

PHOTORESIST REMOVAL

Usually, photoresists are used only as a temporary mask for structuring steps. The last lithography step is therefore usually the removal of the resist mask. On the one hand, this is to be done quickly and without residue, but on the other hand neither the substrate nor the materials already deposited thereon are to be attacked, which is not always an easy task to solve.

This chapter describes which remover is suitable for which photoresists according to which process steps for which substrate materials.

Solubility of Photoresist Films

Non-cross-linked AZ® and TI photoresist films generally can be removed without residue after processing using common removers. If this does not work satisfyingly, the following possible reasons should be considered:

Positive resists begin to thermally cross-link from about 140°C (e.g. during hardbaking, dry etching or coating), which greatly reduces their solubility. If possible, the applied temperatures should be reduced.

An optically induced cross-linking can render resists insoluble by means of deep-UV radiation (wavelength < 250 nm) in combination with higher temperatures. Such conditions may prevail during evaporative coating of e. g. metals, sputtering or dry etching. Due to the low penetration depth of the very short-wave radiation, only the surface of the resist structures is affected by the cross-linking.

The cross-linking intended for negative resists can be amplified by subsequent process steps at higher temperatures, which further complicates the subsequent removal of the resist film. The material re-deposited on the photoresist during dry etching can act as barrier for the stripper and thus prevent the resist film from being removed.

Solvents as Removers

Acetone

Acetone is generally not recommended for the removal of photoresist films because of its high vapour pressure. If acetone is to be used, it is advisable to rinse the acetone contaminated with resist with isopropanol before the acetone evaporates and forms streaks. It is not advisable to heat the acetone to increase the solubility because of the high risk of fire due to its high vapour pressure.

NMP

NMP (1-methyl-2-pyrrolidone) is a generally suitable solvent for removing photoresist layers. The very low vapour pressure of NMP allow heating to 80°C in order to be able to remove even more cross-linked photoresist films. Since NMP has been classified as toxic, alternatives should be considered, such as DMSO.

DMSO

DMSO (dimethyl sulfoxide) heated to 60- 80°C has good performance as photoresist stripper comparable to the performance of NMP, and is a kind of "safer-solvent" substitute for NMP. We have introduced DMSO in semiconductor quality in our product range. Please ask us if you are interested in specifications and/or a sample!

Alkaline Media as Removers

If the chemical stability of the substrate allows for it and no special remover is to be used, aqueous alkaline media such as 2-3% KOH or NaOH (typical developer concentrates) may be used at room temperature to remove photoresist layers as an alternative. Cross-linked photoresist films may also require higher concentrations and / or temperatures.

However, it is to be noted that many metals are etched at high pH values and crystalline silicon is also attacked by highly concentrated alkaline media.

Ready-to-use Strippers

AZ® 100 Remover

AZ® 100 Remover is an amine / solvent mixture and a standard remover for AZ® and TI photoresists. To improve its performance, AZ® 100 Remover can be heated to 60 - 80°C to improve its performance.

TechniStrip® P1316 and P1331

TechniStrip® P1316 for alkaline insensitive, and P1331 for alkaline sensitive substrates are strippers with a very high performance for

- Novolak-based resists (including all AZ® positive resists)
- Epoxy-based resists
- Polyimide, "Bonding glues"
- Dry films

At typical application temperatures of around 75°C, TechniStrip® P1316 dissolves strongly cross-linked resists, also e.g. through dry etching or ion implantation in a few minutes without residues. TechniStrip® P1316 and P1331 can also be used in spraying processes.

TechniStrip® NI555

TechniStrip® NI555 is a stripper with very high performance for Novolak-based negative resists and very thick positive resists like

- AZ® nLOF 2000
- AZ® 15 nXT
- AZ® 40 XT

TechniStrip® NI555 is designed not only to peel cross-linked resists, but also to completely dissolve them without residues. This prevents contamination of the basin and filter by resist fragments, as can occur with standard strippers.

