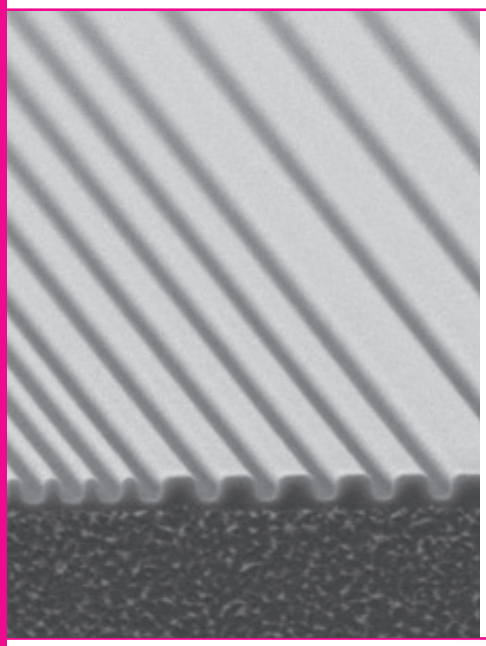
micro resist technology

Resists for Nanoimprint Lithography



Ready-to-use Formulations for Thermal & Photo (UV) Nanoimprint Lithography (NIL)

- Coating of various substrates with excellent film quality (Si, SiO_2, glass, Al, Al_2O_3, plastics)
- Excellent pattern replication fidelity using various mold materials (Si, SiO_2, Ni, OrmoStamp®)
- Superior mold release properties
- Numerous application areas (pattern transfer using dry etch processes, permanent applications)
- Customized solutions and resist formulations designed for industrial high throughput processes
- Safe solvents specified for industrial requirements
- Guaranteed product quality and processing reproducibility
- Manufacturing according to ISO 9001 and ISO 14001

- Made in Germany -

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March 2019

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Imprint Technology	Product Name, available film thickness @ 3000 rpm	Key Features (T_g = glass transition temperature, Imprint temperature ≈ T_g + 60 K)	Imprint Process Plate-to-Plate	Continuous NIL (Roll-to-Roll)	Step & Repeat NIL	Subsequent lift-off (after metal deposition or for residue removal) Single layer	Subsequent lift-off (after metal deposition or for residue removal) Bilayer	Substrate Compatibility Si, SiO_2, glass	Metals (e.g. Au, Al)	Sapphire, Metal oxides	Plastics (e.g.PET, PEN,PC)	Stamp Compatibility Impermeable stamps (Si, SiO_2, Ni, glass, Ormo-Stamp)	Gas permeable soft stamps (PDMS, PFPE)	Recommended Working Stamp Material
Photo, UV-NIL ($\lambda \geq 365$ nm) (i-line)	**mr-NIL210**	For gas-permeable stamp materials in soft UV-NIL processes	●●	○	○	○	●●	●● p	●● p	●● p	●	●	●●	UV-PDMS KER-4690[2]
	mr-NIL210FC	For small pattern imprinting in soft UV-NIL processes with low intensity light sources (<40 mW cm^{-2}), higher etch stable versions available upon request	●●	○	○	○	●●	●● p	●● p	●● p	●	●	●●	UV-PDMS KER-4690[2]
	mr-NIL200 New	For imprints with impermeable stamp materials, no primer or adhesion promoter necessary	●●	○	●●	○	●	●●	●●	●●	●	●●	○	OrmoStamp®[3]
	mr-UVCur26SF	Inkjet dispensable at r.t.due to low viscosity, solvent-free formulation, fast curing for continuous imprint processes (roll-to-roll)	●	●●	●●	○	●	●● p	●● p		●●	●●	○	OrmoStamp®[3], Ni
Heat assisted Photo-NIL	**mr-NIL 6000E**	Photo-curable resist T_g = 1°C, no T_g after imprinting and UV-exposure Short cycle times due to isothermal imprint process (no cooling step) Outstanding pattern stability in subsequent process steps with thermal load (e.g. RIE) Combination of T-NIL and UV-NIL required	●●	○	○	○	●	●●	●●	●●	○	●●	●	OrmoStamp®[3]
Thermal-NIL	**mr-I 9000M**	Thermosetting polymer (crosslinking at imprint temperature), T_g = 35 °C Fabrication of thermally stable nanostrutures, no T_g after imprinting Outstanding pattern stability in subsequent process steps with thermal load (e.g. RIE)	●●	○	○	○	●	●●	●●	●●	●	●●	●	OrmoStamp®[3]
	mr-I 7000R[1]	Efficient release force reduction mr-I 7000R with lower imprint temperature, T_g = 55°C	●●	●	○	●	○	●●	●●	●	●	●●	●	OrmoStamp®[3]
	mr-I 8000R[1]	mr-I 8000R with higher thermal stability in subsequent processes, T_g = 105 °C	●●	○	○	●	○	●●	●●	●	●	●●	○	OrmoStamp®[3]
	SIPOL	Bilayer approach: SIPOL as Si-containing etch mask applied on transfer layer UL1, High aspect ratio patterns achievable (AR>>3), see page 4, T_g = 63 °C	●●	●	○	●	●	●●	●●	●●	●	●●	●	OrmoStamp®[3]
	mr-I T85	Nonpolar thermoplastic polymer for permanent applications, T_g = 85 °C High chemical resistance, superior UV/vis transparency, perfect for e.g. µ-fluidic and bio applications	●●	○	○	●	○	●●	●●	○	○	●●	○	OrmoStamp®[3]
	mr-I PMMA	Thermoplastic polymer for fundamental imprint investigations, low molecular weight 35 kDa, T_g = 105 °C	○	○	○	●	○	●●	●	○	○	●●	○	OrmoStamp®[3]

