



Summary of CSAR 62 and process chemicals

We deliver our products within 1-2 weeks ex work, in-stock products are delivered either immediately or at your desired date. Resists are available in amounts of 30 ml, 100 ml, ¼ l, 1 l, 2.5 l, 6 x 1 l and the respective process chemicals in package sizes of 2.5 l, 5 l, 4 x 2.5 l, 4 x 5 l. We will be glad to submit you an offer.

Type	Application / conditions		Product
Positive-E-Beam	methylstyrene chloroacrylate in anisole positive E-Beam resist CSAR 62 high resolution, high sensitivity, high etching resistant	SX AR	AR-P 6200/2 new
process chemicals	developer for E-Beam resist 6200	X AR	600-54/6, 600-54/8
	thinner for E-Beam resists 600 und 6200	AR	600-01, 600-02 , 600-07, 600-09
	stopper for E-Beam Resists 600, 6200 ; 6510	AR	600-60 ; 600-61
	remover for E-Beam Resists 600, 6200, 6510	AR	600-70, 600-71 , 300-70, 300-72
	adhesion promoters for E-Beam Resists 600, 6200, 7000	AR	300-80, HMDS
9	product portfolio photoresists, e-beam resists, experimental sample		As of May 2013



Preliminary information of new product development

Positive e-beam resist for maximum resolution SX AR-P 6200 (CSAR 62)

1. General description

The electron beam resist **SX AR-P 6200/2** is a positive-tone e-beam resist which provides, depending on the respective developer, high to very high sensitivity and allows to realise resolutions down to the sub-10-nm range. The resist is furthermore characterised by high process and plasma etch stability and in addition very suitable for lift-off processes up to structure sizes of 10 nm.

Due to the very high contrast of > 15 , a resolution of 10 nm can be achieved at a film thickness of 180 nm. Realising an aspect ratio of 18 is thus possible.

Selecting an appropriate developer (X AR 600-54/8), the sensitivity of the resist can be increased to $10 \mu\text{C}/\text{cm}^2$. An even higher resolution power is obtained with the developer X AR 600-54/6.

Main components of the resist are poly(α -methylstyrene-co-chloromethacrylate-methyl ester), an acidifier and the safer solvent anisole.

2. Parameters

Properties / Resist	SX AR-P	6200/2
Solids content	%	9
Viscosity (25 °C)	mPa·s	6
Film thickness at 4000 rpm Semitec CPS 20, open chuck, 2" Si-wafer	μm	0.20
Film thickness at 6000 - 1000 rpm Spin curves S. 4	μm	0.17 – 0.39
Filtration	μm	0.1
Flash point	°C	43
Storage temperature	°C	10-18
Guarantee from date of sale	Month	6

3. Prozess chemicals

Developer	X AR	600-54/6, 600-54/8
Thinner	AR	600-02
Stopper	AR	600-60
Remover	AR	600-71, 300-72
Adhesion promoter	AR	300-80



4. Process steps for SX AR-P 6200:

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I.	• Spin coating (1000 – 6000 rpm)
II.	• Bake: 150 ± 1.0 °C, 30 min, convection oven or 150 ± 1.0 °C, 3 min, hot plate
III.	• Electron beam exposure
IV.	• Development: X AR 600-54/6, X AR 600-54/8 ; Stoppen: AR 600-60

(I) After adapting the resist to the temperature of the preferably air-conditioned working area (optimum conditions 20-25 °C at a relative air humidity of 30-50%, no yellow light required), the resist is applied by spin coating.

(II.) It is recommended to perform the subsequent bake step on a hot plate at 150 °C for 3 min or in a convection oven at 150 °C for 30 min.

(III.) 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 of SX AR-P 6200/2 is 55 $\mu\text{C}/\text{cm}^2$ (dose to clear D_0 , 30 kV, 170 nm layer, developer X AR 600-54/6, Si-wafer). The contrast was determined to be 14.2 (see Fig. 1):

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

An additional increase in sensitivity occurs already during exposure, due to the halogenated acidifiers. A post-exposure bake is thus not mandatory.

