Negative Photoresist AR-N 4600 S/R (Atlas 46)

AR-N 4600 Photo resist series for high film thicknesses

Thick negative resists for electroplating, microsystems technologies and LIGA < 20 µm

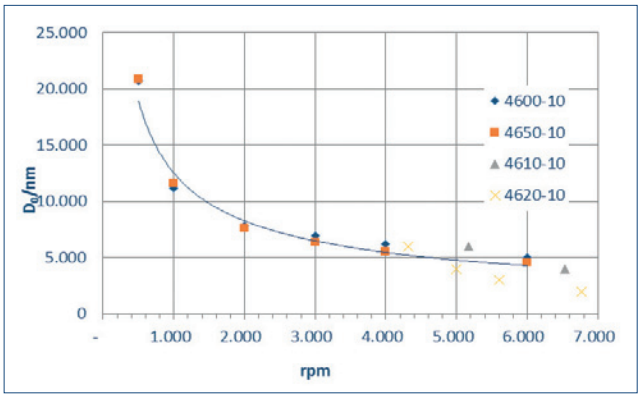
Characterization

- i-line, broadband UV
- very good adhesion properties
- very high sensitivity
- 4600-10 for stable layers of 5 µm - 15 µm
- 4650-10 for removable layers of 5 µm - 15 µm
- further film thicknesses up to about 200 µm available on request
- poly[(o-cresyl glycidyl ether)-co-formaldehyde] and acid generator
- safer solvent PGMEA

Properties I

Parameter / AR-N	4600-10 (S)	4650-10 (R)
Solids content (%)	50	50
Viscosity 25°C (mPas)	172	314
Film thickness/1000 rpm (µm)	10	
Resolution (µm)	2	
Contrast	4	
Flash point (°C)	46	
Storage 6 month (°C)	10-22	8-12

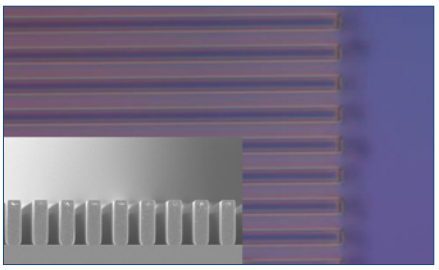
Spin curve



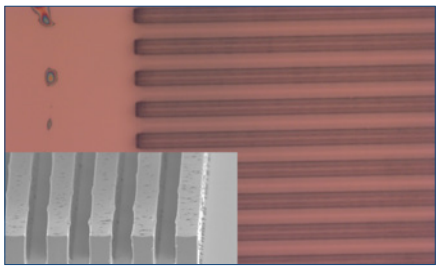
Properties II

Glass trans. temperature (°C)	34-44	
Softening point (°C)	99	
Dielectric constant	3 - 3,3	
Cauchy coefficients	N_0	1,675
	N_1	67
	N_2	101
Plasma etching rates (nm/min)	O_2	400
(1 Pa, O_2 plasma, 230 W (ICP), 160 W (HF))	5 CF_4 + 30 O_2	450

Resist structures



Atlas S (© Martin Luther University Halle-Wittenberg)



Atlas R (© Martin Luther University Halle-Wittenberg)

Process parameter

Substrate	Si 4“ wafer
Softbake	95°C, 5 min, hot plate
Exposure	BB UV, Soft-contact
Development	AR 300-12 pure, 120 sec, 20°C

Process chemicals

Remover	AR 300-12, AR 600-70
Thinner	AR 300-12
Developer	AR 300-12, AR 600-70
Stopper	AR 600-60

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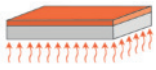
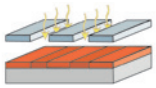
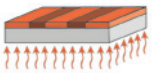
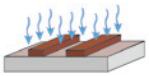
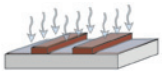
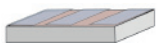
Process conditions

This diagram shows exemplary process steps for resist AR-N 4600. 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 (open chuck) 	AR-N 4600-10 (Atlas S)	AR-N 4650-10 (Atlas R)
	1.000 rpm, 10 µm	
Softbake 	Hot plate: 95°C, 5 min (65°C, 2 min - 95°C, 4 min)	
UV exposure 	Broadband UV, i-line	
	Exposure dose (E_0, BB-UV):	
	120 mJ/cm^2	140 mJ/cm^2
Crosslinking bake 	Hot plate: 105°C, 5 min (65°C, 2 min - 95°C, 7 min - 2 min 105°C)	
Development (21-23°C ± 0,5°C) Puddle 	AR 300-12, 2 min	
Rinse	AR 600-60, H_2O -drying (hot plate)	
Customer-specific Technologies 	Hardbake (optional) (95°C, 10 min / 105°C, 5 min) up to 200°C (gradually)	
Removing 	O_2 plasma ashing	AR 600-70, 30-45 min O_2 plasma ashing

