Materials for Nanoimprint Lithography

micro resist technology

Gesellschaft für chemische Materialien spezieller Photoresistsysteme mbH

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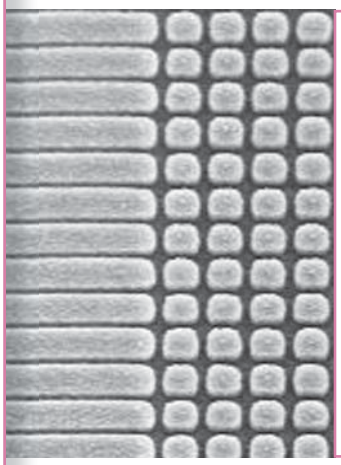

Polymers for thermal & UV-based nanoimprint lithography

- Thermoplastics
- Curing polymers (thermosets)
- UV-curable polymers

Unique features of the nanoimprint polymers

- Excellent film quality
- Coating of various substrate materials, e.g. Si, SiO_2, Al
- Attainable smallest feature size at least 50 nm (depending on mould resolution)
- Excellent pattern transfer fidelity
- Safe solvents

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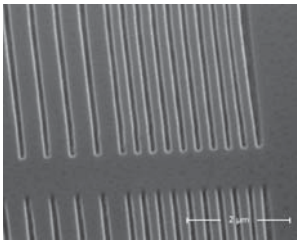
Thermoplastics for Thermal Nanoimprint Lithography

Thermoplastic Polymer	mr-I 7000E	mr-I 8000E	mr-I T85	mr-I PMMA **
Glass transition temperature T_g	60 °C	115 °C	85 °C	105 °C
Imprint temperature	125 – 150 °C	170 – 190 °C	130 – 150 °C	150 – 180 °C
Imprint pressure	20 – 50 bar	20 – 50 bar	5 – 20 bar	20 – 50 bar
Ready-to-use solutions for various film thicknesses * (3000 rpm)	mr-I 7010E 100 nm mr-I 7020E 200 nm mr-I 7030E 300 nm	mr-I 8010E 100 nm mr-I 8020E 200 nm mr-I 8030E 300 nm	mr-I T85-0.3 300 nm mr-I T85-1.0 1.0 µm mr-I T85-5.0 5.0 µm	100 nm 300 nm 500 nm
Diluents	ma-T 1050	ma-T 1050	–	ma-T 1045

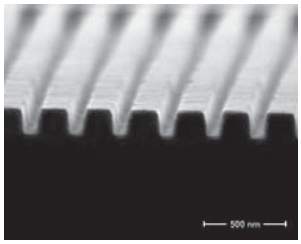
* Different film thicknesses are available on request. ** Available with the low molecular weights 35k or 75k.

mr-I 7000E



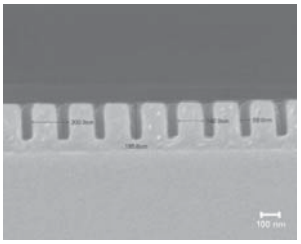
100 nm trenches, pitch 300 & 500 nm,
Film thickness: 200 nm
Imprint: 130 °C, 3 min, 50 bar
Residual layer thickness < 10 nm

mr-I 8000E



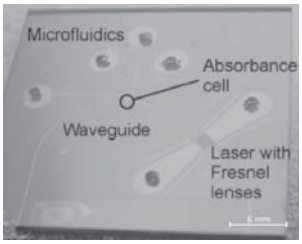
100 nm trenches, pitch 300 nm,
Film thickness: 200 nm
Imprint: 190 °C, 3 min, 50 bar
Residual layer thickness < 10 nm

mr-I 8000E



60 nm trenches, 200 nm pitch,
Film thickness: 200 nm
Imprint: 135 °C, 2 min, 45 bar
(Courtesy of LG Elite)

mr-I T85



Complete device for absorption measurements imprinted in mr-I T85
(Courtesy of DTU Nanotech)

mr-I 7000E & mr-I 8000E for pattern transfer

- Superior imprint characteristics:
  - Short cycle times due to fast polymer flow
  - Low imprint pressure
  - Low residual layer thickness
- High plasma etch resistance comparable to novolak-based photoresists

Applications

- Etch mask for pattern transfer processes
- Fabrication of nanopatterns for: mass data storage, nano-optical devices, sub-wavelength optical elements, photonic crystals, micro displays, LED

mr-I T85 for lab-on-a-chip, micro-optics & bio applications

- Unpolar thermoplastic with very high chemical stability
- Beneficial flow behaviour during imprinting, low imprint pressure
- Excellent UV & optical transparency
- High plasma etch resistance comparable to novolak-based photoresists

