

## Positive E-Beam Resists AR-P 6200 (CSAR 62)

### AR-P 6200 e-beam resists with highest resolution

High-contrast e-beam resists for the production of integrated circuits and masks

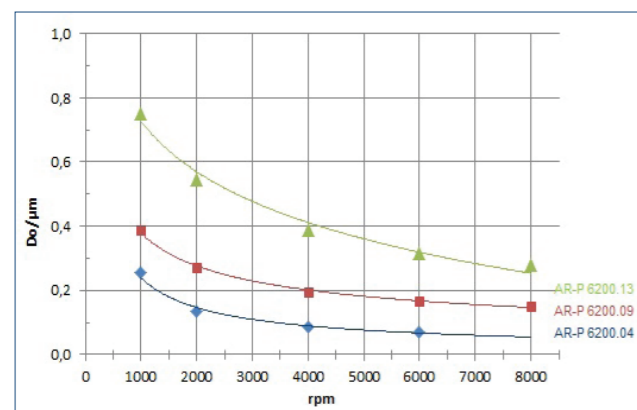
#### Characterisation

- e-beam
- high sensitivity which can be adjusted via the developer
- highest resolution (< 10 nm) and very high contrast
- highly process-stable, high plasma etching resistance
- easy fabrication of lift-off structures
- poly( $\alpha$ -methyl styrene-co- $\alpha$ -chloroacrylate methyl ester) and an enhancer of sensitivity
- safer solvent anisole

#### Properties I

Parameter / AR-P	6200.13	6200.09	6200.04
Solids content (%)	13	9	4
Viscosity 25 °C (mPas)	11	6	2
Film thickness/4000 rpm ( $\mu$ m)	0.40	0.20	0.08
Resolution best value (nm)	6		
Contrast	14		
Flash point (°C)	43		
Storage 6 month (°C)	8 - 12		

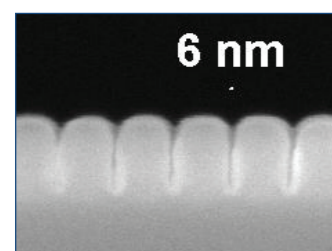
#### Spin curve



#### Properties II

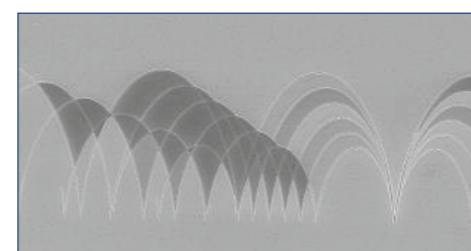
Glass trans. temperature (°C)	148	
Dielectric constant	2.8	
Cauchy coefficients	$N_0$	1.543
	$N_1$	71.4
	$N_2$	0
Plasma etching rates (nm/min) (5 Pa, 240-250 V Bias)	Ar-sputtering	10
	$O_2$	180
	$CF_4$	45
	80 $CF_4$ + 16 $O_2$	99

#### Structure resolution



AR-P 6200.04  
 Resolution of up to 6 nm at film thickness of 80 nm

#### Resist structures



AR-P 6200.09  
 25-nm structures, film thickness of 180 nm, artwork

#### Process parameters

Substrate	Si 4" waver
Tempering	150 °C, 60 s, hot plate
Exposure	Raith Pioneer, 30 kV
Development	AR 600-546, 60 s, 22 °C


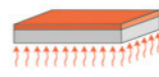
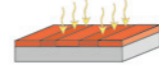
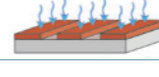
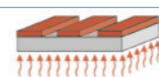


#### Process chemicals

Adhesion promoter	AR 300-80
Developer	AR 600-546, 600-549
Thinner	AR 600-02
Stopper	AR 600-60
Remover	AR 600-71, 300-76

