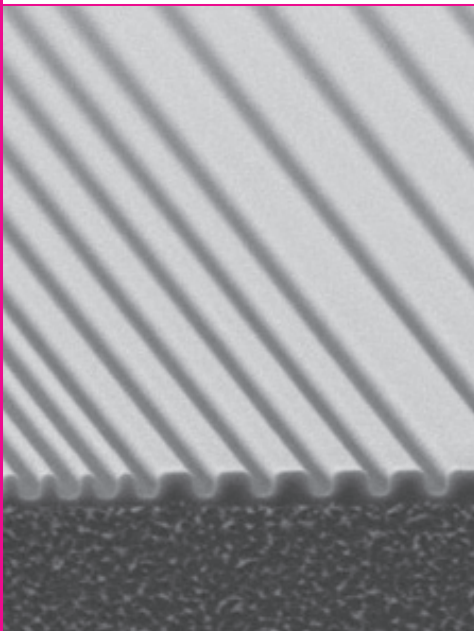


Resists for Nanoimprint Lithography



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

- Coating of various substrates with excellent film quality (Si, SiO₂, glass, Al, Al₂O₃, plastics)
- Excellent pattern replication fidelity using various mold materials (Si, SiO₂, 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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Imprint Technology	Product	Key Features (T_g = glass transition temperature, Imprint temperature $\approx T_g + 60$ K)	Imprint Process				Substrate Compatibility					Stamp Compatibility				Main Applications						
			Plate-to-Plate	Continuous NIL (Roll-to-Roll)	Step & Repeat NIL	Subsequent lift-off (after metal deposition or for residue removal) Single layer Bilayer		Si, SiO ₂ , glass	Metals (e.g. Au, Al)	Sapphire, Metal oxides	Plastics (e.g. PET, PEN, PC)	Multi-layered substrate stacks	Primer	Hard stamps, opaque (Si, Ni, etc.)	Hard stamps, transparent (SiO ₂ , glass)	Ormo-Stamp ^{®2}	Soft Stamps (PDMS, PFPE)	LEDs, photonic crystals, quantum dots	Sub wave-length optical elements (SOE)	Pat-terned sapphire substrates (PSS)	Organic electronics (OLED, OPV, OTFT)	Bio applications, Lab-on-chip ³
Thermal	mr-I 9000M	- Thermosetting polymer ($T_g = 35$ °C) - Fabrication of <u>thermally stable nanostructures</u> , no T_g after imprinting - Outstanding pattern stability in subsequent process steps with thermal load (e.g. RIE)	••••	•							No	••••	••••	••••	•	••••	••••			••••		
	mr-I 7000R¹	- Thermoplastic polymers - <u>Easy demolding</u> , efficient release force reduction - mr-I 7000R (T_g 55 °C) with lower imprint temperature	••••	••••		••••					No	••••	••••	••••	•	••••	••••			••••		
	mr-I 8000R¹	- mr-I 8000R (T_g 105 °C) with higher thermal stability in subsequent processes, e.g. RIE	••••	•	•	••••			••		No	••••	••••	••		••••	••••			••••		
	SIPOL	- Thermoplastic polymer ($T_g = 63$ °C) - High aspect ratio patterns achievable (AR>>3) - Bilayer approach: SIPOL as Si-containing etch mask applied on transfer layer UL1	••••	••••		••••			••••		No	••••	••••	••••	•	••••	••••			••••		
	mr-I T85	- Nonpolar thermoplastic polymer for <u>permanent applications</u> ($T_g = 85$ °C) - High chemical resistance - Superior UV/vis transparency	••••	•							No	••••	••••	••							••••	
	mr-I PMMA	- Thermoplastic polymer ($T_g = 105$ °C) for fundamental imprint investigations (available molecular weights 35 kDa and 75 kDa)	••••			••••					No	••••	••••	••								
Photo, UV ($\lambda \geq 365$ nm) Combined Thermal and Photo	mr-NIL 6000E	- Photo-curable resist ($T_g = 1$ °C) - Short cycle times due to <u>isothermal imprint process</u> (no cooling step) - Outstanding pattern stability in subsequent process steps with thermal load (e.g. RIE), no T_g after imprinting	••••	•							No	••••	••••	••••	••	••••	••••	••••	••••	••••		
	mr-NIL210 	- Photo-curable imprint resist - Excellent compatibility to flexible stamp materials (e.g. PDMS or UV-PDMS KER-4690 ⁴) - High dry etching stability in challenging etching environments (e.g. sapphire)	••••	•					•	Yes (mr-APS1)	•••• (comb. with transparent substrate)	••••	••••	••••		••••	••••	••••	••••	••••		
	mr-UVCur21	- Photo-curable imprint resist - Imprints with <u>hard stamps</u> , fast curing rates - Good dry etching stability	••••	•	••				•	Yes (mr-APS1)	•••• (comb. with transparent substrate)	••••	••••	••••		••	••••			••••		
	mr-XNIL26	- Photocurable imprint resist with excellent stamp release due to <u>intrinsic antisticking characteristics</u> , very low release forces - Excellent wetting characteristics	••••	•	•				••••	••••	Yes (mr-APS1)	•••• (comb. with transparent substrate)	••••	••••		••	••			••••		
	mr-UVCur26SF	- Photo-curable resist formulation - Inkjet dispensable at RT due to low viscosity (15 mPas) - Fast curing for continuous imprint processes (roll-to-roll)		••••	••••				•	Yes (mr-APS1)	•••• (comb. with transparent substrate)	••••	••••	••••		••	••••			••••		

