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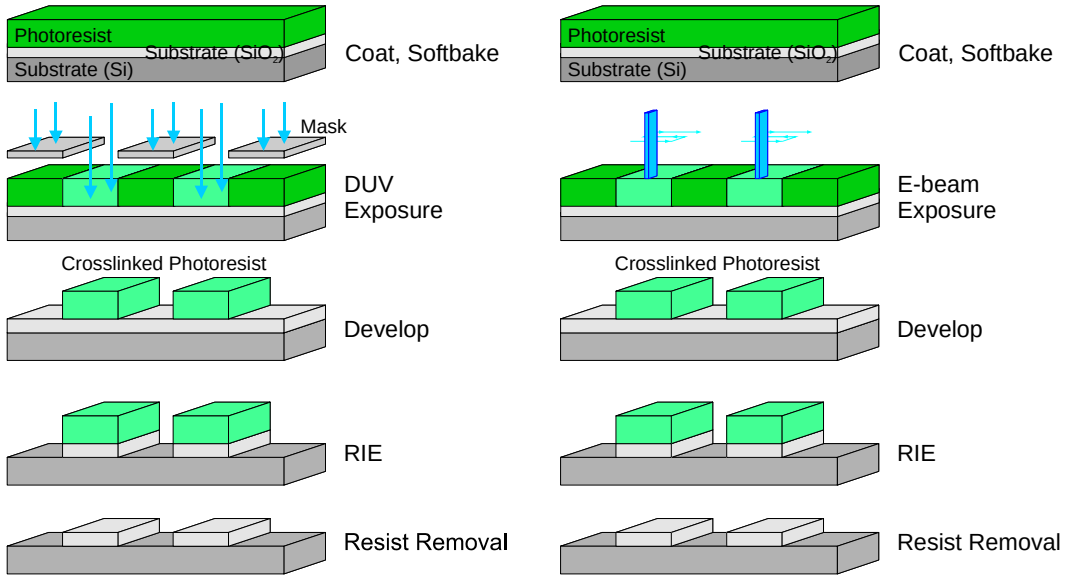
micro resist technology

— Processing guidelines —

Negative Tone Photoresist Series ma-N 2400

Characteristics

ma-N 2400 is a negative tone photoresist series designed for the use in micro- and nanoelectronics. The resists are available in a variety of viscosities.
- electron-beam and DUV-sensitive
- well suitable as an etch mask exhibiting high dry and wet etch resistance
- good thermal stability of the resist patterns
- high resolution capability
- aqueous alkaline development



Process flow for DUV and reactive ion etching (RIE)

Process flow for e-beam and RIE

Physical properties of the resist solution

Resist		**ma-N 2401**	**ma-N 2403**	**ma-N 2405**	**ma-N 2410**
Film Thickness[1]	[µm]	0.1± 0.02	0.3 ± 0.02	0.5 ± 0.05	1.0 ± 0.1
Dynamic Viscosity[2]	[mPa s]	5 ± 1	7 ± 1	8 ± 1	12 ± 1
Density	[g cm^3]	1.005 ± 0.002	1.025 ± 0.002	1.036 ± 0.003	1.056 ± 0.003

[1] Spin coated at 3000 rpm for 30 s
[2] 25°C, 1000 s^{-1}

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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 silicon or silicon dioxide. The specific process parameters to be applied depend on substrate, application and equipment.

Processing conditions

Resist		**ma-N 2401**	**ma-N 2403**	**ma-N 2405**	**ma-N 2410**
Film thickness	[µm]	0.1	0.3	0.5	1.0
Substrate preparation		Oven: 200 °C, 30 min (HMDS for Si and SiO_2 substrates)			
Spin coating	[rpm] [s]	3000 30			
Prebake					
Hotplate	[°C] [s]	90 60	90 60	90 90	90 150
Exposure dose					
e-beam					
20 keV [1]	[µC cm^{-2}]	120 - 200 (D_0 = 80)[3]	170 - 235 (D_0 = 80)[3]	170 - 250 (D_0 = 80)[3]	(D_0 = 80)[3]
50 keV [1]	[µC cm^{-2}]	220 - 350	250 - 350	300 - 350	
DeepUV [2]	[mJ cm^{-2}]	210 ± 20	260 ± 20	330 ± 30	420 ± 50
Development [3] **ma-D 532**	[s]	10 ± 3	30 ± 5	45 ± 10	110 ± 10
ma-D 332	[s]	5 ± 3	10 ± 3	15 ± 5	35 ± 10

[1] exposure dose depends on the pattern size/ resolution - [2] broadband exposure, intensity measured at λ=260 nm
[3] D_0= clearing dose, [4] immersion development

Substrate preparation:

The substrates have to be free of impurities and moisture. They should be baked at 200 °C and cooled to room temperature immediately before coating. Alternatively, oxygen or ozone plasma cleaning is recommended. For improving resist film adhesion to Si and SiO_2 substrates it is advisable to apply an adhesion promoter such as HMDS.

