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.
### Inorganic Developers

**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

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

### Our Photoresists: Application Areas and Compatibilities

<table>
<thead>
<tr>
<th>Recommended Applications</th>
<th>Resist Family</th>
<th>Resist Film Thickness</th>
<th>Recommended Developers</th>
<th>Recommended Removers</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Positive</strong></td>
<td>AZ® 1500</td>
<td>AZ® 1505</td>
<td>0.5 µm</td>
<td>AZ® 351B, AZ® 326 MIF, AZ® 726 MIF, AZ® 826 MIF</td>
</tr>
<tr>
<td>Improved adhesion for wet etching, no focus on steep resist sidewalls</td>
<td>AZ® 1512 HS</td>
<td>AZ® 1514 H</td>
<td>1.0 - 1.5 µm</td>
<td></td>
</tr>
<tr>
<td></td>
<td>AZ® 1518</td>
<td></td>
<td>1.5 - 2.5 µm</td>
<td></td>
</tr>
<tr>
<td></td>
<td>AZ® 4400</td>
<td>AZ® 4533</td>
<td>3 - 5 µm</td>
<td>AZ® 351B, AZ® 326 MIF, AZ® 726 MIF, AZ® 826 MIF</td>
</tr>
<tr>
<td>Spray coating</td>
<td>AZ® 4562</td>
<td></td>
<td>5 - 10 µm</td>
<td></td>
</tr>
<tr>
<td></td>
<td>AZ® 4400</td>
<td>AZ® 4530</td>
<td>1 - 2 µm</td>
<td>AZ® 400K, AZ® 326 MIF, AZ® 726 MIF, AZ® 826 MIF</td>
</tr>
<tr>
<td></td>
<td></td>
<td>AZ® 4560</td>
<td>3 - 5 µm</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>AZ® 4565</td>
<td>6 - 20 µm</td>
<td></td>
</tr>
<tr>
<td></td>
<td>AZ® 4567</td>
<td></td>
<td>10 - 30 µm</td>
<td></td>
</tr>
<tr>
<td></td>
<td>AZ® 4400</td>
<td>AZ® 4530</td>
<td>3 - 5 µm</td>
<td>AZ® 351B, AZ® 400K, AZ® 326 MIF, AZ® 726 MIF, AZ® 826 MIF</td>
</tr>
<tr>
<td></td>
<td></td>
<td>AZ® 4560</td>
<td>6 - 20 µm</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>AZ® 4567</td>
<td>10 - 30 µm</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>AZ® 4400</td>
<td>AZ® 4530</td>
<td>AZ® 351B, AZ® 400K, AZ® 326 MIF, AZ® 726 MIF, AZ® 826 MIF</td>
</tr>
<tr>
<td>AZ® PL 177</td>
<td>AZ® PL 177</td>
<td>5 - 8 µm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AZ® 4999</td>
<td></td>
<td>1 - 15 µm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dip coating</td>
<td>MC Dip Coating Resist</td>
<td></td>
<td>2 - 15 µm</td>
<td>AZ® 351B, AZ® 400K, AZ® 326 MIF, AZ® 726 MIF, AZ® 826 MIF</td>
</tr>
<tr>
<td></td>
<td>AZ® ECI 3000</td>
<td>AZ® ECI 3007</td>
<td>0.7 - 1.5 µm</td>
<td>AZ® 351B, AZ® 326 MIF, AZ® 726 MIF, AZ® 826 MIF</td>
</tr>
<tr>
<td></td>
<td>AZ® ECI 3012</td>
<td>AZ® ECI 3027</td>
<td>1.0 - 1.5 µm</td>
<td>AZ® 351B, AZ® 326 MIF, AZ® 726 MIF, AZ® 826 MIF</td>
</tr>
<tr>
<td></td>
<td>AZ® 9200</td>
<td>AZ® 9245</td>
<td>2 - 4 µm</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>AZ® 9260</td>
<td>3 - 6 µm</td>
<td>AZ® 400K, AZ® 326 MIF, AZ® 726 MIF</td>
</tr>
<tr>
<td></td>
<td></td>
<td>AZ® 9270</td>
<td>5 - 20 µm</td>
<td></td>
</tr>
<tr>
<td></td>
<td>AZ® 701 MR (14 cPs)</td>
<td>AZ® 701 MR (29 cPs)</td>
<td>0.8 µm</td>
<td>AZ® 351B, AZ® 326 MIF, AZ® 726 MIF, AZ® 826 MIF</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2 - 3 µm</td>
<td></td>
</tr>
<tr>
<td><strong>Positive (chem. amplified)</strong></td>
<td>AZ® XT</td>
<td>AZ® 12 XT-20PL-05</td>
<td>3 - 5 µm</td>