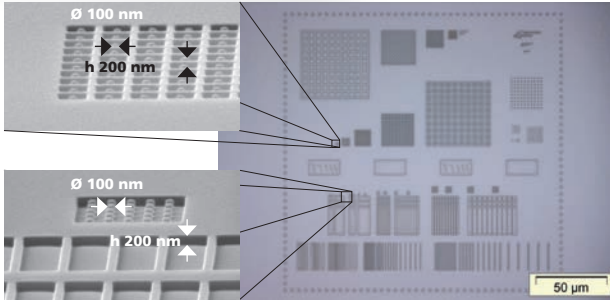
Special designs and innovations - micro resist technology GmbH provides customized solutions of all the aforementioned products on request, e.g. special designs for non-standard film thickness ranges. Please contact us directly.
- micro resist technology GmbH has numerous complementary imprint resist 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 OrmoStamp[®] as stamp replication material please refer to separate brochures and webpage www.microresist.com.
³ See also product group Hybrid Polymers (OrmoComp[®] etc.). Please refer to separate brochures.
⁴ For further information on UV-PDMS KER-4690 as stamp replication material please refer to separate brochures and webpage www.microresist.com.

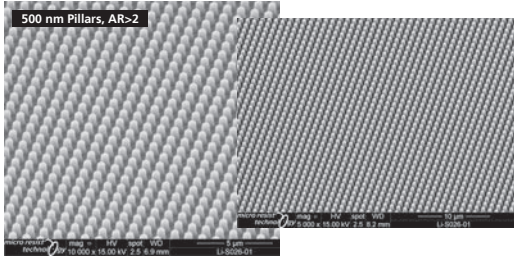
••• excellent •• good • fair

Recent application examples

mr-NIL210



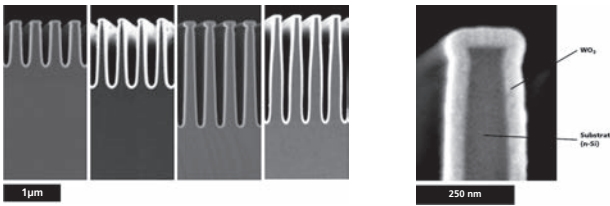
Example 1 Imprint of miscellaneous nano- and micrometer test structures into mr-NIL210 using a UV-PDMS stamp (Shin-Etsu UV-PDMS KER-4690).



Example 2 Large area imprint (50 x 50 mm) of sub micron pillars (500 nm in diameter, 1.12 µm in height) into mr-NIL210 using a UV-PDMS stamp (KER-4690).

mr-UVCur21

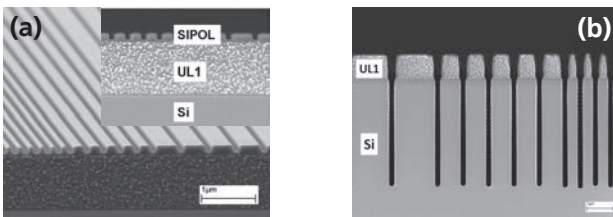
Nanostructuring of photoelectrode surfaces



WO₃ coated photoelectrode surfaces for water splitting fabricated using mr-UVCur21 (images courtesy of M. Schieda and I. Hermann-Geppert, Helmholtz-Zentrum Geesthacht, Germany, and Berkely Lab, USA).