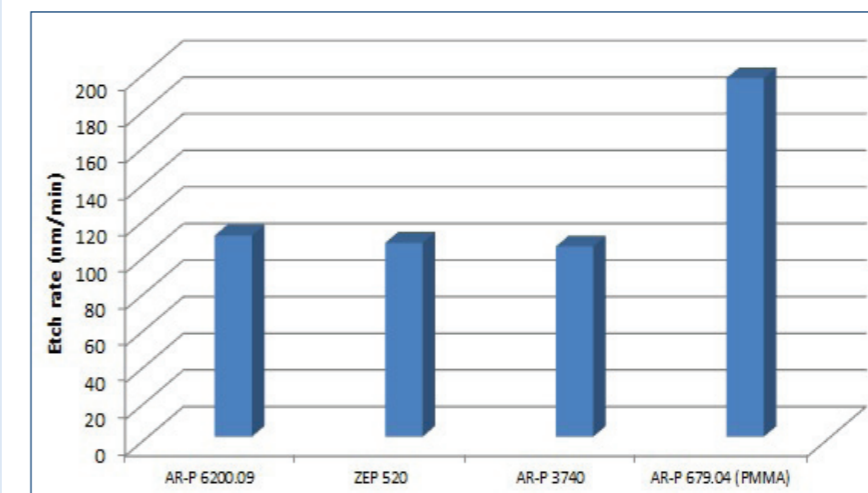
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### Process conditions

This diagram shows exemplary process steps for AR-P 6200 resists. 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 e-beam resists". For recommendations on waste water treatment and general safety instructions, ☞ "General product information on Allresist e-beam resists".

Coating		AR-P 6200.09 4000 rpm, 60 s 0.2 $\mu$ m
Tempering ( $\pm$ 1 °C)		150 °C, 1 min hot plate or 150 °C, 30 min convection oven
E-beam exposure		Raith Pioneer, 30 kV Exposure dose ( $E_0$ ): 65 $\mu$ C/cm <sup>2</sup>
Development (21-23 °C $\pm$ 0.5 °C) puddle		AR 600-546 1 min
Stopping / Rinse		AR 600-60, 30 s / DI-H <sub>2</sub> O, 30 s
Post-bake (optional)		130 °C, 1 min hot plate or 130 °C, 25 min convection oven for slightly enhanced plasma etching resistance
Customer-specific technologies		Generation of semiconductor properties
Removal		AR 600-71 or O <sub>2</sub> plasma ashing

### Plasma etching resistance



CSAR 62 is characterized by a high plasma etching resistance. In this diagram, plasma etching rates of AR-P 6200.09 are compared with those of AR-P 3740 (photoresist), AR-P 679.04 (PMMA resist) and ZEP 520 in  $CF_4$  +  $O_2$  plasma.

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### Processing instructions

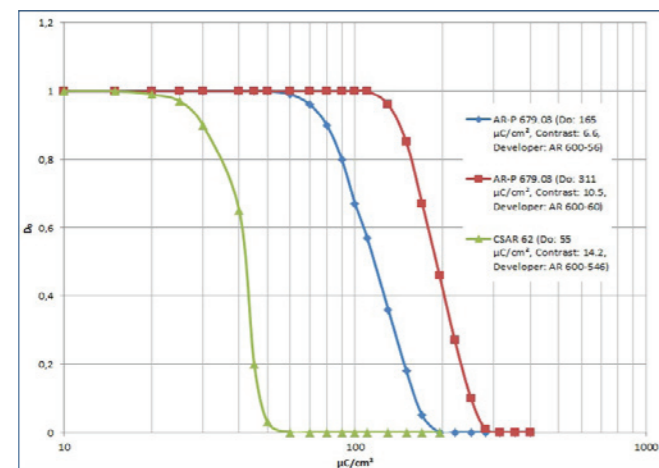
**E-beam exposure:** The required e-beam exposure dose for structural imaging mainly depends on the desired minimum structure size, the developer, the acceleration voltage (1 - 100 kV), and the film thickness.

The exposure dose for AR-P 6200.09 was in this experiment (☞ diagram comparison of CSAR 62 and PMMA) 55  $\mu\text{C}/\text{cm}^2$  (dose to clear  $D_0$ , 30 kV, 170 nm layer, developer AR 600-546, si wafer). The contrast was determined here to 14.2.

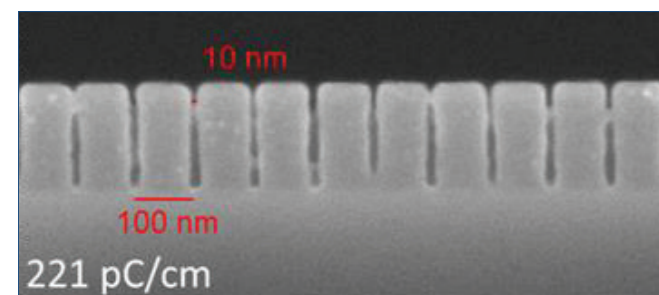
CSAR 62 is thus 3x more sensitive as compared to the standard PMMA resist AR-P 679.03 (developed in AR 600-56), or 6x more sensitive if developed in AR 600-60. Also the contrast is higher by a factor of 2 and 1.4, respectively.