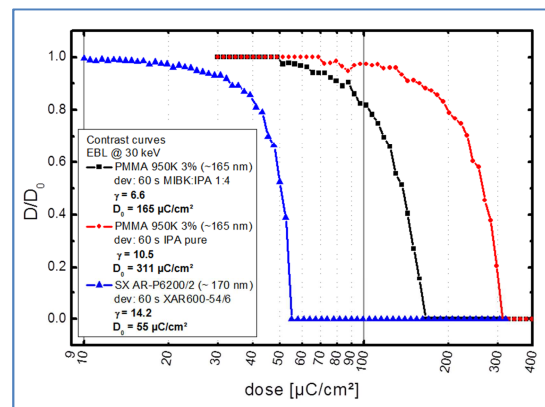


Fig. 1 Comparison D_0 and contrast of CSAR and PMMA

To generate trenches with a width of 10 nm (174 nm layer, 100 nm pitch, see Fig. 2), resist SX AR-P 6200/2 requires a dose of approx. $\mu\text{C}/\text{cm}$ (30 kV, 180 nm, developer X AR 600-54/6).

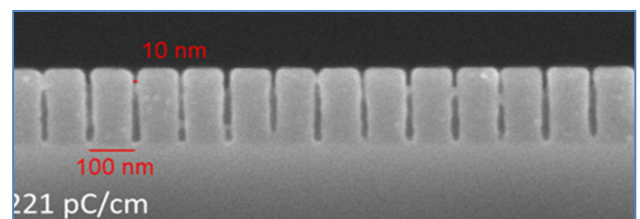


Fig. 2 Max. resolution of CSAR 62 of 10 nm at 180 nm

(IV.) For the development of exposed resist films, both **developer X AR 600-54/6** and **X AR 600-54/8** is recommended. As weaker developer, **X AR 600-54/6** provides a broader process window. If the stronger **developer X AR 600-54/8** is used, the sensitivity can be increased 6-fold to $< 10 \mu\text{C}/\text{cm}^2$.

In principle, also developer AR 600-56 and MIBK may be used for the development, but in this case sensitivity and contrast are substantially lower.

For immersion development, generally development times of 30 - 60 seconds are recommended. **Developer X AR 600-54/6** is well applicable at room temperatures, even after 10 minutes no erosion of unexposed areas is measurable. **Developer X AR 600-54/8** in contrast attacks resist surfaces already after two minutes visibly. If however the development process is carried out at temperatures around 0 °C, no erosion is observed even after 5 minutes (with loss of sensitivity).



The procedure should be stopped quickly after development.

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For this purpose, the substrate is swivelled for 30 seconds in **stopper AR 600-60**.

Optionally, the substrate may thereafter be rinsed for 30 seconds with DI water to remove all solvent residues.

Please note: Rigid rinsing procedures may lead to a collapse of smaller structures (see Fig. 3).

A post-bake at max. 130 °C for specific working steps results in improved etch stability during wet-chemical and plasma-chemical processes.

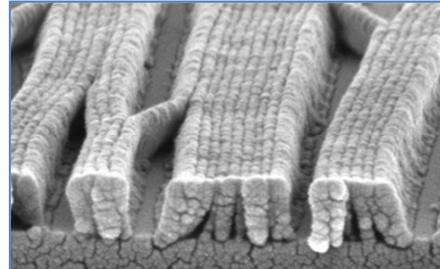


Fig. 3 Collapse of structures caused by too intense rinsing

Lift-off structures

Resist CSAR 62 is well suitable to produce lift-off structures with resolutions in a range down to 10 nm. If the dose is increased by a factor of 1.5-2, narrow trenches with defined undercut can be fabricated.

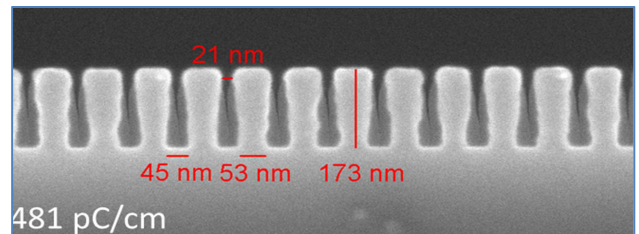


Fig. 4 Undercut structures due to increased dosage

After a vapour-deposition of metal and the subsequent easily performable lift-off, the metal structures remain.

