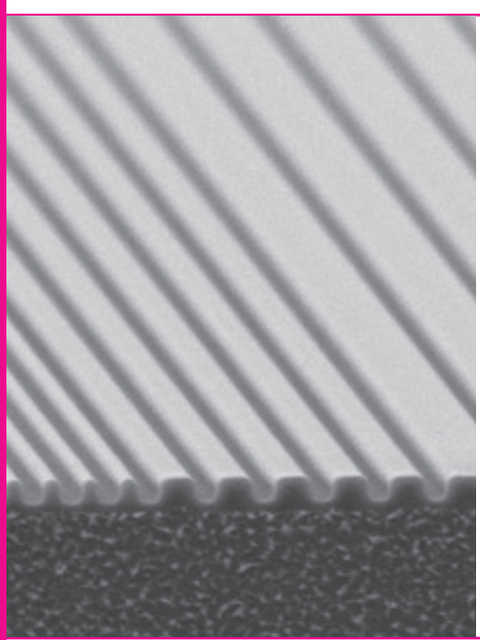
micro resist technology

# 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 -


**micro resist technology** GmbH
Gesellschaft für chemische Materialien spezieller Photoresistsysteme mbH

Köpenicker Str. 325
12555 Berlin
GERMANY

phone +49 30 64 16 70 100
fax +49 30 64 16 70 200
mail sales@microresist.de
info www.microresist.com


www.microresist.com

May 2017

| Imprint Technology | Product | Key Features ($T_g$ = glass transition temperature, Imprint temperature ≈ $T_g$ + 60 K) | Imprint Process: Plate-to-Plate | Imprint Process: Continuous NIL (Roll-to-Roll) | Imprint Process: Step & Repeat NIL | Imprint Process: Subsequent lift-off (after metal deposition or for residue removal): Single layer | Imprint Process: Subsequent lift-off (after metal deposition or for residue removal): Bilayer | Substrate Compatibility: Si, $SiO_2$, glass | Substrate Compatibility: Metals (e.g. Au, Al) | Substrate Compatibility: Sapphire, Metal oxides | Substrate Compatibility: Plastics (e.g.PET, PEN,PC) | Substrate Compatibility: Multi-layered sub-strate stacks | Substrate Compatibility: Primer | Stamp Compatibility: Hard stamps, opaque (Si, Ni, etc.) | Stamp Compatibility: Hard stamps, trans-parent ($SiO_2$, glass) | Stamp Compatibility: Ormo-Stamp®[2] | Stamp Compatibility: Soft Stamps (PDMS, PFPE) | Main Applications: LEDs, photonic crystals, quantum dots | Main Applications: Sub wave-legth optical elements (SOE) | Main Applications: Pat-terned sapphire sub-strates (PSS) | Main Applications: Organic elec-tronics (OLED, OPV, OTFT) | Main Applications: Bio appli-cations, Lab-on-chip [3] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Thermal | **mr-I 9000M** | - Thermosetting polymer ($T_g$ = 35 °C)<br>- Fabrication of thermally stable nanostructures, no $T_g$ after imprinting<br>- Outstanding pattern stability in subsequent process steps with thermal load (e.g. RIE) | ••• | • | | | •• | ••• | •• | •• | ••• | | No | ••• | ••• | ••• | • | ••• | ••• | | ••• | |
| | **mr-I 7000R**[1] | - Thermoplastic polymers<br>- Easy demolding, efficient release force reduction<br>- mr-I 7000R ($T_g$ 55 °C) with lower imprint temperature | ••• | ••• | | ••• | | ••• | ••• | •• | •• | | No | ••• | ••• | ••• | • | ••• | ••• | | ••• | |
| | **mr-I 8000R**[1] | - 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)<br>- High aspect ratio patterns achievable (AR≫3)<br>- Bilayer approach: SIPOL as Si-containing etch mask applied on transfer layer UL1 | ••• | ••• | | ••• | •• | ••• | ••• | ••• | ••• | | No | ••• | ••• | ••• | • | ••• | ••• | | ••• | |
| | **mr-I T85** | - Nonpolar thermoplastic polymer for permanent applications ($T_g$ = 85 °C)<br>- High chemical resistance<br>- 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 | ••• | ••• | •• | | | | | | |
| Combined Thermal and Photo | **mr-NIL 6000E** | - Photo-curable resist ($T_g$ = 1 °C)<br>- Short cycle times due to isothermal imprint process (no cooling step)<br>- Outstanding pattern stability in subsequent process steps with thermal load (e.g. RIE), no $T_g$ after imprinting | ••• | • | | | •• | ••• | ••• | ••• | ••• | | No | ••• | ••• | ••• | •• | ••• | ••• | ••• | ••• | |
| Photo, UV (λ ≥ 365 nm) | **mr-NIL210** New | - Photo-curable imprint resist<br>- Excellent compatibility to flexible stamp materials (e.g. PDMS or UV-PDMS KER-4690[4])<br>- High dry etching stability in challenging etching environments (e.g. sapphire) | ••• | • | | | •• | ••• | ••• | ••• | ••• | • | Yes (mr-APS1) | ••• (comb. with tranparent substrate) | ••• | ••• | ••• | ••• | ••• | ••• | ••• | |
| | **mr-UVCur21** | - Photo-curable imprint resist<br>- Imprints with hard stamps, fast curing rates<br>- Good dry etching stability | ••• | • | •• | | •• | ••• | • | | ••• | • | Yes (mr-APS1) | ••• (comb. with transparent substrate) | ••• | ••• | | •• | ••• | | ••• | |
| | **mr-XNIL26** | - Photocurable imprint resist with excellent stamp release due to intrinsic antisticking characteristics, very low release forces<br>- Excellent wetting characteristics | ••• | • | • | | •• | ••• | ••• | | ••• | ••• | Yes (mr-APS1) | ••• (comb. with transparent substrate) | ••• | ••• | | •• | •• | | ••• | |
| | **mr-UVCur26SF** | - Photo-curable resist formulation<br>- Inkjet dispensable at RT due to low viscosity (15 mPas)<br>- Fast curing for continuous imprint processes (roll-to-roll) | | ••• | ••• | | •• | ••• | •• | | ••• | • | Yes (mr-APS1) | ••• (comb. with transparent substrate) | ••• | ••• | | •• | ••• | | ••• | |