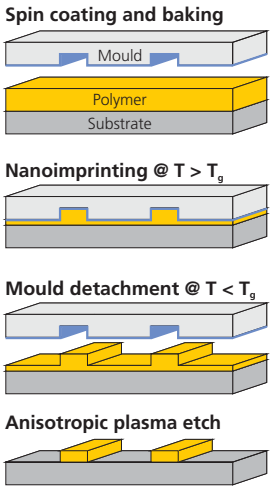
Applications

- Lab-on-a-chip systems
- Bio applications
- Fabrication of nano and micro-patterns for: micro-optical components, waveguides, microfluidics

mr-I PMMA

- Low molecular weights (35k, 75k)
- For fundamental nanoimprint investigations

NIL process Thermoplastics

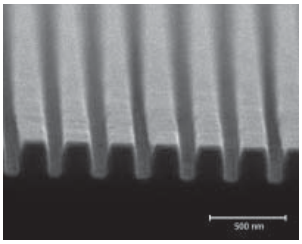


Curing Polymers for Thermal Nanoimprint Lithography

Curing Polymer	mr-NIL 6000	mr-I 9000E	mr-I 9000M
Glass transition temperature *before curing*	40 °C	35 °C	35 °C
Imprint conditions	100 – 110 °C (isothermal process), 30 – 50 bar, UV exposure (broad band or i-line)	120 °C, 30 – 50 bar	100 °C, 30 – 50 bar, 2nd imprint step at 140 °C optional to increase thermal stability
Ready-to-use solutions for various film thicknesses * (3000 rpm)	mr-NIL 6000.1 100 nm mr-NIL 6000.2 200 nm mr-NIL 6000.3 300 nm	mr-I 9010E 100 nm mr-I 9020E 200 nm mr-I 9030E 300 nm	mr-I 9030M 300 nm mr-I 9050M 500 nm mr-I 9100M 1.0 µm
Diluents	ma-T 1045	ma-T 1045	ma-T 1045

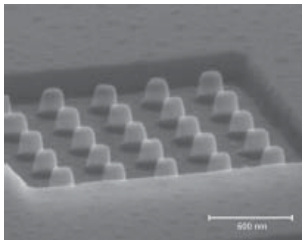
* Different film thicknesses are available on request.

mr-NIL 6000



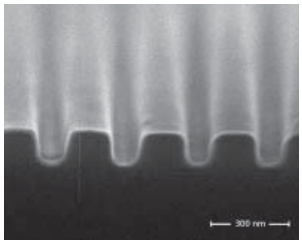
100 nm trenches, 300 nm pitch
Film thickness: 250 nm
Imprint: 100 °C, 30 bar

mr-I 9000E



200 nm dots
Film thickness: 200 nm
Imprint: 120 °C, 50 bar

mr-I 9000M



Well preserved 200 nm lines & 100 nm trenches after imprint & subsequent annealing to 260 °C

mr-NIL 6000 high performance resist

- Combined thermal & UV nanoimprinting
- Short imprint cycle times, isothermal process: imprinting, UV flood exposure & mould release *at the same temperature*
- Very low residual layer thickness (<10 nm)
- Plasma etch resistance comparable to conventional novolak-based photoresists

Applications
- Etch mask for pattern transfer processes
- Permanent structures, e.g. in microfluidics or optics
- Single & multilayer systems

mr-I 9000E for pattern transfer

- Short imprint cycle times
- Thermal curing during imprint
- Very low residual layer thickness (<10 nm)
- Plasma etch resistance comparable to conventional novolak-based photoresists

Applications
- Etch mask for pattern transfer processes
- Single & multilayer systems

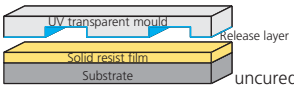
mr-I 9000M for micro & nanofabrication

- Simultaneous imprint of nano & micropatterns
- High thermal stability of imprinted patterns up to 260 °C
- Thermal curing during imprint
- Isothermal mould release (no cooling phase)

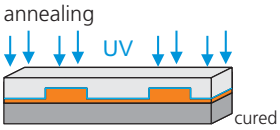
Applications
- Permanent applications in micro & nanofabrication (e.g. nanoimprint mould)
- Single & multilayer systems

