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UV-enhanced Substrate Conformal Imprint Lithography Using an Epoxy Based Polymer

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Motivation

UV-enhanced substrate conformal imprint lithography (UV-SCIL) is an inovative full wafer scale nanoimprint technology using an UV curing resist. Common resists for the UV-SCIL technology usually contain inorganic chemistry. This fact limits the suitable dry etching processes for these resists if used as etching masks. All common resists for SCIL or UV-SCIL need long curing processes (3min – 15min). In this work, the presented polymer is an at all organic material, DELO-KATIOBOND OM VE 110707 (OM VE 110707) from DELO Industrial Adhesives. The advantage of organic materials used as masks for dry etching is that they are well suitable for standard dry etch processes. Another advantage of the UV curing epoxy polymer for UV-SCIL is the reduction of curing time compared to commonly used resists.

This work presents a full process chain for a structure transfer into silicon substrates via UV-SCIL using the epoxy based polymer OM VE 110707 as imprint resist:

- **Spin coating**
- **Imprinting**
- **Minimization of the residual layer**
- **Etching**

Experimental setup

UV-SCIL principle

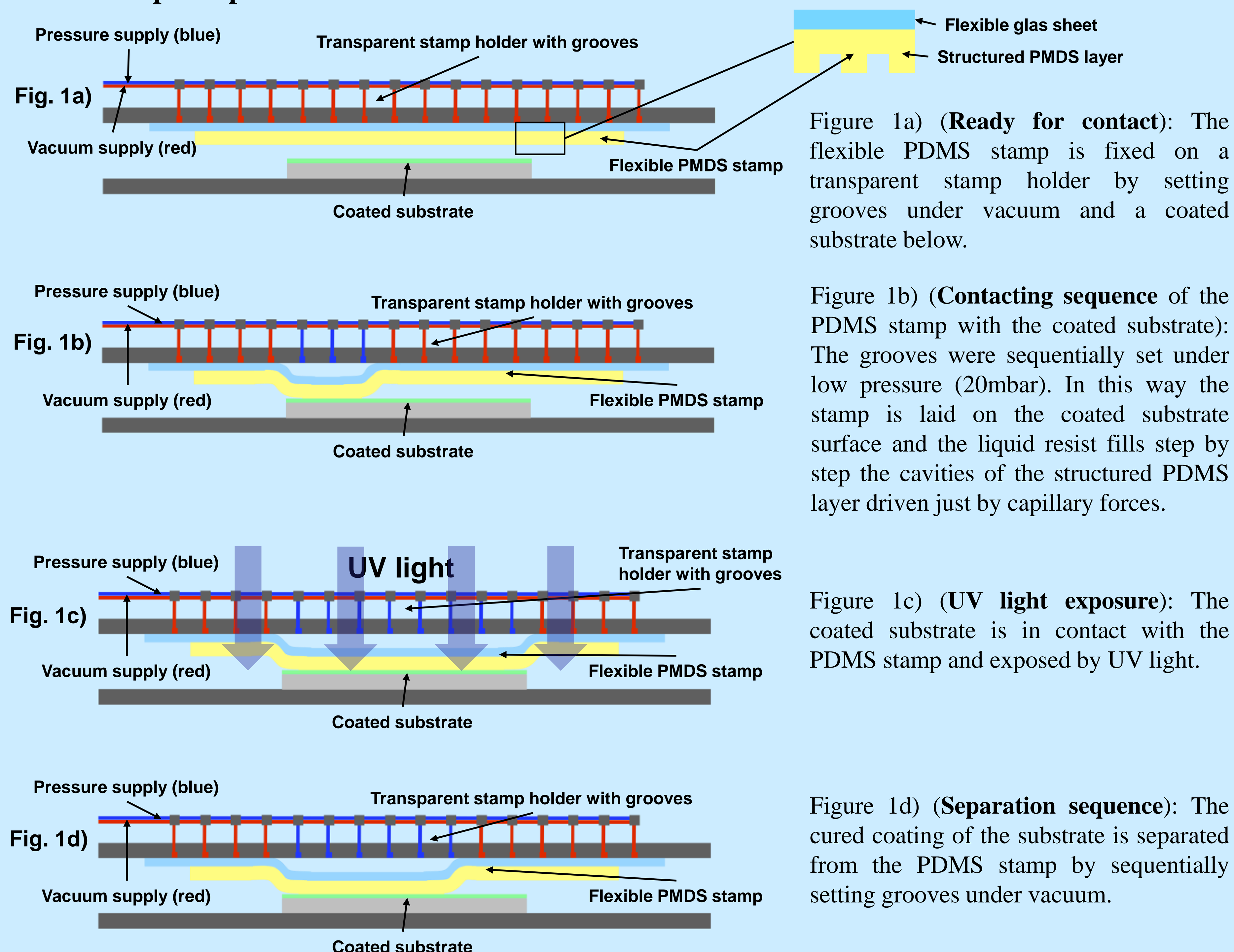

Figure 1a) (**Ready for contact**): The flexible PDMS stamp is fixed on a transparent stamp holder by setting grooves under vacuum and a coated substrate below.

Figure 1b) (**Contacting sequence** of the PDMS stamp with the coated substrate): The grooves were sequentially set under low pressure (20mbar). In this way the stamp is laid on the coated substrate surface and the liquid resist fills step by step the cavities of the structured PDMS layer driven just by capillary forces.

Figure 1c) (**UV light exposure**): The coated substrate is in contact with the PDMS stamp and exposed by UV light.

Figure 1d) (**Separation sequence**): The cured coating of the substrate is separated from the PDMS stamp by sequentially setting grooves under vacuum.

Figure 2a

Figure 2b

Figure 2a, b: Working MA8/BA8 Mask Aligner with SCIL tooling at Fraunhofer IISB cleanroom

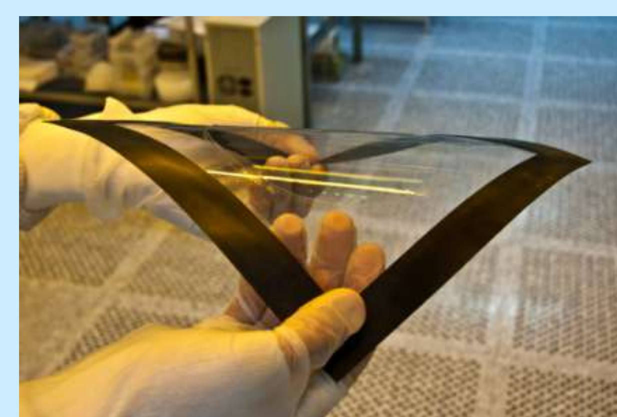

Figure 3: Flexible PDMS stamp for UV-SCIL

Experimental results

Spin coating

For spin coating, OM VE 110707 was diluted with cyclopentanone (CP). With the developed process for OM VE 110707, film thicknesses from 50nm to 600nm (Figure 4) with a standard deviation of 5nm can be achieved. CP is an industrially used thinner for epoxy based resists.