SIPOL

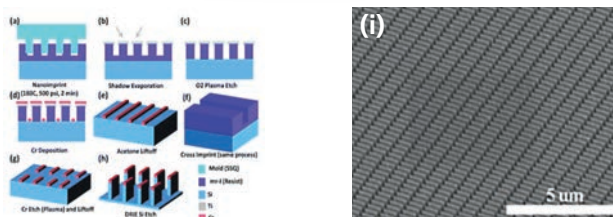
Pattern amplification for high aspect ratio



a) L/S imprinted 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.

mr-I 8000R

Silicon Nanowalls for Lithium Ion Batteries

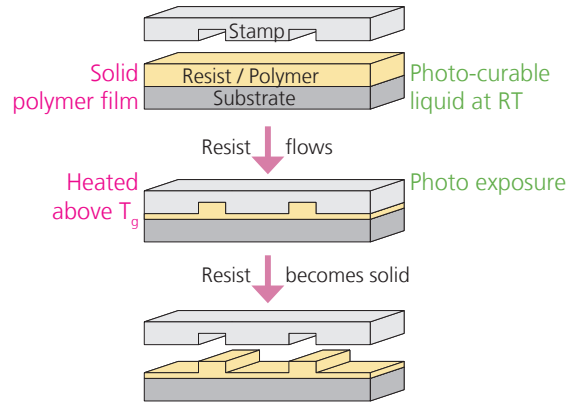


a-h) Two dimensional imprint process for the fabrication of Si nanowalls for Lithium Ion Batteries using mr-I 8000R as thermoplastic NIL resist; i) SEM image of the fabricated 200 nm Si nanowall array (J. Wan *et al.*, J Mater Chem A 2 2014 6051).

Imprint process

Thermal NIL
Thermoplastics and Thermosets

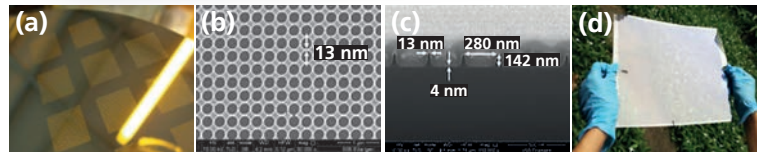
Photo-NIL (UV-NIL)
Photo-curable resists



Future Innovations

Alternative coating and imprint technologies

Inkjet dispensing, gravure & spray coating, etc.

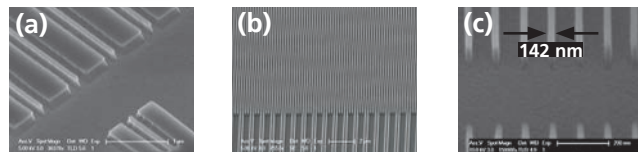


a) Resist dots of inkjet dispensed mr-UVCur26SF at RT onto 6 inch Si wafer; b) S&R imprinted nanoapertures using mr-UVCur26SF; c) Cross-sectional view of the imprinted nanoapertures of b), residual layer thickness minimization to 4 nm by inkjet deposition of an effectual amount of resist, (all courtesy of M.Rumler, FhG IISB, Germany); d) imprinted antireflection moth-eye pattern on PC using inkjet dispensed mr-UVCur26SF (courtesy of IMRE, Singapore).

Product	Viscosity (@ RT)	Resist Characteristics
mr-UVCur21SF	31 mPas	Solvent free formulation of mr-UVCur21 featuring equal material characteristics
mr-UVCur26SF	16 mPas	Inkjet-dispensable at RT, high plasma etch stability, recommended for R2R-NIL
mr-XNIL26SF	147 mPas	Solvent-free formulation of mr-XNIL26, low release forces after imprint

Bilayer applications

Lift-off and aspect ratio amplification



a) L&S pattern after break through etch of resist and 100 nm UL3 using oxygen plasma; b) evaporated metal lines after lift-off of UL3 using DI H₂O at RT; c) 40 nm metal lines after lift-off of UL3 (courtesy of B. Vratzov, Nanotechnology & Devices, NT&D, Germany).

	UL1 series	UL3 series (experimental)
Application	Bilayer for high AR and lift-off	Bilayer for high AR and lift-off
Film thickness	300, 500, 1000 nm	50 – 2000 nm
Solvent compatibility	PGMEA, acetone, etc.	PGMEA, acetone, etc.
Resist compatibility	Excellent	Excellent
Neutral wet lift-off	Ethanol, IPA	DI H ₂ O
Dry etching	O ₂ (100% organic)	O ₂ (100% organic)
Etch performance	High dry etching stability	High dry etching stability