

Self-Assembly of Rod-Coil Block Copolymers for Optoelectronics

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Abstract – Block copolymer techniques for nanopatterning may be extended to polymers for photovoltaics to pattern the crucial 10nm lengthscale of exciton diffusion, but the necessary chemical conjugation of the polymeric backbone dramatically effects the self-assembly behavior. While classical block copolymer self-assembly is easily expressed in a two dimensional, universal phase diagram, rod-coil block copolymer self-assembly is characterized by a competition between the separation of unlike blocks and the alignment interaction of the rigid chains. Within this talk, both the physics of self-assembly as well as applications to device structures and the role of nanoscale morphology on device performance will be discussed.

While polymers hold significant potential as low cost, mechanically flexible, light weight large area photovoltaics and light emitting devices (OLEDs), their performance relies crucially on understanding and controlling the morphology on the nanometer scale. Two important materials constraints are responsible for the morphology challenges faced in these fields. The 10nm lengthscale of exciton diffusion sets the patterning lengthscale necessary to affect charge separation in photovoltaics. The imbalance of electrons and holes mobilities in most organic materials necessitates the use of multiple components in many device architectures. Both devices rely crucially on crystal/grain structure for improved charge transport. These requirements for hierarchical patterning in large area, solution processed devices suggest that block copolymer strategies previously employed for more classical, insulating polymer systems may be very useful in organic electronics. The thermodynamics of these materials, however, is distinct from classical block copolymers due to the conformational asymmetry of a rigid, conjugated polymer chain and liquid crystallinity. We have created a weakly segregated rod-coil block copolymer system by minimizing enthalpic interactions and maximizing conformational asymmetry. The accessible phase transitions of this unique system allow us to explore the thermodynamics of self-assembly. Further, this main chain liquid crystalline block copolymer system has numerous handles which we can use to control the orientation of the internal interfaces within the active layer of a device. With this ability to control order on the 10nm scale, we have probed the effect of morphology on photovoltaic and OLED performance using bipolar block copolymers which incorporate electron donating and accepting moieties for photovoltaics and electron/hole transporting moieties for OLEDs.

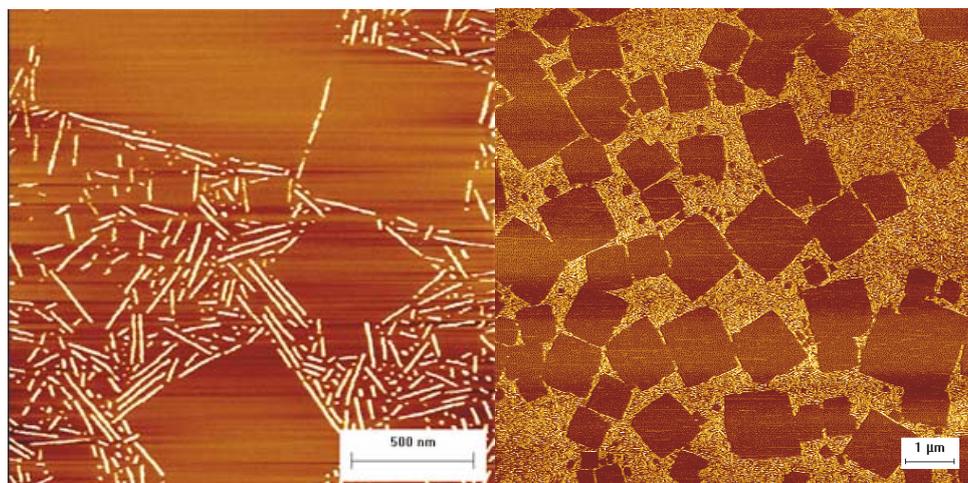


Figure 1: Atomic Force Microscope Image of a Self-Assembled Rod-Coil Polymer Thin Film