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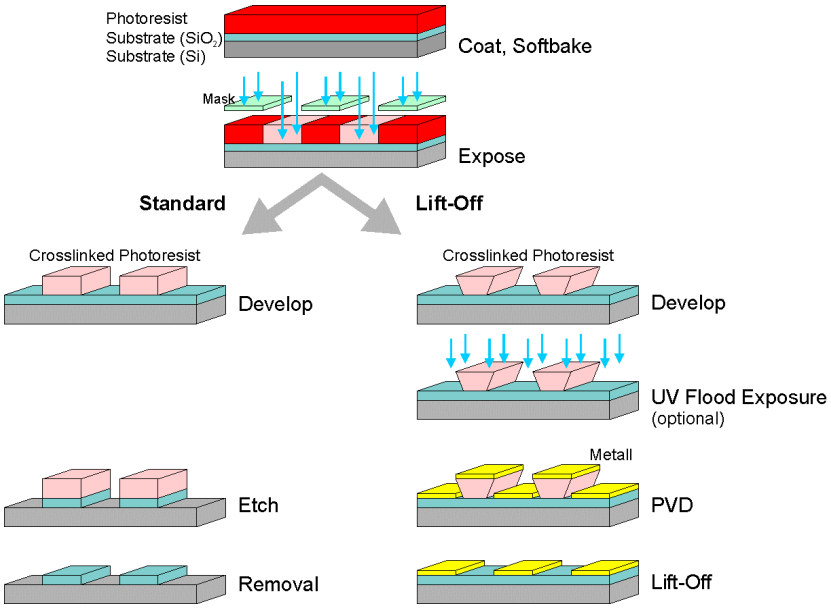
micro resist technology

— Processing guidelines —

Negative Tone Photoresist Series ma-N 1400

Characteristics

ma-N 1400 is a negative tone photoresist series designed for the use in microelectronics and microsystems technology. The resists are available in a variety of viscosities.
- well suitable as an etch mask exhibiting high dry and wet etch resistance
- excellent for pattern transfer with PVD and lift-off processes
- high thermal stability of the resist patterns
- aqueous alkaline development



Process flow for reactive ion etching (RIE)

Process flow for pattern transfer with physical vapour deposition (PVD) and lift-off

Physical properties of the resist solution

Resist		ma-N 1405	ma-N 1407	ma-N 1410	ma-N 1420
Film Thickness[1]	[µm]	0.5 ± 0.08	0.7 ± 0.1	1.0 ± 0.1	2.0 ± 0.1
Dynamic Viscosity[2]	[mPa s]	9 ± 1	11 ± 1	13 ± 1	29 ± 1
Density	[g cm^{-3}]	1.032 ± 0.002	1.040 ± 0.002	1.053 ± 0.003	1.071 ± 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 resist and unexposed resist films have to be processed under yellow light. 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 - STANDARD PROCESS

Resist		**ma-N 1405**	**ma-N 1407**	**ma-N 1410**	**ma-N 1420**
Film thickness	[µm]	0.5	0.7	1.0	2.0
Substrate preparation		Oven: 200 °C, 30 min (HMDS for Si and SiO_2 substrates)			
Spin coating	[rpm] [s]	3000 30			
Prebake					
Hotplate	[°C] [s]	100 60	100 60	100 90	100 120
Oven	[°C] [min]	100 – 105 15 – 30			
Exposure dose[1]	[mJ cm^{-2}]	300 ± 20	350 ± 30	450 ± 30	550 ± 30
Development[2] (ma-D 533/S)	[s]	20 ± 5	25 ± 5	30 ± 10	60 ± 10

[1] broadband exposure, intensity measured at λ=365 nm
[2] 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 1400 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.

