Ultra-High Refractive Index Polymers in the Visible Wavelength for Nanoimprint Lithography

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The development of advanced photonic devices working in the visible light promises a revolution in a broad range of areas from biochemical sensing to quantum computing. Over the last years, novel nanophotonic devices were demonstrated but are still limited to research laboratories due to the lack of suitable materials with high refractive index and optical transparency. Polymers with high index of refraction can find a broad range of applications including light emitting diodes (LEDs), CMOS sensors, large area displays, eyeglasses and optical elements for augmented reality. Polymers, in general, are easy to process, are lightweight and can be cost-effective. The majority of polymers present low refractive index values ranging from 1.50 to 1.60 and the design and synthesis of purely organic polymers with higher refractive index ($n > 1.70$) and high transparency has proven extremely challenging.
Here, we demonstrate the development of organic polymers with ultra-high refractive index ($n = 1.90$) for thin-film applications. The synthesized polymers show high transparency in the visible wavelength, are easy to process and soluble in common non-polar solvents. They are among the organic polymers with the highest refractive index ever reported (figure 1a). The developed polymers can be nanopatterned via nanoimprint lithography (figure 1b), a powerful tool to fabricate nanostructures following a simple and scalable high-throughput process. UV and thermal nanoimprint processes were employed to pattern different structures on the polymer films. The patterned films represent the directly nanoimprinted polymers with the highest refractive index found in the literature.
As a proof-of-demonstration, applications including nanoimprinted photonic crystals, microlenses and antireflective structures (figure 2) patterned on ionizing scintillators, fiber endfaces and curved optical elements have been performed. This work shows that the design and synthesis of organic polymers with high refractive index and optical transparency are feasible and opens a promising route to the realization of novel photonic devices and applications.

Reference:

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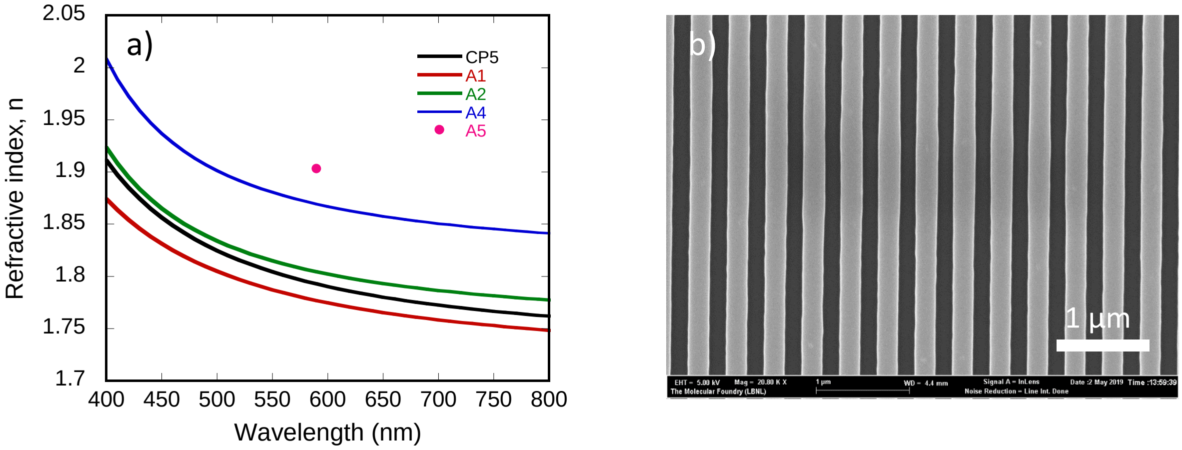

Figure 1. a) Refractive index of infrared polymers developed by HighRI Optics; b) SEM image of a nanoimprinted infrared transparent polymer with a refractive index of 1.90.

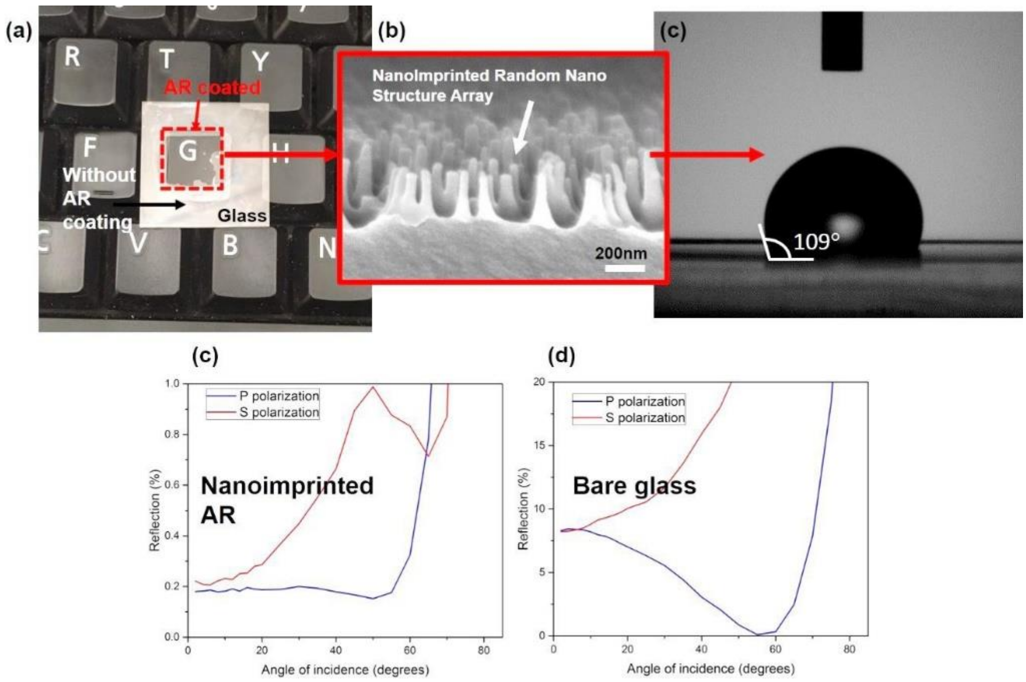

Figure 2. (a) A photograph of a silica substrate with imprinted RAR, replicated from black silicon. Both sides of the silica substrate are coated with RAR, indicated in a red dotted square. This image shows that imprinted regions successfully minimize the reflection from the room backlight. (b) Cross-sectional image of the imprinted RAR using a commercial imprint material (n = 1.51). (c) A photograph of the contact angle measurement revealing that the imprinted structure is hydrophobic (contact angle = 109 deg) (c)-(d) Polarization- dependent reflection as a function of the angle of incidence @ 520 nm measured from the imprinted region (c) and a bare glass (d) for comparison.