ALLRESIST

Innovation
Creativity
Customer-specific solutions

Protective Coating PMMA Electra 92 (AR-PC 5090)

Conductive protective coating for non-novolak-based e-beam resists

Top layer for the dissipation of e-beam charges on insulating substrates

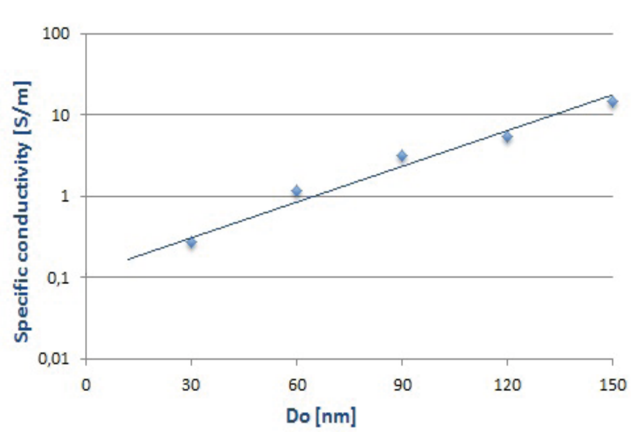
Characterisation

- as protective coating, this resist is not sensitive to light / radiation
- thin, conductive layers for the dissipation of charges during electron exposure
- coating of non-novolac PMMA, CSAR 62, HSQ et al.
- longterm-stable and cost-efficient alternative to Espacer
- easy removal with water after exposure
- polyaniline-derivative dissolved in water and IPA

Properties I

Parameter / AR-PC	5090.02
Solids content (%)	2
Viscosity 25°C (mPas)	1
Film thickness/4000 rpm (nm)	42
Film thickness/1000 rpm (nm)	100
Resolution (µm) / Contrast	-
Flash point (°C)	28
Storage 6 month (°C)	8 - 12

Conductivity

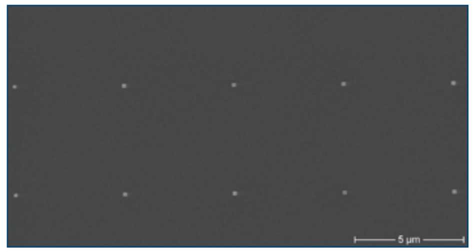


Conductivity measurements of AR-PC 5090.02 layers obtained after spin deposition. For thinner films, the resistance increases and the conductivity decreases.

Properties II

Conductivity in layer 60 nm (S/m)	1.2	
Cauchy-Koeffizienten	N_0	-
	N_1	-
	N_2	-
Plasma etching rates (nm/min) (5 Pa. 240-250 V Bias)	Ar-sputtering	-
	O_2	185
	CF_4	68
	80 CF_4 + 16 O_2	120

REM dissipation of charges



200 nm-squares written on quartz without distortion caused by charges with AR-P 662.04 and AR-PC 5090.02

Process parameters

Substrate	4" wafer quartz with AR-P 662.04
Coating	2000 rpm, 60 nm
Soft bake	85 °C

Process chemicals

Adhesion promoter	-
Developer	-
Thinner	-
Remover	DI-water

ALLRESIST

Innovation
Creativity
Customer-specific solutions

Protective Coating PMMA Electra 92 (AR-PC 5090)

Process conditions

This diagram shows exemplary process steps for resist Electra 92 - AR-PC 5090.02 and PMMA-resist AR-P 664.04. All specifications are guideline values which have to be adapted to own specific conditions.