O₂ Combustion

If wet-chemical removers are either not suitable or generally not desired because of a too high cross-linking of the photoresist film, photoresists can also be combusted in O₂ plasma.

Our Photoresists: Application Areas and Compatibilities

Recommended Applications ¹		Resist Family	Photoresists	Resist Film Thickness ²	Recommended Developers ³	Recommended Removers ⁴
Positive	Improved adhesion for wet etching, no focus on steep resist sidewalls	AZ [®] 1500	AZ [®] 1505	≈ 0.5 μm	AZ [®] 351B, AZ [®] 326 MIF, AZ [®] 726 MIF, AZ [®] Developer	AZ [®] 100 Remover, TechniStrip [®] P1316, TechniStrip [®] P1331
			AZ [®] 1512 HS	≈ 1.0 - 1.5 μm		
			AZ [®] 1514 H	≈ 1.2 - 2.0 μm		
			AZ [®] 1518	≈ 1.5 - 2.5 μm		
	AZ [®] 4500	AZ [®] 4533	≈ 3 - 5 μm	AZ [®] 400K, AZ [®] 326 MIF, AZ [®] 726 MIF, AZ [®] 826 MIF		
		AZ [®] 4562	≈ 5 - 10 μm			
	AZ [®] P4000	AZ [®] P4110	≈ 1 - 2 μm	AZ [®] 400K, AZ [®] 326 MIF, AZ [®] 726 MIF, AZ [®] 826 MIF		
AZ [®] P4330		≈ 3 - 5 μm				
AZ [®] P4620	≈ 6 - 20 μm					
AZ [®] P4903	≈ 10 - 30 μm					
AZ [®] PL 177	AZ [®] PL 177	≈ 3 - 8 μm	AZ [®] 351B, AZ [®] 400K, AZ [®] 326 MIF, AZ [®] 726 MIF, AZ [®] 826 MIF			
Spray coating	AZ [®] 4999		≈ 1 - 15 μm	AZ [®] 400K, AZ [®] 326 MIF, AZ [®] 726 MIF, AZ [®] 826 MIF		
Dip coating	MC Dip Coating Resist		≈ 2 - 15 μm	AZ [®] 351B, AZ [®] 400K, AZ [®] 326 MIF, AZ [®] 726 MIF, AZ [®] 826 MIF		
Steep resist sidewalls, high resolution and aspect ratio for e. g. dry etching or plating	AZ [®] ECI 3000	AZ [®] ECI 3007	≈ 0.7 μm	AZ [®] 351B, AZ [®] 326 MIF, AZ [®] 726 MIF, AZ [®] Developer		
		AZ [®] ECI 3012	≈ 1.0 - 1.5 μm			
		AZ [®] ECI 3027	≈ 2 - 4 μm			
AZ [®] 9200	AZ [®] 9245	≈ 3 - 6 μm	AZ [®] 400K, AZ [®] 326 MIF, AZ [®] 726 MIF			
	AZ [®] 9260	≈ 5 - 20 μm				
Elevated thermal softening point and high resolution for e. g. dry etching	AZ [®] 701 MiR	AZ [®] 701 MiR (14 cPs) AZ [®] 701 MiR (29 cPs)	≈ 0.8 μm ≈ 2 - 3 μm	AZ [®] 351B, AZ [®] 326 MIF, AZ [®] 726 MIF, AZ [®] Developer		
Positive (Chem. amplified)	Steep resist sidewalls, high resolution and aspect ratio for e. g. dry etching or plating	AZ [®] XT	AZ [®] 12 XT-20PL-05	≈ 3 - 5 μm	AZ [®] 400K, AZ [®] 326 MIF, AZ [®] 726 MIF	
			AZ [®] 12 XT-20PL-10	≈ 6 - 10 μm		
AZ [®] 12 XT-20PL-20	≈ 10 - 30 μm					
AZ [®] 40 XT	≈ 15 - 50 μm					
AZ [®] IPS 6050			≈ 20 - 100 μm			
Image Re-verseal	Elevated thermal softening point and undercut for lift-off applications	AZ [®] 5200	AZ [®] 5209	≈ 1 μm	AZ [®] 351B, AZ [®] 326 MIF, AZ [®] 726 MIF	
			AZ [®] 5214	≈ 1 - 2 μm		
		TI	TI 35ESX	≈ 3 - 4 μm		
TI xLift-X	≈ 4 - 8 μm					
Negative (Cross-linking)	Negative resist sidewalls in combination with no thermal softening for lift-off application	AZ [®] nLOF 2000	AZ [®] nLOF 2020	≈ 1.5 - 3 μm	AZ [®] 326 MIF, AZ [®] 726 MIF, AZ [®] 826 MIF	
			AZ [®] nLOF 2035	≈ 3 - 5 μm		
	AZ [®] nLOF 2070	≈ 6 - 15 μm				
	AZ [®] nLOF 5500	AZ [®] nLOF 5510	≈ 0.7 - 1.5 μm			
Improved adhesion, steep resist sidewalls and high aspect ratios for e. g. dry etching or plating	AZ [®] nXT	AZ [®] 15 nXT (115 cPs)	≈ 2 - 3 μm	AZ [®] 326 MIF, AZ [®] 726 MIF, AZ [®] 826 MIF		
		AZ [®] 15 nXT (450 cPs)	≈ 5 - 20 μm			
AZ [®] 125 nXT		≈ 20 - 100 μm	AZ [®] 326 MIF, AZ [®] 726 MIF, AZ [®] 826 MIF			

