Roll-to-Plate UV-Nanoimprinting for Micro and Nano-Optics

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Nanoimprint Lithography [1][2][3] has been proven to be a production technology for various applications ranging from the production of microlenses (e.g. [4]) to the use in the fabrication of vertical cavity surface emitting lasers (VCSELs) [5].

In most of these cases nanoimprint is performed on wafer scale. To go to larger areas roller-based nanoimprint has been proposed very early on [6]. A lot of work has been done on roll-to-roll based Nanoimprint [7][8][9], much less on roll-to-plate NIL using rigid substrates.

To address the challenges of large area nanoimprinting on rigid and also non-transparent substrates, we are currently setting up and testing a roll-to-plate UV-based nanoimprint tool. It is based on [10] and comprises a transparent roller and a substrate translation stage. A transparent stamp or printing plate can be mounted on the roller. The UV light-source is located inside this roller. The light of a water cooled array of UV-LEDs is focused the nip, i.e. to the point where roller and substrate meet. The tool is designed to handle substrates up to 30x60cm² in size with a thickness of up to 10mm. The printing speed can range from 1m/min to 10m/min.

The device is not completely finished at the moment, as inkjet printing and slot die coating devices still have to be installed to directly include large area coating capabilities. We nevertheless can already do first printing tests. To perform these tests a glass plate was mounted on the granite substrate table. A polymer foil was placed on top of the glass-plate and coated with a UV-curable imprint material.

We successfully replicated features with a broad range of dimensions. Figure 1 shows a linescan of a microptical teststructure, while figure 2 a linescan of a test-hologram. The height as well as the period of the features differs by several orders of magnitude. Figure 3 shows a typical printed hologram structure. In Figure 4 a photograph of the tool during UV-imprinting including the printing plate can be seen.

With the material combinations that were tested separation was very easy, actually the foils didn't need to be fixed on the glass plate at all to allow successful automatic separation after the imprinting. We used printing plates made from UV-curable resin material or a UV-curable PDMS and Stensborg's X29 imprinting resist. For both combinations separation was automatic, so the foil separated itself from the printing plate.

We will present further printing results with a wider range of micro- and nanoscale features and also first results on the large area coating of the UV-curable materials. The authors acknowledge funding from the rollerNIL and ePaper projects (funded by FFG, the Austrian Research Promotion Agency).

References

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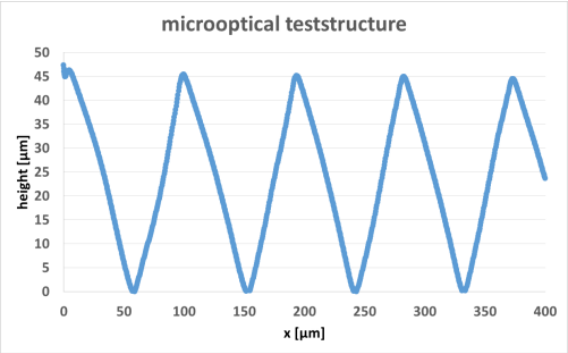

Figure 1. Linescan (Profilometer) of a roll-to-plate imprinted microoptical teststructure, feature height approx. 45µm, period approx. 100µm.

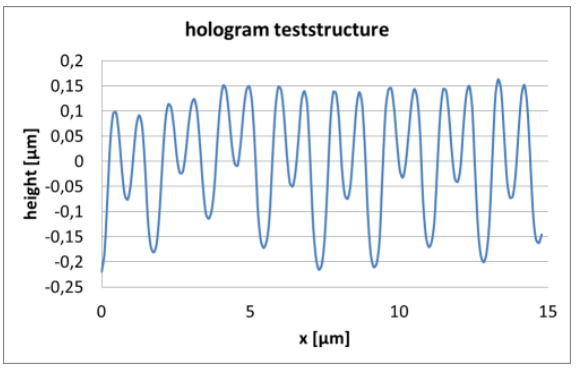

Figure 2. Linescan (AFM) of a roll-to-plate imprinted holographic teststructure, feature height approx. 350nm, period approx. 880nm.

Figure 3. Pptical micrograph of a hologram testpattern corresponding to figure 2.

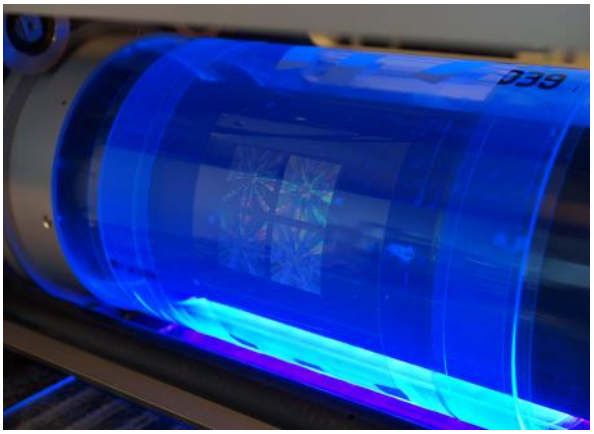

Figure 4. Photograph of the roller during imprinting with a printing plate mounted to the roller.