Process-stable negative resists SX AR-N 8400 (Medusa 84 SiH)

Etch-stable e-beam resist series SX AR-N 8400

Experimental sample/custom-made product

Characterization

- Hydrogen silsesquioxane dissolved in butyl acetate
- Highest resolution e-beam resist
- Improved shelf life and stability, as butyl acetate reduces gelling and particle formation
- Elimination of the presumably carcinogenic solvent MIBK

Important user information

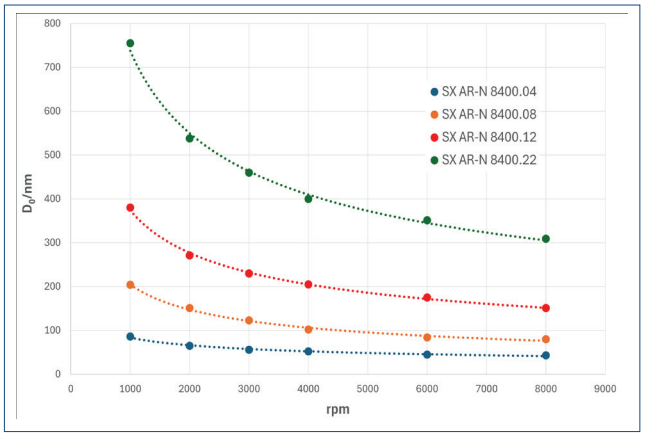
Medusa 84 SiH must not be transferred to glass containers or filtered using a glass pre-filter, as this will cause it to gel irreversibly. The Medusa 84 SiH has to reach room temperature before opening the bottle. Condensing water can affect the shelf life, as the resist is sensitive to moisture.

Properties I

Parameter SX AR-N	8400.04	8400.08	8400.12	8400.22
Solids content (%)	4	8	12	22
Film thickness/ 4000 rpm (nm)	50	100	200	400
Flash point (°C)	<35			
Storage temperature*	8-12 °C		from -18 °C	

*The products have a guaranteed shelf life of 3 months from the date of sale if stored as directed and can also be used without guarantee until the label date. Note: Deep-freeze storage extends the shelf life.

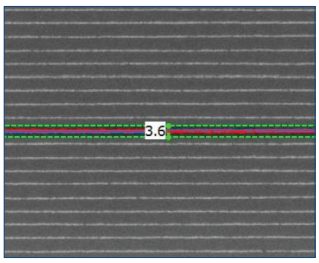
Spin curve



Properties II

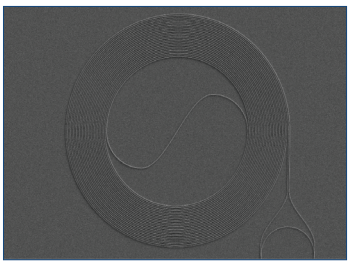
Dielectric constant	3.0	
Cauchy coefficients	N0	1,409
	N1	46
	N2	0
Plasma etching rates (nm/min) 1 Pa reactor pressure 500 W ICP power -100 V bias substrate electrode 50 sccm of the respective process gas (42 sccm for CF4 / 25 sccm each for CF4 + O2) 20 °C wafer temperature	Ar	34
	SF6	146
	CF4	175
	CF4+O2	82
	O2	5.5
	Cl2	64

Structure resolution



Single lines with a resolution of 3.6 nm and very low LER written with the RAITH Voyager EBL-System at 50kV, 120 pA, dose: 14.700 pC/cm, developer: KOH 1% 1 min.
© Raith Dortmund

Resist structures



100 nm line/space structures written on silicon at 1000 µC/cm² @ 100 kV and developed with AR 300-73 (6.5% TMAH solution).
© J. Hohmann, KIT-IMT Karlsruhe

Process parameter

Substrate	Si 4“ wafer
Softbake	90 °C, 1 min, hot plate
Exposure	Raith Pioneer 30 kV
Development	AR 300-73, 60-90 s, 23 °C

Process chemicals

Adhesion promoter	AR 300-80 new
Developer	AR 300-44, AR 300-73
Thinner	Butylacetate VLSI-grade
Stopper / Remover	DI-H_2O / BOE or 1% HF

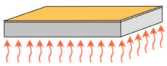
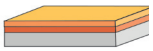
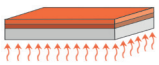
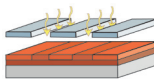
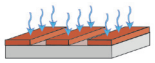
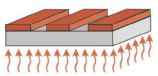
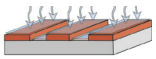
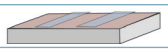
ALLRESIST

