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# High-resolution negative resists Medusa 82

## Etch-stable e-beam resists SX AR-N 8200/1

Experimental sample/custom-made product

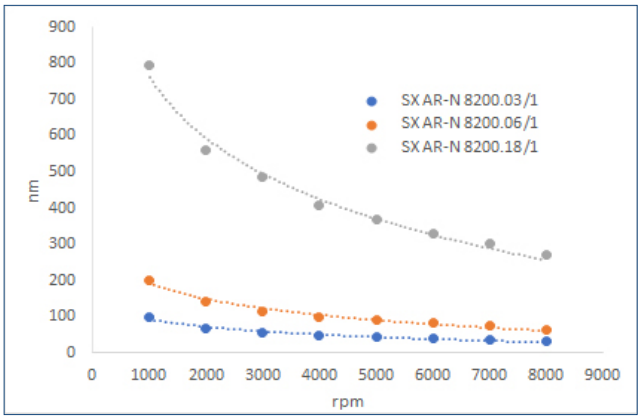
### Characterization

- high-resolution e-beam resist (10 nm)
- etch-stable resist structures available in two film thicknesses
- comparable to HSQ, but higher process stability, easier to remove, considerably higher shelf life
- sensitivity is increased by a factor of 20 if an additional tempering step is applied
- silsesquioxane dissolved in 1-methoxy-2-propanol

### Properties I

| Parameter SX AR-N | 8200.03 | 8200.06 | 8200.18 |
|---|---|---|---|
| Solids content (%) | 3,0 | 6,0 | 18,0 |
| Viscosity 25°C (mPas) | 2,3 | 2,5 | 3,2 |
| Film thickness/4000 rpm (µm) | 50 | 100 | 400 |
| Resolution (nm) | 10 | 13 | 20 |
| Contrast | 5 | 5 | 5 |
| Flash point (°C) | 38 | | |
| Storage 6 month (°C) | 8 - 12 | | |

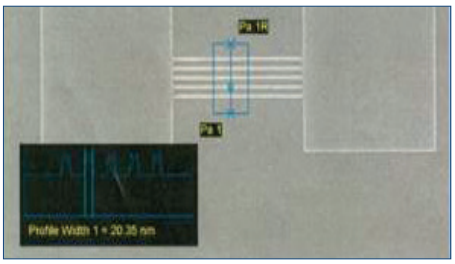
### Spin curve




### Properties II

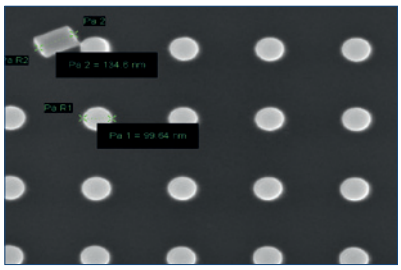
| | | |
|---|---|---|
| Glass trans. temperature (°C) | | |
| Dielectric constant | | |
| Cauchy coefficients | N0 | 1,461 |
| | N1 | 72 |
| | N2 | 0 |
| Plasma etching rates (nm/min) (1 Pa, 230 W Bias) | Ar sputtern | |
| | $O_2$ | 6 |
| | $CF_4$ | |
| | 30 $CF_4$ + 5 $O_2$ | 220 |

### Structure resolution



11 nm structures produced with SX AR-N 8200.03/1

### Resist structures



100 nm bars with SX AR-N 8200.06/1

### Process parameter

| | |
|---|---|
| Substrate | Si 4“ wafer |
| Softbake | 150 °C, 10 min, hot plate |
| Exposure | Raith Pioneer 30 KV |
| Development | AR 300-44, 90 s, 23 °C |

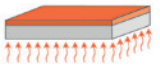
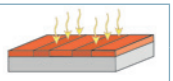
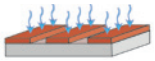
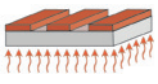
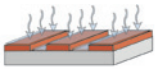
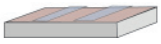
### Process chemicals

| | |
|---|---|
| Developer | AR 300-44 |
| Thinner | AR 600-07 |
| Stopper | DI water |
| Remover | 2n NaOH, BOE |

# High-resolution negative resists Medusa 82

## Process conditions

This diagram shows exemplary process steps for resist SX AR-N 8200. 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".

