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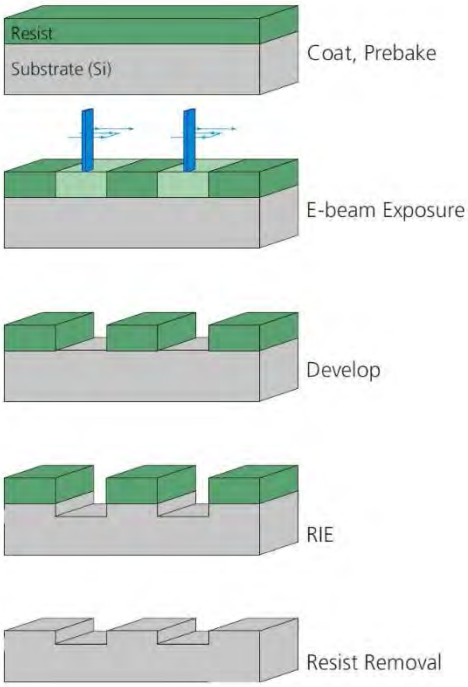
Positive Tone Electron Beam Resist Series mr-PosEBR

Characteristics

mr-PosEBR is an acrylate-based positive tone resist material for high resolution electron-beam lithography. The resists are available in a variety of viscosities.

- Highly sensitive
- Well suitable as etch mask exhibiting high dry etch resistance
- High resolution capability
- Suitable for 3D surface patterning
- Safer solvent anisole

Process flow



Physical properties of the resist solution

Properties		mr-PosEBR 0.05	mr-PosEBR 0.1	mr-PosEBR 0.3
Film thickness[1]	[nm]	50 ± 10	100 ± 10	300 ± 20
Dynamic viscosity[2]	[mPa s]	2.5 ± 0.3	3.4 ± 0.3	9.3 ± 0.3
Density[3]	[gcm^{-3}]	1.000 ± 0.002	1.004 ± 0.002	1.017 ± 0.002

[1] Spin coated at 3000 rpm for 30 s [3] 25 °C, 1000 s^{-1} [4] 20 °C

Processing

Best patterning results are obtained at temperatures of 20 – 25 °C and a relative humidity of 40 – 46 %. The guidelines relate to standard processing of resist films spin coated on Si or SiO_2. 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

Resist		mr-PosEBR 0.05	mr-PosEBR 0.1	mr-PosEBR 0.3
Film thickness	[nm]	50	100	300
Substrate preparation		oxygen plasma, oven: 30 min @ 200°C for Si and SiO_2 substrates		
Spin coating	[rpm] [s]	3000 30	3000 30	3000 30
Prebake				
Hotplate	[°C] [min]	150 1	150 1	150 1
Exposure Dose				
30 keV 100 keV	[µC cm^{-2}] [µC cm^{-2}]	75 – 200 340 – 500	75 – 200 340 – 500	75 – 200 340 – 500
Development mr-Dev 800 (Amyl acetate)[1]	[s]	20 - 30	20 - 30	60
Rinse Isopropanol	[s]	60	60	60

[1] immersion

Substrate preparation

The substrates have to be free of impurities and moisture. Oxygen or ozone plasma cleaning is recommended. Then the substrates should be baked at 200 °C and cooled to room temperature immediately before coating.

Coating

Uniform coatings are obtained by spin-coating of the mr-PosEBR solutions in the thickness range indicated in the spin curves (Fig. 1). Please select the appropriate spin speed required for the desired film thickness and application. The information refers to an open spin-coating system. Film thicknesses are obtained with a single coat and measured after the prebake process.

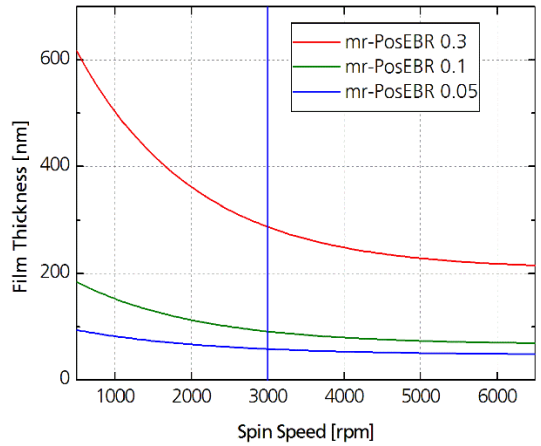

Fig. 1. Spin curves of mr-PosEBR solutions; film thicknesses were measured after the prebake process.