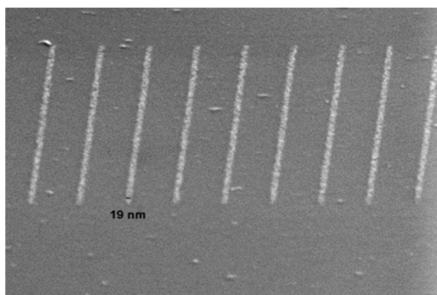


Fig. 5 19-nm metal lines after lift process

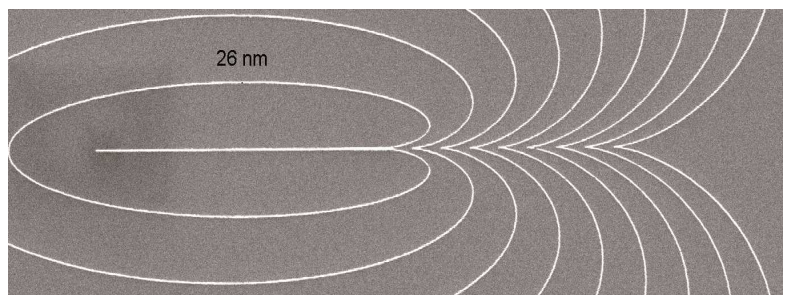


Fig. 6 CrAu test structures with a line width of 26 nm
(Dr. Büttner, MLU Halle)

Additional data for CSAR 62

Cauchy coefficients

The Cauchy coefficients are $N_0 = 1.542$ and $N_1 = 72$.

Plasma etch resistance

CSAR 62 is characterised by a high plasma etch resistance. Fig. 7 exemplarily shows the etch rates of SX AR-P 6200/2 in comparison to AR-P 3740 (positive photoresist), to AR-P 679.04 (PMMA e-beam resist), and to ZEP 520.

