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Block copolymer based bottom-up nanolithography: Materials, processes, and applications

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The future of circuit miniaturization is based on the development of novel functional materials and the improvement of nanofabrication and characterization techniques. The performance of semiconductor electronics is coupled to the resolution of the lithographic process; and to keep pace with historic growth rates (e.g., Moore's Law), the dimensions of critical circuit elements are shrinking toward 10 nm. The development of micro- and nano- technology depends on the ability to fabricate micro and nanosized structures with high precision. The most sophisticated semiconductor devices, such as microprocessors and memory chips, are patterned with top-down projection lithographic techniques. In parallel, the bottom-up approach is based on hierarchical self-assembly of complex structures departing from molecular building blocks through molecular recognition and molecule-surface interactions. There are advantages and drawbacks in both approaches. In top-down methodologies further downsizing is critically related to issues both with light particle dimensions and also thermal management. On the other hand, it is highly challenging to achieve long-range translational order and robustness of the fabricated systems with bottom-up approaches. Block-copolymers (BCPs) are promising materials in the field that successfully compromises top-down and bottom-up methodologies. BCP materials to control feature ordering, orientation, alignment and defect density besides the formation of 'on-chip' resist from the BCP nanopatterns by plasma etch and transferring the pattern into the substrate will be discussed. The demonstrated results are promising and pertinent in the nanotechnology field and with vast applicability such as in the fabrication of nanoimprint lithography stamps, nanosensors, nanofluidic devices or in narrow and multilevel interconnected lines.

Biography

Dipu Borah has completed his Ph.D. from Dibrugarh University, India in 2005. He was a postdoctoral research fellow at Seikei University, Tokyo under Indo-Japan Cultural Exchange Program from 2006-2007. Currently, he is a senior postdoctoral researcher at University College Cork, Ireland. His current research interests are in the block copolymer self-assembly, self-assembled monolayer, graphoepitaxy, nanopatterning, electrochemical sensor, etc. He has published more than 35 papers in reputed journals.

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A facile route to ferroelectric polymer nanowires with highly anisotropic piezoelectric responses

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The unique properties of polymer nanostructures under confinements, make them promising for application in various electronic, optical and mechanical devices. As a typical organic ferroelectric material, the copolymer of vinylidene fluoride and trifluoroethylene [P(VDF-TrFE)] has been widely used in sensors, actuators and other microelectromechanical systems. Recently, their application in flexible nonvolatile memories and photovoltaic devices etc., has stimulated renewed research interest on highly ordered nanostructures of the material. Particularly, one-dimensional copolymer ferroelectric nanowires with anisotropic piezoelectric responses are of importance for both fundamental science and application points of view because they can be used for investigating the size dependent behaviors and for devices such as nanogenerators.

Here we report a template-free solution method for the fabrication of highly ordered P(VDF-TrFE) nanowires with anisotropic piezoelectric response on various substrates. The molecular dipoles in the nanowires are preferentially oriented parallel relative to the substrate plane, while the macromolecular backbones are oriented perpendicular to the substrate plane. As the ferroelectricity in copolymer originates from the alignment of molecular dipoles, such a molecular orientation leads to a significant difference in lateral and vertical piezoelectric responses. A flat-on lamellar structure and a thin layer melt crystallization nanowire formation mechanism were proposed. This facile and efficient P(VDF-TrFE) nanowire fabrication route is promising to be used for nanoscale energy harvesting devices.

Biography

Dong Guo received his Ph.D. degree in Tsinghua University, Beijing, China, in 2003. From 2003 on, he has been working on both organic and inorganic ferroelectric materials. He has authored and coauthored over 60 publications. He is now a '100 Talented Program' Professor and the director of the functional materials group in Institute of Acoustics, Chinese Academy of Science. The current research of his group is focused on various piezoelectric, ferroelectric and semiconductive materials, and their application in sensors, actuators and memories, etc.

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