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SCALABLE DIRECTED ASSEMBLY OF NANOSTRUCTURED SOFT MATERIALS

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Molecular self-assembly of block copolymers and small molecule surfactants gives rise to a rich phase behavior as a function of temperature, composition, and other variables. The ability to precisely control their chemical functionality combined with the readily tunable characteristic length scales (~1-100 nm) of their self-assembled mesophases identifies these systems as a versatile and attractive class of materials for compelling applications ranging from selective transport to lithography. A longstanding problem in this area is the inability to reliably and rapidly generate well-ordered structures with specified orientations in, and over, application-relevant geometries, and dimensions, respectively, i.e. to direct their self-assembly in useful ways. In this presentation I will discuss recent advances in scalable approaches for directing the assembly of soft nanostructured materials, and novel routes for generating highly ordered soft heterostructures.

First, we consider the directed self-assembly of soft mesophases using magnetic fields, principally through the use of in situ x-ray scattering studies. Field alignment is predicated on a sufficiently large product of magnetic anisotropy and grain size to produce magnetostatic interactions which are substantial relative to thermal forces. We examine the role of field strength on the phase behavior and alignment dynamics of a series of soft mesophases. The ability to produce highly ordered functional materials over macroscopic length scales is demonstrated and we explore the role of alignment and connectivity in controlling anisotropic ionic transport in block copolymers for battery applications.

Second, we examine electrospray deposition as a novel tool to generate well-ordered block copolymer thin films. The success of the method relies on slow deposition of sub-attoliter quantities of material delivered in sub-micron droplets produced by electrospray atomization. We demonstrate the ability to continuously deposit thin films with vertically aligned microstructure, and to assemble heterostructures through sequential depositions of materials, without constraints associated with the need to utilize orthogonal solvents.