Coating:

Uniform coatings are obtained by spin coating of ma-N 2400 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.

It is recommended to use a filter when applying the resist to the wafer for spin-coating.

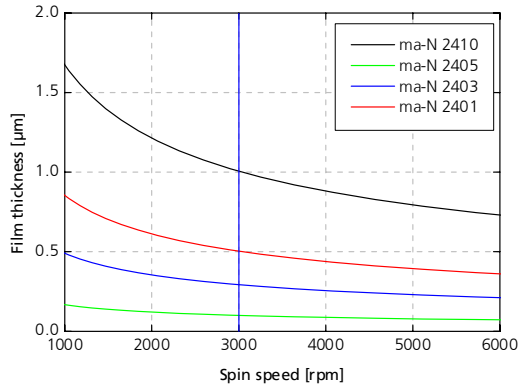

Fig. 1: Spin curves of ma-N 2400 series, 30 s spin time

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.

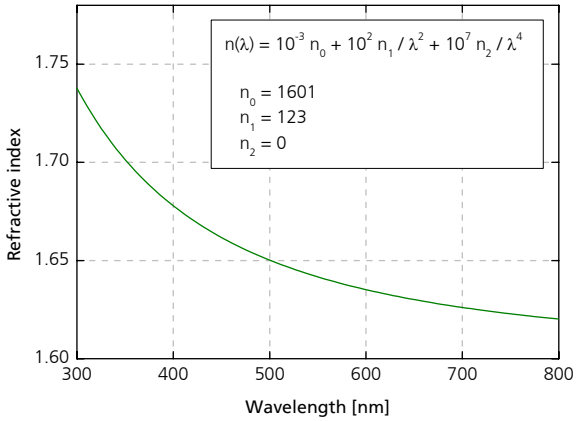

Fig. 2: Refractive index vs. wavelength, Cauchy coefficients of unexposed ma-N 2400

Prebake:

Resist films are baked on a hotplate at 90 °C. If required, the etch resistance and thermal stability of the resist can be increased by applying a higher prebake temperature (max. 110 °C) or a longer prebake time. The developing time will increase in this case.

Exposure:

The resists are effective for e-beam exposure and Deep UV-exposure.

Resolution and aspect ratio for different types of exposure

	e-beam exposure	Deep UV exposure
Aspect ratio	6	2
Resolution	50 nm	200 nm

E-beam exposure

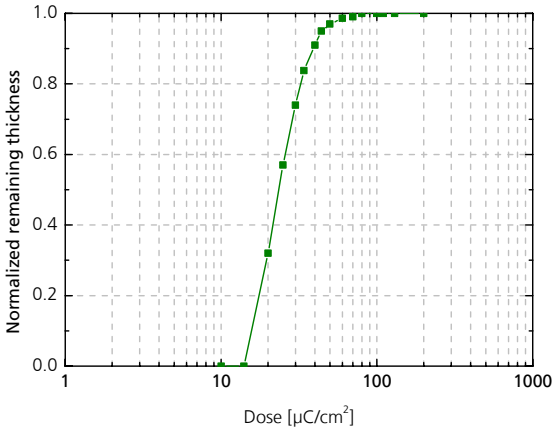

Fig. 3: Sensitivity curve at 20 keV electron energy

With higher electron energies the exposure dose shifts to higher doses. For a specific film thickness the generation of smaller features requires higher exposure doses (~1,5 x D_0) than larger features.

Deep UV exposure

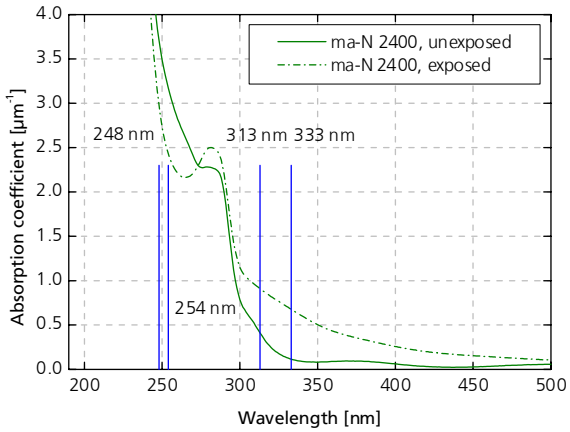

Fig. 4: UV/vis absorption of unexposed and exposed ma-N 2400

Develop:

Ready-to-use developers **ma-D 532** (metal ion free) and **ma-D 332** are recommended. The temperature of the developer should be 20 – 25 °C. The developed resist films are thoroughly rinsed with deionized water for about 5 – 10 min and then dried.