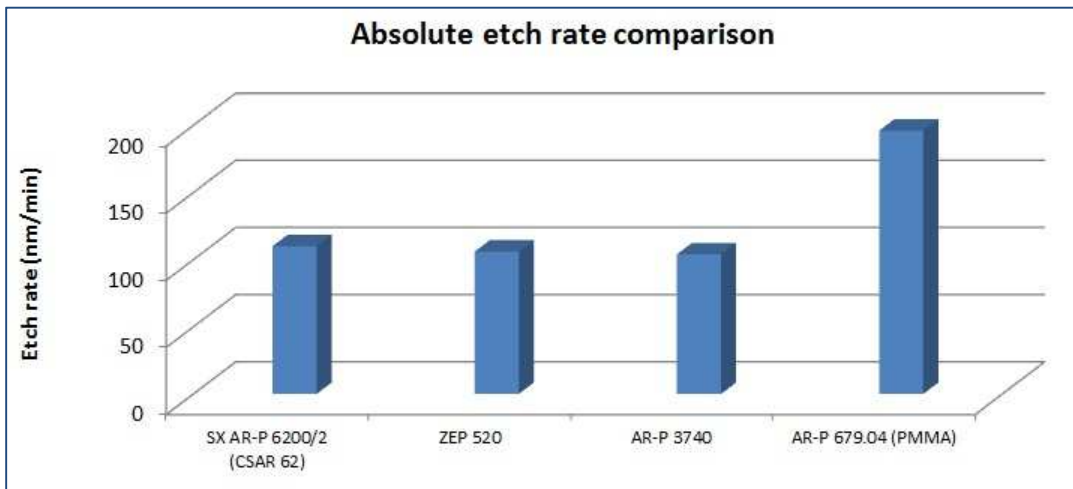


Fig. 7 Comparison of etch rates

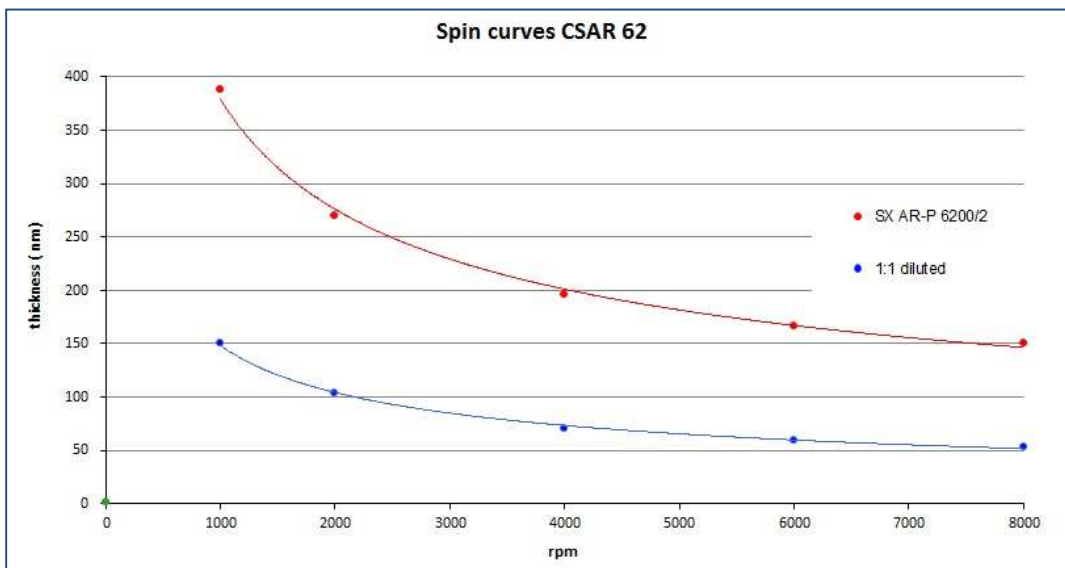


Fig. 8: Spin curves SX AR-P 6200/2 (10 % solid matter) and 1:1 diluted (5 % solid matter)

5. Cleaning and Removal

For the cleaning and removal of soft-baked substrates, polar solvent mixtures such as **remover AR 600-71** and **thinner AR 600-02** can be used. To remove hard-baked layers it is recommended to use the **remover AR 600-71** and **AR 300-72**. Very hard-baked layers (plasma processing or UV-stabilization) need a treatment with oxidizing acids or O₂ plasma.

6. Waste Water Disposal

Liquid or solid wastes have to be disposed at proper deposit places or by controlled combustion in officially authorized plants.

7. Safety References

Resists and thinner contain organic solvents. Adequate ventilation in the working area is demanded. Avoid direct contact with products and their vapours. Wear safety goggles and rubber gloves!

Further information is provided in our EC material safety data sheets.

As of: May 2013



Preliminary information of new product development:

Developer X AR 600-54/6 and AR 600-54/8 for e-beam resist SX AR-P 6200 (CSAR 62)

1. General description

Developers X AR 600-54 are colourless, organic solvent mixtures which are suitable for the development of electron beam exposed structures of the e-beam resist CSAR 62.

Using **developer X AR 600-54/8**, exposed structures can be developed more rapidly, while a higher contrast is achieved in the slower development process with **developer X AR 600-54/6**.

Properties	X AR	600-54/6	600-54/8
Density (20 °C)	g/cm ³	0,876	0,917
Water content max.	%	0,1	0,1
Non-volatile matter max.	%	0,002	0,002
Flash point	°C	41	16
Grade of filtration	µm	0,2	

3. Application information

For the development of exposed resist films of CSAR 62, both **developers X AR 600-54/6** and **X AR 600-54/8** are well suited. As weaker developer, **developer X AR 600-54/6** provides higher resolution, whereas a 6-fold higher sensitivity can be achieved with **X AR 600-54/8**.

Development times of 30 - 60 seconds at 21 - 23 °C are recommended for immersion development. If the **developer X AR 600-54/6** is used, even after 10 minutes no erosion of unexposed areas is measurable. **Developer X AR 600-54/8** attacks resist surfaces already after two minutes visibly. If however the development is carried out at temperatures around 0 °C, even after 10 minutes no erosion occurs (with loss of sensitivity).

The development should be terminated quickly with **stopper AR 600-60**.

4. Storage

Kept in sealed original containers and stored at a temperature between 10 – 22 °C the use of the developer is guaranteed for 6 month from date of sale.

5. Safety Information

Liquid or solid wastes have to be disposed at proper deposit places or by controlled combustion in officially authorized plants. The thinner is a mixtures of organic solvents. Adequate ventilation in the working area is demanded. Avoid direct contact with products and their vapours. Wear chemical goggles and protective gloves.

Further information is provided in our EC material safety data sheets.

As of: May 2013



Thinner AR 600-01, 600-02, 600-07, 600-09

For E-Beam Resists Series AR-P 600 and 6200

1. General Description

The Thinners AR 600-01, 600-02, 600-07 and 600-09 are colourless mixtures of organic solvents. They are used to adjust film thickness of e-beam resists of the series AR-P 600 and 6200. For dilution it is recommended to add the thinner to a beaker containing the resist and to homogenize this mixture by stirring.

The Thinners can also be used to strip for non hard baked resist layers and to clean the devices.

2. Parameters

Properties	AR	600-01	600-02	600-07	600-09
Density at 20 °C	g/cm ³	1.108	0.99	0.960	1.036
Water content max.	%	0.1	0.1	0.1	0.1
Non-volatile matter max.	%	0.005	0.005	0.005	0.005
Flash point	°C	28	43	38	46
Filtration	µm	0.2	0.2	0.2	0.2
Suitable for edge bead removal and for cleaning purposes	AR-P	631 - 671	632 – 672, 6200	617	639 – 679

3. Instructions for Processing

Stronger dilutions of the resists may result in gel formation of the polymers which leads to particles in the resist films during the coating process. Diluted resists should therefore be subjected to ultra-filtration (0.2 µm) prior to use. In most cases it is more advantageous to adjust the desired film thickness by varying the spin speed or to use a pre-adjusted resist. Special adjustments of film thickness values are possible on request and at extra charge.