An additional increase in sensitivity due to addition of sensitivity-enhancing components occurs already during exposure. A post-exposure bake is thus not required.

For the fabrication of 10-nm trenches (174 nm film, 100 nm pitch), AR 6200.09 requires a dose of approx. 220 pC/cm (30 kV, developer AR 600-546)



Comparison  $D_0$  and contrast CSAR 62 and PMMA



Maximum resolution CSAR 62 of 10 nm (180 nm)

**Development:** For the development of exposed resist films, developers AR 600-546, 600-548 and 600-549 are recommended. As weaker developer, AR 600-546 provides a wider process window. If the stronger developer AR 600-548 is used, the sensitivity can be increased 6-fold to  $< 10 \mu\text{C}/\text{cm}^2$ . The intermediate developer AR 600-549 renders the CSAR 62 twice as sensitive as compared to AR 600-546, it shows also no dark erosion and has a contrast of 4.

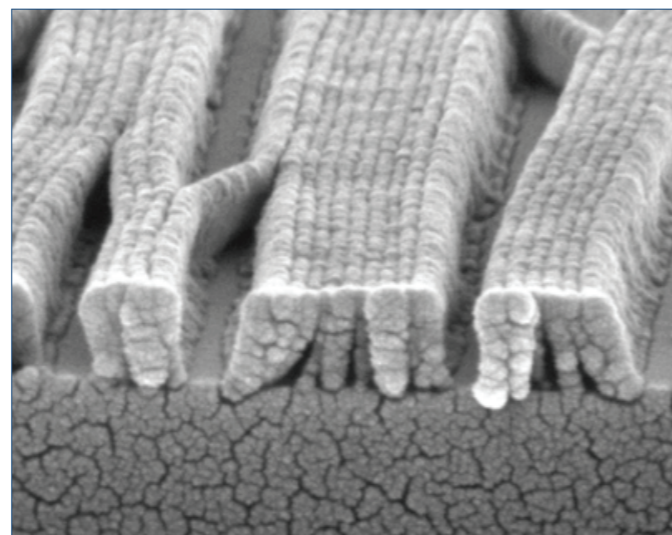
For immersion development, generally development times of 30 - 60 seconds are recommended. If developer AR 600-546 is used, even after 10 minutes at room temperature no erosion of unexposed areas is detected.

Developer AR 600-548 in contrast attacks resist surfaces already after two minutes visibly. If however the development process is carried out at temperatures of approx. 0 °C, no dark erosion is observed even after 5 minutes (which is however associated with a reduction of sensitivity).

The development procedure should be stopped quickly. For this purpose, the substrate is moved for 30 seconds in stopper AR 600-60. Optionally, the substrate may thereafter be rinsed for 30 seconds with DI water to remove all residual solvent.

Note: Please take into account that rigid rinsing procedures may lead to a collapse of smaller structures (☞ see image below).

A post-bake for special working steps at max. 130 °C results in a slightly improved etching stability during wet-chemical and plasma-chemical processes.



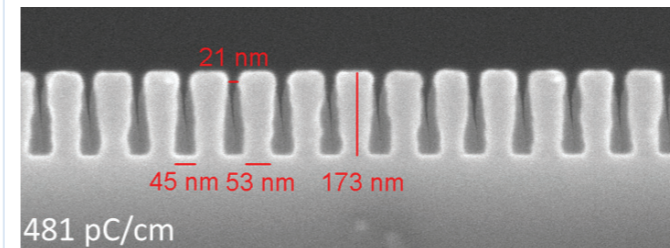
Danger of collapsed lines after too rigid rinsing

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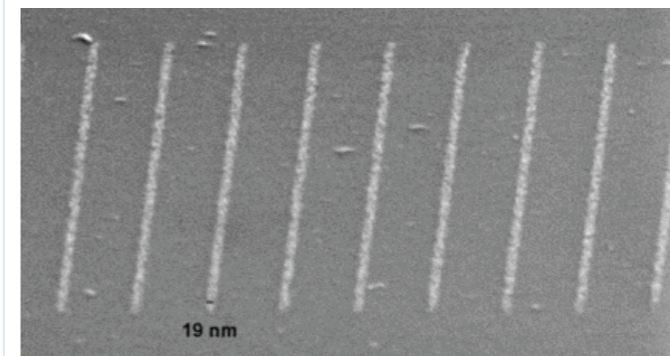
#### Lift-off structures:

Resist CSAR 62 is well suited to generate lift-off structures with a resolution of up to 10 nm. If the dose is increased by a factor of 1.5 - 2, narrow trenches with defined undercut can be fabricated with AR-P 6200.09.

