Thermoplastics for Thermal Nanoimprint Lithography

<table>
<thead>
<tr>
<th>Thermoplastic Polymer</th>
<th>mr-I 7000E</th>
<th>mr-I 8000E</th>
<th>mr-I T85</th>
<th>mr-I PMMA **</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glass transition temperature Tg</td>
<td>60 °C</td>
<td>115 °C</td>
<td>85 °C</td>
<td>105 °C</td>
</tr>
<tr>
<td>Imprint temperature</td>
<td>125 – 150 °C</td>
<td>170 – 190 °C</td>
<td>130 – 150 °C</td>
<td>150 – 180 °C</td>
</tr>
<tr>
<td>Imprint pressure</td>
<td>20 – 50 bar</td>
<td>20 – 50 bar</td>
<td>5 – 20 bar</td>
<td>20 – 50 bar</td>
</tr>
<tr>
<td>Ready-to-use solutions for various film thicknesses (3000 rpm)</td>
<td>mr-I 7010E 100 nm</td>
<td>mr-I 7020E 200 nm</td>
<td>mr-I 7030E 300 nm</td>
<td>mr-I 8010E 100 nm</td>
</tr>
<tr>
<td>Diluents</td>
<td>ma-T 1050</td>
<td>ma-T 1050</td>
<td>ma-T 1050</td>
<td>ma-T 1045</td>
</tr>
</tbody>
</table>

Curing Polymers for Thermal Nanoimprint Lithography

<table>
<thead>
<tr>
<th>Curing Polymer</th>
<th>mr-NIL 6000</th>
<th>mr-I 9000E</th>
<th>mr-I 9000M</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glass transition temperature before curing</td>
<td>40 °C</td>
<td>35 °C</td>
<td>35 °C</td>
</tr>
<tr>
<td>Imprint conditions</td>
<td>100 – 110 °C (isothermal process), 30 – 50 bar, UV exposure (broad band or i-line)</td>
<td>120 °C, 30 – 50 bar</td>
<td>100 °C, 30 – 50 bar, 2nd imprint step at 140°C optional to increase thermal stability</td>
</tr>
<tr>
<td>Ready-to-use solutions for various film thicknesses (3000 rpm)</td>
<td>mr-NIL 6000.1 100 nm</td>
<td>mr-NIL 6000.2 200 nm</td>
<td>mr-NIL 6000.3 300 nm</td>
</tr>
<tr>
<td>Diluents</td>
<td>ma-T 1045</td>
<td>ma-T 1045</td>
<td>ma-T 1045</td>
</tr>
</tbody>
</table>

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

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

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

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

NIL process
Thermoplastics
- Spin coating and baking
- Nanoimprinting \( T > T_g \)
- Isothermal mould release

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 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

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

NIL process mr-NIL 6000
- Spin coating & prebake
- Nanoimprinting \( T > T_g \)
- UV flood exposure and annealing
- Anisotropic plasma etch

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

NIL process mr-I 9000E & mr-I 9000M
- Spin coating & prebake
- Nanoimprinting \( T > T_g \)
- Thermal curing during imprint
- Anisotropic plasma etch

Applications
- Permanent applications in micro & nanofabrication (e.g. nanoimprint mould)
- Single & multilayer systems
UV-curable Polymers for UV-based Nanoimprint Lithography

<table>
<thead>
<tr>
<th>UV-curable Polymer</th>
<th>mr-UVCur06</th>
<th>mr-UVCur21</th>
<th>mr-UVCur21SF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coating method</td>
<td>Spin coating</td>
<td>Spin coating</td>
<td>Dispensing, spin coating</td>
</tr>
<tr>
<td>Process conditions</td>
<td>Imprint: room temperature process, low imprint pressures (&gt;100 mbar), imprint in vacuum or under atmospheric pressure</td>
<td>UV exposure: broad band or H- line, curing time few seconds</td>
<td></td>
</tr>
<tr>
<td>Smallest feature size</td>
<td>50 nm &lt; 2</td>
<td>&lt; 30 nm &gt; 2</td>
<td>&lt; 30 nm &gt; 2</td>
</tr>
<tr>
<td>Aspect ratio</td>
<td>50 nm &lt; 2</td>
<td>&lt; 30 nm &gt; 2</td>
<td>&lt; 30 nm &gt; 2</td>
</tr>
<tr>
<td>Ready-to-use solutions for various film thicknesses *</td>
<td>240 nm</td>
<td>100 nm</td>
<td>1.5 μm (spin coating)</td>
</tr>
<tr>
<td>Diluents</td>
<td>mr-T 1070</td>
<td>mr-T 1070</td>
<td>mr-T 1070</td>
</tr>
<tr>
<td>Adhesion Promoter</td>
<td>mr-APS1</td>
<td>mr-APS1</td>
<td>mr-APS1</td>
</tr>
</tbody>
</table>

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

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
- Micro and nanofluidics
- Microelectronics

Materials for Nanoimprint Lithography

- 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, SiO₂, Al
- Attainable smallest feature size at least 50 nm (depending on mould resolution)
- Excellent pattern transfer fidelity
- Safe solvents

Imprinted lines, sub-30 nm resolution (Courtesy of AMD)
80 nm lines, pattern depth 1.10 nm (Courtesy of AMD)
300 nm trenches, residual layer thickness < 10 μm (Courtesy of Profactor)
500 nm squares transferred into SiO₂ after imprinting, CHF₃ plasma (Courtesy of FSU Jena)

Imprints, sub-30 nm resolution (Courtesy of AMD)
80 nm lines, pattern depth 1.10 nm (Courtesy of AMD)
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