Can Cyclic Block Copolymers Meet the Needs for Next-Generation Nanolithography?

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Among the next generation of technologies, we expect medical diagnostic devices that are more accurate and portable; electronic devices that are faster, smaller, and capable of storing more information; and energy sources that are cleaner without sacrificing capacity or power. Self-assembling block copolymer (BCP) systems with tunable nano- and micro-structured morphologies can address these challenges. Inspired by prior work that showed cyclic BCPs could self-assemble with feature sizes 20-40% smaller than their linear analogues, we sought to evaluate the properties of cyclic BCPs and linear/cyclic BCP blends in the context of nanolithography requirements – sub-10 nm feature sizes, narrow interfacial width, self-assembly at low molecular weights, and vertical orientation of nanostructures. In this talk, I will discuss the challenges associated with the synthesis of strongly-segregating cyclic BCPs and how the use of dissipative particle dynamics simulations (collaboration with Prof. Hank Ashbaugh, Tulane) enabled us to evaluate the benefits and drawbacks of using cyclic BCPs for nanolithography. Specifically, through simulation we found that the reduction in feature sizes achievable by molecular cyclization is limited by finite chain size effects; the absolute interfacial width of a self-assembled cyclic BCP is less than that of its linear analogue, but as a fraction of the domain size it is larger; although cyclic BCP domain size is insensitive to linear BCP impurities, the minimum segregation strength (degree of polymerization) required for self-assembly increases slightly; and cyclic BCPs are more sensitive than linear BCPs to surface effects that lead to horizontal rather than vertical lamellar orientation. I will conclude with my thoughts on the question posed in the title, “Can Cyclic Block Copolymers Meet the Needs for Next-Generation Nanolithography?”