¹ In general, almost all resists can be used for almost any application. However, the special properties of each resist family makes them specially suited for certain fields of application.

² Resist film thickness achievable and processable with standard equipment under standard conditions. Some resists can be diluted for lower film thicknesses; with additional effort also thicker resist films can be achieved and processed.

³ Metal ion free (MIF) developers are significantly more expensive, and reasonable if metal ion free development is required.

Our Developers: Application Areas and Compatibilities

Inorganic Developers

(typical demand under standard conditions approx. 20 L developer per L photoresist)

AZ[®] Developer is based on sodium phosphate and –metasilicate, is optimized for minimal aluminum attack and is typically used diluted 1 : 1 in DI water for high contrast or undiluted for high development rates. The dark erosion of this developer is slightly higher compared to other developers.

AZ[®] 351B is based on buffered NaOH and typically used diluted 1 : 4 with water, for thick resists up to 1 : 3 if a lower contrast can be tolerated.

AZ[®] 400K is based on buffered KOH and typically used diluted 1 : 4 with water, for thick resists up to 1 : 3 if a lower contrast can be tolerated.

AZ[®] 303 specifically for the AZ[®] 111 XFS photoresist based on KOH / NaOH is typically diluted 1 : 3 - 1 : 7 with water, depending on whether a high development rate, or a high contrast is required

Metal Ion Free (TMAH-based) Developers

(typical demand under standard conditions approx. 5 - 10 L developer concentrate per L photoresist)

AZ[®] 326 MIF is 2.38 % TMAH- (TetraMethylAmmoniumHydroxide) in water.

AZ[®] 726 MIF is 2.38 % TMAH- (TetraMethylAmmoniumHydroxide) in water, with additional surfactants for rapid and uniform wetting of the substrate (e. g. for puddle development)

AZ[®] 826 MIF is 2.38 % TMAH- (TetraMethylAmmoniumHydroxide) in water, with additional surfactants for rapid and uniform wetting of the substrate (e. g. for puddle development) and other additives for the removal of poorly soluble resist components (residues with specific resist families), however at the expense of a slightly higher dark erosion.