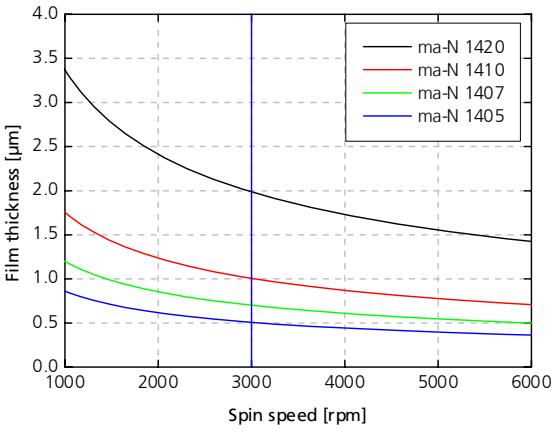


Fig. 1: Spin curves of the ma-N 1400 series, 30 s spin time

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.

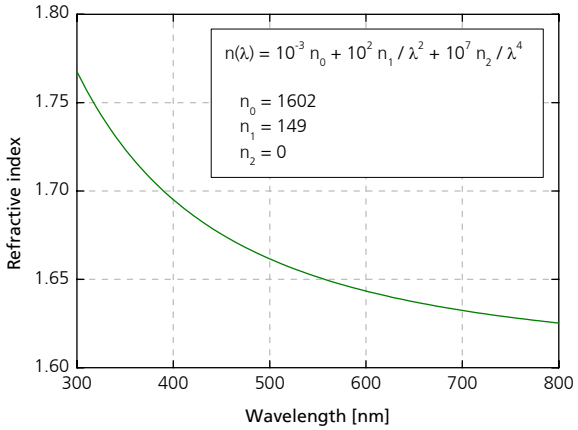


Fig. 2: Refractive index vs. wavelength, Cauchy coefficients of unexposed ma-N 1400

Prebake:

Resist films are baked on a hotplate at 100 – 120 °C.
The prebake temperature has to be adapted to the respective substrate material.

Recommended prebake temperatures for ma-N 1400 on different substrates

Substrate	**Si**	**Au**	**Si_3N_4**	**GaAsP/GaAs**
Prebake temperature [°C]	100 – 120	120	120	100

If required, the etch resistance and thermal stability of the resist can be increased by applying a higher prebake temperature (max. 160 °C) or a longer prebake time. The developing time will increase in this case.

Exposure:

The resists are effective for broadband or i-line exposure.

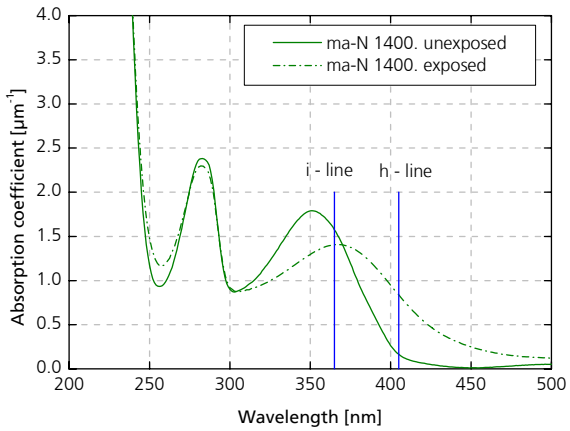


Fig. 3: UV/vis absorption of unexposed and exposed ma-N 1400

The exposure dose has to be adapted to the respective substrate material due to its reflectivity.
For patterning ma-N 1400 on glass it is recommended to cover the backside of the transparent substrate with a black foil, which absorbs the radiation and prevents light scattering.

Recommended relative exposure doses for ma-N 1400 on different substrates

Substrate	**Si**	**Au**	**Si_3N_4**	**GaAsP/GaAs**
Relative exposure doses	1	0.5 x dose (Si)	1 – 1.5 x dose (Si)	1 – 1.2 x dose (Si)

Develop:

Ready-to-use developer **ma-D 533/ S** is recommended. The temperature of the developer should be 20 – 25 °C. The developed resist films are thoroughly rinsed with deionized water 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 30 min. A temperature ramp is beneficial in order to reduce pattern reflow.