4. Storage

Functionality guaranteed for 6 months from date of sale if stored dry at a constant temperature between 10 – 22 °C. That does not apply to opened containers. These should be closed air-tight after opening and used as soon as possible.

5. Safety Information

Thinners contain organic solvents, thus it is necessary to take care of an appropriate exchange of air in the working room. Avoid direct contact with products and their vapour! Wear chemical goggles and protective gloves! Please ask for safety data sheets!

As of May'13



Stopper AR 600-60, 600-6I for E-Beam Resists

I. General Description

The **Stopper AR 600-60** and **AR 600-6I** are a colourless mixture of organic solvents. The **AR 600-60** is used to stop the process of development of the E-Beam Resist Series **AR-P 600** and **CSAR 62**.

The Stopper **AR 600-6I** is suitable to stop development process of **AR-P 6510**.

The stopper removes all residues of the developer and leaves the developed structures unchanged.

2. Parameters	AR	600-60	600-6I
Density at 20 °C	g/cm ³	0.785	0.964
Water content max.	%	0,1	20
Non-volatile matter max.	%	0.002	0.002
Flash point	°C	12	105
Filtration	µm	0.2	

3. Instructions for Processing

During processing small amounts of developer will continuously contaminate the stopper bath and thus influence the efficiency of stopping. A constant change of the stopper or the use of two consecutive bathes is highly recommended.

By adding the **Stopper AR 600-60** (10 - 20 % of the developer volume) to the **Developers AR 600-50, AR 600-55 and AR 600-56** a decrease of the development of AR-P 600 speed can be achieved.

4. Storage

Functionality guaranteed for 6 months from date of sale if stored dry at a constant temperature between 10 - 22°C. That does not apply to opened containers; these should be closed air-tight after opening and used as soon as possible.

5. Safety Information

Stoppers contain organic solvents. Adequate ventilation in the working area is demanded. Avoid direct contact with products and their vapours. Wear chemical goggles and protective gloves!

Please ask for safety data sheets!

As of July. '12



Remover AR 600-70, 600-71 and AR 300-70, 300-72, 300-73 Stripping of resist layers

I. General Description

The Remover AR 600-70, 600-71 and AR 300-70, 300-72 are colourless clear solutions for stripping resists based on methyl methacrylate/ methacrylic acid or styreneacrylate (E-Beam Resist) as well as diazonaphtho-quinone/ novolac (common positive photoresist).

All removers are suitable for unbaked as well as baked resists. The Remover AR 600-70 is the usual standard version. The Remover AR 300-70 is used for special applications such as stripping of higher baked e-beam resists and metal vapour deposited resists in lift-off process (for example the lift-off resist AR-P 5350). The newly offered Remover AR 600-71 is particularly efficient for the removal of hard baked (up to 210 °C) e-beam resist layers and baked (up to 170 °C) photoresist films.

The Remover AR 300-72 and 300-73 are created for the new resist systems CAR 44 and AR-P 5400. Additionally AR 300-72 removes thin and very strong adhesive resist layers.

The remover AR 300-70 and 300-72 and AR 600-70, 600-71 contain organic solvents, the AR 300-73 is an aqueous-alkaline remover. These four removers do not contain phenol or halogen; they are metal ion free and mixable with water.

2. Parameters

Properties / Remover	AR	600-70	600-71 new	300-70	300-72	300-73
				Can be heated to 80°C	Can be heated to 80°C	
Density (20 °C)	g/cm ³	0,79	1,02	1,03	1,03	1,00
Non-volatile matter max.	%	0,002	0,002	0,002	0,002	0,002
Flash point	°C	-16	-4	97	98	-
Filtration	µm			0,2		

Suitable as AR Remover for AR Photoresists:

no bake-step required		suitable	suitable	suitable	suitable	suitable
Time for removal in case of 1.5 µm; 25 °C	s	5	5	5	5	5
baked at 150-170 °C		suitable	suitable	suitable	suitable	suitable
Time for removal in case of 1.5 µm; 25 °C	s	30	5 ... 15	15	15	20
baked at 180-210 °C		not suitable	not suitable	suitable	suitable	not suitable
Time for removal in case of 1.5 µm; 50 °C	s	-	-	120	120	-

