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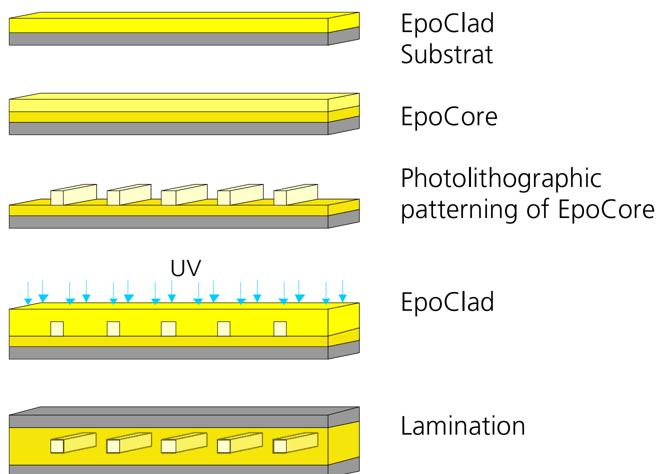
Negative Tone Photoresists EpoClad

Characteristics

EpoClad is a chemically amplified negative tone photoresist series for micro systems technology

- specifically designed for optical applications in micro systems technology
- application as cladding material in optical wave guiding in combination with EpoCore
- excellent thermal stability of the resist patterns
- UV sensitive
- high transparency to visible light
- development in organic solvents



Process flow for the preparation of polymeric waveguides by UV-lithography

Physical properties of the resist solutions

Properties	EpoClad _2	EpoClad _5	EpoClad _10	EpoClad _20	EpoClad
Thickness range[1] [µm]	2 – 6	3 – 14	5 – 25	10 – 60	30 – 120
@ 3000 rpm, 30 s [µm]	2.0 ± 0.2	5.0 ± 0.5	10 ± 1	20 ± 2	-
@ 1700 rpm, 60 s [µm]	-	-	-	-	50 ± 5
Dynamic viscosity[2] @ 150 s^{-1} [mPa*s]	75 ± 10	330 ± 20	850 ± 40	3000 ± 120	12000 ± 500
@ 1000 s^{-1} [mPa*s]	75 ± 10	330 ± 20	800 ± 40	2500 ± 100	
Density[3] [g cm^{-3}]	1.172 ± 0.002	1.181 ± 0.002	1.185 ± 0.002	1.191 ± 0.002	1.200 ± 0.002
Refractive index n_D^{25}	1.502 ± 0.002	1.517 ± 0.002	1.525 ± 0.002	1.534 ± 0.002	1.544 ± 0.002

[1] Spin coated at 750 to 6000 rpm, [2] 25 °C, [3] 20 °C

Processing

Best patterning results are obtained at temperatures of 20 – 25 °C and a relative humidity of 40 – 46 %. The resist and unexposed resist films have to be processed under yellow light. The guidelines relate to standard processing of resist films spin coated on Si, SiO_2 or FR4. The specific process parameters to be applied depend on substrate, application and equipment.

This information is based on our experience and is, to the best of our knowledge, true and accurate. It should inform you about our products and their application processes. We do not guarantee special properties of our products nor their use for specific processes.

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Processing conditions for EpoClad

Resist		EpoClad_2	EpoClad_5	EpoClad_10	EpoClad_20	EpoClad
Film thickness	[µm]	2	5	10	20	50
Substrate preparation		Dehydration bake, oven: 30 min @ 200 °C for Si and SiO_2, Oxygen plasma for FR4, As cladding on top of patterned EpoCore: oxygen plasma				
Spin coating	[rpm] [s]	3000 30	3000 30	3000 30	3000 30	1700 60
Relaxation	[min]			5	10	15
Prebake						
Hotplate	[°C] [min]	120 5	120 5	120 5	50/ 90/ 120 5/ 5 / 10	50/ 90 / 120 5 / 5 / 10 - 20
Oven	[°C] [min]					90 - 120 45 - 90
Relaxation	[min]			10	20	30
Exposure dose	[mJ cm^{-2}]	250 ± 50	350 ± 50	350 ± 50	500 ± 100	500 ± 100
(365nm)[1]		Flood exposure for cladding				
Post exposure bake (PEB)						
Hotplate	[°C] [min] [°C] [min]	120 3 - 5	120 3 - 5	120 5	120 5 - 10	120 5 - 10 or 50 / 90/ 120 5 / 5 / 5 - 10
Oven	[°C] [min]					90 - 120 45 - 60
		Slow cooling down to room temperature				
Development[2]	[s]	60 ± 10	90 ± 20	120 ± 20	180 ± 30	240 ± 60
mr-Dev 600		Not applicable for the cladding				
Hardbake		Also for the embedded waveguide				
Hotplate	[°C] [min]	120 – 140 30 - 60				
		Slow cooling down to room temperature				

[1] broadband exposure, intensity measured at λ=365 nm [2] immersion development

Substrate preparation:

The substrates have to be free of impurities and moisture. Si substrates should be baked at 200 °C and cooled to room temperature immediately before coating. Alternatively, oxygen or ozone plasma cleaning is recommended. Oxygen or ozone plasma cleaning is recommended for FR 4 substrates.

Coating:

Uniform coatings are obtained by doctor blading or spin coating of the EpoClad solutions in the thickness range indicated in the spin curves. Please select the appropriate resist type and spin speed required for the desired film thickness and application. The information refers to an open spin-coating system. Film thicknesses are attained with a single coat. The film thickness is measured after the prebake process.

