DIRECTED SELF-ASSEMBLY OF BLOCK COPOLYMER BLENDS INTO NONREGULAR DEVICE-ORIENTED STRUCTURES

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The future of many applications at the nanoscale, for example in the fields of microelectronics and photonics, rests upon the ability to produce well-defined patterns with nanometer precision. The conventional method of patterning devices at these length scales involves photolithography, however, significant difficulties are encountered as the critical dimensions are reduced to sub-50 nm. An emerging approach to nanofabrication is the integration of self-assembling materials into existing manufacturing strategies so as to simultaneously achieve molecular-level process control and the ability to produce useful architectures. Diblock copolymers are promising self-assembling materials that form ordered nanostructures, including spheres, cylinders, and lamellae, whose shape and dimensions depend on the molecular weight and composition of the polymer. Block copolymer lithography refers to the use of these ordered structures in thin films as templates for patterning through selective etching or deposition. Prior applications of block copolymer lithography have been limited to the fabrication of devices that do not require perfect structure ordering and that are formed of periodic arrays of structures, such as flash memory devices, magnetic storage media, silicon capacitors, and quantum dots.

Our approach, in comparison, utilizes block copolymer lithography to achieve all the important characteristics of conventional photolithography including pattern perfection over macroscopic areas, dimensional control of features within exacting tolerances and margins, and registration and overlay. Recently we have found that the domains of block copolymer films could be directed to assemble perfectly over arbitrarily large areas and in registry with lithographically defined chemical surface patterns with tailored interfacial interactions. In addition, we have demonstrated that by directing the assembly of blends of block copolymers and homopolymers on chemically nanopatterned substrates, it is possible to pattern nonregular device-oriented structures such as sharp bends. Mean field simulations indicate that the local redistribution of homopolymer within the blend domains greatly facilitates the formation of these nonregular geometries. In the short term, the technological implication of this hybrid top-down bottom-up technique is that the molecular control of structure dimensions afforded by self-assembling block copolymer materials may be harnessed for applications that require patterns significantly more complex than simple periodic arrays.