Tailored designs and innovations	- micro resist technology GmbH provides customized solutions of all the aforementioned products on request, e.g. special designs for non-standard film thickness ranges. Please contact us directly. - micro resist technology GmbH has numerous complementary imprint resist prototypes for different applications which have not been commercialized yet. Please contact us directly with your requirements and your process to get the most suitable product recommendation.

[1] Conventional resist formulations mr-I 7000E and mr-I 8000E without fluorinated components are still available upon request in equal film thickness ranges.
[2] For further information on UV-PDMS KER-4690 as stamp replication material please refer to separate brochures and webpage www.microresist.com.
[3] For further information on OrmoStamp® as stamp replication material please refer to separate broschures and webpage www.microresist.com.

●● excellent
● fair
○ not recommended
p Primer / adhesion promoter required
r.t. Room temperature

Product series	Standard film thickness in nm (3000 rpm)	Max. available film thickness in µm (3000 rpm)
mr-NIL210	100, 200, 500, 1000, 2000	50.0
mr-NIL210FC	100, 200	-
mr-NIL200	100, 200, 300	1.0
mr-NIL 6000E	100, 200, 300	6.0
mr-I 9000M	100, 200, 300, 500, 1000	3.0
mr-I 7000R/8000R	100, 200, 300	5.0
SIPOL	100, 200	1.5
mr-I T85	300, 1000, 5000	20
mr-I PMMA35k	100, 300, 500	4

mr-NIL210

Soft UV-NIL with light sources > 40 mW cm^{-2}

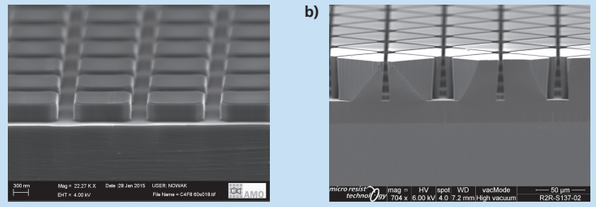

Fig. 1: a) Patterns imprinted into mr-NIL210 and transferred into Al, (courtesy of AMO GmbH, Germany), b) imprinted undercut structures in size of several micron imprinted with elastic working stamp made of UV-PDMS KER-4690

