SCIL technology; from sample to production

Marc A. Verschuuren[1*] and Rob Voorkamp[1]

[1] *Philips SCIL Nanoimprint Solutions,*
De Lismortel 31, 5612 AR, The Netherlands. Email address: marc.verschuuren@philips.com

Substrate Conformal Imprint Lithography (SCIL), a full wafer based nanoimprint method that uses soft PDMS stamps capable of sub-10nm resolution, is used since 2008 for production of VCSEL lasers. In 2015 Philips started a dedicated technology venture to bring high volume production solutions to the market. This is based on high volume production tooling, dedicated resist and stamp material development and collaborating with customers to progress quickly from initial demonstration to process development and verification, pilot production and transfer to the end customer production line.

SCIL solves the limitations of soft-stamp based NIL techniques and allows low pressure, truly wafer scale conformal contact and sub-10 nm resolution. The in-house developed imprint resist offers additional functionality (chemical, physical) which lowers the total cost of ownership of the patterning process. [1] The combination of our sol-gel based resists with X-PDMS soft conformal stamps has demonstrated industry leading stamp lifetime of up to 1100 imprints on 200mm wafers for sub-50nm patterns with sub-nm pattern variation. This is a significant improvement compared other published results. [2]

In the nanophotonics field nanoimprint can have a high added value, especially in the emerging fields of meta-lenses and augmented reality applications. This is due to the combination of deep sub-micron patterns and typically high refractive index materials ($n > 1.8$, pref. $n > 2.3$), all on large areas. SCIL is developing fully inorganic high index functional resists which are directly patterned with high resolution, achieve a high refractive index and exhibit low shrinkage. Fig. 1a. shows the range in refractive index of our NanoGlass resists and in 1b. the direct replication of high aspect ratio slanted gratings in high index fully inorganic resist.
Inorganic resist materials have distinct advantages but are not always the best option for a process. SCIL has tested many organic UV curable resist materials available on the market but found that none of these would provide the high resolution, fast curing and stamp lifetime of our NanoGlass range. SCIL has therefore started the development of our own fully organic UV curable resist material and in the contribution, we will update on the performance of these systems.

In the past, SCIL has demonstrated sub-10nm overlay performance for areas up to ~10cm^2 using a table-top SCIL test setup with a piezo controlled stage. [1,3] Over the last year we have designed, built and integrated automatic overlay alignment functionality in our AutoSCIL production platform. The system is designed to achieve ~ 1 µm overlay accuracy in x,y over 150mm and 200mm full wafers. The overlay alignment step will have negligible effect on the production throughput of ~40 and 35 wafers/hour for 150mm and 200mm wafers respectively.

Figure 2 shows an overlay error map of a 200mm wafer. The errors are on 16 points between a 1st and 2nd imprinted and aligned pattern. A magnification error and shift is found which is due to the imprints being made at slightly elevated temperatures and which is consistent with the difference in the thermal expansion coefficient for the stamp back-plate and silicon wafer. In this contribution, SCIL will share more and detailed information on the overlay performance of the AutoSCIL platform.

References

1. Marc A. Verschuuren, Mischa Megens, Yongfeng Ni, Hans van Sprang and Albert Polman, Adv. Opt. Techn. 6(3-4) 243–264 **(2017)**
2. Hubert Teyssedre, Stefan Landis, et. al. Adv. Opt. Techn. 6(3-4) 277 **(2017)**
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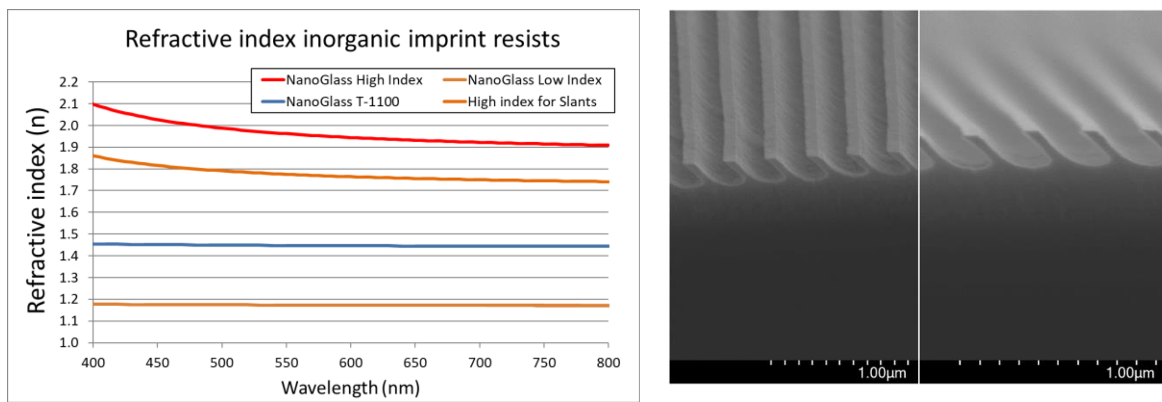
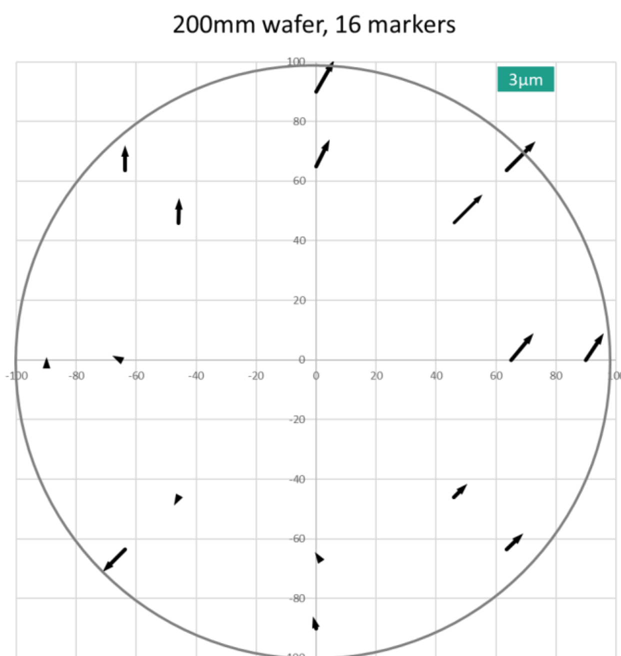


Fig. 1. A. Optical dispersion of our NanoGlass resists. B. SEM images of directly imprinted slanted cured at 200°C



Overlay error between 1st imprinted layer and a 2nd, aligned imprinted layer on a 200mm wafer.

Fig. 2. Overlay error map of a 200mm wafer for two imprinted patterns.