| | | | |
|---|---|---|---|
| Coating  | SX AR-N 8200.03 | SX AR-N 8200.06 | SX AR-N 8200.18 |
| | 4.000 rpm, 50 nm | 4.000 rpm, 100 nm | 4.000 rpm, 400 nm |
| Softbake (± 1 °C)  | 150 °C, 10 min, hot plate | | |
| E beam exposure  | Raith Pioneer, acceleration voltage 30 kV | | |
| | Exposure dose (E0): 1300 µC/cm² | 2000 µC/cm² | |
| Hardbake (optional)  | To enhance the sensitivity 170 °C, 10 min, hot plate | | |
| | 60 µC/cm² | 85 µC/cm² | |
| Development  | AR 300-44 | | |
| (21-23 °C ± 0,5 °C) Puddle | 90 s | | |
| Rinse | DI water, 30 s | | |
| Customer-specific Technologies  | | | |
| Removing  | 2 n NaOH | | |

Note on stability: Liquid Medusa resists are stable for up to 6 months if kept refrigerated at least 8 - 12 °C. Coated substrates can be stored under normal conditions and processed without any loss of sensitivity or resolution even after several weeks. Current studies show that irradiated substrates can be processed even after 21 days without significant loss of sensitivity.

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# High sensitive negative resists Medusa 82 UV

## Etch-stable, high-resolution e-beam resists SX AR-N 8250/1

Experimental sample/custom-made product

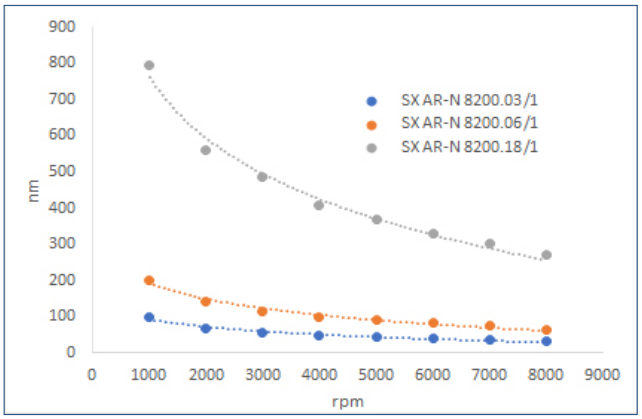
### Characterization

- high-resolution e-beam resist, also sensitive in EUV (13.5 nm) and DUV (250 nm) range
- comparable to HSQ, but with by a factor of 20 higher sensitivity, easier to remove
- considerably higher shelf life
- silsesquioxane and acid generator dissolved in 1-methoxy-2-propanol

### Properties I

| Parameter SX AR-N | 8250.03 | 8250.06 | 8250.18 |
|---|---|---|---|
| Solids content (%) | 3,0 | 6,0 | 18,0 |
| Viscosity 25°C (mPas) | 2,3 | 2,5 | 3,2 |
| Film thickness/4000 rpm (µm) | 50 | 100 | 400 |
| Resolution (nm) | 15 | 15 | 20 |
| Contrast | 8 | 8 | 8 |
| Flash point (°C) | 38 | | |
| Storage 6 month (°C) | 8 - 12 | | |

### Spin curve




### Properties II

| | | |
|---|---|---|
| Glass trans. temperature (°C) | | |
| Dielectric constant | | |
| Cauchy coefficients | N0 | 1,461 |
| | N1 | 72 |
| | N2 | 0 |
| Plasma etching rates (nm/min) (1 Pa, 240-250 V Bias) | Ar sputtern | |
| | $O_2$ | 7 |
| | $CF_4$ | |
| | 30 $CF_4$ + 5 $O_2$ | 240 |

### Strukturauflösung

200 nm bars, written at 100 kV with SX AR-N 8200.03/1

### Resist structures

Medusa 82 UV structure with higher sensitivity

### Process parameter

| | |
|---|---|
| Substrate | Si 4“ wafer |
| Softbake | 150 °C, 10 min, hot plate |
| Exposure | Raith Pioneer 30 KV |
| Development | AR 300-44, 90 s, 23 °C |

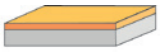
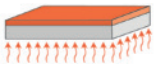
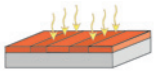
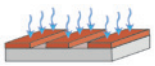
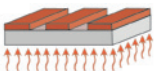
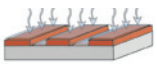
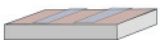
### Process chemicals

| | |
|---|---|
| Developer | AR 300-44 |
| Thinner | AR 600-07 |
| Stopper | DI water |
| Remover | 2n NaOH, BOE |

# High sensitive negative resists Medusa 82 UV

## Process conditions

This diagram shows exemplary process steps for resist SX AR-N 8250. 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".