Innovation
Creativity
Customer-specific solutions

Process-stable negative resists SX AR-N 8400 (Medusa 84 SiH)

Process conditions

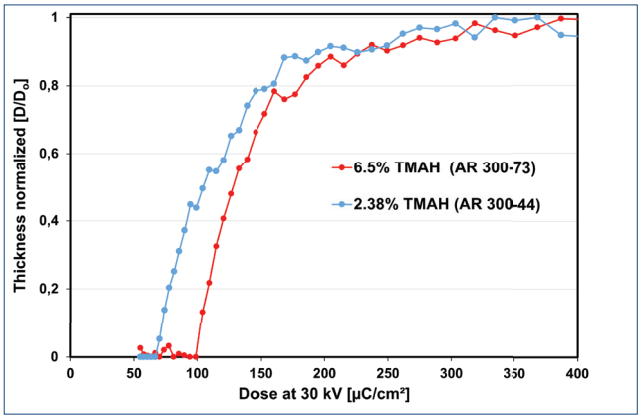
This diagram shows exemplary process steps for the resist series SX AR-N 8400. All specifications are guideline values which have to be adapted to own specific conditions. For further information on processing ☞ „Detailed instructions for optimum processing of photoresists". For recommendations on waste water treatment and general safety instructions ☞ „General product information on Allresist photoresists".

1. Coating		SX AR-N 8400.08 4000 rpm, 60 s, 100 nm
1. Tempering (± 1 °C)		90 °C, 1 min hot plate or 90 °C, 5 min convection oven
2. Coating		AR-PC 5094.02 for insulating substrates (quartz, glass, GaN); opt. for conductive substrates, 4000 rpm, 30 s , 40 nm
2. Tempering (± 1 °C)		90 °C, 2 min hot plate
E-Beam exposure		30 kV Raith Pioneer Exposure dose (E_0): 250 µC/cm² Medusa 84 SiH is more sensitive than HSQ products from other suppliers, which is why less dose & writing time is required.
Removing		AR-PC 5094.02 DI-H_2O, 60 s
Development (21-23 °C ± 0,5 °C) Puddle		SX AR-N 8400.08 AR 300-44, for optimized contrast: AR 300-73
Rinse		DI-H_2O, 30 s
Post-Tempering optional		250 °C, 30 min hot plate or 250 °C, 30 min convection oven for improved plasma etching resistance
Customised technologies		Generation of semiconductor properties, etching, sputtering
Removing		BOE 5:1 or 1% HF

Note on stability: Coated substrates can be stored under normal conditions and processed without loss of sensitivity or resolution even after several days. The use of vacuum or inert gas is not necessary.

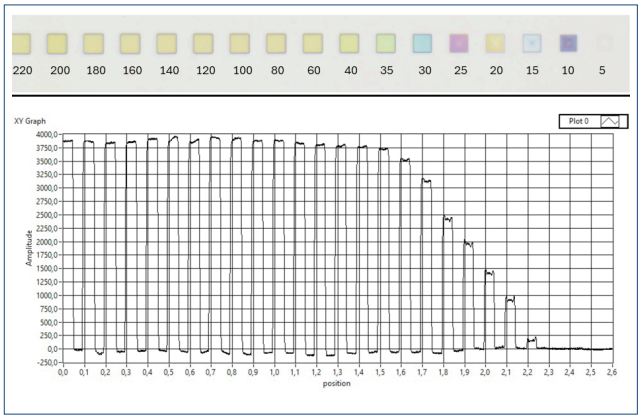
Process-stable negative resists SX AR-N 8400 (Medusa 84 SiH)

Contrast curve



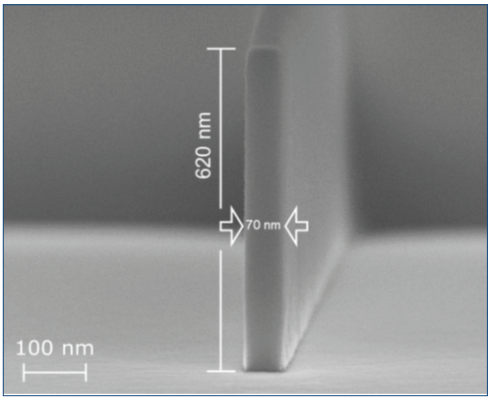
Contrast curves of Medusa 84 SiH with a dwell time of 3 days between irradiation and development. Developing with a higher TMAH concentration leads to improved contrast with only a slightly higher dose.

