Positive and Negative Photoresists AR-U 4000

AR-U 4000 image reversal resist series

Image reversal resist for the fabrication of integrated circuits

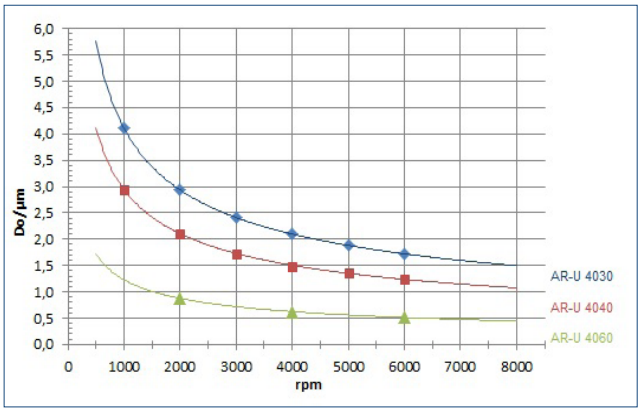
Characterisation

- bb UV, i-line, g-line, neg exposure up to 450 nm
- high photosensitivity, high resolution
- depending on the processing protocol, pos. or neg. image with structures in the sub-µm range
- positive working without additional process steps
- high contrast in the negative mode, pronounced undercut profiles are possible (lift-off)
- combination of novolac and bisazide
- safer solvent PGMEA

Properties I

Parameter / AR-U	4030	4040	4060
Solids content (%)	37	34	23
Viscosity 25 °C (mPas)	28	19	6
Film thickness/4000 rpm (µm)	1.8	1.4	0.6
Resolution (µm)	0.8	0.7	0.5
Contrast	3.0	3.0	3.5
Flash point (°C)	42		
Storage 6 month (°C)	8 - 12		

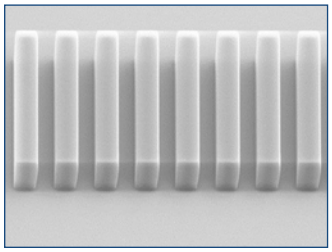
Spin curve



Properties II

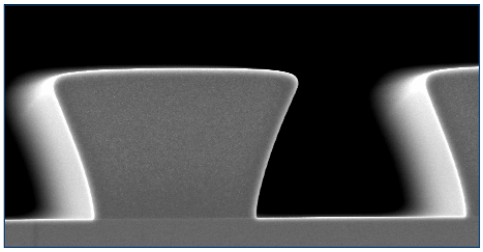
Glass transition temperature	108		
Dielectric constant	3.1		
Cauchy coefficients unexposed / exposed	N_0	1.620	1.618
	N_1	57.0	82.8
	N_2	220.4	130.5
Plasma etching rates (nm/min) (5 Pa, 240-250 V Bias)	Ar-sputtering	8	
	O_2	169	
	CF_4	40	
	80 CF_4 + 16 O_2	89	

Structure resolution



AR-U 4040
1.0 µm positive structures at a film thickness of 1.4 µm

Resist structures



AR-U 4030
Undercut negative structures at a film thickness of 2.5 µm

Process parameters

Substrate	Si 4“ wafer
Tempering	90 °C, 1 min, hot plate
Exposure	g-line stepper (NA: 0.56)
Development	AR 300-35, 1 : 1, 60 s, 22 °C

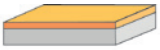
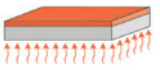
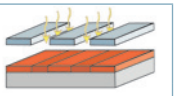
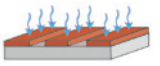
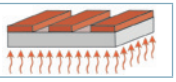
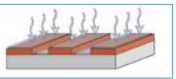
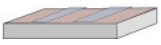
Process chemicals

Adhesion promoter	AR 300-80
Developer	AR 300-35, AR 300-26
Thinner	AR 300-12
Remover	AR 300-76, AR 300-72

Positive and Negative Photoresists AR-U 4000

Process conditions

This diagram shows exemplary process steps for AR-U 4000 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 photoresists". For recommendations on waste water treatment and general safety instructions, ☞ "General product information on Allresist photoresists".