1. Coating	AR-P 662.04 on insulating substrates (quartz, glass, GaAs) 4000 rpm, 60 s, 140 nm
1. Soft bake (± 1 °C)	150 °C, 2 min hot plate or 150 °C, 30 min convection oven
2. Coating	AR-PC 5090.02 2000 rpm, 60 s , 60 nm
2. Tempering (± 1 °C)	90 °C, 2 min hot plate or 85 °C, 25 min convection oven
E-beam exposure	ZBA 21, 20 kV Exposure dose (E_0): 110 µC/cm² (AR-P 662.04, 140 nm)
Removal	AR-PC 5090.02 DI-water, 60 s
Development (21-23 °C ± 0.5 °C) puddle	AR-P 662.04 AR 600-56, 2 min
Stop	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 stability
Customer-specific technologies	Generation of e.g. semi-conductor properties, etching, sputtering
Removal	AR 600-71 or O_2 plasma ashing

Processing instructions

The conductivity may be varied by adjusting the thickness with different rotational speeds. Thicker layers of 90 nm thus have a 2.5 times higher conductivity as compared to 60 nm thick layers.

For the build-up of an even conductive layer, the substrate should be wetted with the resist solution before the spin process is started.

Protective Coating Novolac Electra 92 (AR-PC 5091)

Conductive protective coating for novolac-based e-beam resists

Top layer for the dissipation of e-beam charges on insulating substrates

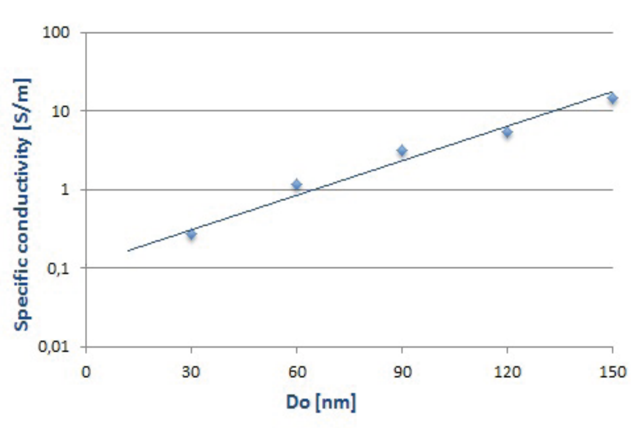
Characterisation

- as protective coating, this resist is not sensitive to light / radiation
- thin, conductive layers for the dissipation of charges during electron exposure
- coating of novolac-based e-beam resist AR-N 7000
- longterm-stable and cost-efficient alternative to Espacer
- easy removal with water after exposure
- polyaniline-derivative dissolved in water and IPA

Properties I

Parameter / AR-PC	5091.02
Solids content (%)	2
Viscosity 25°C (mPas)	1
Film thickness/4000 rpm (nm)	31
Film thickness/1000 rpm (nm)	80
Resolution (µm) / Contrast	-
Flash point (°C)	39
Storage 6 month (°C)	8 - 12

Conductivity



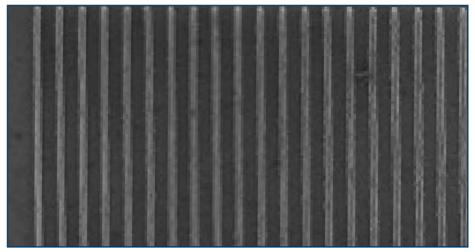
Resistance measurements of AR-PC 5091.02 layers obtained after spin deposition. For thinner films, the resistance increases and the conductivity decreases.

Note: Novolac-based e-beam resists possess other surface properties than CSAR 62 or PMMA. AR-PC 5091 was thus developed with a different solvent mixture. In all other respects however, the polymer composition of AR-PC 5090 and AR-PC 5091 is identical so that both resists are referred to as "Electra 92".

Properties II

Conductivity in layer 60 nm (S/m)	1.2	
Cauchy-Koeffizienten	N_0	-
	N_1	-
	N_2	-
Plasma etching rates (nm/min) (5 Pa. 240-250 V Bias)	Ar-sputtering	-
	O_2	185
	CF_4	68
	80 CF_4 + 16 O_2	120

REM dissipation of charges



50 nm lines written on glass at a pitch of 150 nm with AR-N 7520.07 and AR-PC 5091.02

Process parameters

Substrate	4" wafer quarz with AR-N 7520.07 neu
Coating	2000 rpm, 60 nm
Soft bake	50 °C

Process chemicals

Adhesion promoter	-
Developer	-
Thinner	-
Remover	DI-water

Protective Coating Novolac Electra 92 (AR-PC 5091)

Process conditions

This diagram shows exemplary process steps for resist Electra 92 (AR-PC 5091.02) and e-beam resist AR-N 7520.07 new. All specifications are guideline values which have to be adapted to own specific conditions.

