatically accelerates self-assembly, overcoming severe barriers to patterning at the hundred-nanometer feature size range (or higher) [6]. In this size range, self-assembled features that are commensurate with the wavelengths of visible light can potentially be used to mimic biological, structurally colored surfaces.

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