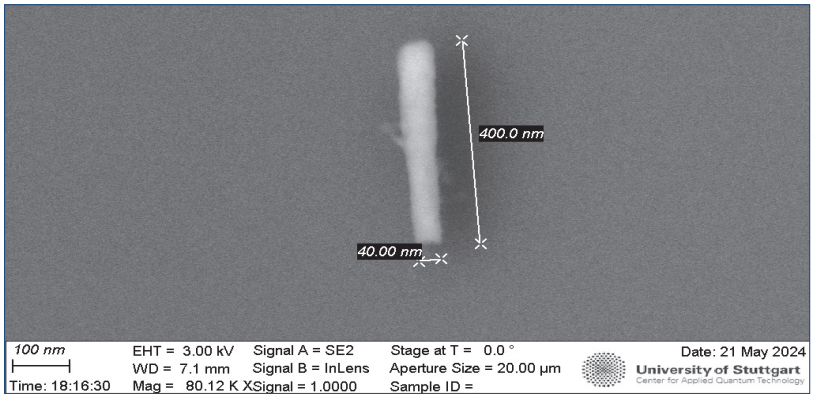
Grey tone application



Grey scale structures written on silicon with 30 kV. The top row shows the squares with the dose used in µC/cm². The stylus profilometer shows the remaining height in Å after development with 2.38 % TMAH.
© Zsuzsanna Márton, ELI-ALPS Hungary

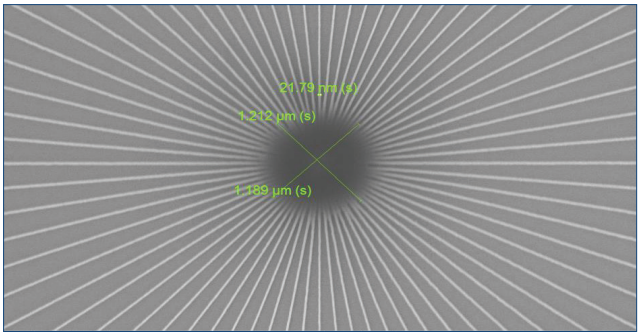
Structures with a high aspect ratio

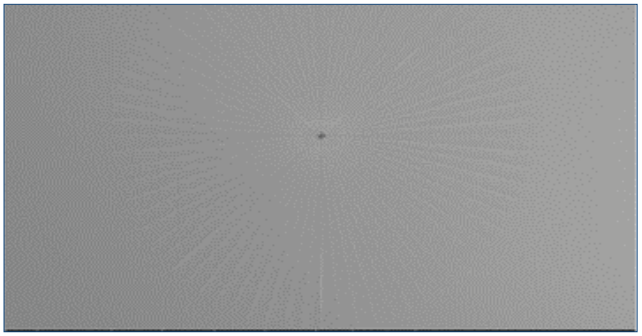




Left: Wall-structures written on GaAs with 600 µC/cm² @100 kV, 200 pA, developed with AR 300-73 (6.5% TMAH) for 60 s, PAB & PEB: 5 min @ 100 °C hotplate. © Yurii Kutovyi, FZ Jülich // Right: Nanorod written on silicon with 2000 µC/cm² @ 50kV and developed with AR 300-44 (2.38% TMAH). Aspect ratio of up to 10 was achieved. © R. Stöhr, ZAQuant University of Stuttgart

Electra 94 as conductive coating for charge dissipation





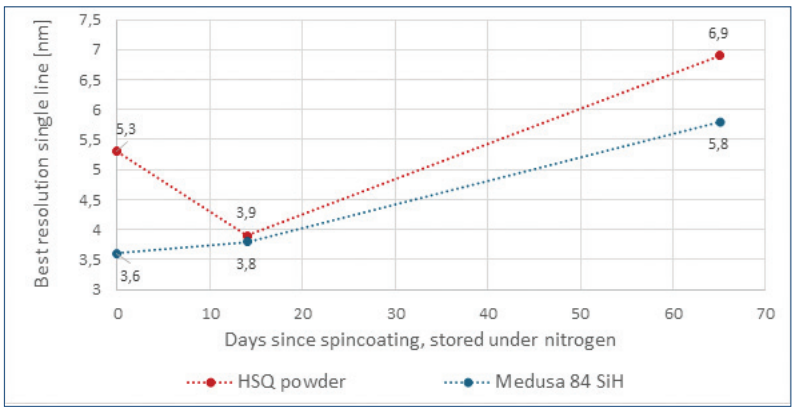
Siemens star written on quartz with the new conductive coating Electra 94 (AR-PC 5094.02) spun on to prevent charge build-up. This variant of Electra 94 specially developed for HSQ, has excellent coating and adhesion properties. © B. Drent, AMOLF NanoLab Amsterdam