1. Coating	AR-N 7520.07 new on insulating substrates (quartz, glass, GaAs) 4000 rpm, 60 s, 100 nm
1. Soft bake (± 1 °C)	85 °C, 1 min hot plate or 85 °C, 30 min convection oven
2. Coating	SX AR-PC 5000/91.2 2000 rpm, 50 s , 50 nm
2. Soft bake (± 1 °C)	50 °C, 2 min hot plate or 45 °C, 25 min convection oven
E-beam exposure	Raith Pioneer, acceleration voltage 30 kV Exposure dose (E_0): 30 µC/cm², 100 nm spaces & lines
Removal optional	AR-PC 5091.02 (The removal step can also be carried out simul- DI-H_2O, 60 s taneously with the subsequent development step.)
Development (21-23 °C ± 0.5 °C) puddle	AR-N 7520.07 new AR 300-47, 50 s
Rinse	DI-H_2O, 30 s
Post-bake (optional)	85 °C, 1 min hot plate or 85 °C, 25 min convection oven for slightly enhanced plasma etching stability
Customer-specific technologies	Generation of e.g. semi-conductor properties, etching, sputtering
Removal	AR 600-70 or O_2 plasma ashing

Processing instructions

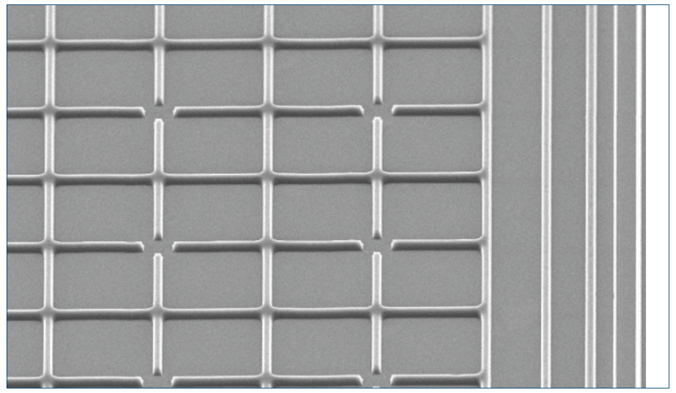
The conductivity may be varied by adjusting the thickness with different rotational speeds. Thicker layers of 90 nm thus have a 2.5 times higher conductivity as compared to 60 nm thick layers. In the case that crack formation is observed after tempering of the protective coating, the tempering step can be omitted.

For the build-up of an even conductive layer, the substrate should be wetted with the resist solution before the spin process is started.

Protective Coating Electra 92

Application examples for PMMA-Electra 92

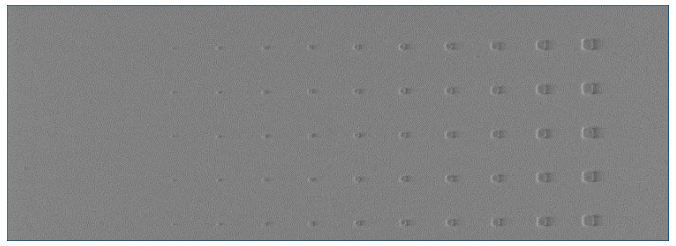
Shelf live of Electra 92



Conductivity properties of differently aged Electra 92 batches

The conductivity was determined as a function of the measured temperature. At temperatures < 100 °C, both resists show a virtually identical conductivity. Electra 92 is thus characterised by a very long shelf life. Conductivity measurements up to a temperature of 160 °C which were performed directly on a hotplate showed a large increase of the conductivity by a factor of 10 (see diagram). This fact is due to the complete removal of water from the layer. After a few hours of air humidity absorption under room conditions, the conductivity decreases again to the initial value. In the high vacuum of e-beam devices, the water is also completely removed and the conductivity thus increases accordingly. This effect has been demonstrated in direct conductivity measurements under mediate vacuum conditions. Temperatures above 165 °C destroy the polyaniline irreversibly and no conductivity is observed any more.

