Advantages of Inkjet Coating Combined with Nanoimprint Lithography in Nanostructured AR Waveguide Fabrication

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Optical performance in photonic device manufacturing relies on well-controlled and uniform residual layer thickness [1]. This is in particular challenging for AR waveguides as they usually require different fill factors for e.g. in-coupling and out-coupling structures. Usually, the optical functionality of the waveguide is achieved by structuring polymer layers on top of a glass substrate with binary, multi-level, blazed or slanted gratings. Direct replication of such patterns into UV-curing polymers using nanoimprint lithography is well established and has proven to be a technically and commercially viable way to manufacture advanced photonic elements, such as AR waveguides [2]. As the refractive index of polymers in the visible spectrum is, up to now, limited to about 1.9, alternative approaches have been developed using dielectric materials with refractive indices up to 2.6. To achieve that, a dielectric layer is deposited as an etch mask on the glass substrate. The layer is lithographically patterned and structures are then transferred into the high refractive index layer by etching [3].

However, for both approaches with the imprinted layer as functional grating or as an etch mask to transfer the pattern into a high refractive index layer, a well-controlled and uniform low bulk layer underneath the imprinted waveguides is of high importance and needs to be adjusted according to the design of such structures. Inkjet coating offers multiple advantages compared to conventional spin coating for these applications. It allows printing of different patterns, different layer thicknesses and even different materials on the same substrate. In addition, the material consumption is considerably reduced compared to spin coating.

In this work, several process capabilities of inkjet coating will be shown. Results for both inkjet printed and spin coated substrates will be compared. A low residual layer thickness suitable for etching the imprinted layer into a substrate will be achieved with AR typical designs addressing different fill factors. Furthermore, the developments of high refractive index resins suitable for inkjet and nanoimprint will be investigated.

Reference:

[1] Kevin R. Curtis, “Unveiling Magic Leap 2’s Advanced AR Platform and Revolutionary Optics”, Proc. SPIE 11932, SPIE AR, VR, MR Industry Talks 2022, 119320P (8March 2022); DOI:10.1117/12.2632495

[2] C. Thanner, A. Dudus, D. Treiblmayr, G. Berger, M. Chouiki, S. Martens, M. Jurisch, J. Hartbaum and M. Eibelhuber, “Nanoimprint Lithography for Augmented Reality Waveguide Manufacturing”, Proceedings Volume 11310, Optical Architectures for Displays and Sensing in Augmented, Virtual, and Mixed Reality (AR, VR, MR); DOI: 10.1117/12.2543692

[3] M. Eibelhuber, C. Thanner, D. Treiblmayr, S. Pochon, W. Frost, J. Ferreira, D. Pearson, S. Baclet, “Towards AR waveguides with refractive index 2.0 utilizing nanoimprint lithography”, Conference: Optical Architectures for Displays and Sensing in Augmented, Virtual and mixed Reality (AR, VR, MR) II; DOI: 10.1117/12.2579595

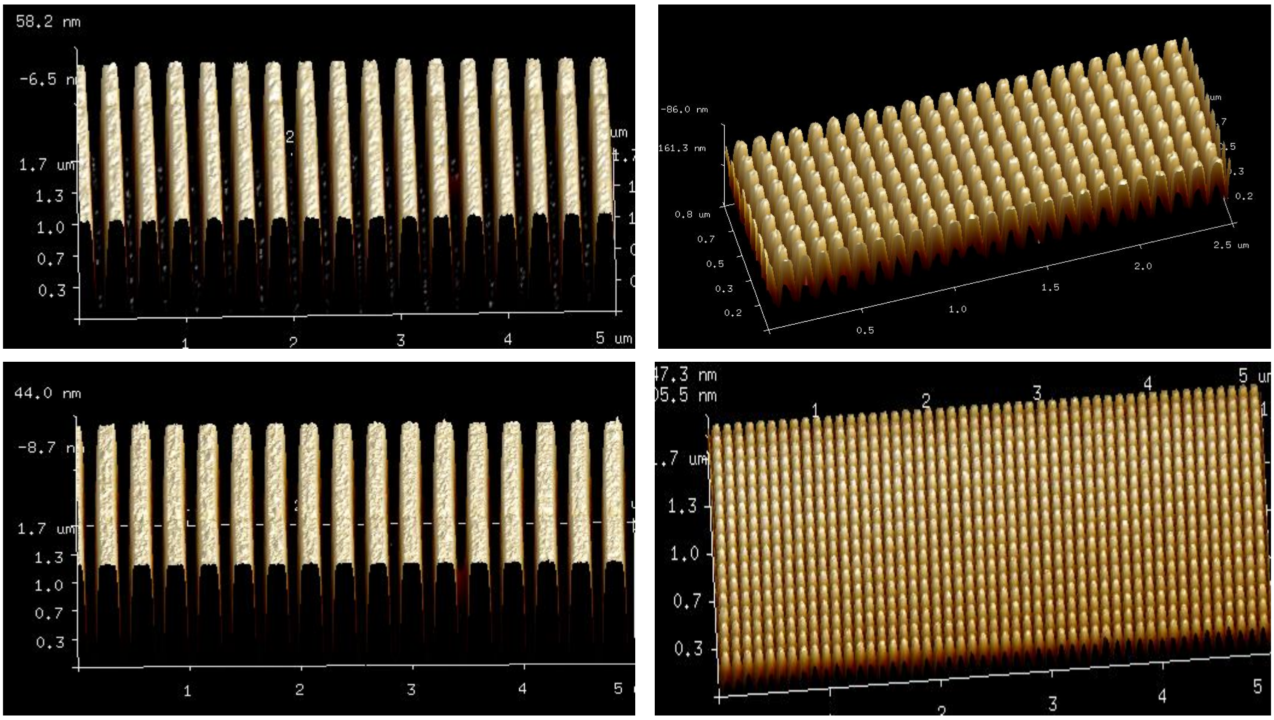

Figure 1. Spin coating compared to inkjet coating: AFM showcasing the resolution down to 50 nm (top: spin coated, bottom: inkjet coated)

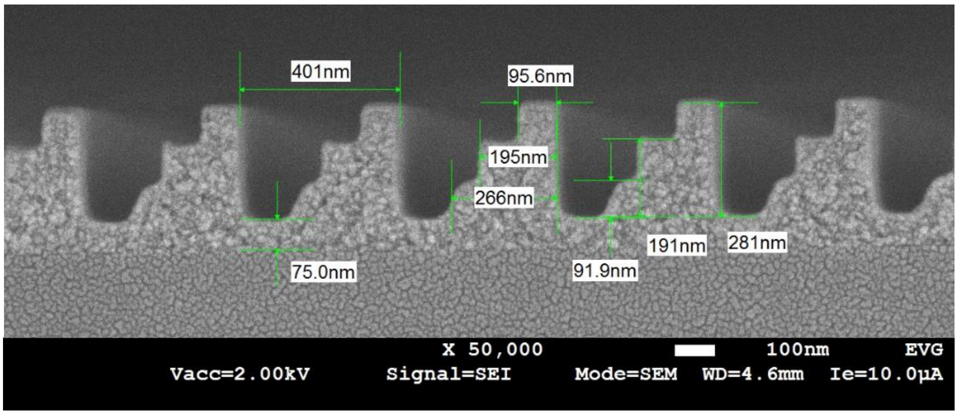

Figure 2. Low and uniform RLT adjusted to the fill factor