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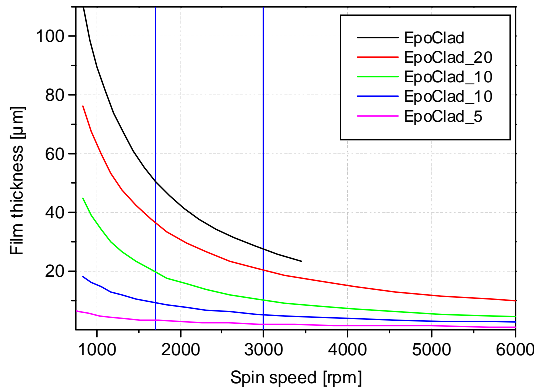

Fig. 1: Spin curve EpoClad Series, 30 s spin time and for EpoClad 60 s spin time

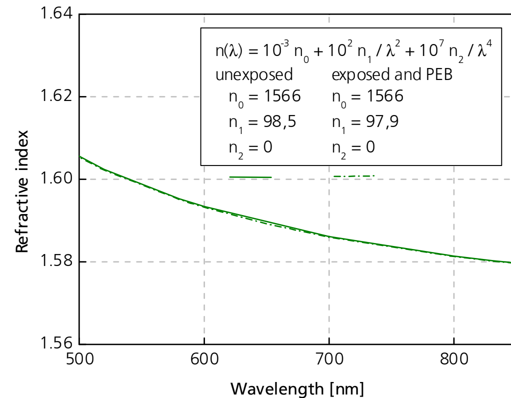

Fig. 2: Refractive index vs. wavelength, Cauchy coefficients of unexposed and of exposed and post exposure baked EpoClad

The refractive index of the resist film depending on the wavelength and the Cauchy equation are given in Fig. 2. This information is needed for ellipsometric or other optical thickness measurement.

Prebake:

Patterning & Cladding

Resist films are baked on a hotplate at 50 °C. Then the temperature is gradually (8 – 9 K/ min) increased to 120 °C and the film is baked at this temperature.
Alternatively thin resist films are baked on a hotplate at 120 °C.
Thick resist films are alternatively baked in a convection oven at 90 – 120 °C.

Exposure:

The resist is effective for broadband or i-line exposure.

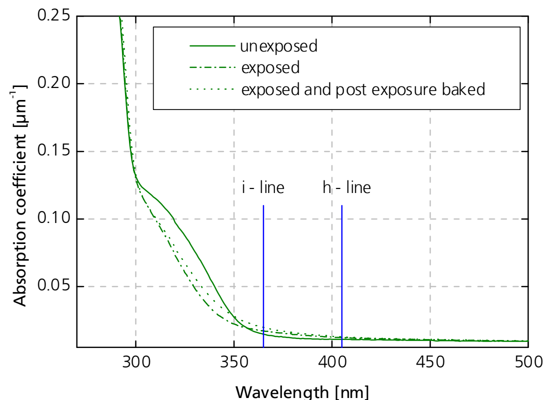

Fig. 3: UV/ vis absorption of unexposed, exposed and post exposure baked EpoClad

Post Exposure Bake - PEB:

Patterning & Cladding

Immediately after exposure the resist films are baked at 50 °C. Then the temperature is gradually (8 – 9 K/min) increased to 120 °C and the film is baked at this temperature.
Alternatively thin resist films are baked at 120 °C.
Thick resist films are alternatively baked in a convection oven at 90 – 120 °C.
After the PEB the resist films are slowly cooled down to room temperature to avoid pattern stress.

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Develop:

Ready-to-use developer **mr-Dev 600** is recommended. The temperature of the developer should be 20 – 25 °C. The developed resist films are thoroughly rinsed with isopropanol and then dried.

Hardbake:

If required, the etch resistance and the thermal stability of the resist can be increased. Hardbaking of the developed resist patterns is suggested in an oven at 120 – 140 °C. A temperature ramp is beneficial in order to avoid pattern stress and delamination.

Removal:

Ready-to-use removers **mr-Rem 660** (NMP based) and **mr-Rem 500** (NMP free) are recommended. This also can be done at temperatures of 40 – 60 °C assisted by ultrasonics. Oxygen plasma is also suitable for the removal of the resist. Please note that the material is strongly cross-linked after the processing and therefore its removal is not easy.

Storage

Storage at temperatures of 18 – 25 °C is recommended. Do not store EpoClad series a refrigerator. Resist and unprocessed resist films have to be stored under yellow light. Keep the bottle closed when not in use. Under these conditions a shelf life of 1 year from the date of manufacture is ensured.

Disposal

Unexposed resist: dispose of as halogen free solvent
Exposed resist: dispose of as resist/old resist

Environmental and health protection

Ensure that there is adequate ventilation while processing the resist. Avoid contact of the resist with skin and eyes and breathing solvent vapours. Wear suitable protective clothing, safety goggles and gloves.

Equipment

EpoClad is compatible with commercially available photoresist processing equipment. The data given in these guidelines were obtained using:
- Convac spin coater or Suss Delta 6 spin coater without cover
- Contact hotplate/ convection oven
- Suss MA 56 mask aligner (UV 400)
- Immersion development

Patterning examples

Fig. 4: EpoClad 50 x 50 µm structures on FR4 substrate

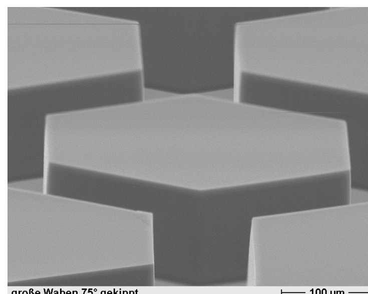

Fig. 5: 100 µm EpoClad, test pattern

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