CSAR 62 on glass with Electra 92 for deriving



30 – 150 nm squares of CSAR 62 on glass

The combination of CSAR 62 with Electra 92 - AR-PC 5090.02 offers the best options to realise complex e-beam structuring processes on glass or semi-insulating substrates like e.g. gallium arsenide. The excellent sensitivity and highest resolution of the CSAR are complemented harmoniously by the conductivity of Electra 92.

CSAR 62 and Electra 92 on glass

Substrate	Glas 24 x 24 mm
Adhesion AR 300-80	4000 rpm; 10 min, 180 °C hot plate
Coating AR-P 6200.09	4000 rpm; 8 min, 150 °C hot plate
Copating AR-PC 5090.02	4000 rpm; 5 min, 105 °C hot plate
E-beam-irradiation	Raith Pioneer; 30 kV, 75 μC/cm²
Removal Electra 92	2 x 30 s water, dipping bath
Bath (drying)	30 s AR 600-60
Development CSAR 62	60 s AR 600-546
Stopping	30 s AR 600-60

At a CSAR 62 film thickness of 200 nm, squares with an edge length of 30 nm could reliably be resolved on glass.

PMMA Lift-off on glass with Electra 92

200 nm squares produced with 2-layer PMMA lift-off

Initially, the PMMA resist AR-P 669.04 (200 nm thickness) was coated on a quartz substrate and tempered. The second PMMA resist AR-P 679.03 was then applied (150 nm thickness) and tempered, followed by coating with Electra 92. After exposure, Electra 92 was removed with water, the PMMA structures were developed (AR 600-56) and the substrate vaporised with titanium/gold. After a liftoff with acetone, the desired squares remained on the glass with high precision.

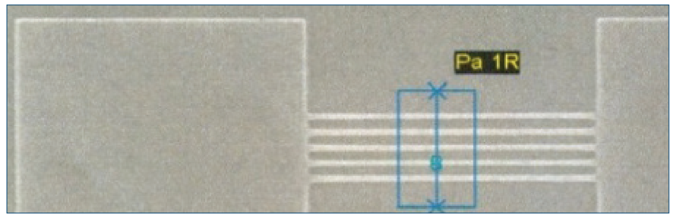
PMMA-Lift-off auf Glas mit Electra 92

Substrate	Glas 25 x 25 mm
Coating AR-P 669.04	4000 rpm; 3 min, 150 °C hot plate
Coating AR-P 679.03	4000 rpm; 3 min, 150 °C hot plate
Coating AR-PC 5090.02	2500 rpm; 5 min, 105 °C hot plate
E-beam irradiation	Raith Pioneer; 30 kV, 75 μC/cm²
Removal Electra 92	2 x 30 s water
Development PMMAs	60 s AR 600-56
Stopping	30 s AR 600-60
Steaming	titanium/gold

Protective Coating Electra 92

Application examples for PMMA Electra 92

Electra 92 with HSQ on quartz

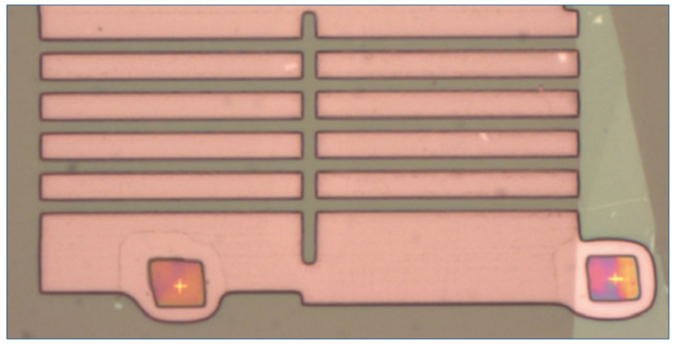


20 nm bars of HSQ, prepared on quartz AR-PC 5090.02

After a coating of Electra 92 on an HSQ resist, even this resist can be patterned on a quartz substrate with very high quality. The HSQ resist (20 nm thickness) was irradiated with the required area dose of 4300 μC/cm².