Coating 	AR-U 4030 4000 rpm, 60 s 1.8 µm	AR-U 4040 4000 rpm, 60 s 1.4 µm	AR-U 4060 4000 rpm, 60 s 0.6 µm
Tempering (± 1 °C) 	90 °C, 1 min hot plate or 85 °C, 25 min convection oven		
UV exposure 	Broadband UV, 365 nm, 405 nm, 436 nm Exposure dose (E_0, broadband UV stepper):		
	38 mJ/cm²	34 mJ/cm²	28 mJ/cm²
Development (21-23 °C ± 0,5 °C) puddle 	AR 300-35, 1 : 1 60 s	AR 300-35, 1 : 1 60 s	AR 300-35, 1 : 2 60 s
Rinse	DI-H_2O, 30 s		
Post-bake (optional) 	Not required		
Customer-specific technologies 	Generation of e.g. semiconductor properties or lift-off		
Removal 	AR 300-76 or O_2 plasma ashing		

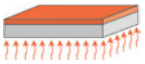
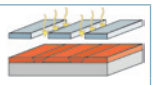
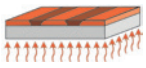
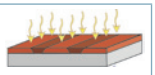
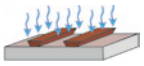
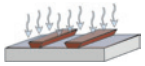
Development recommendations

Resist / Developer positive process	AR 300-26	AR 300-35	AR 300-47
AR-U 4030 (1.8 µm)	1 : 4	1 : 1	1 : 2
AR-U 4040 (1.4 µm)	1 : 5	1 : 1	1 : 2
AR-U 4060 (0.6 µm)	1 : 8	1 : 2	1 : 3

Positive and Negative Photoresists AR-U 4000

Process conditions negative process

This diagram shows exemplary process steps for AR-U 4000 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 photoresists". For recommendations on waste water treatment and general safety instructions, ☞ "General product information on Allresist photoresists".

Coating 	AR-U 4030	AR-U 4040	AR-U 4060
	4000 rpm, 60 s 1.8 µm	4000 rpm, 60 s 1.4 µm	4000 rpm, 60 s 0.6 µm
Tempering (± 1 °C) 	90 °C, 1 min hot plate or 85 °C, 25 min Convection oven		
Image-wise UV exposure 	Broadband UV, 365 nm, 405 nm, 436 nm; 90 % layer build up Exposure dose (E_0, broadband UV stepper):		
	42 mJ/cm²	36 mJ/cm²	30 mJ/cm²
Image reversal bake 	115 °C, 4 min hot plate or 110 °C 25 min convection oven		
Flood exposure 	Broadband UV stepper: approx. twice of image-wise without mask Exposure dose (E_0, broadband UV stepper):		
	74 mJ/cm²	68 mJ/cm²	55 mJ/cm²
Development (21-23 °C ± 0,5 °C) puddle 	AR 300-35, 4 : 3 60 s	AR 300-35, 1 : 1 60 s	AR 300-35, 2 : 3 60 s
Rinse	DI-H_2O, 30 s		
Post-bake (optional)	Not required		
Customer-specific Technologies 	Generation of e.g. semiconductor properties or lift-off		
Removal 	AR 300-70 or O_2 plasma ashing		

Development recommendations

Resist / Developer negative process	AR 300-26	AR 300-35	AR 300-47
AR-U 4030 (1.8 µm)	1 : 4	4 : 3	3 : 2
AR-U 4040 (1.4 µm)	1 : 5	1 : 1	2 : 3
AR-U 4060 (0.6 µm)	1 : 6	2 : 3	1 : 2

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Processing instructions

Positive resist:

The image reversal resist can be used as normal positive-tone resist. Since this resist has the potential to be cross-linked due to its specific components, a softbake at only 85 °C (oven) or 90 °C (hot plate) after coating is recommended. A relatively high exposure dose has to be chosen for the generation of vertical edges. If trenches with falling edges (e.g. 60° angles) are desired, the image-wise exposure has to be reduced considerably. An undercut cannot be obtained in positive processes.