NIL process mr-NIL 6000

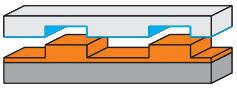
Spin coating and prebake



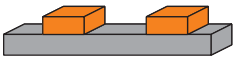
Nanoimprint @ $T_i > T_g$, UV flood exposure and annealing



Mould release @ $T_i < T_{g,\,cured}$

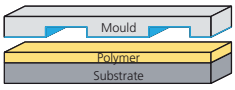


Anisotropic plasma etch

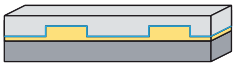


NIL process mr-I 9000E & mr-I 9000M

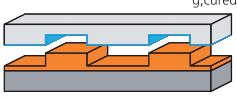
Spin coating & prebake



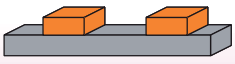
Nanoimprinting @ $T>T_g$ & thermal curing $T \Rightarrow T_{g,cured}$



Mould release @ $T<T_{g,cured}$



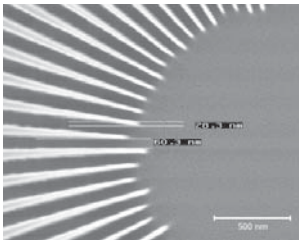
Anisotropic plasma etch



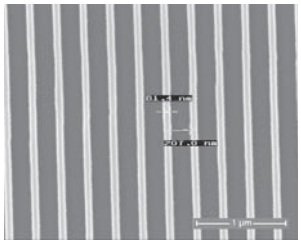
UV-curable Polymers for UV-based Nanoimprint Lithography

UV-curable Polymer	mr-UVCur06	mr-UVCur21	mr-UVCur21SF
Coating method	Spin coating	Spin coating	Dispensing, spin coating
Process conditions	Imprint: room temperature process, low imprint pressures (>100 mbar), imprint in vacuum or under atmospheric pressure UV exposure: broad band or i-line, curing time few seconds		
Smallest feature size Aspect ratio	50 nm < 2	< 30 nm > 2	< 30 nm > 2
Ready-to-use solutions for various film thicknesses * (3000 rpm)	240 nm	100 nm 200 nm 300 nm	1.6 µm (spin coating)
Diluents	mr-T 1070	mr-T 1070	mr-T 1070
Adhesion Promoter	mr-APS1	mr-APS1	mr-APS1

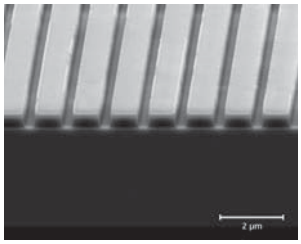
* Different film thicknesses are available on request for mr-UVCur21.



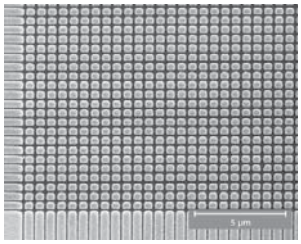
Imprinted lines, sub-30 nm resolution (Courtesy of AMO)



80 nm lines, pattern depth 110 nm (Courtesy of AMO)



300 nm trenches, residual layer thickness < 10 nm (Courtesy of Profactor)

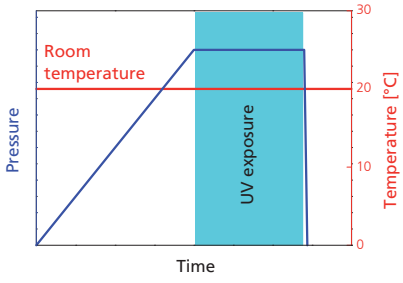


500 nm squares transferred into SiO_2 after imprinting, CHF_3 plasma (Courtesy of FSU Jena)

- Compatibility with various nano-imprint tools
- Wafer-scale or step & repeat imprints
- Superior imprint characteristics:
  - **Short cycle times** due to fast filling of mould cavities
  - Pattern **resolution below 30 nm** (mr-UVCur21, limited by the mould, not by the polymer)
  - **Very low residual layer thickness** (< 10 nm)
  - **Short curing times,** low UV doses, compatibility with various UV lamps and filter systems
- **High plasma etch resistance,** no residues after oxygen plasma etching

Applications

- Etch mask for pattern transfer processes (dry and wet etching)
- Fabrication of nanopatterns
  - -Data storage
  - -Nano-optical devices, sub-wavelength optical elements
  - -Photonic crystals
  - -Optical metamaterials
  - -Micro and nanofluidics
  - -Microelectronics



UV-NIL process