

Processing Guidelines – mr-I T85 series

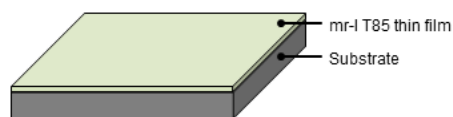
mr-I T85 Series: Thermoplastic Polymer for Nanoimprint Lithography with outstanding optical properties

Characteristics

mr-I T85 is a thermoplastic polymer for nanoimprint lithography with outstanding optical properties and chemical stability. It has a glass transition temperature (T_g) of 80 °C. mr-I T85 formulations are provided as ready-to-use solutions for various film thicknesses.

Processing Scheme

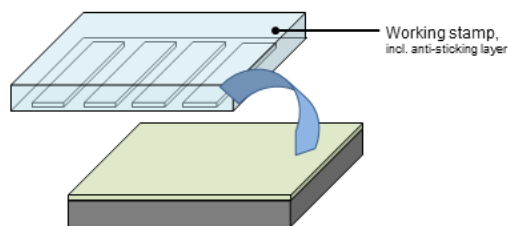
1. Spin-coating of MRT T-NIL resist and soft-bake



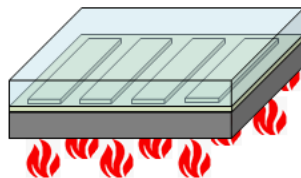
$f_{\text{rotation}} = 3000 \text{ rpm}$
 $t = 30 \text{ sec.}$

$v = 140^\circ\text{C}$
 $t = 120 \text{ sec.}$

2. Align stamp and attach

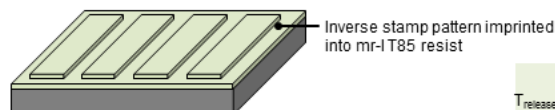


3. Nanoimprint step of mr-I T85



$p_i = 5 - 10 \text{ bar}$
 $T_i = 130 - 150^\circ\text{C}$
 $t_i = 1 - 4 \text{ min}$

4. Detach stamp



$T_{\text{release}} < T_g = 60-75^\circ\text{C}$

5. Pattern transfer via RIE or use as permanent patterns for optical applications

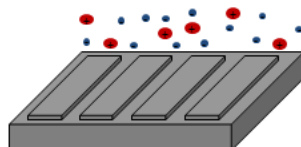


Fig.1: Process scheme of thermal nanoimprint lithography with mr-I T85.

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Processing Details

Resist formulations ¹	mr-I T85-0.3	mr-I T85-1.0	mr-I T85-5.0
Film thickness in nm	300 ± 20	1000 ± 50	5000 ± 100
Substrate preparation	Spin clean with 2-propanol and dehydrate on a hotplate at 200 °C for 5 min or apply O ₂ plasma treatment		
Coating spin speed [rpm]	3000		
time [s]	30		
Prebake (hotplate) [°C]	140		
[min]	2		
Imprinting parameters			
Imprint Temperature [°C]	130 – 150		
Imprint Time [min]	1 – 4		
Imprint Pressure [bar]	5 – 15		
Release Temperature [°C]	60 – 75		

¹ Customization of film thickness can be done up to 20 µm.

Standard Processing Conditions

Best results are accomplished at temperatures of 20–25 °C and a relative humidity of 40–46 %. The specific process parameters depend on substrate material, equipment, and application.

Dilution of mr-I T85

mr-I T85 is delivered in exact film thickness as guaranteed by the manufacturer, self-dilution is not recommended.

Substrate Preparation

The substrates have to be free of impurities and moisture. Silicon substrates should be spin-cleaned with acetone / 2-propanol, baked at 200 °C for 5 min. and cooled down to room temperature immediately before coating. Alternatively, short oxygen or ozone plasma cleaning is recommended.

Coating

Uniform coatings are obtained by spin coating of the resist formulations. A spin time of at least 30 s is recommended. Extended spin duration time is considered to decrease the film thickness and may improve also the film thickness homogeneity.

Prebake

Spin-coated mr-I T85 resist films are baked on a hotplate at 100 °C for 2 min. The prebake step removes residual solvent in the spin-coated film.

Stamp Preparation

Hard stamps like Si, Quartz, Ni, etc.: For defect-free imprints and low release forces using silicon, nickel or quartz stamps, it is highly recommended to treat and equip the stamp surface with a release agent. A well-suited release agent for silicon or silicon dioxide is F₁₃-TCS (trichloro-(1H,1H,2H,2H-perfluorooctyl)-silane, CAS number [78560-45-9]), that is commercially available from many suppliers of specialty chemicals.

Polymer stamps: mr-I T85 can also be used in combination with hard polymeric working stamps like the commercially available product OrmoStamp®. Please follow the separate processing guidelines for the

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stamp preparation with OrmoStamp®. Other options as working stamps are PFPE, PUA, or other polymer systems, whereas, the relatively high pressure and temperature during mr-I T85 processing needs to be considered.

Imprint Conditions

Main factors determining the imprint conditions are the rheological behaviour of the polymer, the mould layout (feature size, density of the patterns etc.), the residual layer thickness to be attained and the imprinting tool. Typically nanoimprint polymers are heated to 50–80K above T_g . The mr-I T85 series can be imprinted in any tool suitable for doing thermal nanoimprint lithography. Commercial nanoimprint tools as provided e.g. by EV Group (AUT), SUSS MicroTec (GER), NIL Technology (DEN), Obducat (SWE), or others may be used.

It is recommended to imprint on the lower end of the process window and to choose rather low pressure and temperature values for the first trials. mr-I T85 performs well because of its optimised flow properties. Very high imprinting pressures and temperatures are proven to be a source of defects and should be avoided.