During uv exposure, the alkali-insoluble naphthoquinone diazides (NCDs) are converted into alkali-soluble indenecarboxylic acid derivatives which then are removed together with the likewise alkali-soluble novolac during the development. A high exposure dose ensures a complete photolysis of NCDs in the entire layer. As a result of the high and constant development rate, vertical edges are produced. With these short exposure times, lower layers of the resist are only incompletely exposed, the development rate is thus slowed down towards the bottom and a slope is generated. Note: The temperature stability of positively developed structures can be significantly increased if a final flood exposure and tempering at 95-105 °C is carried out.

Negative resist:

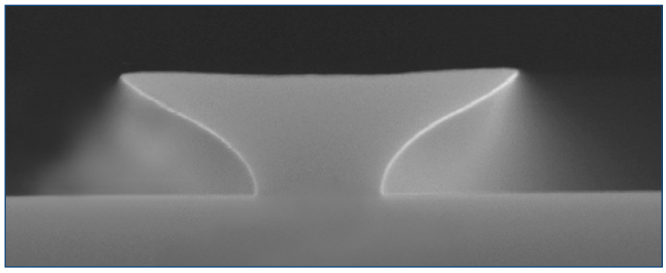
This resist also allows for the production of negative structures. The resist contains an amine component which exhibits no influence during positive processes. If however the image-wise exposed resist layer is tempered after exposure, the amine in exposed areas reacts with indenecarboxylic acid and a crosslinking results which renders exposed areas alkali-insoluble. To increase the efficiency of the negative process, an exposure of still unexposed areas using flood exposure is required. During flood exposure, the alkali-soluble indenecarboxylic acid is formed, in the up to this step unexposed areas, however crosslinked structures remain unchanged. The following development produces then a negative image.

To generate of vertical edges, a high image-wise expose dose has to be chosen in the negative mode. Intensifying the reversal bake supports the formation of vertical walls. For the generation of lift-off structures, the image-wise expose dose should be rather low.

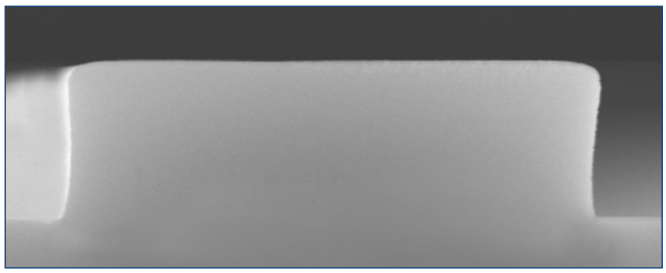
As described for the positive mode, a trench with a slope will be formed in this case. During the reversal bake, the trench becomes alkali-insoluble again, while the subsequent flood exposure renders all other areas alkali-soluble. The typical undercut structures particularly well suited for lift-off processes will remain after development.

Increasing the undercut:
- low image-wise exposure
- low temperature during reversal bake
- extension of development time

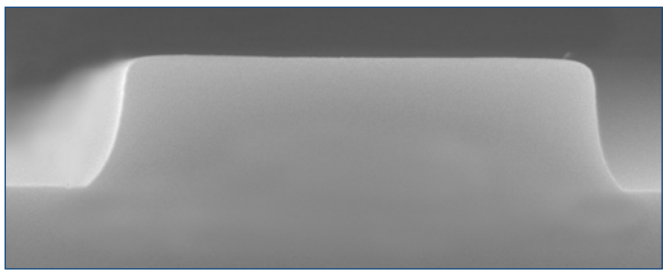
Vertical edges:
- high image-wise exposure
- high temperature during reversal bake
- reduction of development time



Pronounced undercut, low exposure dose, low bake temperature



Vertical edges, high exposure dose, high bake temperature



Positive image with “slope”, low exposure dose