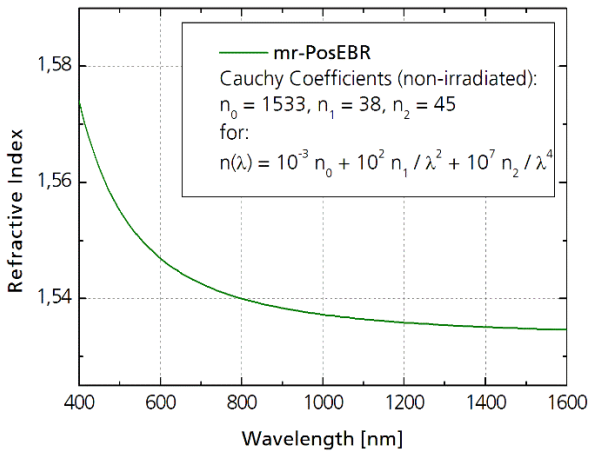

Fig. 2. Dispersion curve of mr-PosEBR; inset shows Cauchy coefficients and the corresponding Cauchy equation.

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

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Prebake

Resist films are baked on a hotplate at 150 °C for 1 minute. Then the resist films are allowed to cool down to room temperature.

Physical properties of the solid resist material

Material		**mr-PosEBR**
Molecular weight M_n / M_w	[gmol^{-1}]	70 000 ± 15 000 / 120 000 ± 20 000
Polydispersity Index (PDI)		1.7 ± 0.2
T_g	[°C]	120 ± 4
Cauchy coefficients, for: $n(\lambda) = 10^{-3}n_0 + \frac{10^2 n_1}{\lambda^2} + \frac{10^7 n_2}{\lambda^4}$		n_0 = 1533 n_1 = 38 n_2 = 45
Dry etch selectivity vs. Si (SF_6/CF_4 etch process)[1]		~2.5
Elemental Composition		
Carbon [C]	[%]	64
Hydrogen [H]	[%]	6
Nitrogen [N]	[%]	0
Oxygen [O]	[%]	22
Chlorine [Cl]	[%]	8

[1] SF6 = 5 sccm, CF4 = 45 sccm; P_RIE = 50 W -> DC Bias 330 V; P_ICP = 200 W, p = 15 mTorr, T = 18 °C; He backing: 9.8 Torr; duration: 60 sec.

Exposure

The resist is specifically designed for patterning via electron beam lithography. With higher electron energies the exposure dose shifts to higher doses (see Fig. 3).

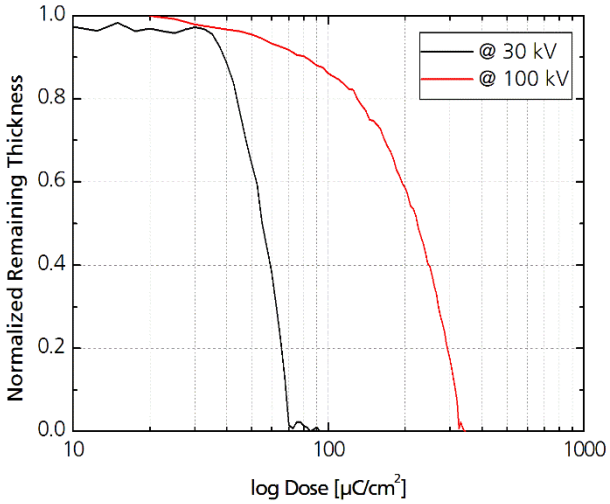

Fig. 3. Contrast curves of mr-PosEBR at different electron energies (film thickness 300 nm).

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Development

mr-Dev-800 (Amyl acetate) is recommended as developer. The temperature of the developer should be 20 – 25 °C. The developed resist films are thoroughly rinsed with isopropanol (IPA) and then dried. The developing time depends on film thickness and pattern resolution.

Removal

Acetone is recommended as remover. After resist removal the substrates are rinsed in isopropanol and then dried.

Solubility

In solubility tests the unexposed mr-PosEBR resist material showed good solubility in butan-2-one (MEK), anisole, tetrahydrofuran (THF), and acetone. They are insoluble in n-amyl acetate and mixtures of methyl-isobutyl-ketone (MIBK) : iso-propanol (IPA) 1:1 as well as IPA : H_2O 97:3.

Storage

Storage of the resist solution at temperatures of 18 – 25 °C is recommended. Keep the bottles closed when not in use. A shelf life of 12 months from the date of manufacture is ensured under appropriate storage conditions.

Disposal

Unexposed resist: dispose of as halogen containing solvent.
Developer and removers: 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 and the process chemicals with skin and eyes and breathing solvent vapours.
Wear suitable protective clothing, safety goggles and gloves.
Please, review the current product Material Safety Data Sheet before using the products.