mr-NIL210FC

Soft UV-NIL with low intensity light sources or pattern size <200nm

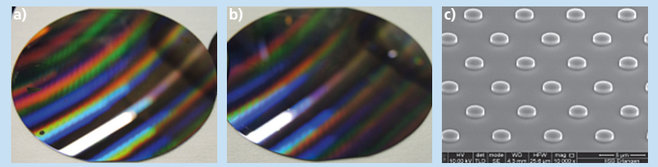

Fig. 2: a) 1st full wafer imprint of a series on 4 inch Si using a SÜSS SCIL mask aligner add-on, b) 50th subsequent imprint using the same stamp as for a) without detecting any stamp degradation defects, c) finally etched patterns into Si of image b)

mr-NIL200

Primer-free imprinting

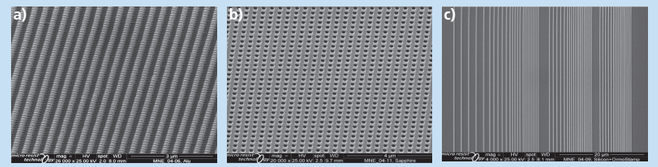

Fig. 3: a) Imprinted pillars into mr-NIL200 on Al: Ø = 200 nm; h = 300 nm; pitch: 400 nm, b) inverted structure of a) on sapphire, c) imprint on Si, width 200nm,100nm, 75 nm with differing pitch, height 200nm. All imprints have been conducted without the use of any primer.

mr-UVCur26SF

Inkjet dispensing of resist materials for RIE

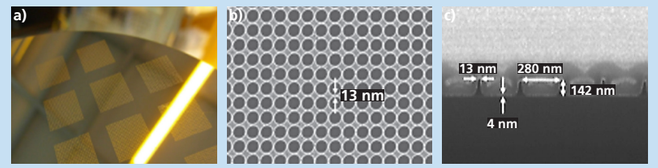

Fig. 4: a) Inkjet dispensed droplets of mr-UVCur26SF at r.t. onto 6 inch Si wafer, b) S&R imprinted nanoapertures using mr-UVCur26SF, c) cross-sectional view of the imprinted nanoaptertures of b), residual layer thickness minimization to 4 nm by inkjet deposition of an effectual amount of resist (pictures courtesy of Fraunhofer IISB, Germany).

Recent application examples

mr-NIL200

Primer-free UV-NIL

micro resist technology continuously renews its material portfolio for NIL and we are happy to introduce the 2nd generation of UV-NIL resists which are suitable for industrial manufacturing processes where non-gas-permeable stamp materials can be applied. mr-NIL200 has excellent adhesion properties, making a primer or adhesion promoter coating obsolete in most cases.

Spectrometer-on-chip by S&R-NIL

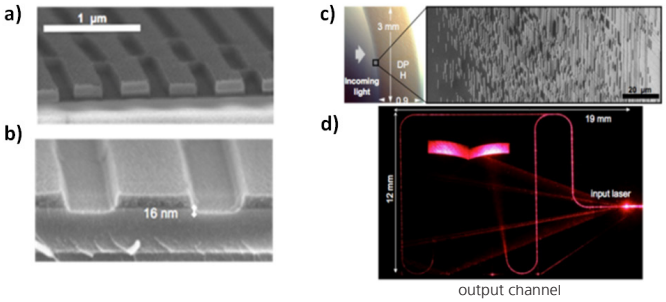

Fig. 1: Imprint of mr-NIL200 on SiN/SiO_2/Si substrate stack: a) etched residual layer (O_2/Ar plasma), b) pattern transfer into SiN (O_2/CHF_3 plasma), c) imprinted chip, d) optical waveguide output channel (images courtesy of abeam technologies, USA, and Molecular Foundry, USA)

SIPOL

Pattern amplification

SIPOL is a silicon containing thermoplastic polymer with a T_g of 62°C for T-NIL applications. In a bilayer process with the corresponding UL1 underlayer, it can be used for pattern amplification due to the fact that oxygen plasma can form a SiO_2 hard mask which can be used afterwards to etch the organic underlayer UL1, see Figure 3 for proposed dry etching process. This process offers the great benefit of low propensity of imprint defects since very low aspect ratio can be imprinted, but high aspect ratio can be obtained via etching.