Residual polymer layer removal

The residual layer remaining in between the imprinted patterns is removed by oxygen reactive ion etching (RIE) in order to open the window to the substrate.

Removal / Stripping

Plasma-based removal: A full removal of processed resist residues is preferably achieved by applying oxygen plasma. Since mr-I T85 only contains organic components, there are no residuals left over on the substrate after plasma treatment with pure oxygen.

Wet-chemical stripping: Not possible or contact the manufacturer for further information, respectively.

Storage

Storage at temperatures of 15 – 25 °C is recommended. Storage in a refrigerator is not required. Keep mr-I T85 bottles closed when not in use. Under these conditions, a shelf life of 12 months from the date of manufacture is ensured.

Disposal

Dispose of as halogen-free solvent.

Environmental and Health Protection

mr-I T85 should be handled with the same care as usual for all chemicals. Ensure that there is adequate ventilation while processing the materials. Avoid contact with skin and eyes and breathing solvent vapours. Wear suitable protective clothing, safety goggles and gloves. The product related material safety data sheet is delivered with the product and should be read carefully.

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Attachment

Specifications of the liquid mr-I T85 formulation

Parameter	mr-I T85-0.3	mr-I T85-1.0	mr-I T85-5.0
Appearance/colour	colourless, clear	colourless, clear	colourless, clear
Film thickness ¹⁾ [nm]	300 ± 20	1000 ± 50	5000 ± 100
Density @ 25 °C [g cm ⁻³]	0.871 ± 0.005	0.879 ± 0.005	0.891 ± 0.005
Refractive index n _D ²⁵ ²⁾	1.491 ± 0.002	1.493 ± 0.002	1.497 ± 0.002

¹⁾ Spin-coated at 3000 rpm for 30 s ²⁾ refractive index of the resist formulation is measured at 589 nm and 25 °C

Physical Parameters of the mr-I T85 Polymer

mr-I T85 before imprinting	
Glass transition temperature T _g [°C]	80
Thermal behaviour	Thermoplastic
Processed mr-I T85 polymer (imprinted)	
Glass transition temperature T _g [°C]	80
Thermal behaviour	Thermoplastic

Film Thickness and Spin Curves

The thickness data of spin-coated films refer to an open spin-coating system. For film thickness measurements using ellipsometric methods the Cauchy coefficients given in Figure 4 can be used.

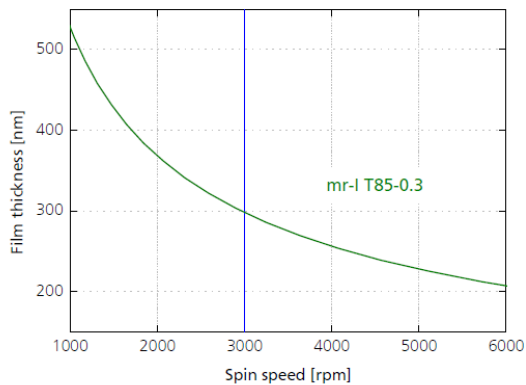


Fig. 2: Spin curve mr-I T85-0.3, 30 s spin time

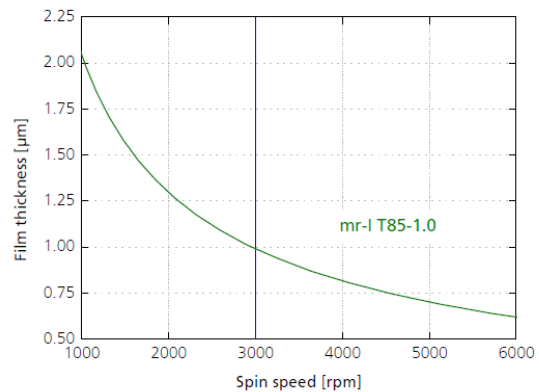


Fig. 3: Spin curve mr-I T85-1.0, 30 s spin time

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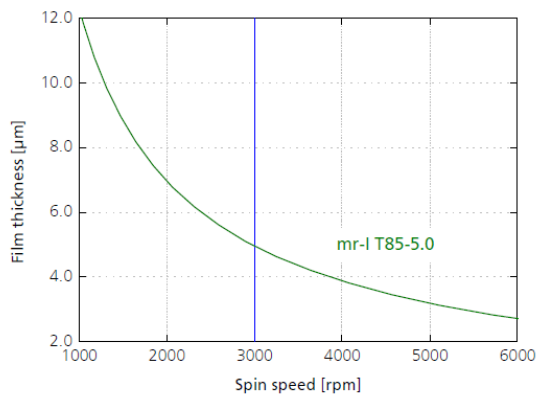


Fig. 4: Spin curve mr-I T85-5.0, 30 s spin time

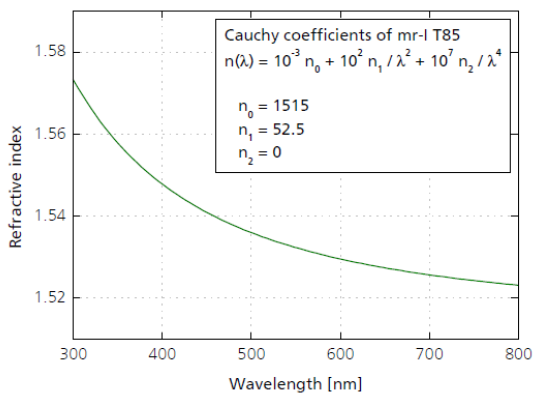


Fig. 5: Refractive index vs. wavelength, Cauchy coefficients of mr-I T85

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