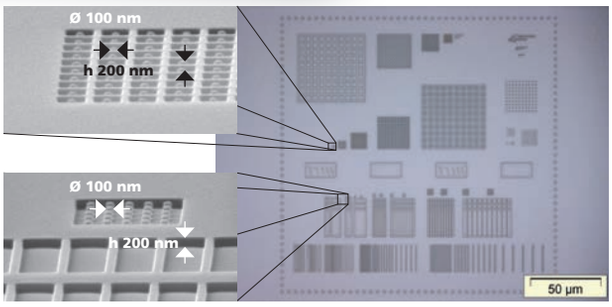
| | |
|---|---|
| Special designs and innovations | - micro resist technology GmbH provides customized solutions of all the aforementioned products on request, e.g. special designs for non-standard film thickness ranges. Please contact us directly.<br>- micro resist technology GmbH has numerous complementary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

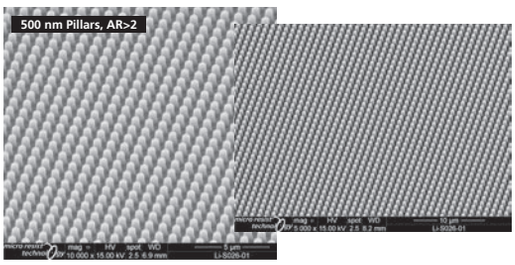
••• excellent  •• good  • fair

# Recent application examples

## mr-NIL210



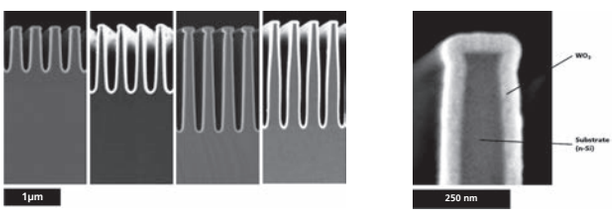

Example 1 Imprint of miscellaneous nano- and micrometer test structures into mr-NIL210 using a UV-PDMS stamp (Shin-Etsu UV-PDMS KER-4690).