| | | | |
|---|---|---|---|
| Coating  | SX AR-N 8250.03 | SX AR-N 8250.06 | SX AR-N 8250.18 |
| | 4.000 rpm, 50 nm | 4.000 rpm, 100 nm | 4.000 rpm, 400 nm |
| Softbake (± 1 °C)  | 150 °C, 10 min, hot plate | | |
| E beam exposure  | Raith Pioneer, acceleration voltage 30 kV | | |
| | Exposure dose (E0): 60 µC/cm² | 85 µC/cm² | |
| Hardbake (optional)  | Hardbake can be omitted since no further sensitivity increase is achieved. | | |
| Development (21-23 °C ± 0,5 °C) Puddle  | AR 300-44<br>90 s | | |
| Rinse | DI-Wasser, 30 s | | |
| Customer-specific Technologies  | | | |
| Removing  | 2 n NaOH | | |

Note on stability: Liquid Medusa resists are stable for up to 6 months if kept refrigerated at 8 - 12 °C. Coated substrates can be stored under normal conditions and processed without any loss of sensitivity or resolution even after several weeks. Current studies show that irradiated substrates can be processed even after 21 days without significant loss of sensitivity.

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# High-resolution negative resists Medusa 82

## Processing instructions

The sensitivity changes in dependence on the acceleration voltage. While 1300 µC/cm² is sufficient at 30 kV, this value increases to 4000 µC/cm² at 100 kV. Figure 1 shows the corresponding dose scale (90 s AR 300-44, 23 °C). Recommended are development times of 60-90 s.

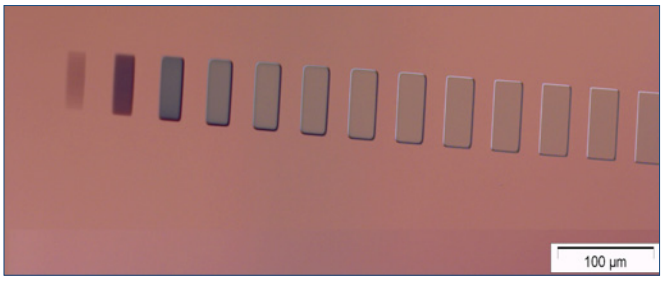


Figure 1: Dose scale (400 – 5000 µC/cm²) Medusa 82. Resist: SX AR-N 8200.06/1 - 100 nm; coating: 60 s 4000 rpm; soft-bake: 15 min @ 120 °C; exposure: Raith Pioneer, 30 kV; development: 90 s AR 300-44; 23 °C; stopping: 30 s DI water

Also AR 300-46, AR 300-47 and AR 300-73 can be used for development, but the different developer concentrations affect the required development time and the dose. AR 300-44 results in a contrast of 4.7 at a required dose of 690 µC/cm², while AR 300-73 results in a contrast of 4.6 at a required dose of 785 µC/cm² under otherwise equal conditions.

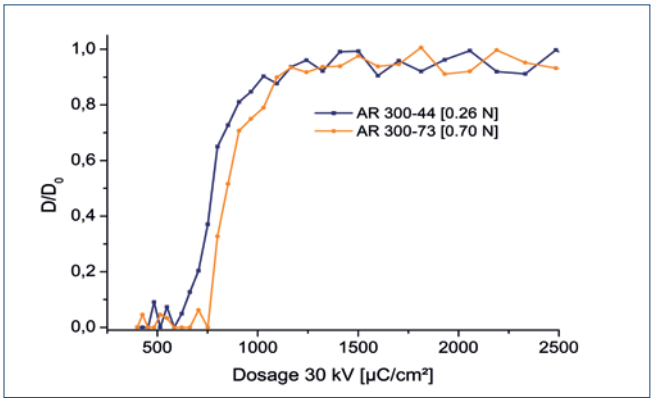


Figure 2: Influence of developer concentration on contrast and dose

To increase sensitivity, a post exposure bake may be required after irradiation, which increases the sensitivity the increases by a factor of 8 at 100 kV and even by a factor of 20 at 30 kV. In addition, also the contrast is increased.

