



Improved Method to Create and Transfer Nanoscale Patterns Using Self-Assembling Block Copolymers

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The Wisconsin Alumni Research Foundation (WARF) is seeking commercial partners interested in developing a new technique for creating and transferring chemical and physical nanoscale patterns using self-assembling block copolymers.

Overview

The development of nanoscale components is becoming increasingly important as complex electromechanical, chemical and biological nanodevices are engineered to fulfill specific responsibilities in industry and progressively integrated into consumer products. Size reduction in semiconductor technologies, for example, has spawned investigation of advanced photolithography techniques to etch complex circuits onto silicon wafers. However, each type of radiation possesses a characteristic wavelength, which ultimately limits the resolution of conventional photolithographic techniques.

Due to wavelength limitations, even advanced lithographic techniques such as deep ultraviolet or liquid immersion are not able to attain resolution below about 30 nanometers. Other approaches like electron or ion beam lithography are uneconomical for several reasons, including long etching times or energy requirements, and therefore are utilized mainly in lithographic mask fabrication. The ability to easily create patterns smaller than is possible using modern photolithographic methods, on the scale of tens of nanometers and below, will facilitate commercial manufacture of nanodevices and promote their integration into industry as well as the consumer marketplace.

UW-Madison researchers previously developed a relatively inexpensive method for creating complex three-dimensional nanoscale patterns using self-assembling block copolymers on activated two-dimensional templates (see WARF reference number P06066US). This technique exploits the thermodynamic stability of the copolymer to induce spontaneous transformation from a two-dimensional to a three-dimensional nanostructure when heated above the copolymer's glass transition temperature. The specific patterning of the two-dimensional substrate and the copolymer composition are used to control final three-dimensional shape.

The Invention

UW-Madison researchers now have developed an improved method of creating and transferring chemical or physical nanoscale patterns using block copolymers. This method builds upon the researchers' previous inventions by controlling the chemistry of the copolymer pattern to facilitate reactions that lead to transferring of the chemical or physical patterns. The copolymers used in such an approach comprise two or more constituent units engineered to exhibit distinct chemical properties based on blocking of monomer units and branching thereof. Different chemical properties among monomer units establish micro-phase separation at the polymer surface and allow ink or transfer molecules to be sequestered into specific copolymer blocks to generate distinct patterns. The ink molecules are designed to interact with a second substrate, commonly by raising the temperature just above the glass transition temperature, to facilitate mass transfer of the ink and reproduce the copolymer template pattern.

Traditional lithography techniques can be incorporated into the new method, creating the master template to which the copolymers are adhered. The master template also can be fabricated via chemically nanopatterned surface techniques. The master template is

regenerated after each use, but also may be replicated given specific inks that facilitate the bonding of a new copolymer surface after initial copying. This method can be used to rapidly and easily generate chemical or physical patterns to be employed in all fields of nanotechnology, such as manufacture of integrated circuits.

Applications

- Manufacture of media disks, magnetic disk drives or similar binary storage devices
- Manufacture of periodic, non-regular or integrated circuit regular fabric architectures by transferring chemical patterns instead of topographic patterns
- Replication of chemical patterns at least an order of magnitude smaller than existing lithographic technology
- Fabrication of templates or masks for traditional lithography

Key Benefits

- Can be integrated into existing nanoscale manufacturing processes
- Improves pattern quality and throughput of current optical lithography techniques
- Reduces cost of manufacture as compared to optical lithography of a similar resolution
- Allows more complicated geometry at the surface than lithographic templates
- Avoids pitfalls of topographic transfer used in nanoimprint lithography
- Can facilitate pattern replication via molecular transfer to secondary substrates
- Can generate a reusable master pattern template to replicate patterns with irregular features
- Increases density by a factor of four as compared to optical lithography
- Enhances resolution down to the domain size of block copolymers, approximately five nanometers, which is two to three times greater than optical lithography
- Enhances uniformity with respect to size, placement, vacancies and proximity effects

Publications

- Park S.M., Ravindran P., La Y.H., Craig G.S.W., Ferrier N.J. and Nealey P.F. 2007. Combinatorial Generation and Replication-Directed Assembly of Complex and Varied Geometries with Thin Films of Diblock Copolymers. Langmuir 23, 9037-9045.

Tech Fields

- [Semiconductors & Integrated Circuits : Design & fabrication](#)
- [Semiconductors & Integrated Circuits : Lithography.](#)

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