Suitable as AR Remover for AR E-Beam Resists:

baked at 150-170 °C, PMMA		suitable	suitable	suitable	suitable	not suitable
Time for removal in case of 1.5 µm; 25 °C	min	5	3	10	10	-
baked at 190-210 °C, Copol.		Fit for certain duties only	suitable	Fit for certain duties only	Fit for certain duties only	Fit for certain duties only
Time for removal in case of 1.5 µm; 25 °C	min	15	10	20	15	15
baked at: 150-210 °C, CSAR 62		not suitable	suitable	suitable	suitable	not suitable
Time for removal in case of 0.2 µm; 25 °C	min	-	0,3	3	2	-



3. Instruction for Processing

AR 600-70, 600-71, 300-70, 300-72, 300-73

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Owing to very different processing technologies these introductions are only of exemplary character. It is recommended to test the remover in the given context.

Resist coatings can be removed by immersion in the **Remover AR 600-70, 600-71** or the **Remover AR 300-70** (puddle, dip). Stripping rate depends on previous heat treatment, thickness of resist layer and temperature of the remover. Unbaked resists are stripped in a few seconds, baked coatings require minutes (☞ table, the times are only examples!). To reduce the stripping time it is possible to heat the **removers AR 300-70 and 300-72** up to 80 °C.

The **Remover AR 600-70, AR 300-70, 300-72 and 300-73** can be rinsed either with deionized water, clean remover or with a suitable thinner according to the used technology.

In cases of hard-baked or cured resist coatings the use of oxidizing acids or oxygen plasma stripping is recommended.

4. Storage

Unopened original containers of **Remover AR 600-70, 300-70, 300-72 and 300-73** should be stored in a dry place and at a temperature between 10-22 °C, **Remover AR 600-71** at a temperature between 10-18 °C. Under these conditions, usability of the remover is guaranteed for at least 6 month from date of sale.

5. Safety References

The Remover AR 300-70, 300-72 and AR 600-70, 600-71 are mixtures of organic solvents. Adequate ventilation in the working area is demanded. Avoid direct contact with products and their vapours.

Avoid contact with the remover **AR 300-73**. Solutions of this remover are alkaline caustic liquids that attack the skin. Wear chemical goggles and protective gloves.

Please ask for safety data sheets!

As of May '13



Adhesion Promoters for resists AR 300-80 and HMDS

1. General Description

The **Adhesion Promoters AR 300-80** and **HMDS** can be used for improving the adhesion of photo- and e-beam resists. **The Promoter AR 300-80** contains a silicon organic compound diphenylsilandiole dissolved in a mixture of safer solvent propylene glycol methyl ether acetate. The well known HMDS consists only of hexamethyldisilazane. The coating takes place by evaporation.

The AR 300-80 is a fine, simple and cheap alternative to the HMDS. In most cases it generates better adhesion for known critical substrate surfaces (e.g. metals, SiO₂ or GaAs) than HMDS.

2. Instructions for Processing

AR 300-80: The AR 300-80 has a very simple application. Normal spin coating can be used for deposition (1,000-6,000 rpm). The thickness of diphenylsilandiole depends on speed of rotation. We recommend high speed of rotation (low concentration of diphenylsilandiole, 4,000-6,000 rpm). A too high concentration can decrease the adhesion.

Coated substrates should be prebaked on hot plate (2 min) or in convection oven (25 min) at a temperature of 180 °C. The bake generates a very smooth and thin layer (< 30 nm).

Photoresists or protective coatings can be spin coated after substrates are cooled down.

HMDS: HMDS can evaporate by room temperature or by temperatures up to 160 °C.

The vapour forms a monomolecular layer (< 5 nm). The substrate can be used for coating without a following bake. The application of HMDS needs the corresponding equipment.

3. Storage

Stability of adhesion promoters is limited by absorption of atmospheric humidity. Therefore storage in open bottles is to be avoided. Complete functionality of adhesion promoters is guaranteed for 6 months from date of sale if kept in sealed original containers and stored dry at a constant temperature between 10 - 22 °C.

4. Safety Information

Liquid wastes have to be disposed at proper deposit places or by controlled combustion in officially authorized plants. The adhesion promoters are mixtures of organic solvents. Take care for good ventilation in the working area and avoid contact with the products and their vapours! Wear chemical goggles and protective gloves.

Please ask for safety data sheets!

As of Jan. '07