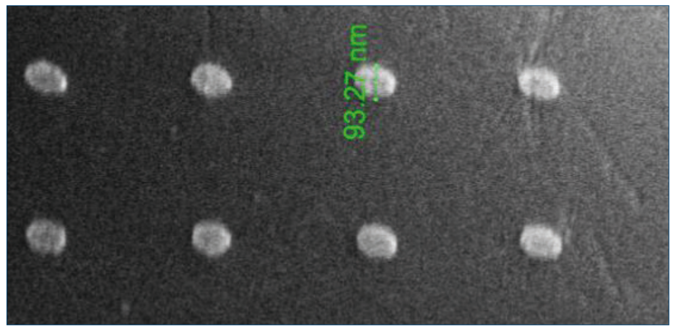
SX AR-PC 5000/90.2 was subsequently completely removed within 2 minutes with warm water and no residues could be detected. After development of the HSQ resist, the structures with high-precision 20 nm bars remained.

Lift-off struktures on garnet



Lift-off structures on garnet (University of California, Riverside, Department of Physics and Astronomy)

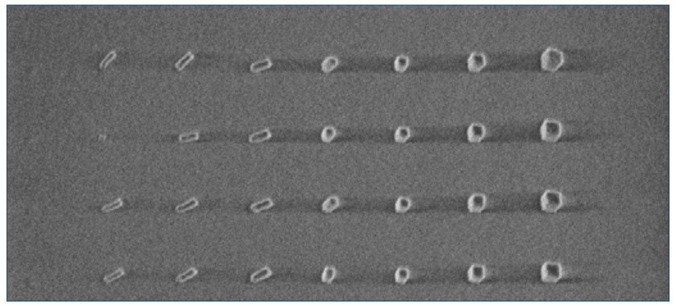
Plasmonic structures on quartz



Silver nanoparticles on quartz, generated with AR-P 672.11 and AR-PC 5090.02 (Aarhus University, Denmark)

Application examples for Novolac Electra 92

Electra 92 and AR-N 7700 on glass

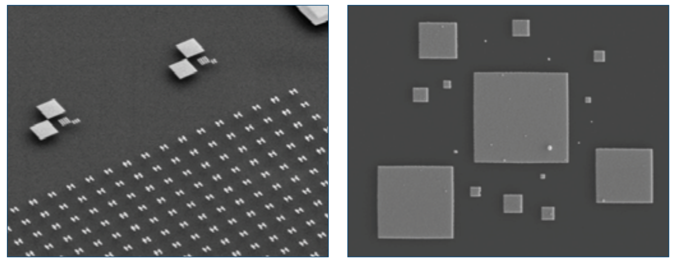


60 – 150 nm squares (100 nm height) on glass with AR-N 7700.08 and AR-P 5091.02

Novolac-based e-beam resists possess other surface properties than CSAR 62 or PMMA. For this reason, AR-PC 5091.02 was designed with a different solvent composition. E-beam resist AR-N 7700.08 was at first spincoated on glass, dried, coated with Electra 92 and baked at 50 °C. After irradiation, the Electra layer was removed within 1 minute with water and the e-beam resist then developed. The resulting resolution of 60 nm is very high for chemically amplified resists.

On highly insulating substrates for SEM applications

Electrostatic surface charges caused by a deflection of the incident electron beam can be extremely disturbing and interfere with a correct imaging. To avoid this effect, e.g. gold is evaporated onto the sample which however also entails disadvantages since some structures change irreversibly due to thermal effects. Studies demonstrated that the conductive coating Electra 92 can be used as alternative. The coating on electrically highly insulating polymers or glass also enables high-quality images of nanostructures in SEM:



SEM images: Highly insulating polymer structures coated with AR-PC 5090.02

After SEM investigation, the conductive coating was completely removed with water, and structures could still be used further.