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Plasma etching of high molecular weight block-co-polymer patterns into glass for optical applications

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Nanostructured surfaces that engineer the interaction between incident light and an object are a topic of both scientific and manufacturing significance.[1] One drawback to manufacturing these structured surfaces is their limited up-scalability to large areas due to limitations of conventional UV lithographic approaches, the inability to pattern curved surfaces and the high cost of necessary infrastructure. Block copolymers (BCPs) show much promise for nanolithography applications, as they can address these issues. In this work, a solution process based on high molecular weight BCP self-assembly is used to impart cylindrical patterns to glass substrates, with subwavelength features. The feature sizes and spacings are designed to efficiently scatter visible light. We present BCP phase separation leading to well-ordered hexagonal nano-patterns with feature diameters of ~130 ± 15 nm and periodicity of ~160 ± 20 nm. Ni ions are selectively incorporated into the P2VP block, and UV/ozone processing allows for the pattern to be transferred as a metal oxide etch mask. ICP-RIE plasma etching was performed, transferring the pattern into the substrate. The resulting nano-pillars form a Gradual Refractive INdex (GRIN) change and result in drastically reduced reflectance. Over a wide range of angles, the reflectivity is reduced by 40% in the range of 1100 nm – 2 µm, with only one side of the glass, treated. This nano-patterning process based on BCPs is applicable for a wide range of substrates, both curved and planar, it has the added advantage that it avoids the previous inherent size limitations of BCPs (5-100 nm), and it makes surfaces suitable for enhanced transparency, light focusing, anti-reflection and tuning photon absorption. This technique facilitates fabrication of a high density ordered an array of nano-pillars with tunable height, which are easily scalable and can be formed at room temperature. GRIN may now achieve a broadband elimination of reflections, outperforming other anti-reflective coatings for high-quality glass optics.

Biography

Riley Gatensby graduated from Trinity College Dublin in 2012 with an undergraduate degree in Nanoscience, Physics, and Chemistry of Advanced Materials. He subsequently undertook postgraduate studies where he worked on synthesizing and characterizing two-dimensional semiconducting transition metal dichalcogenides. He earned his PhD in 2018 from the Department of Chemistry, Trinity College Dublin. He is currently a postdoctoral researcher in the Intelligent Nano Surfaces group of Dr. Parvaneh Mokarian. His current research interests focus on the plasma etching of BCP patterns into different substrates for optical, semiconductor, lithographic and energy applications.

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