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Novel Polymers for UV-enhanced Substrate Conformal Imprint Lithography

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Motivation

Common resists for the substrate conformal imprint lithography (SCIL) or UV-enhanced substrate conformal imprint lithography (UV-SCIL) contain usually inorganic chemistry. This fact limits the suitable dry etching processes. All common resists for SCIL or UV-SCIL need long curing times (3min – 15min). However, purely organic materials are investigated in this work. The advantage of organic materials used as masks for dry etching is that they are well suited for standard dry etching processes. As shown, another advantage of UV polymers for UV-SCIL is the reduction of curing time compared to commonly used resists. So, using UV curing polymers shortens the overall SCIL process time essentially.

Experimental setup

For first investigations on UV-curing polymers for UV-SCIL, the UV-SCIL process was emulated on a NPS 300 nanoimprint stepper. After these experiments a process flow from material deposition to etching for the appropriate polymers was developed (see Table 1). Table 2 gives an overview about investigated polymers and their behavior.

Table 1: Process flow overview

Process	Method	System
Material deposition	Spin coating	Manual coating system
Imprinting	UV-SCIL	MA8/BA8 Mask Aligner with SCIL upgrade from SUSS MicroTec
Etching	dry etching with HBr plasma	ICP-RIE system from STS

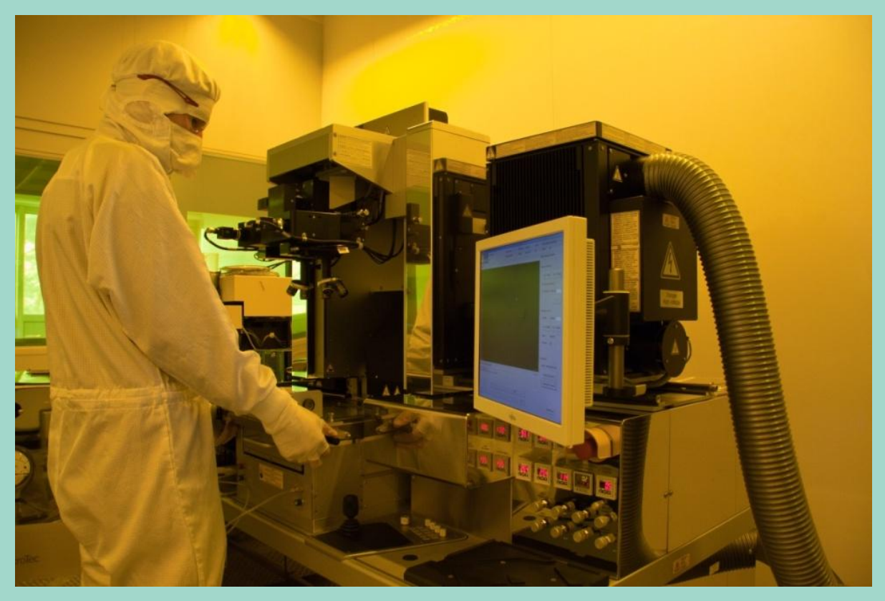

Figure 2a

Figure 2b

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

Experimental results

UV-SCIL emulation on NPS 300

Table 2: List of tested UV-curing polymers for UV-SCIL

Name of tested UV-curing polymer	Polymer base	Imprint result
NOA 61; Norland Products	Acrylates	Weak substrate adhesion
NOA 84, Norland Products	Acrylates	Curing not possible
NOA 89, Norland Products	Acrylates	No substrate adhesion
mr-UVCur21SF, micro resist technologies	Acrylates	Curing not possible
mr-UVCur06, micro resist technologies	Acrylates	Homogenous imprint
Photobond OM VE 512494, DELO Industrial Adhesives	Acrylates	Curing not possible
Photobond GB310, DELO Industrial Adhesives	Acrylates	Strong adhesion to PDMS stamps
Katiobond OM VE 110707 , DELO Industrial Adhesives	Epoxides	Homogenous imprint