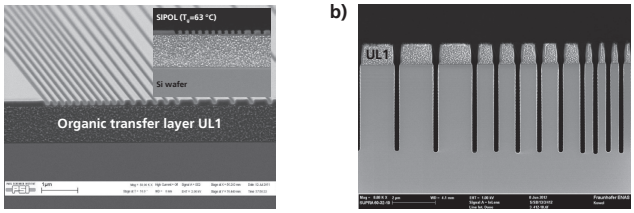

Fig. 2: a) L/S patterns nanoimprinted into SIPOL resist (top layer) on top of organic transfer layer UL1 dappled), inlay: cross sectional view of a), b) Imprint of a) transferred into Si using a Bosch process resulting in an aspect ratio of ca. 20.

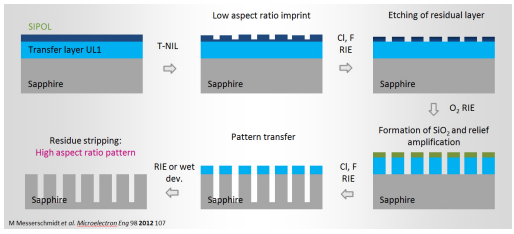

Fig. 3: Proposed dry etching process of SIPOL in combination with underlayer UL1 in a bilayer process.

Bilayer applications

Lift-off and aspect ratio amplification

micro resist technology develops and provides polymer thin films which can be applied in bilayer applications for e.g. pattern amplification or lift-off processes. The general process plus of our new underlayer materials is that they can be developed under neutral conditions. Many underlayers require e.g. alkaline developments making them inapplicable for alkaline sensitive materials like Al, organic molecules or bio-molecules and our underlayers solve this problem via neutral development capability.

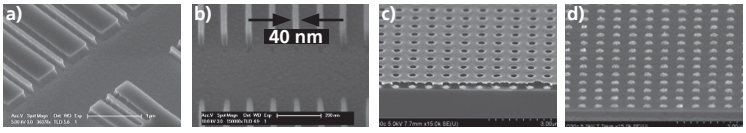

Fig. 4: a) L&S pattern after break through etch of resist (30 nm of Photo-NIL resist) and 100 nm UL3E using oxygen plasma. b) 40 nm metal lines after lift-off of UL3E (courtesy of Nanotechnology & Devices, NT&D, Germany), c) 40 nm Cr evaporation before and d) after lift-off of UL3E creating dots with 200 nm diameter (courtesy of 5microns GmbH, Germany).

	UL1 series	UL3E series (prototype)
Application	Bilayer for high AR	Bilayer for high AR and lift-off
Film thickness	300, 500, 1000 nm	Sub 100 – 200 nm
Solvent compatibility	PGMEA, acetone, etc.	PGMEA, acetone, etc.
Resist compatibility	Excellent	Excellent
Neutral wet lift-off	Ethanol, IPA	UL3E-Dev
Dry etching	O_2 (100% organic)	O_2 (100% organic)
Etch performance	High dry etching stability	High dry etching stability