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

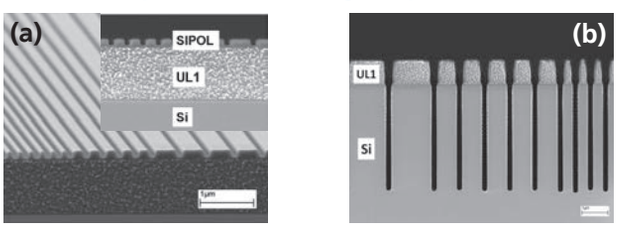
### Nanostructuring of photoelectrode surfaces




$WO_3$ 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

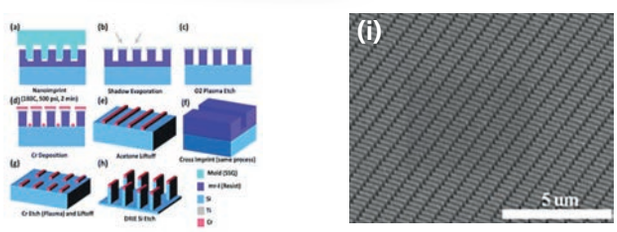
### Pattern amplification for high aspect ratio




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

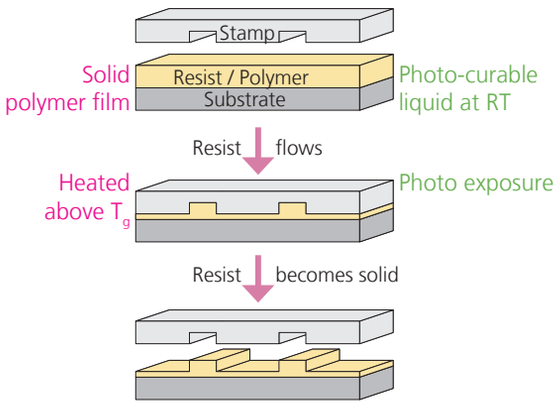



a)-h) Two dimensional imprint process for the fabrication of Si nanowalls for Lithium Ion Batteries using mr-I 8000R as thermoplastic NIL resist; i) SEM image of the fabricated 200 nm Si nanowall array (J. Wan *et al.,* J Mater Chem A 2 2014 6051).

# Imprint process

**Thermal NIL**
Thermoplastics and Thermosets

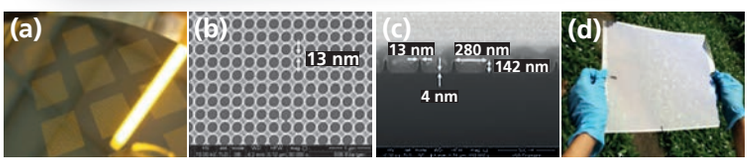
**Photo-NIL (UV-NIL)**
Photo-curable resists




# Future Innovations

## Alternative coating and imprint technologies

### Inkjet dispensing, gravure & spray coating, etc.

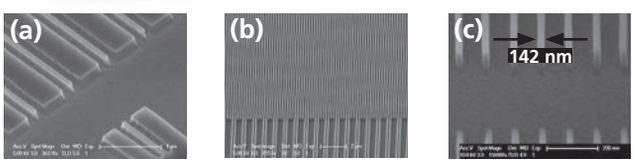



a) Resist dots of inkjet dispensed mr-UVCur26SF at RT onto 6 inch Si wafer; b) S&R imprinted nanoapertures using mr-UVCur26SF; c) Cross-sectional view of the imprinted nanoaptertures of b), residual layer thickness minimization to 4 nm by inkjet deposition of an effectual amount of resist, (all courtesy 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 $H_2O$ 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 $H_2O$ |
| Dry etching | $O_2$ (100% organic) | $O_2$ (100% organic) |
| Etch performance | High dry etching stability | High dry etching stability |