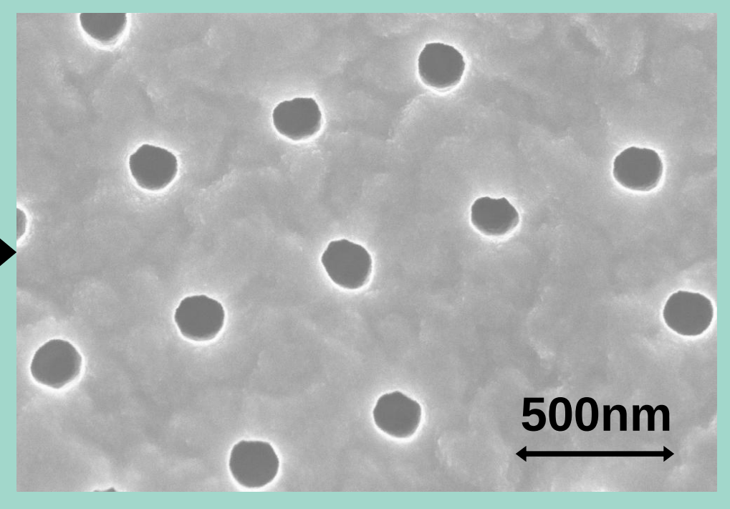

Figure 3a): Secondary electron microscopy (SEM) image of a structured partially cured Photobond OM VE 512494 imprint

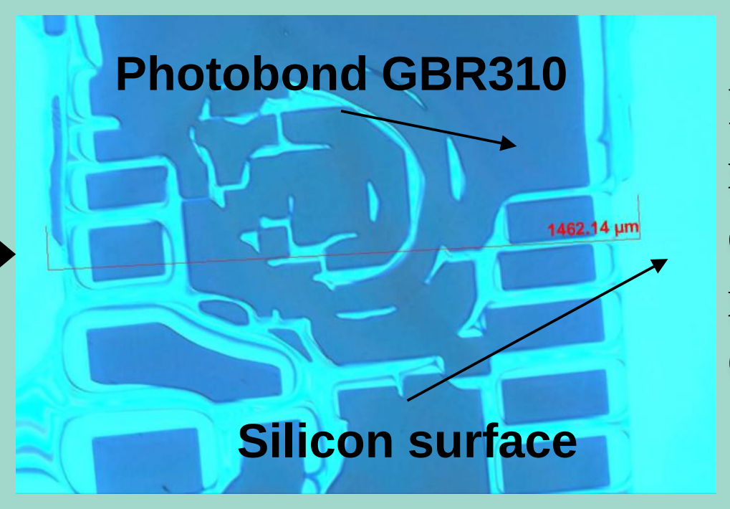

Figure 3b): Optical microscopy image of a partially released Photobond GB310 imprint

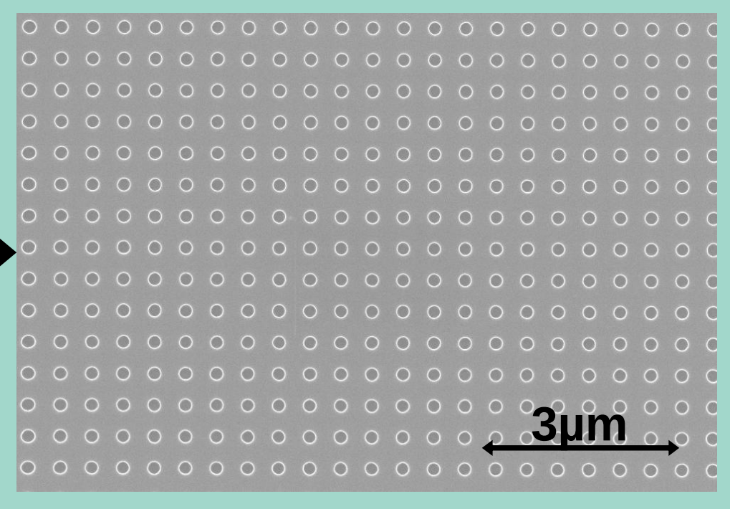

Figure 3c): SEM image of a structured and cured Katiobond OM VE 110707 imprint

Spin Coating

For spin coating, Katiobond OM VE 110707 was diluted with chlorobenzene. With the developed process for Katiobond OM VE 110707, film thicknesses from 50nm to 300nm (Figure 4) with a standard deviation of 3nm were achieved. For mr-UVCur06, a well known coating process was used from micro resist technologies.

