Block Copolymer Self-Assembly for Nanofabrication: The Importance and Characterization of Interfacial Roughness Between Copolymer Domains

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Self-assembling materials are being pursued for nanofabrication as alternatives to traditional top-down lithographic techniques. Block copolymers in thin films have been particularly well studied because of their ability to spontaneously generate large arrays of cylindrical and linear structures with dimensions of 5-50 nanometers. Future success in applying block copolymers for nanofabrication, e.g. for magnetic storage media or integrated circuits, not only will exploit the sub-lithographic dimensions that can be achieved, but also will require extremely tight control (within a few nanometers) over the structure shapes and dimensions. In theory, the thermodynamics of self-assembling systems are expected to produce structures with perfectly smooth surfaces and interfaces, as well as monodisperse dimensions. In reality, however, block copolymer structures in thin films have interfaces influenced by the external surfaces and thermal fluctuations leading to a certain degree of interface roughness and variability in domain size.

Here we will highlight approaches for controlling block copolymer assembly in thin films to achieve long-range order and device-oriented geometries, as well as discuss the origins of interfacial roughness in such systems. Directed self-assembly using chemical surface patterns will be emphasized. In this approach a substrate patterned with stripes of different chemistries, and thus different surface energies, is preferentially wet by the domains of a lamellar block copolymer and used to control assembly. Experiments that provide a quantitative characterization of the roughness of the interface between lamellar domains in thin films will be presented. Chemically striped substrates with sinusoidal rough boundaries between the regions of different surface chemistry have been used to investigate the propagation of roughness from the external substrate into the domain interfaces of the assembled block copolymer. The roughness of the interface between copolymer domains has been characterized as a function of the wavelength and amplitude of the roughness in the chemical surface pattern.