Development recommendations

Resist / Developer	AR-N 4600-10	AR-N 4650-10
AR 600-70	fast	fast
AR 300-12	middle	middle
AR 600-07	slow	slow

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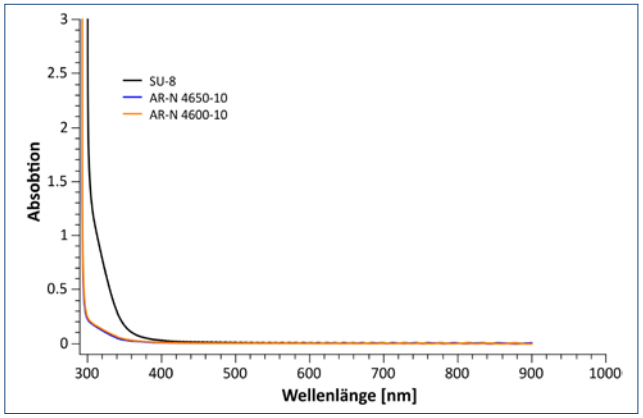
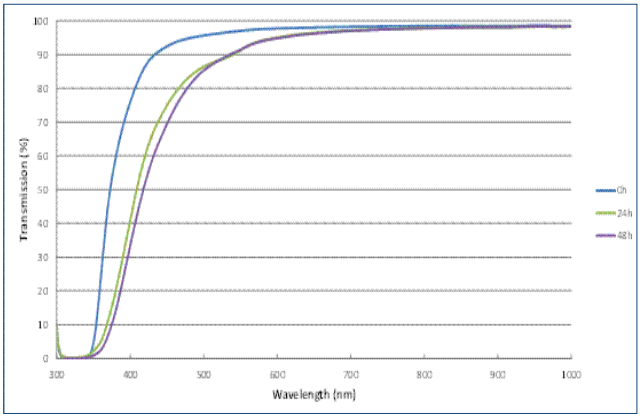
UV/VIS NIR

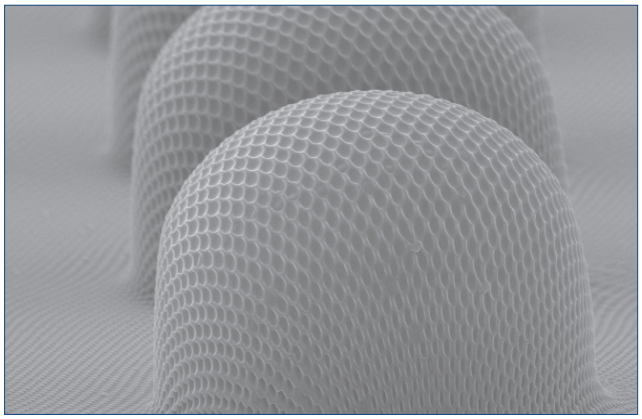


UV/VIS spectra of 10 µm layers Atlas S and Atlas R in comparison to SU-8

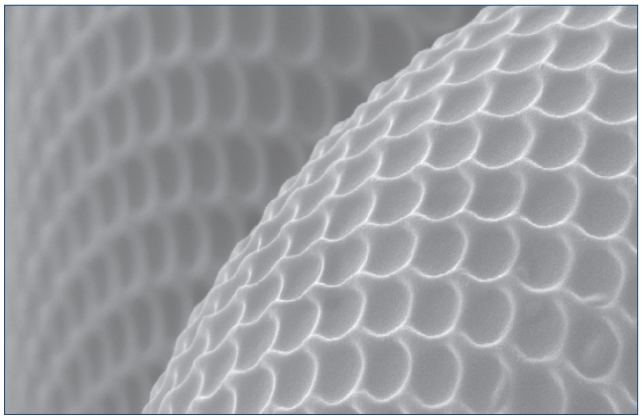


UV/VIS spectra of Atlas 46. Yellowing caused by varying the duration of broadband UV exposure after curing.