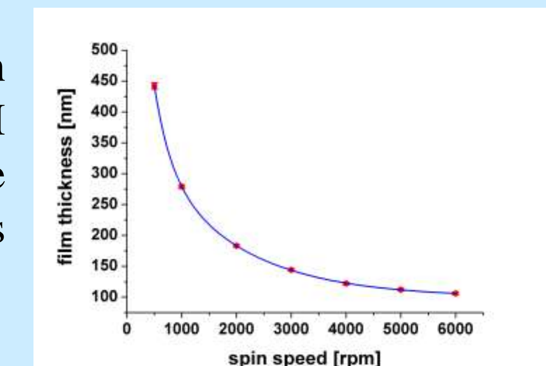

Figure 4: Spin speed curve for OM VE 110707 diluted with 83wt% CP

Imprinting

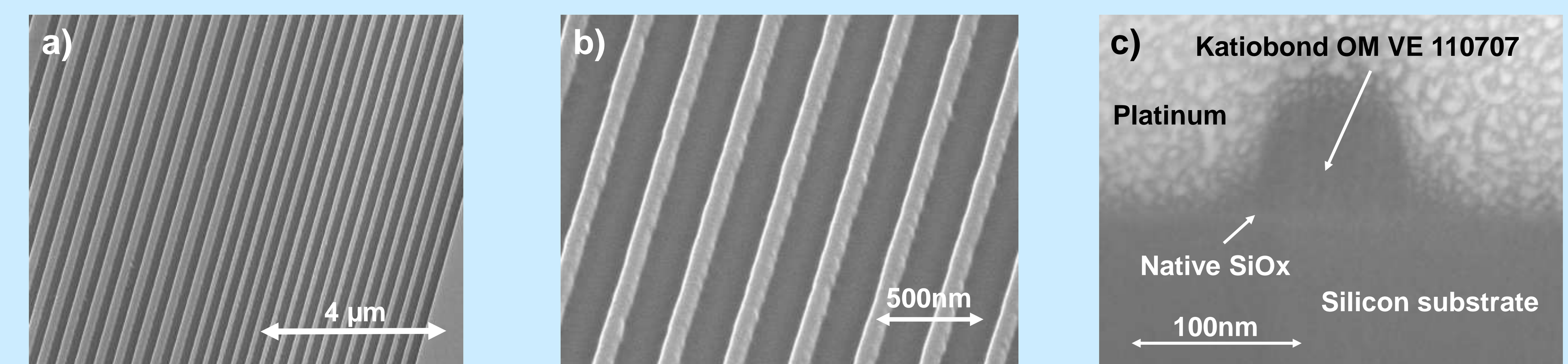

Figure 5: a), b) SEM images and c) SEM cross section of an imprinted line and space structure with OM VE 110707, 17s exposure time

The images in Figure 5a), b) and c) show that a homogenous structure transfer into OM VE 110707 is possible with UV-SCIL. They also show that a resolution of 100nm can be achieved using only 17s exposure time for the curing of the epoxy polymer.

Minimization of residual layer

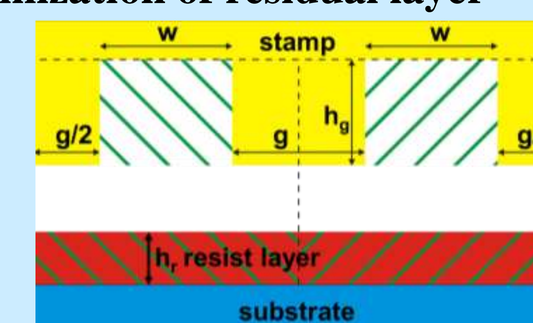

Figure 6: Schematic cross section of a stamp area with a line and space structure, green indicated areas have to have the same size for residual layer free imprints