NIL process scheme

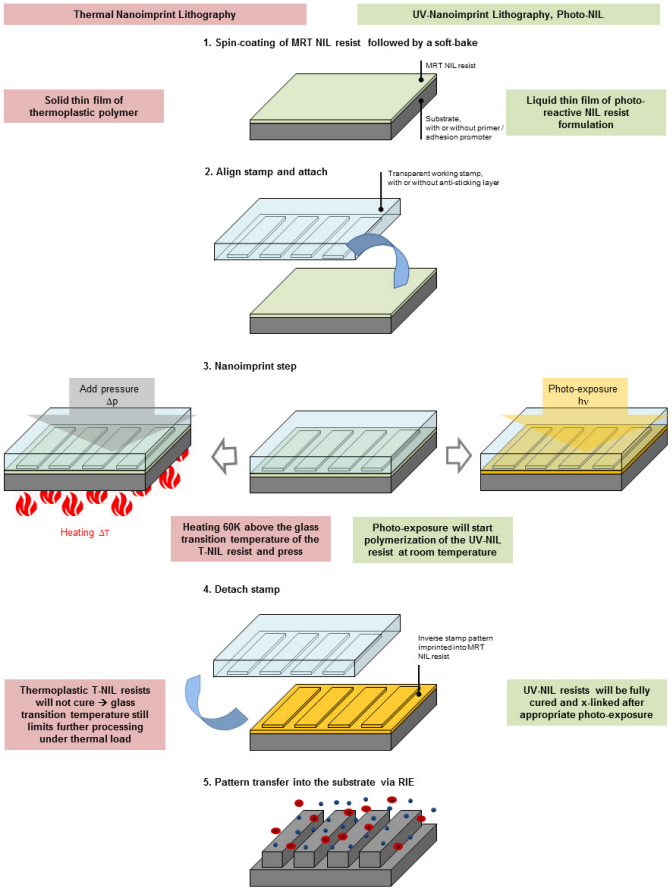

Fig. 5: NIL process scheme, magenta: Thermal NIL (T-NIL), green: Photo-NIL (P-NIL, UV-NIL).

Alternative coating and imprint technologies

Inkjet dispensing of high refractive index prototypes

Inkjet dispensing of UV-NIL materials becomes more and more relevant due to economies of scale. Hence, *micro resist technology* develops different solvent-free UV-curable materials which can be dispensed via inkjet approach at room temperature or at slightly increased temperatures. The main purpose of those UV-NIL resists is to provide a) high dry etching stability for pattern transfer approaches or b) high refractive index for optical applications.

UV-NIL material	dyn. Viscosity at 25°C [mPas]	Refractive index at 593 nm (liquid)	Refractive index at 593 nm (solid)
mr-UVCur26SF	16	1.480	1.518
mr-InkNIL501_XP	19	1.557	1.593
mr-InkNIL505_XP	31	1.556	1.592
mr-InkNIL506_XP	56	1.580	1.612

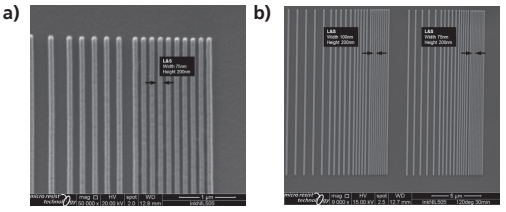

Fig. 6: a) imprint of L&S pattern into mr-InkNIL505_XP , 75nm width, 200nm height, b) same imprint of a) after reflow test 120 °C for 30min indicates no pattern collapse.

R2R-UV-NIL of demanding structures

Continuous roller-based processes pave the way to equip tens of meters of flexible substrates with nanostrcutures. *micro resist technology* provides materials which are fast curing and solvent-free especially developed for R2R-UV-NIL, applicable as dry etch mask for pattern transfer or for permanent applications.

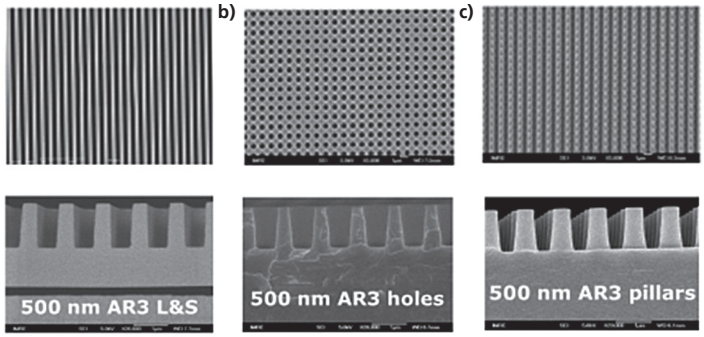

Fig. 7: a-c) SEM image of imprinted aspect ratio 3 patterns using inkjet dispensed mr-UVCur26SF on PC fabricated in a Photo-NIL R2R process at r.t. (courtesy of IMRE, Singapore).

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