Nanoimprint process to mass manufacture highly-angled high-RI gratings for augmented reality combiners

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Abstract

Blazed and slanted gratings present particularly interesting optical properties in that they can diffract light predominantly into one side of the diffraction plane ($m \leq 0$ or $m \geq 0$). This is useful in a variety of applications, especially for augmented reality (AR) display combiners, where slanted gratings are commonly used to reduce ghosts and improve efficiency. However, angled gratings are difficult to manufacture in volume. Nanoimprint lithography (NIL) has been explored as a route to mass manufacture AR waveguides with slanted structures. Nonetheless, NIL presents several challenges associated with the process of molding and releasing angled features, which result in a constrained process window and the possibility to imprint grating with low aspect ratio and slant angle. An additional challenge of NIL is the choice of imprinted material, which should have the right mechanical and optical properties and the highest desired refractive index. A technology solution to manufacture diffractive optics in volume with large slant angles (>45°) and a high refractive index is necessary in order to have products such as AR glasses reach the consumer market.

In this paper we report a series of breakthroughs that our Optics and Display Research team at Facebook Reality Labs (FRL) has achieved, which allow for replication of gratings with a slant angle up to 60° and an aspect ratio of 10:1 in a material with refractive index of 1.90 (RI). A study of the replication process, optimization of materials and processes will be presented. Pattern fidelity, RI uniformity and repeatability of the grating optical response are tracked as function of imprint number.

To the best of our knowledge, these results are the first public demonstration of a scalable process to manufacture AR combiners with highly slanted structures in a material with a refractive index of 1.90.