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.

Processing conditions - LIFT-OFF

For patterning metal layers by physical vapour deposition (PVD: evaporation, sputtering) undercut pattern profiles are beneficial. Undercut patterns are easily achieved using ma-N 1400. For clean lift-off processing, the film thickness should be 1.5 to 2 times that of the metal deposition layer.
The resist films should be stabilized for the PVD process as follows:

1. Prebake at higher temperatures up to 160 °C and/ or prolonged prebake time and
2. Deep UV flood exposure of the resist patterns at wavelengths of 200 – 300 nm with twice to fivefold the patterning exposure dose at 365 nm.

Generation of undercut patterns:

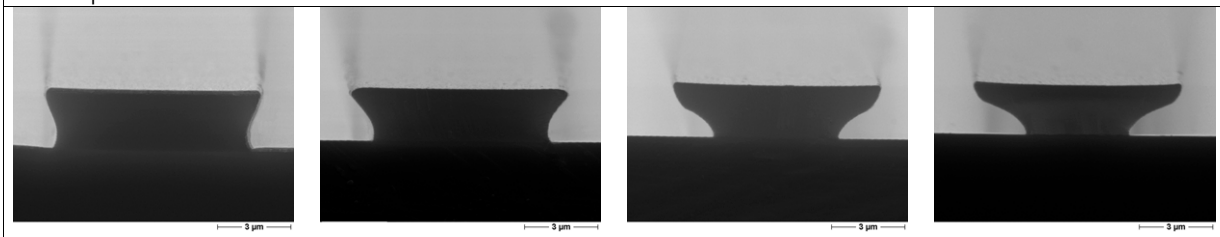
The standard lithographic process of ma-N 1400 results in nearly vertical pattern profiles. Undercut patterns can be attained by reducing the exposure dose and/ or increasing the developing time. An increase in the developing time is preferred for ma-N 1400. The exposure dose should correspond to that of the standard process.

Undercut pattern of ma-N 1400 on silicon substrates

Film thickness [µm]	**Prebake [°C, s]**	**Exposure dose (365 nm) [mJ cm^{-2}]**	**Development with ma-D 533/S**	
			Time [s]	**Undercut [µm]**
2.0	100, 120	550	65 80 100 120	0.6 0.8 1.7 2.1
	160, 120	550	130 170 190	0 0.5 1.0
4.5 (double coat)	100, 300	1500	220	3.0

Examples

Undercut patterns of 2 µm thick **ma-N 1400**
Prebake: 100 °C, 120 s
Exposure dose: 550 mJ cm^{-2} (365 nm)
Develop with ma-D 533/S: time → undercut



65 s → 0.6 µm | 80 s → 0.8 µm | 100 s → 1.7 µm | 120 s → 2.1 µm

Note: Higher prebake temperatures, prolonged prebake times and increased exposure doses lead to an increased developing time and reduce the undercut.

Physical vapour deposition (PVD) - evaporation, sputtering:

Patterns of ma-N 1400 exhibit high thermal stability and can be used for evaporation and sputtering of metals, such as silver, tin, gold, copper and aluminium.

Note: In dependence on the conditions of metal evaporation and especially when the metals are sputtered, a thermal stabilization by increased prebake and/ or UV flood exposure of the patterned resist is necessary. Besides, short breaks in the sputtering process for reducing resist heating lead to clean lift-off results.

Lift-off:

Remover **mr-Rem 660** or N-methylpyrrolidone (NMP) at temperatures of 40 – 60 °C assisted by ultrasonics is suitable for residue free removal of the resist after the PVD process. The use of acetone assisted by ultrasonics is also recommended.

Storage

Storage at temperatures of 18 – 25 °C is recommended. Do not store ma-N 1400 resists in a refrigerator. Resists 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 6 months 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 1400 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 1400 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
- Suss MA 56 mask aligner (UV 400)
- immersion development