ALLRESIST

Innovation
Creativity
Customer-specific solutions

Positive E-Beam Resists AR-P 610 series

AR-P 617 e-beam resists for nanometer lithography

Copolymer resist series for the production of integrated circuits and masks

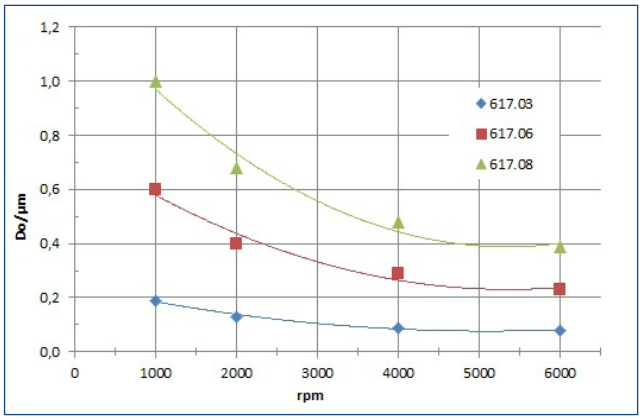
Characterisation

- e-beam, deep UV (248 nm)
- highest resolution, high contrast
- strong adhesion to glass, silicon and metals
- 3-4 times more sensitive than PMMA
- sensitivity can be adjusted via the softbake
- for planarization and multi-layer processes
- temperature-stable up to 240 °C
- copolymer on the basis of methyl methacrylate and methacrylic acid, safer solvent 1-methoxy-2-propanol

Properties I

Parameter / AR-P	617.03	617.06	617.08
Solids content (%)	3.0	6.0	8.0
Viscosity 25 °C (mPas)	7	20	36
Film thickness/4000 rpm (nm)	90	290	480
Resolution best value (nm)	10		
Contrast	6		
Flash point (°C)	38		
Storage 6 month (°C)	10 - 22		

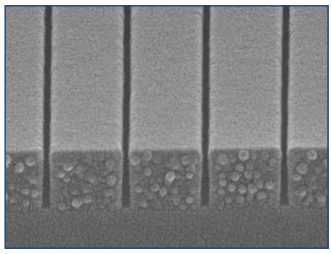
Spin curve



Properties II

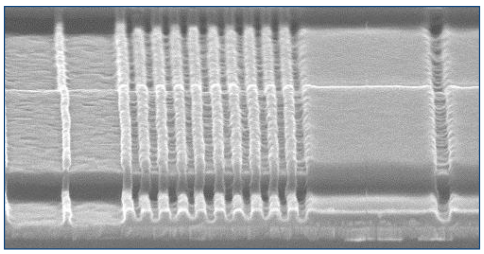
Glass trans. temperature (°C)	150	
Dielectric constant	2.6	
Cauchy coefficients	N_0	1.488
	N_1	44.0
	N_2	1.1
Plasma etching rates (nm/min) (5 Pa, 240-250 V Bias)	Ar-sputtering:	16
	O_2	291
	CF_4	56
	80 CF_4 + 16 O_2	151

Structure resolution



AR-P 617.03
30 nm trenches at film thickness of 120 nm

Resist structures



AR-P 617.03
150 nm lines across 200 nm oxide steps

Process parameters

Substrate	Si 4“ waver
Soft bake	200 °C, 2 min, hot plate
Exposure	ZBA 21, 20 kV
Development	AR 600-50, 2 min, 21°C

Process chemicals

Adhesion promoter	AR 300-80 new
Developer	AR 600-50, AR 600-55
Thinner	AR 600-07
Stopper	AR 600-60
Remover	AR 600-71, AR 300-76