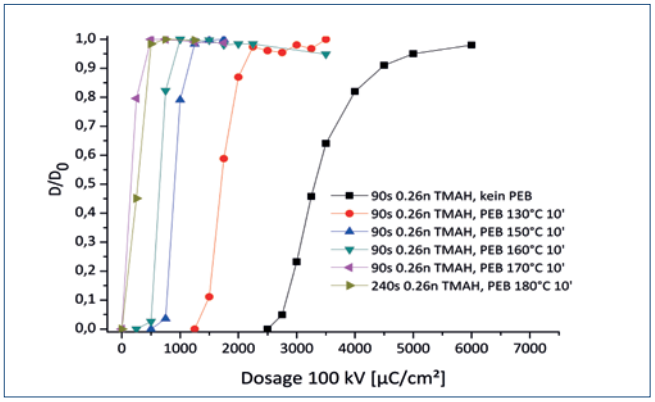


Figure 3: Influence of post exposure bake temperature on the dose. Resist: SX AR-N 8200.06/1; coating: 60 s 4000 rpm; soft-bake: 10 min; exposure: 100 kV; post exposure bake 10 min; development: 90 s AR 300-44; 23°C; stopping: 30 s DI water

# High sensitive negative resists Medusa 82 UV

## Processing instructions

Medusa 82 and Medusa 82 UV can both be processed under similar conditions (annealing, development, removal), but they differ with respect to their sensitivity. Resist Medusa 82 UV contains a photoacid generator to increase the sensitivity and is already 20 times more sensitive if normal process conditions (without post exposure bake) are used. This is especially important für sensitive substrates which might be damaged by an additional heat treatment. Fig. 4 shows a comparison of both resists at different acceleration voltages without post exposure bake:

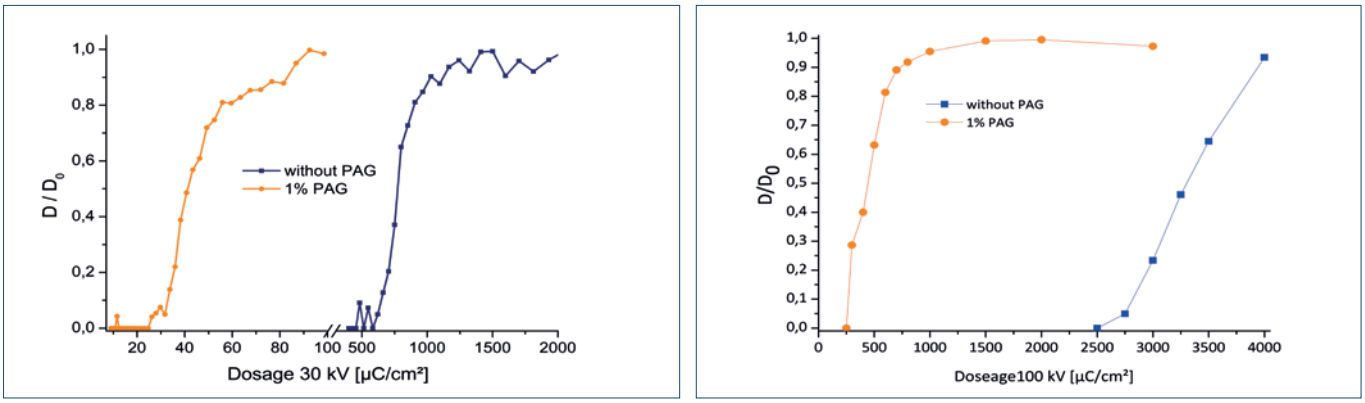


Figure 4: Comparison of the sensitivity of SX AR-N 8200.06/1 (blue) and SX AR-N 8250.06/2 (orange); on the left side at 30 kV, on the right at 100 kV acceleration voltage. Development was performed in AR 300-44, 90 s, 23 °C and without post exposure bake.

For Medusa 82 UV, an additional tempering step after exposure does not result in a further increase in sensitivity:

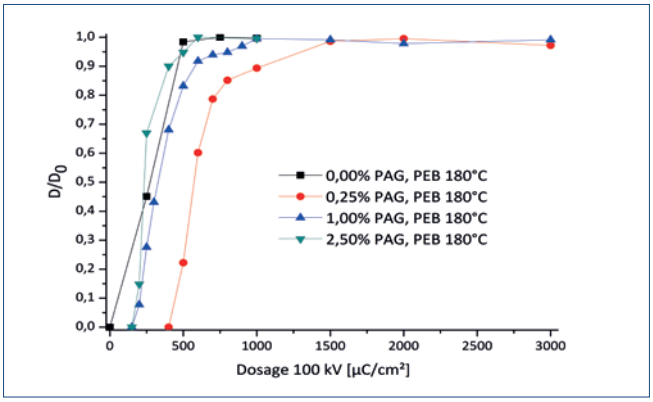


Figure 5: Combination of post exposure bake and photoacid addition

Also AR 300-46, AR 300-47 or AR 300-73 can be used for the development of Medusa 82 UV. The different developer concentrations however influence the required development time and the required dose.