Hardbake (optional):

If required, the etch resistance and the thermal stability of the resist can be further increased. Hardbaking of the developed resist patterns is suggested in an oven at 100 °C for approximately 5 – 15 min.

Removal:

Ready-to-use removers **mr-Rem 660** (solvent based) and **ma-R 404/S** (strongly alkaline) are recommended. Acetone, N-methylpyrrolidone (NMP) or oxygen plasma is also suitable for the residue free removal of the resist.

Storage

Storage at temperatures of 18 – 25 °C is recommended. Do not store ma-N 2400 resists in a refrigerator. Keep the bottle closed when not in use. Under these conditions a shelf life of 6 month 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

ma-N 2400 resist series contains "safe solvents". Ensure that there is adequate ventilation while processing the resists. Avoid contact of the resists with skin and eyes and breathing solvent vapours. Wear suitable protective clothing, safety goggles and gloves.

Equipment

ma-N 2400 resists are compatible with most commercially available photoresist processing equipment. The data given in these guidelines were obtained using:
- Convac spin coater or Suss RC 5 spin coater without cover
- contact hotplate/ convection oven
- ZBA 23H and LION LV1 with 20 keV, Leica EBPG 5000plus with 20 and 50 keV
- High pressure mercury lamp without UV filter
- immersion development

Patterning examples (by courtesy of IPHT/ Jena and HHI/ Berlin)

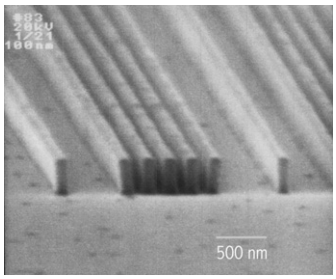

Fig.: 0.35 µm ma-N 2400, e-beam exposed, 100 and 90 nm lines/ spaces

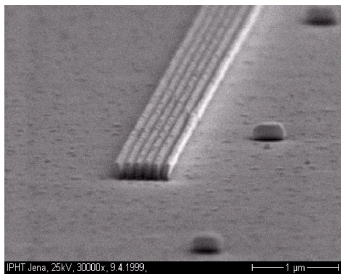

Fig.: 0.18 µm ma-N 2400, e-beam exposed, 50 nm lines/ spaces

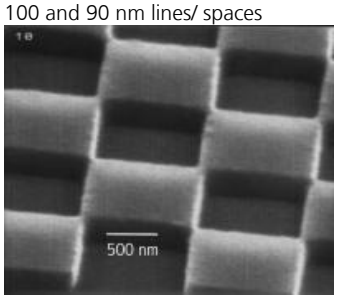

Fig.: 0.3 µm ma-N 2400, e-beam exposed, chess pattern

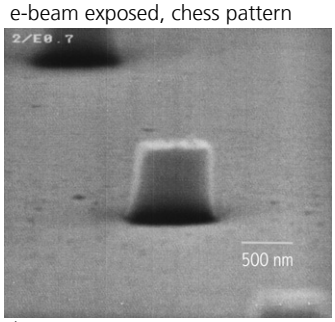

Fig.: 0.75 µm ma-N 2400, e-beam exposed, 0.8 µm wide dots

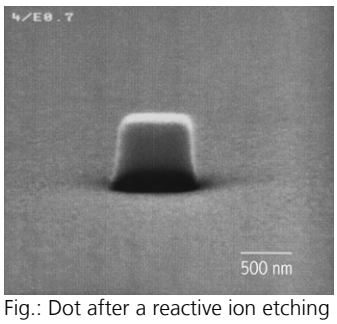

Fig.: Dot after a reactive ion etching with CF_4 (power: 60 W)

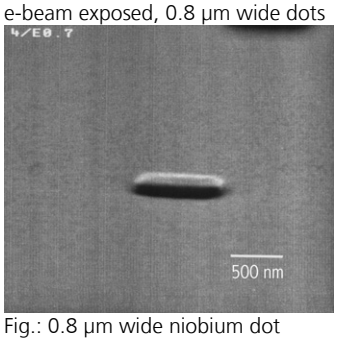

Fig.: 0.8 µm wide niobium dot after resist remove

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