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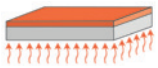
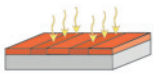
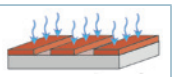
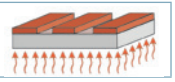
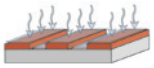
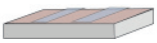
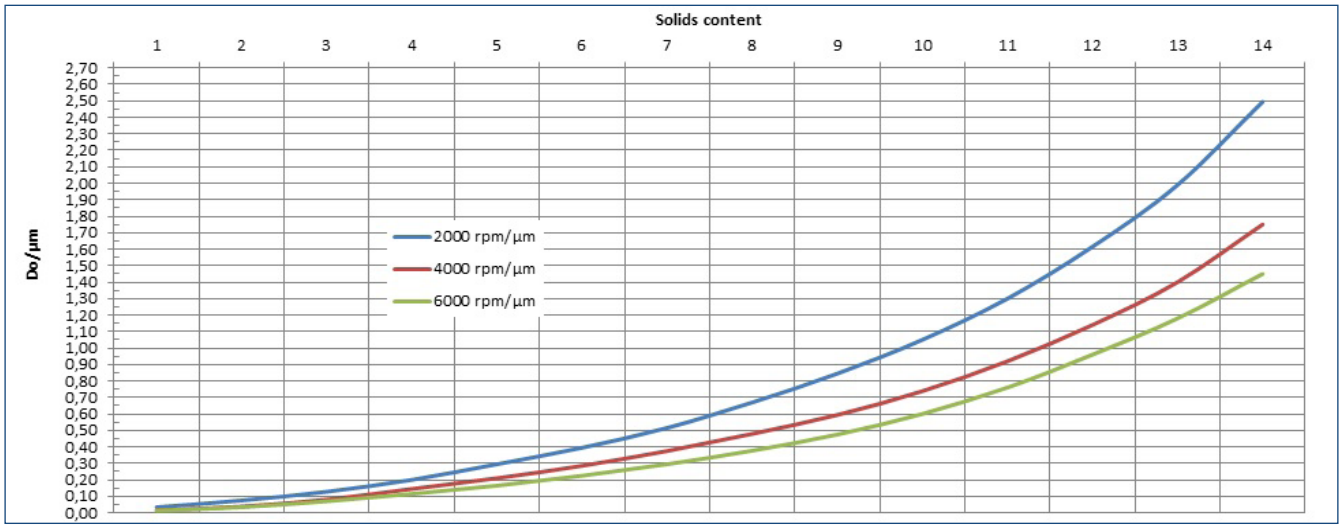
Process conditions

This diagram shows exemplary process steps for resists of the AR-P 610 series. 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 617.06 4000 rpm, 60 s, 290 nm
Soft bake (± 1 °C) 	200 °C, 25 min hot plate or 200 °C, 60 min convection oven
E-beam exposure 	ZBA 21, 20 kV Exposure dose (E_0): 30 µC/cm^2, 500 nm space & lines
Development (21-23 °C ± 1 °C) puddle  Stopping	AR 600-50, 60 s AR 600-60, 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 300-76 or O_2 plasma ashing

Film thickness of AR-P 617 vs. solids content and spin number



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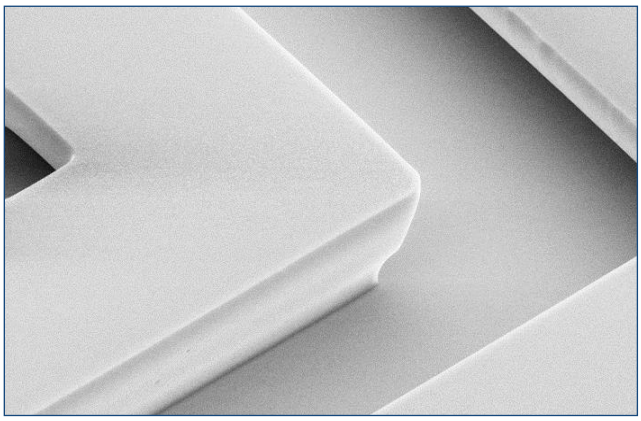
Processing instructions

The sensitivity of the resist increases with increasing softbake temperature due to the more intense formation of anhydrides of the methacrylic acid under separation of water (☞ diagram dose vs. softbake temperature). AR-P 617 tempered at 200 °C is therefore about 20 % more sensitive as compared to a tempering at 180 °C. The dose can be adjusted accordingly, which is of major importance for two-layer systems with two layers of AR-P 617. In this case, at first the bottom layer is dried at 200 °C and then tempered at 180 °C together with the upper film.

