Development of Visible Light/IR Diffractive Optical Elements for Beam Shaping Using Nanoimprint Lithography

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Primary CNF Tools Used: Nanonex NX-2500

Abstract:

The development process in nanoimprint lithography is a key piece of technology for optical device fabrications, such as Diffractive Optical Elements. Our developed UV curable resins with refractive indices of 1.8-2.0 have now been successfully imprinted without any defects. This technology will not only improve the device performance, but also expand the applications of nanoimprint lithography for use with an array of optical devices.

Summary of Research:

Many fields have begun looking to the development of nanofabrication technologies to achieve better resolution, improved variation of critical dimensions, and improved placement accuracy in their technology. Nanoimprint lithography has shown to be a promising avenue from which to accomplish these goals at a low cost, for a wide variety of consumer applications [1]. However, the development process can be quite challenging since the optimized conditions vary depending on the mold design and chosen materials.

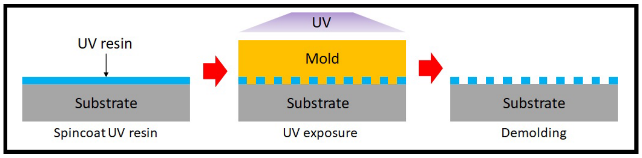

Figure 1: A schematic of nanoimprint lithography.

Applications for Diffractive Optical Elements (DOEs) have attracted a lot of attention, as they can implement versatile functionalities such as beam shaping and phase encoding [2]. For such applications, high refractive index materials are highly sought after to improve the performance of these devices. HighRI Optics is developing a series of high refractive index nanoimprint resins with the refractive index n ~ 1.8-2.0, representing one of the highest commercially available RI values [3]. Here we report on the successful fabrication of DOEs using our developed materials with a refractive index of up to 2.0.

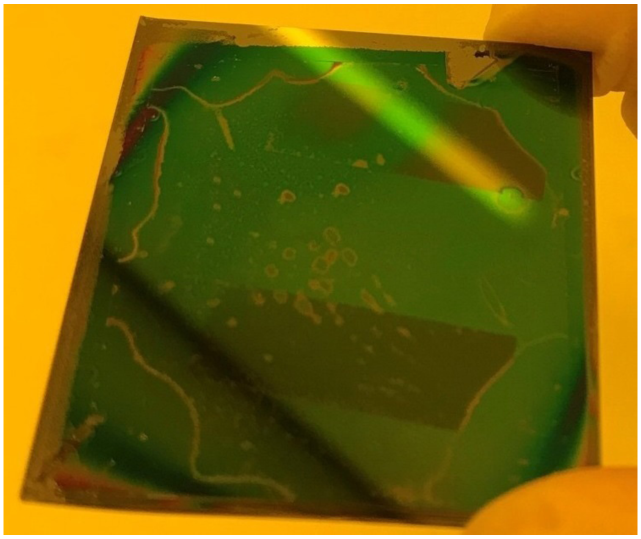

Figure 2: Imprinted patterns in the high refractive index polymer with many defects.

Silicon or fused silica wafers were spin-coated with the high refractive index materials, and nanoimprint lithography was performed using Nanonex NX-2500 as shown in Figure 1. Following UV exposure, the master mold was demolded from the UV resin layer to achieve the desired replicated patterns. Figure 2 shows an image of the imprinted patterns fabricated in our facility, and Figure 3 displays an image of the same patterns fabricated at CNF. The results clearly show an increase in the quality of the imprinted patterns, and no defects were observed on the device.

Conclusions and Future Steps:

By optimizing the imprint conditions, our developed materials with high refractive index have been successfully imprinted with the necessary patterns for DOE applications. This technology is expected to greatly improve the performance of DOEs for versatile applications such as augmented reality and virtual reality devices. Our next steps are to continue optimizing the fabrication process to suit more complex designs, as well as to further increase the refractive index of the materials.

References:

[1] S. Chou, P. R. Krauss, and P. J. Renstrom, Science, 272, 5258, 85 (1996).

[2] A. Siemion, Sensors, 21, 100 (2021).

[3] C. Pina-Hernandez, et al., Scientific Reports, 7, 17645 (2017).

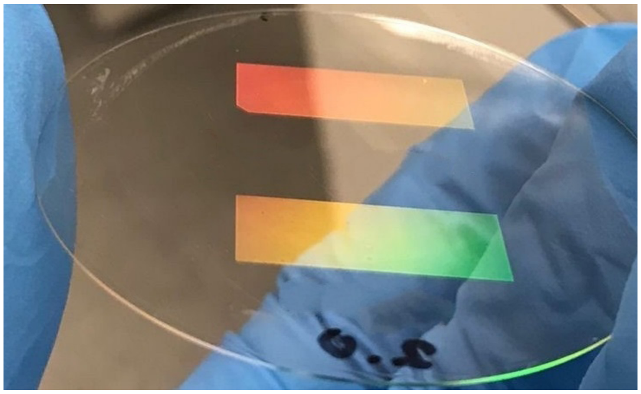

Figure 3: Imprinted patterns in the high refractive index polymer with no defects.