Large-area Nanoimprint Lithography as a solution for mass manufacturing of AR optics

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Through the addition of nano- and/or micro-structures to surfaces, nanoimprint lithography (NIL) enables performance enhancement of existing optical elements, as well as the creation of novel optical functionalities for emerging applications. As an emerging application, Augmented Reality (AR) benefits from the ability of NIL to add complex waveguiding structures onto glass with high imprint fidelity and nano-scale resolution, decreasing fabrication complexity compared to traditional lithography techniques. Utilizing the highly repeatable nature of the NIL process, it has previously been demonstrated that waveguide manufacturing processes can be created which meet the stringent quality requirements as set by industry. As such, leading AR optics manufacturers have already adopted NIL for small scale manufacturing.

For NIL to grow as a viable mass manufacturing technology for AR optics in the consumer market, imprint quality and throughput are equally critical. At Morphotonics, large-area NIL equipment and processes are developed to enable scalability of the NIL manufacturing process beyond traditional wafer scale, while retaining imprint quality. By combining UV imprint accuracies with large area display manufacturing methods, Morphotonics has developed large area Roll-to-Plate (R2P) imprinting equipment capable of imprinting on Gen5 sized substrates (1100 mm x 1300 mm), Figure 1. With the availability of large-area imprinting equipment and processes, over 5 to 20 times more individual products can be manufactured in one imprint cycle as compared to wafer scale imprinting, Figure 2. Hereby the manufacturing throughput significantly increases, meeting the scalability demand.

As a consequence of such scalability, the challenge for large-area imprinting lies in retaining imprint quality (such as texture fidelity, pitch variation, and residual layer thickness variation) over the entire Gen5 area. To achieve retained imprint quality, accurate control over imprinting parameters, such as the used line pressure, are required throughout every stage of the process repeatedly over the lifetime of the working stamp or ‘flexible stamp’.

In this talk, Morphotonics presents state-of-the art replication quality by large-area R2P imprinting, providing an insight into the potential of large area NIL for manufacturing of high-end optical components such as AR waveguides. To this end, our latest developments regarding low residual layer thickness imprinting, residual layer thickness uniformity, and master upscaling technology, are addressed.

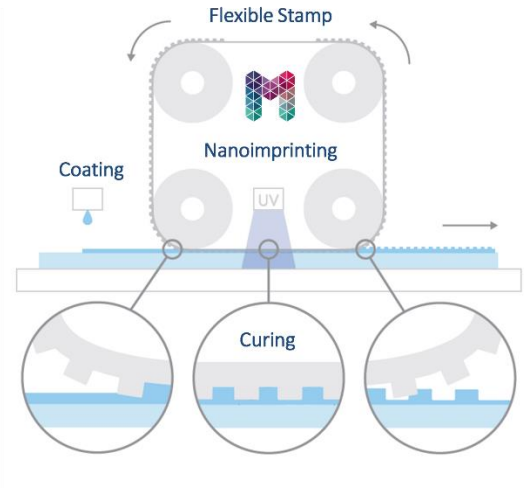

Figure 1. Schematic illustration of the large-area NIL process.

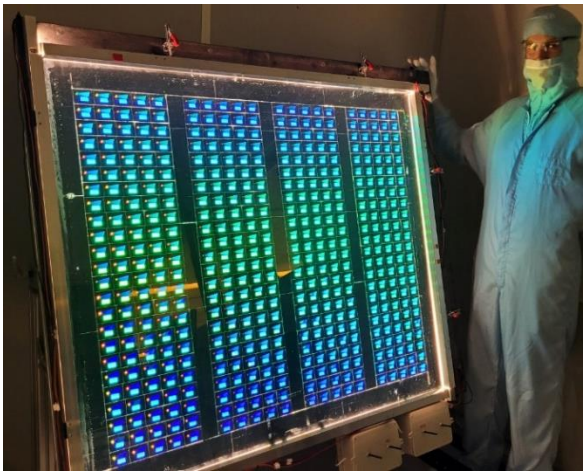

Figure 2. Image illustrating scalability potential of large-area NIL, showing a single Gen5 imprint containing 480 waveguides.