Equipment

mr-PosEBR is compatible with commercially available photoresist processing equipment. The data given in these guidelines were obtained using:
- SAWATEC spin coater or Süss Delta 6 spin coater
- Contact hotplate/ convection oven
- RAITH150 Two (30 kV)
- RAITH EBPG 5000+ (100 kV)
- Immersion development

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Patterning examples[1]

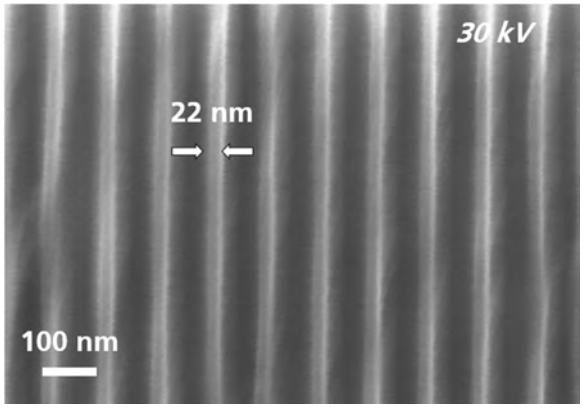

Fig. 4. Grating pattern in mr-PosEBR 0.3, dose: 100 µC/cm² @ 30 kV.

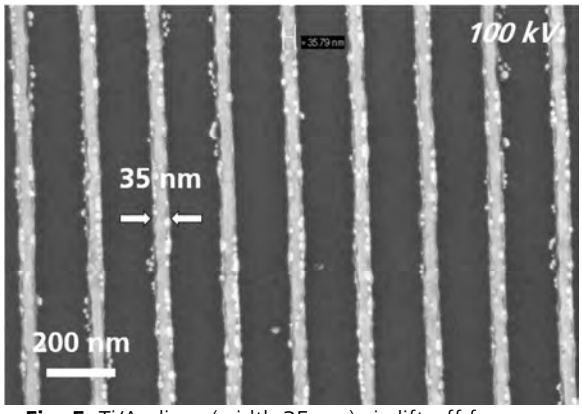

Fig. 5. Ti/Au lines (width 35 nm) via lift-off from mr-PosEBR 0.1, patterned with 520 µC/cm² @ 100 kV.

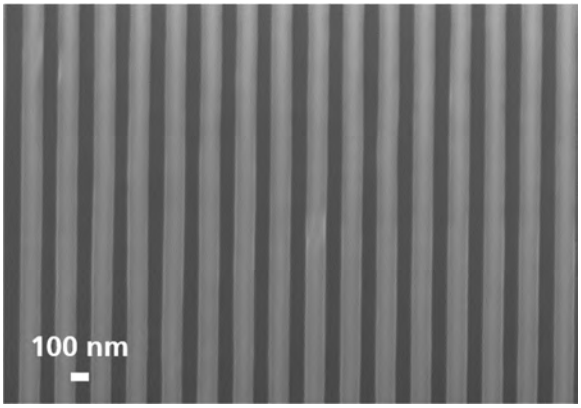

Fig. 6. Line and space pattern (period 200 nm) etched into Si via RIE (SF_6/CF_4)[2] with mr-PosEBR as etch mask

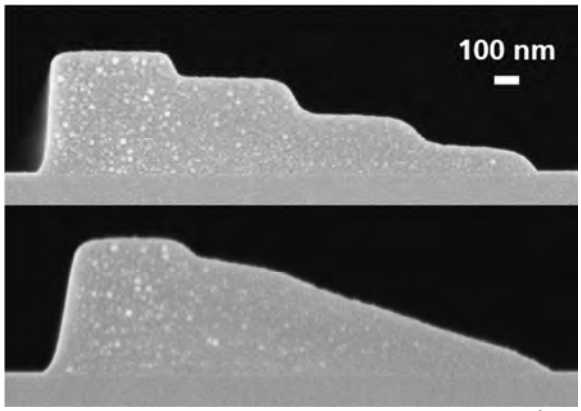

Fig. 7. Multistep grayscale pattern in mr-PosEBR before and after thermal reflow

[1] by courtesy of Max Planck Institute for the Science of Light, Erlangen (DE), (Fig. 4, 6, 7) and Paul Scherrer Institute, Villigen (CH), (Fig. 5, 8).
[2] SF6 = 5 sccm, CF4 = 45 sccm; P_RIE = 50 W -> DC Bias 330 V; P_ICP = 200 W, p = 15 mTorr, T = 18 °C; He backing: 9.8 Torr; duration: 60 sec.

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