MAR05-2004-006400

Abstract for an Invited Paper
for the MAR05 Meeting of
the American Physical Society

Block Copolymer Lithography

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During the past half decade, extensive resources have been allocated to the development and implementation of new lithographic exposure tools for use by the microelectronics industry to pattern devices with critical dimensions of 50 nm and below. During this same timeframe relatively modest investments were made in the development of imaging materials. As feature dimensions shrink to below 50 nm, however, traditional materials such as chemically amplified photoresists may not be suitable to overcome significant new challenges with respect to problems such as line edge roughness and critical dimension control at the atomic and molecular level respectively. We explore and develop new materials and processes for advanced lithography in which self-assembling block copolymers are integrated into existing manufacturing processes for patterning high resolution structures that are useful for the fabrication of microelectronic devices. A principal concept is to combine the properties of advanced exposure tools (registration, pattern perfection) with the principles of molecular self-assembly (structures of molecular dimensions, thermodynamic control over pattern dimensions and line edge roughness) to meet strict criteria for device manufacturing at the nanoscale. Here we demonstrate that by depositing thin films of ternary blends of block copolymers and homopolymers on chemically nanopatterned substrates with tailored interfacial interactions, we can direct the assembly of perfectly ordered and registered domains with respect to the lithographically defined underlying surface pattern with considerable process latitude. We also demonstrate for the first time that it is possible to direct the assembly of block copolymer domains with non-linear patterns and arbitrary shapes.