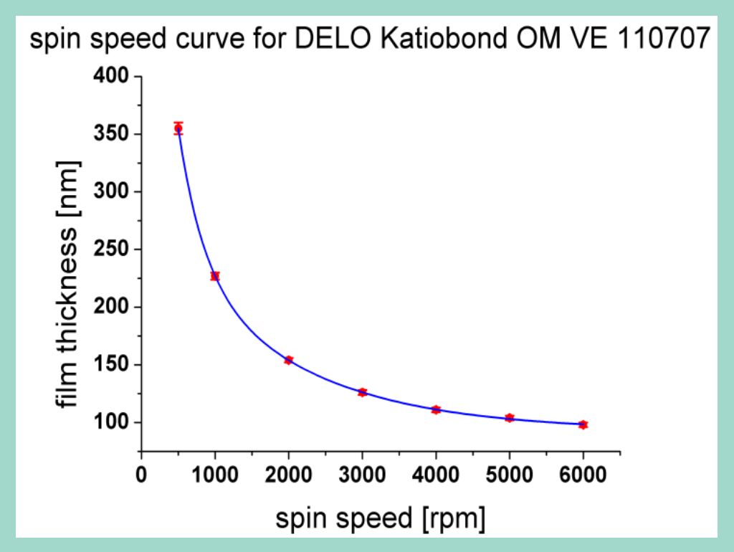

Figure 4: Spin speed curve for Katiobond OM VE 110707 diluted with 80wt% chlorobenzene

Imprinting by UV-SCIL

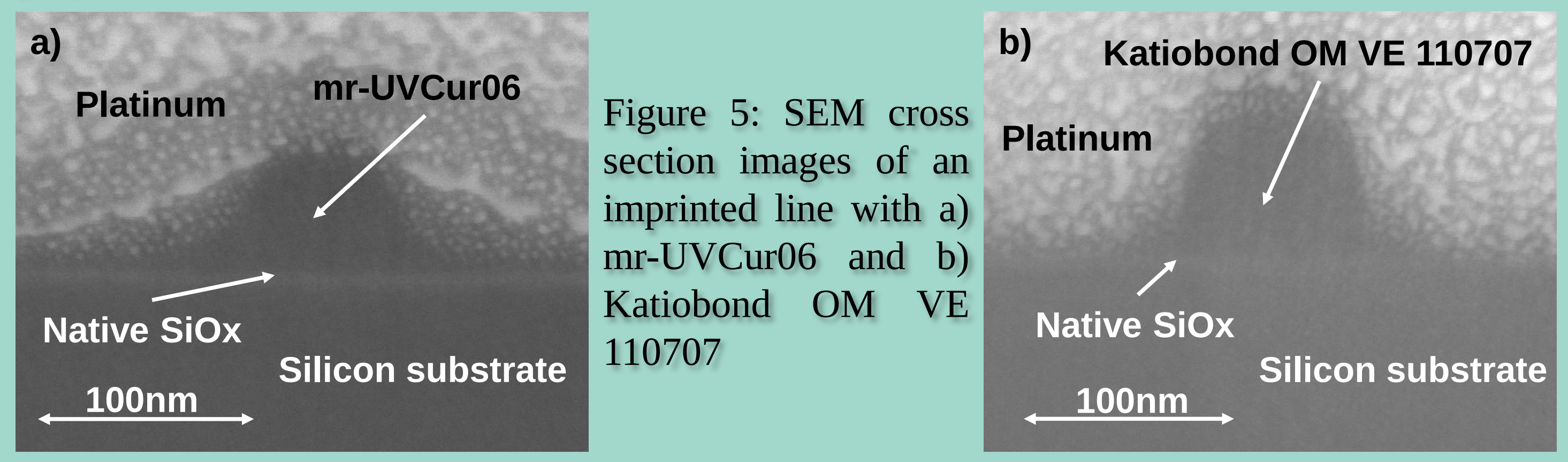

Figure 5: SEM cross section images of an imprinted line with a) mr-UVCur06 and b) Katiobond OM VE 110707