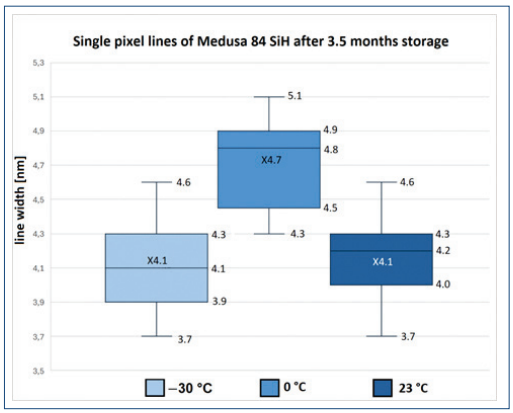
Process-stable negative resists SX AR-N 8400 (Medusa 84 SiH)

Process stability and storage under nitrogen atmosphere

The HSQ polymer, developed by Allresist, has a unique manufacturing and purification process. This results in the Medusa 84 SiH product being optimised in terms of its properties, such as minimum feature size, line edge roughness and process stability. This was confirmed in a study conducted by RAITH GmbH with their Voyager EBL-System at 50kV, 120 pA, base dose: 12.000 pC/cm, developer: KOH 1% 1 min. The Medusa 84 SiH was compared with an HSQ powder, and the smallest possible line width was determined.

The highest achievable resolution of the Medusa 84 SiH is 3.6 nm on a freshly coated wafer (day 0), whereas the HSQ powder achieved significantly poorer values of 5.3 nm. Medusa 84 SiH also demonstrates a more consistent increase in achievable line width, with minimal change to 3.8 nm after 14 days. In contrast, the HSQ powder exhibited greater fluctuations throughout the entire observation period.

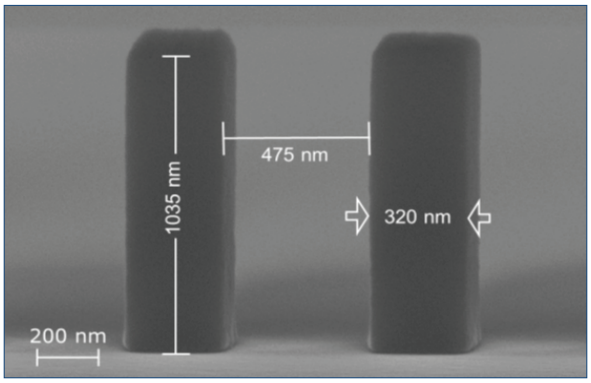




After 3.5 months, the effects of storing the Medusa 84 SiH resist solution at different temperatures (-30°C, 0°C and 23°C) showed only minor fluctuations. No degradation was observed despite storage temperatures exceeding the recommended range of 8-12 °C.

Double-coating for extended layer thickness range

Medusa 84 SiH allows for layer thicknesses of up to 1400 nm with double coating. This expands the range of applications for the thickest variant, SX AR-N 8400.22, which achieves a thickness of only 800 nm in a single coating at 1000 rpm. This improvement is achieved through the use of butyl acetate as a solvent instead of MIBK, as well as the high purity of the HSQ polymer in the solution.



© Yurii Kutovyi, FZ Jülich

The double coating process was demonstrated at FZ Jülich and requires precise control of the process flow. The final patterned structures of the double coating process are shown in the picture below. The process begins with a spin-coating step at 2,000 rpm using the SX AR-N 8400.22, followed by a 5-minute bake at 210 °C on a hotplate. It is critical that the wafer is allowed to cool for five minutes before the second spin-coating is applied. A second post-application bake is then carried out for 5 minutes at 130 °C (hotplate). Electron-beam exposure is then carried out at 100 kV with a beam current of 200 pA and a dose of 600 µC/cm². No post-exposure bake is required. Development is performed in AR 300-73 (6.5% TMAH) for seven minutes, followed by rinsing with deionised water and blow-dry.