Roll-to-Plate nanoimprint lithography for large-area applications: equipment, materials and processes

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The interest for nanoimprint as enabling technology for applications in the field of photonics, solar, lighting and displays is growing. The relative ease and speed at which surfaces can be patterned is important to play a role in these markets. For small areas and devices, wafer-scale nanoimprint can be suitable. For large areas and devices a more cost effective solution is needed. With roll-to-plate nanoimprinting large areas can be patterned in a single imprint step, enabling fast pattering for large-area applications.

Single-step, full field imprinting requires a large-area master. For large-area imprinting this can present a limitation because most mastering methods are only available for wafer sized areas. To overcome this limitation, multiple wafer-sized masters can be merged together to form one large master. We will present a method to "tile" small size masters together. In figure 1 an example is shown of what can be achieved. The large area master has several defined areas with various structures ranging from 150 um pyramids to 100 nm gratings in height. The seam between the small masters can be as small as a few micrometer.

When transferring a pattern from a large area master to a large area substrate, deviations in lateral dimensions can have a big impact. While on wafer scale differences in expansion between materials can result in acceptable deviations, the same relative difference in expansion results in unacceptable absolute deviations on larger areas. Using flex stamps with expansion coefficients which match those of the master and substrate can limit the deviations to a large extent. We will present different flex stamp types which are compatible with the large area roll-to-plate imprinting process and which can be chosen to match the substrate material. In figure 2 the expansion of 3 types of flex stamps are depicted.

Next to the masters and flex stamps, the imprint resists must be compatible with the large area processing. Recently, there is a lot of interest in materials with a refractive index of 1.7 or above. This refractive index cannot be achieved with organic components alone. We have developed a material with a refractive index of 1.7 which is solvent-free and compatible with large area UV curing imprint processes. We will present the results of imprints made with this material.

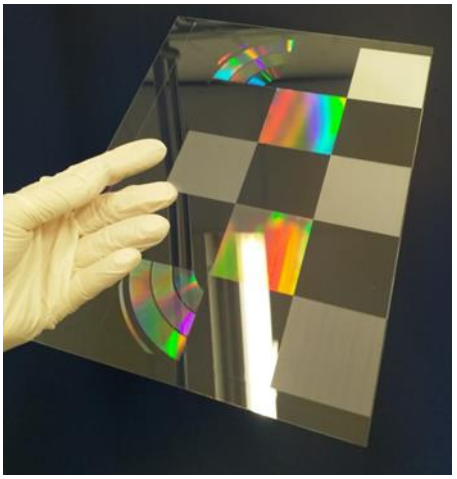

Figure 1. “Tiled” large area master

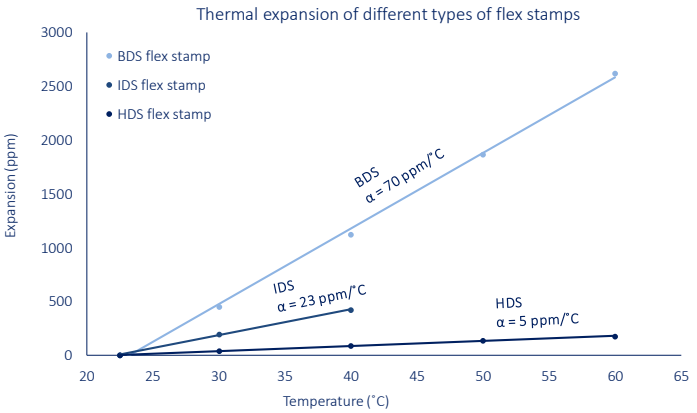

Figure 2. Thermal expansion of different types of flex stamps.