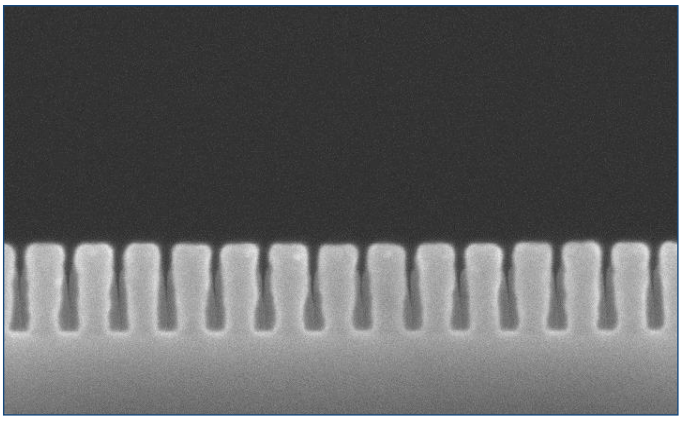
Due to differentiation processes, the lower layer is attacked faster by the developer and pronounced undercut structures are formed (lift-off). These lift-off structures can also be produced with the two-layer system PMMA/copolymer. At first AR-P 617 is coated and tempered at 190 °C, then the PMMA resist AR-P 679.03 is applied by spin-coating and dried at 150 °C. After exposure, both layers are developed in one step e.g. with AR 600-56, treated with stopper AR 600-60 and rinsed.

Lift-off structure with two layers of AR-P 617



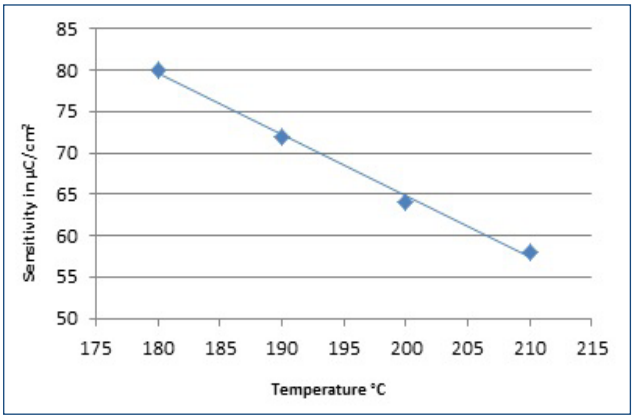
After development with AR 600-50
Bottom: AR-P 617.06, 400 nm thick, tempered at 200 °C
Top: AR-P 617.06, 500 nm thick, tempered at 180 °C

Undercut structure with PMMA/Copolymer



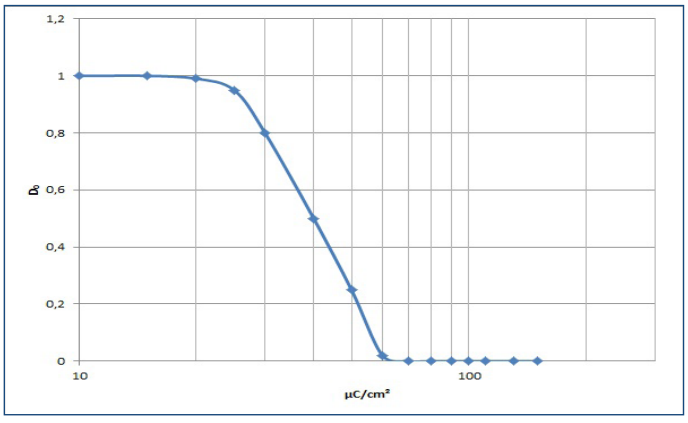
Two-layer system PMMA/copolymer after development
Bottom: AR-P 617.06, 400 nm thick, tempered at 190 °C
Top: AR-P 679.06, 180 nm thick, tempered at 150 °C

Dose vs. softbake temperature for AR-P 617



With increasing temperature, the sensitivity of AR-P 617.08 (film thickness 680 nm) increases linearly.

