Filler-Free NIL Compatible Ultra-High Refractive Index Resins for Photonic Applications

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Nanoimprint lithography (NIL) technology has steadily advanced over the last decades as a cost-effective fabrication technology for mass production. NIL has been known to achieve single-digit resolution, reduce fabrication process steps, and lower capital equipment costs. While it has trailed behind traditional optical lithography technology, with the recent emergence of photonic applications in telecommunications, sensing, consumer electronics, automotive, etc., NIL has been gaining its footing as an ideal lithography technology for light-enabled applications.

Optical polymers are fabricated into micro and nano surface topologies using NIL for photonic applications. The optical properties of the optical polymers play an essential role from the design stage of the optical component. Optical polymers' haze, color, transparency, and refractive index (RI) directly affect visual performance. Besides the optical properties, mechanical properties, environmental reliability, and process compatibility are necessary hurdles to overcome that heavily depend on the applications. High refractive index polymers give attractive advantages to existing lower index polymers (ex. n = 1.55) in terms of optical performance, device footprint, and manufacturability, and it also enables new applications which are not possible with the existing optical polymers. The availability of high-refractive-index materials, combining it with the NIL strengths in manufacturability (high resolution & fidelity nanopatterning over a large area at low cost), would play a critical part in supporting the growing photonics industry.

HighRI Optics reports on the advancement and progresses on the UV-curable 1.8 RI NIL materials without metal oxide fillers, which makes it the highest refractive index value amongst the filler-free & NIL-compatible materials. Filler-free material can also function as a polymer matrix to form nanocomposites with a tuneable RI between 1.90 and 2.05. Optical properties, NIL performance, NIL performance on high-volume manufacturing tools, NIL repeatability, and reliability validations (e.g., accelerated aging and high temperature/high humidity tests) are presented to demonstrate basic functionality and show the minimum environmental impacts on the high refractive index materials. High-refractive index materials are also compatible with various fabrication processes with tunable thicknesses. Breakthrough technology and devices need a new chemical material, and the functional high refractive index materials can be an essential part of the ecosystem to enable the mass production of future photonic devices.

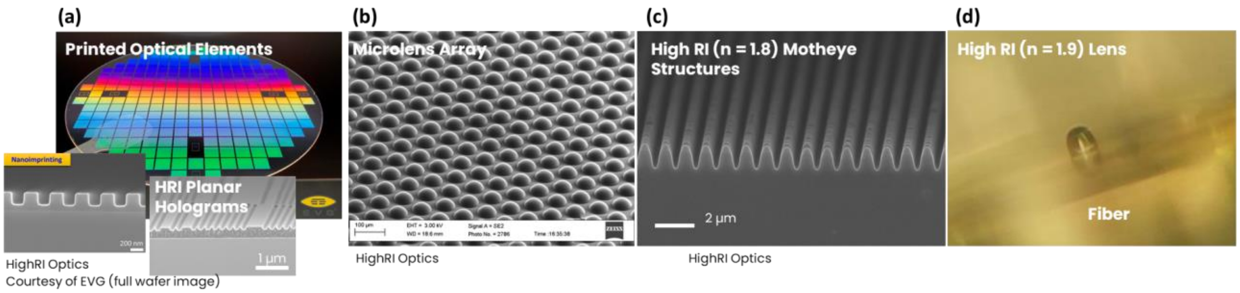

Figure 1. Applications of high refractive index materials using Nanoimprint Lithography: (a) Nanoimprinted high refractive index optical elements, (b) microlens array, (c) Refractive index moth-eye anti-reflection coating, (d) high-refractive index lens on an optical fiber.