“Single crystals and bespoke textures in self-assembled soft materials”

Résumé: Controlling structure and thereby manipulating the use properties of condensed matter is a central concern in materials science. A striking disparity exists in our ability to enact such structural control in self-assembled soft materials, relative to hard condensed matter systems. In this talk we examine strategies for directing self-assembly in nanostructured soft materials to create single crystals and bespoke textures. Our work elucidates physical processes that are relevant for such directed self-assembly, in part by leveraging in situ scattering tools, with an overall goal of exploiting fundamental understanding to create useful materials or devices. In particular, we consider the use of magnetic fields and confinement effects for directed self-assembly of soft mesophases of block copolymers and discotic liquid crystals. The ability to produce highly ordered functional materials over macroscopic length scales is demonstrated. We explore the role of alignment and connectivity in creating materials with highly anisotropic ion transport, and in creating highly selective nanofiltration membranes with uniformly aligned nanopores produced by molecular self-assembly. Application of orthogonal fields, and field processing across sequential phase transitions enables a novel realization of macroscopic single crystals of self-assembled mesophases with precisely specified texture. Recent progress on low field (sub-1 T) alignment and the associated potential to develop bespoke textures in block copolymers using local field screening are presented.