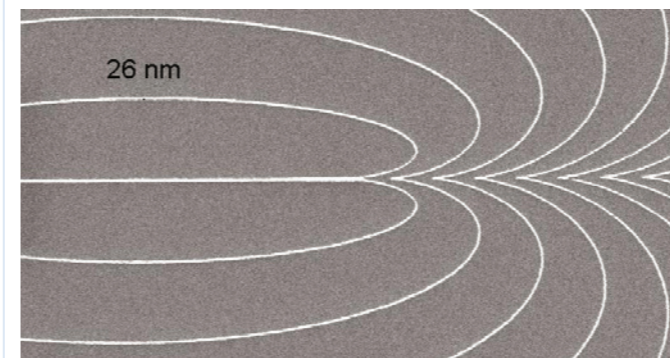


Undercut structures obtained with increased exposure dose

After vapour-deposition of metal and subsequent easy lift-off, metal structures remain



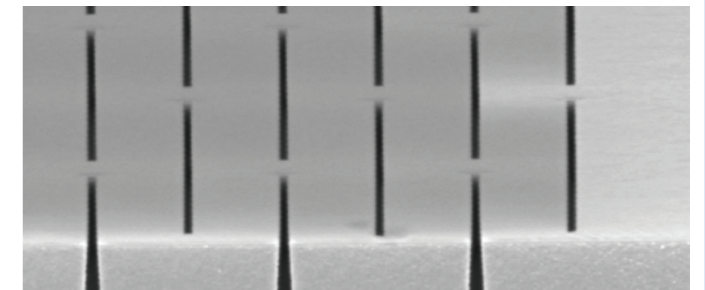
19-nm metal lines after lift-off process with AR-P 6200.09



CrAu test structures with a line width of 26 nm

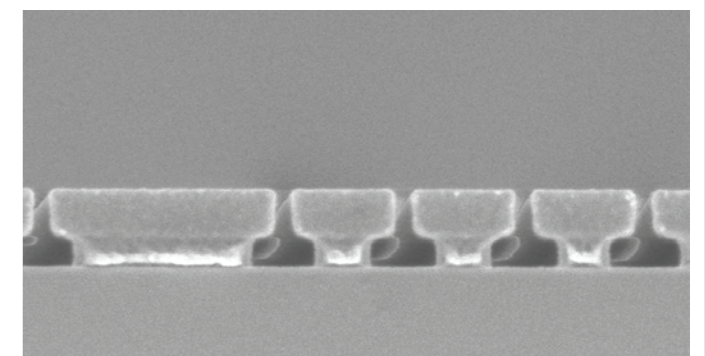
#### High layers for special applications:

Films with a thickness of up to 800 nm can be produced with AR-P 6200.13, and even 1.5- $\mu\text{m}$  films are possible with experimental sample SX AR-P 6200/10.



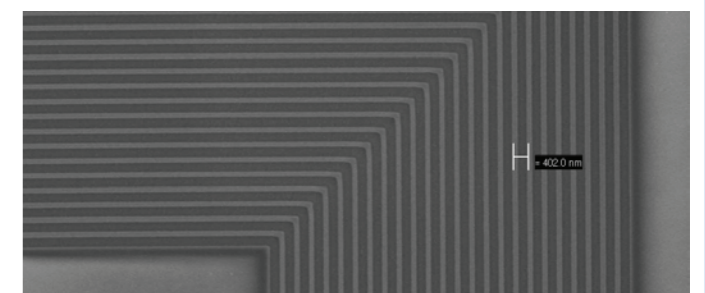
AR-P 6200.13: 100-nm trenches in 830-nm thick layer

CSAR 62 is also applied in various two-layer systems and can be used both as bottom and as top resist.



AR-P 6200.09 as top resist for extreme lift-off applications

Another field of application for CSAR 62 is the production of mask blanks which are coated with our resist and offered by our partners:



At a film thickness of 380 nm, 100-nm lines and spaces can be obtained on a chrome mask with AR-P 6200.13. The sensitivity is 12  $\mu\text{C}/\text{cm}^2$  (20 kV, AR 600-548).