Our Removers: Application Areas and Compatibilities

AZ[®] 100 Remover is an amine solvent mixture and standard remover for AZ[®] and TI photoresists. To improve its performance, AZ[®] 100 remover can be heated to 60 - 80°C. Because the AZ[®] 100 Remover reacts highly alkaline with water, it is suitable for this with respect to sensitive substrate materials such as Cu, Al or ITO only if contamination with water can be ruled out..

TechniStrip[®] P1316 is a remover with very strong stripping power for Novolak-based resists (including all AZ[®] positive resists), epoxy-based coatings, polyimides and dry films. At typical application temperatures around 75°C, TechniStrip[®] P1316 may dissolve cross-linked resists without residue also, e.g. through dry etching or ion implantation. TechniStrip[®] P1316 can also be used in spraying processes. For alkaline sensitive materials, TechniStrip[®] P1331 would be an alternative to the P1316. Nicht kompatibel mit Au oder GaAs.

TechniStrip[®] P1331 can be an alternative for TechniStrip[®] P1316 in case of alkaline sensitive materials. TechniStrip[®] P1331 is not compatible with Au or GaAs.

TechniStrip[®] NI555 is a stripper with very strong dissolving power for Novolak-based negative resists such as the AZ[®] 15 nXT and AZ[®] nLOF 2000 series and very thick positive resists such as the AZ[®] 40 XT. TechniStrip[®] NI555 was developed not only to peel cross-linked resists, but also to dissolve them without residues. This prevents contamination of the basin and filter by resist particles and skins, as can occur with standard strippers. TechniStrip[®] NI555 is not compatible with Au or GaAs.

TechniClean[™] CA25 is a semi-aqueous proprietary blend formulated to address post etch residue (PER) removal for all interconnect and technology nodes. Extremely efficient at quickly and selectively removing organo-metal oxides from Al, Cu, Ti, TiN, W and Ni.

TechniStrip[™] NF52 is a highly effective remover for negative resists (liquid resists as well as dry films). The intrinsic nature of the additives and solvent make the blend totally compatible with metals used throughout the BEOL interconnects to WLP bumping applications.

TechniStrip[™] Micro D2 is a versatile stripper dedicated to address resin lift-off and dissolution on negative and positive tone resist. The organic mixture blend has the particularity to offer high metal and material compatibility allowing to be used on all stacks and particularly on fragile III/V substrates for instance.

TechniStrip[™] MLO 07 is a highly efficient positive and negative tone photoresist remover used for IR, III/V, MEMS, Photonic, TSV mask, solder bumping and hard disk stripping applications. Developed to address high dissolution performance and high material compatibility on Cu, Al, Sn/Ag, Alumina and common organic substrates.

Our Wafers and their Specifications

Silicon-, Quartz-, Fused Silica and Glass Wafers

Silicon wafers are either produced via the Czochralski- (CZ-) or Float zone- (FZ-) method. The more expensive FZ wafers are primarily reasonable if very high-ohmic wafers (> 100 Ohm cm) are required.

Quartz wafers are made of monocrystalline SiO₂, main criterion is the crystal orientation (e. g. X-, Y-, Z-, AT- or ST-cut)

Fused silica wafers consist of amorphous SiO₂. The so-called JGS2 wafers have a high transmission in the range of ≈ 280 - 2000 nm wavelength, the more expensive JGS1 wafers at ≈ 220 - 1100 nm.

Our glass wafers, if not otherwise specified, are made of borosilicate glass.

Specifications

Common parameters for all wafers are diameter, thickness and surface (1- or 2-side polished). Fused silica wafers are made either of JGS1 or JGS2 material, for quartz wafers the crystal orientation needs to be defined. For silicon wafers, beside the crystal orientation (<100> or <111>) the doping (n- or p-type) as well as the resistivity (Ohm cm) are selection criteria.

Prime-, Test-, and Dummy Wafers

Silicon wafers usually come as „Prime-grade“ or „Test-grade“, latter mainly have a slightly broader particle specification. „Dummy-Wafers“ neither fulfill Prime- nor Test-grade for different possible reasons (e. g. very broad or missing specification of one or several parameters, reclaim wafers, no particle specification) but might be a cheap alternative for e. g. resist coating tests or equipment start-up.