The imprints in Figure 5a) and b) were both performed with the same stamp. The comparison between them shows that the flanks of the line imprinted with Katiobond OM VE 110707 are much steeper than the flanks of the line with mr-UVCur06. The exposure times were 17s for Katiobond OM VE 110707 and 180s for mrUVCur06. Compared to all commonly used resists these evaluated curing times are much shorter, especially for Katiobond OM VE 110707. The big difference between 17s for Katiobond OM VE 110707 and 180s for mrUVCur06 can be explained by oxygen inhibition of the polymerization of UV curing acrylates. The oxygen diffused in the porous PDMS inhibits the polymerization reaction of the acrylate.

Etching

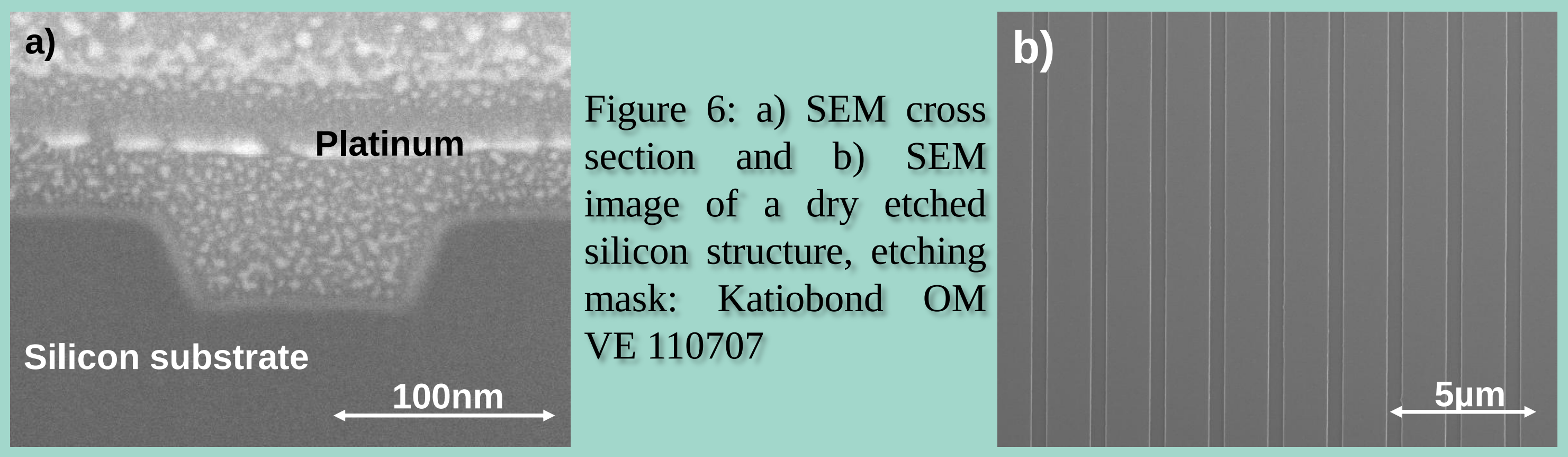

Figure 6: a) SEM cross section and b) SEM image of a dry etched silicon structure, etching mask: Katiobond OM VE 110707

Table 3: Summarized properties of the two polymers

	mr-UVCur06	Katiobond OM VE 110707
Polymer base	acrylates	epoxides
Oxygen inhibition	yes	no
Exposure Time	180s	17s
Etching rate for argon sputter process	200nm/min	100nm/min
Silicon dry etch selectivity for HBr process	>1	>2

Conclusions

This work introduces two kinds of fully organic polymers for UV-SCIL, Katiobond OM VE 110707 and mr-UVCur06. For these UV-curing polymers, UV-SCIL processes were developed. Using these polymers for UV-SCIL, the exposure time and thus, the overall process time can be reduced essentially compared to all commonly used resists. The work showed also that these polymers can serve as etching masks for HBr dry etching processes.

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