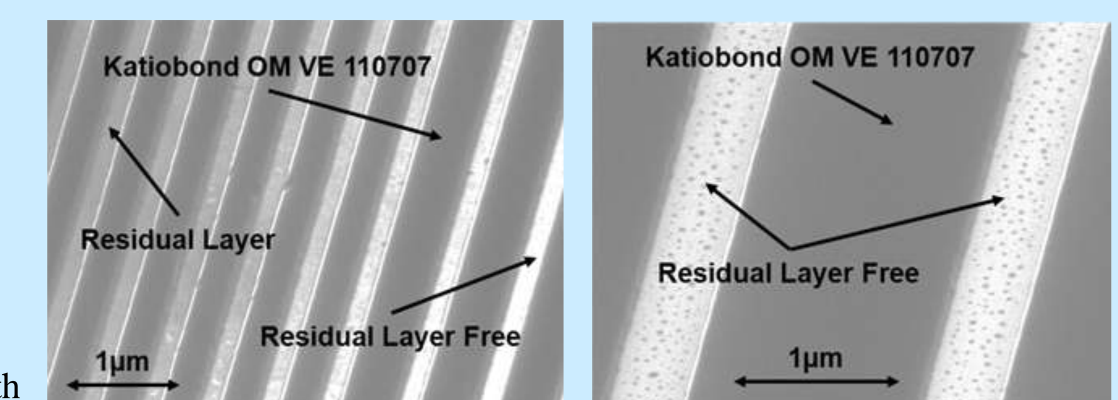

Figure 7: SEM images of an imprinted line and space structure with OM VE 110707

The requirement for a residual layer free imprint is that the total volume of the cavities in the structure on the stamp needs to be at least the same as the volume of the initial resist layer (see e.g. Figure 6). Figure 7 a) and b) show that nearly residual free imprints are possible using UV-SCIL with OM VE 110707. Thereby the filling of cavities in the stamp is driven only by capillary forces. The applied pressure on the stamp is only 20mbar.

Etching

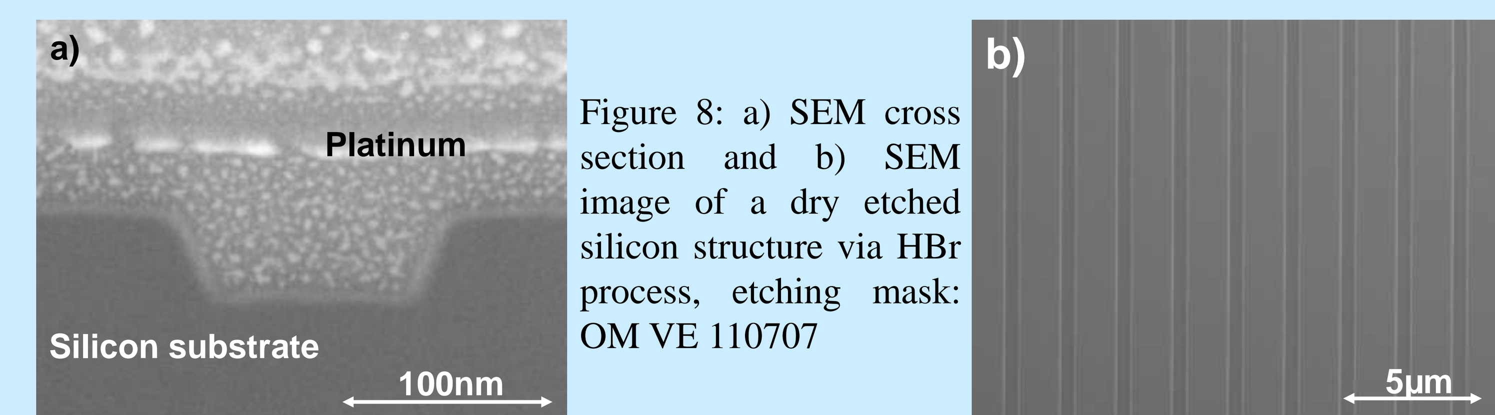

Figure 8: a) SEM cross section and b) SEM image of a dry etched silicon structure via HBr process, etching mask: OM VE 110707

Conclusion

The steps of the developed process chain for the structure transfer via UV-SCIL with the epoxy based resist OM VE 110707 are concluded in the following:

- **Spin coating:** Film thicknesses between 50nm and 600nm can be achieved using **CP as thinner**.
- **Imprinting:** Imprints of 100nm resolution could be performed using an **exposure time of only 17s**. This short exposure reduces the overall process time essentially compared to common resists for UV-SCIL.
- **Minimization of the residual layer:** With an optimized feature design, **nearly residual layer free** imprints are possible.
- **Etching:** The structured OM VE 110707 layer can serve as etching mask for standard silicon dry etch processes.

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