Our Silicon-, Quartz-, Fused Silica and Glass Wafers

Our frequently updated wafer stock list can be found here: [è www.microchemicals.com/products/wafers/waferlist.html](http://www.microchemicals.com/products/wafers/waferlist.html)

Further Products from our Portfolio

Plating

Plating solutions for e. g. gold, copper, nickel, tin or palladium: [è www.microchemicals.com/products/electroplating.html](http://www.microchemicals.com/products/electroplating.html)

Solvents (MOS, VLSI, ULSI)

Acetone, isopropyl alcohol, MEK, DMSO, cyclopentanone, butylacetate, ... [è www.microchemicals.com/products/solvents.html](http://www.microchemicals.com/products/solvents.html)

Acids and Bases (MOS, VLSI, ULSI)

Hydrochloric acid, sulphuric acid, nitric acid, KOH, TMAH, ... [è www.microchemicals.com/products/etchants.html](http://www.microchemicals.com/products/etchants.html)

Etching Mixtures

for e. g. chromium, gold, silicon, copper, titanium, ... [è www.microchemicals.com/products/etching_mixtures.html](http://www.microchemicals.com/products/etching_mixtures.html)

Further Information

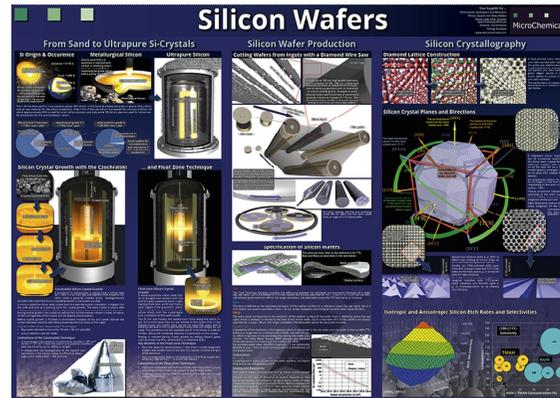
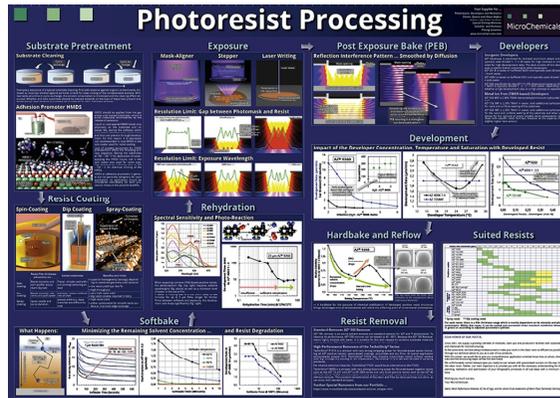
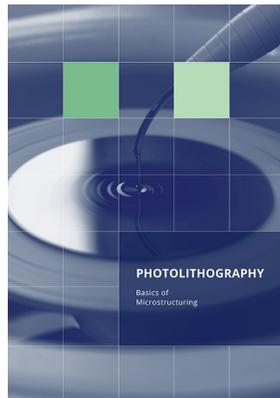
Technical Data Sheets:

www.microchemicals.com/downloads/product_data_sheets/photoresists.html

Material Safety Data Sheets (MSDS):

www.microchemicals.com/downloads/safety_data_sheets/msds_links.html

Our Photolithography Book and -Posters



We see it as our main task to make you understand all aspects of microstructuring in an application-oriented way.

At present, we have implemented this claim with our book **Photolithography** on over 200 pages, as well as attractively designed DIN A0 posters for your office or laboratory.

We will gladly send both of these to you free of charge as our customer (if applicable, we charge shipping costs for non-European deliveries):

www.microchemicals.com/downloads/brochures.html

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