Imprinting

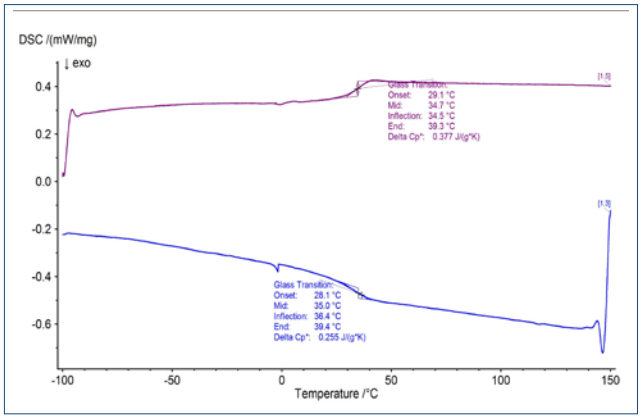


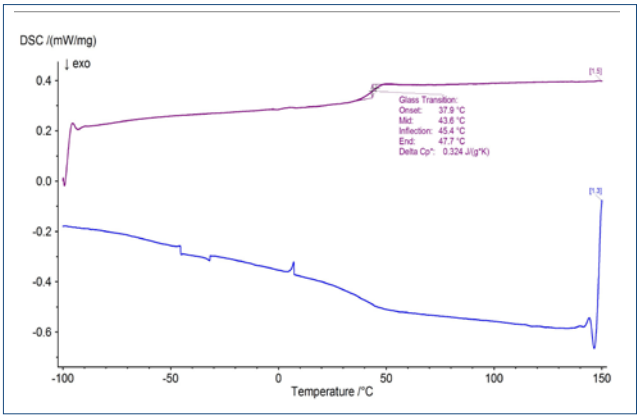
Combined nano- and microstructures, produced by imprinting of AR-N 4600 (© Uni Wuppertal)



Close-up view of AR-N 4600 (© Uni Wuppertal)

DSC





Dynamic differential scanning calorimetry (DSC) of polymers used (left Atlas S, right Atlas R)

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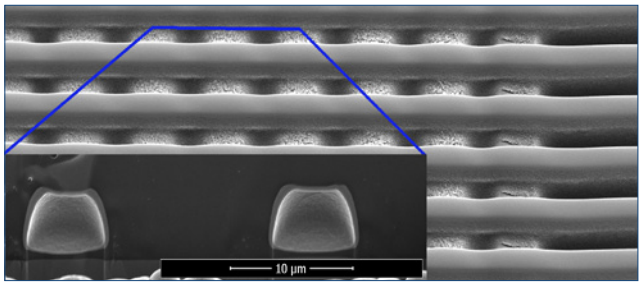
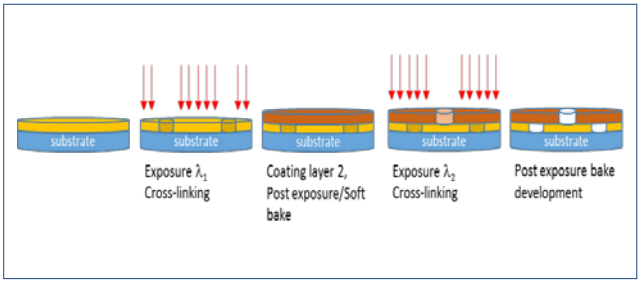
Bridges



Bridge structure of two-layer system with AR-N 4600-10 (bottom) and SX AR-N 4620-10/1 (top)



Process description of "bridge construction" with AR-N 4600-10 (bottom, BB-UV) and SX AR-N 4620-10/1 (top, g-line)

Additional information

Processing

Layer thickness values of Atlas R and Atlas S are pre-adjusted to 10 µm at a spin speed of 1000 rpm. It is recommended to perform the subsequent tempering step on the hotplate at 95 °C for 5 min. Temperature ramps or stepwise drying, e.g. 65 °C for 2 minutes, followed by 95 °C for 4 minutes, can improve the resolution.

Both resists can be structured by i-line or broadband UV exposure. Prior to irradiation, substrates should be cooled to room temperature. It is recommended to perform the following tempering step for cross-linking on the hotplate at 105 °C for 2 min.

Ramps or stepwise cross-linking procedures like e.g. 65 °C for 2 minutes, followed by 95 °C for 7 minutes and 105 °C for 2 minutes, can improve the resolution. In general, the stability of resists increases with higher temperatures and longer bake times, but this requires on the other side longer development times. The use of temperature ramps is also recommended for cooling since cooling too fast may result in stress cracking.