Gradation curve of AR-P 617



At a film thickness of 350 nm, a contrast of 5.0 was determined (30 kV, developer AR 600-50)

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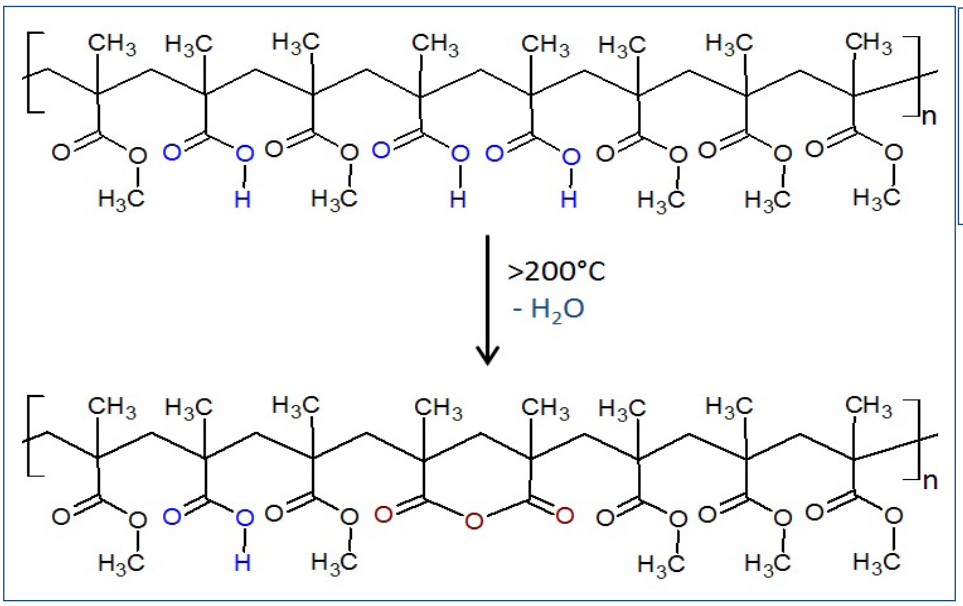
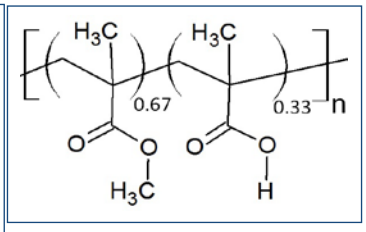
Sensitivity-enhancing reaction during tempering

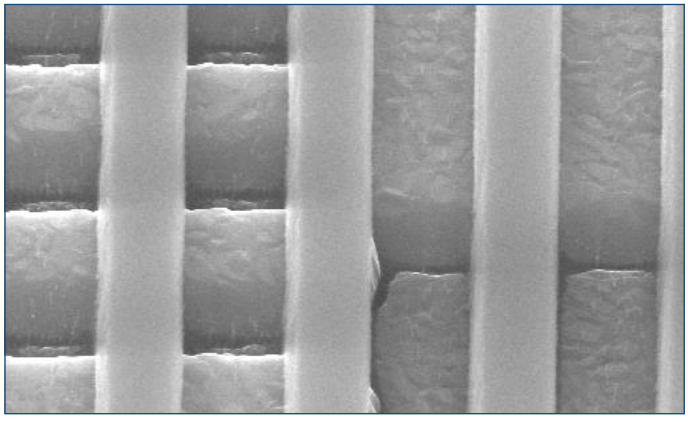




The copolymer composed of methyl methacrylate and methacrylic acid is, in contrast to pure PMMA products, able to form a 6-ring during thermal loading. In this case, 2 methacrylic acid groups have to be arranged adjacent to each other in the polymer chain (see large structural formula left), which statistically occurs with sufficiently high frequency at a mixing ratio of 2 : 1 (see molecular formula top right).
The reaction is possible at this temperature, since the water which is produced during the reaction is a very good leaving group.

The 6-ring which is formed breaks apart more easily during irradiation with electrons than the aliphatic chain remainder which causes the higher sensitivity of the copolymer. Once adjusted, the sensitivity will remain unchanged. The reverse ring-opening reaction is impossible.

Planarization with AR-P 617



AR-P 617.12 Structures across topologies

Due to the excellent coating properties is it possible to level out topologies which are present on the wafer before development. In this example, 200 nm high oxide structures were coated with AR-P 617.08. The film thickness was 780 nm. After exposure (20 kV) and development (AR 600-50, 2 min), the structured wafer is covered with entirely planar resist lines.