Directed Self-assembly of Bottlebrush, Rod-Coil, and Multiblock Copolymers

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Abstract

Directed self-assembly (DSA) of block copolymers offers compelling opportunities for the generation of dense patterns with small period. The utility of DSA can be enhanced by expanding the range of possible microdomain geometries available, and by developing methods to direct their self-assembly in the out-of-plane direction to make three dimensional structures. We will describe morphologies created by Si-containing triblock terpolymers, rod-coil copolymers, and bottlebrush copolymers, including zigzags, bends, junctions, tiling patterns and hierarchical structures with two independently tunable periods. As an example, a Janus bottlebrush triblock terpolymer yielded layers made up of meshes of one block in a matrix of a second block, separated by layers of a third block. The meshes have sub-20 nm period and 54 degree or 90 degree angles, and can be aligned in topographical substrate features. Sequential self-assembly can produce three dimensional structures, including orthogonal mesh patterns, by assembling one block copolymer on another. We also describe metal infiltration of block copolymers by immersion in an acid solution of a metal salt, which locks the self-assembled structure, and reversibility of the metallization by immersion in a solution of a complexing agent, unlocking the structure so that it can evolve in response to annealing. Combinations of novel polymers, templating approaches, and processing techniques yield an extensive array of rectilinear and 3D pattern geometries that can expand current DSA capabilities.