Development

AR 300-12 is recommended as standard developer, but also AR 600-07 (fast development) or AR 600-70 (gentle development) is suitable. If AR-N 4600-10 (S) is used for development, no dark erosion is observed even after comparably long development times. If the development with AR 300-12 is performed for too long, increased dark erosion of AR-N 4650-10 may result, and a too long development with AR 600-70 can even cause complete removal.

Stopper AR 600-60 is recommended for a particularly residue-free rinsing after development, followed by rinsing with DI water. It is also possible to rinse resist layers immediately after development directly with DI water and to dry them on the hotplate.

The sensitivity for a layer thickness of 10 µm is about 110 – 160 mJ/cm^2 in the broadband UV range (process description on page 3).

Removal

Coated structures of AR-N 4650-10 (R) can be removed with thinner AR 300-12 or AR 600-70. Depending on the degree of cross-linking (dose, temperature and bake time), required removal times may be considerably longer than 30 minutes.

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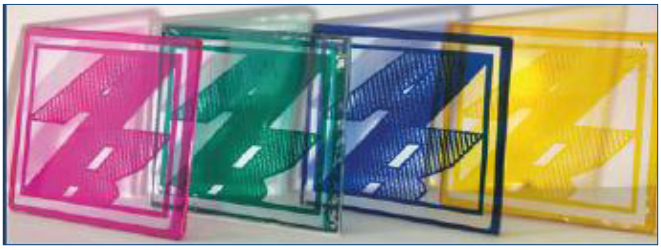
Dyed and fluorescent films with Atlas 46

Different coloured, optionally also fluorescent dyes can be embedded into the negative-working Atlas 46 S. These dyes are process-stable, and structuring is performed in the same manner as in standard processes with uncoloured Atlas 46 S films.



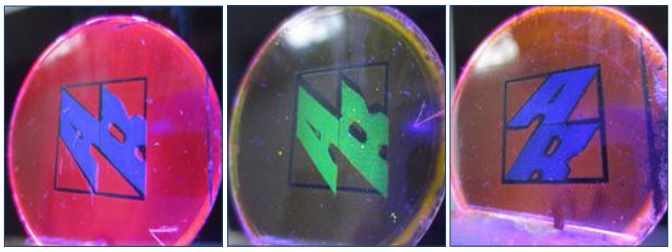
Varicoloured company logo with Atlas 46 S, film thickness 5 µm

The use of different fluorescent dyes allows a defined adjustable emission in variable wavelength ranges. Fluorescent resist films are e.g. applied in microscopy. By embedding dyes into Atlas 46 S, resist films can be created that optionally show violet, blue, green, yellow, orange or red fluorescence. The intense fluorescence is retained even after a tempering at 150 °C, and the intense UV exposure required for cross-linking of Atlas films exhibits no adverse effect on the emission properties of these layers.

Differently fluorescing Atlas 46 films (irradiation with black light)

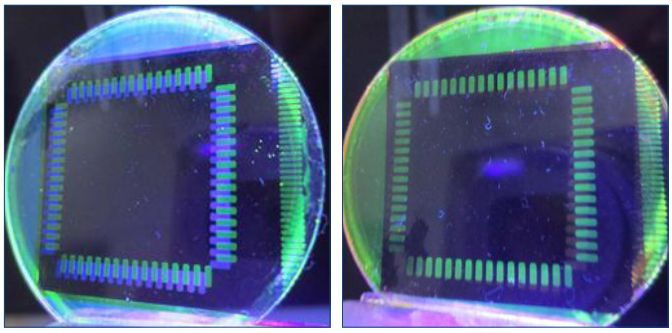
Also two-colour fluorescent resist architectures could be realized. For this purpose, glass panes were pre-treated with AR 300-80new to optimize the adhesive properties and subsequently coated with different fluorescent Atlas 46 S variants. Exposure was carried out using different masks. After the following PEB, development was carried out with AR 300-12 and films were dried. The developed structures were then coated with a second, differently coloured resist variant with the greatest possible colour contrast, e.g. blue – yellow or red – yellow.

No mixing occurred since the already produced structures turned out to be highly stable. The second exposure and PEB step analogous to the first step allowed a selective structuring of the upper layer. After development with AR 300-12, the differently fluorescing areas on the substrate become visible in black light:



AR logo realised with two-coloured emission in black light

Also differently fluorescent lines adjacent to each other (or optionally overlapping) can be created in the same way:



Different fluorescent line patterns, left: parallel arrangement, right: overlapping lines