<td>AZ® 351B, AZ® 326 MIF, AZ® 726 MIF, AZ® 826 MIF</td>
</tr>
<tr>
<td>Steep resist sidewalls, high resolution and aspect ratio for e. g. dry etching or plating</td>
<td>AZ® 12 XT-20PL-10</td>
<td></td>
<td>6 - 10 µm</td>
<td></td>
</tr>
<tr>
<td></td>
<td>AZ® 12 XT-20PL-20</td>
<td></td>
<td>10 - 30 µm</td>
<td></td>
</tr>
<tr>
<td></td>
<td>AZ® 40 XT</td>
<td></td>
<td>15 - 50 µm</td>
<td></td>
</tr>
<tr>
<td>Dip coating</td>
<td>AZ® IPS 6050</td>
<td></td>
<td>20 - 100 µm</td>
<td></td>
</tr>
<tr>
<td><strong>Image Reversal</strong></td>
<td>AZ® 5200</td>
<td>AZ® 5209</td>
<td>1.0 µm</td>
<td>AZ® 351B, AZ® 326 MIF, AZ® 726 MIF</td>
</tr>
<tr>
<td>Elevated thermal softening point and undercut for lift-off applications</td>
<td>AZ® 5214</td>
<td></td>
<td>1.2 - 2.5 µm</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ti</td>
<td>Ti 35S4X</td>
<td>3 - 4 µm</td>
<td>AZ® 351B, AZ® 326 MIF, AZ® 726 MIF</td>
</tr>
<tr>
<td></td>
<td>Ti xLift-X</td>
<td></td>
<td>4 - 8 µm</td>
<td>TechniStrip® P1331</td>
</tr>
<tr>
<td><strong>Negative (Cross-linking)</strong></td>
<td>AZ® nLOF 2000</td>
<td>AZ® nLOF 2020</td>
<td>1.5 - 3 µm</td>
<td>AZ® 326 MIF, AZ® 726 MIF, AZ® 826 MIF</td>
</tr>
<tr>
<td>Negative resist sidewalls in combination with no thermal softening for lift-off application</td>
<td>AZ® nLOF 2035</td>
<td></td>
<td>3 - 5 µm</td>
<td></td>
</tr>
<tr>
<td></td>
<td>AZ® nLOF 2070</td>
<td></td>
<td>6 - 15 µm</td>
<td></td>
</tr>
<tr>
<td></td>
<td>AZ® nLOF 5510</td>
<td></td>
<td>0.7 - 1.5 µm</td>
<td></td>
</tr>
<tr>
<td></td>
<td>AZ® nLOF 5500</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Improved adhesion, steep resist sidewalls and high aspect ratios for e. g. dry etching or plating</td>
<td>AZ® 15 nXT (115 cPs)</td>
<td></td>
<td>2 - 3 µm</td>
<td>AZ® 326 MIF, AZ® 726 MIF, AZ® 826 MIF</td>
</tr>
<tr>
<td></td>
<td>AZ® 15 nXT (450 cPs)</td>
<td></td>
<td>5 - 20 µm</td>
<td></td>
</tr>
<tr>
<td></td>
<td>AZ® 125 nXT</td>
<td></td>
<td>20 - 100 µm</td>
<td>AZ® 326 MIF, AZ® 726 MIF, AZ® 826 MIF</td>
</tr>
</tbody>
</table>

1. Recommended development volumes depend on the resist thickness and the process conditions, and can be adjusted as necessary.
2. Resists can be diluted with any water-compatible solvent appropriate for the thickness of the resist film.
3. Metal on free (MIF) developers are significantly more expensive, and reasonable if metal free development is required.
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 positive 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® P1316 would be an alternative to the P1316. Nicht kompatibel mit Au oder GaAs.

TechniStrip® P1313 can be an alternative for TechniStrip® P1316 in case of alkaline sensitive materials. TechniStrip® P1313 is not compatible with Au or GaAs.

TechniStrip® N155 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® N155 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® N155 is not compatible with 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™ NFS2 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: É www.microchemicals.com/products/wafers/waferlist.html

Further Products from our Portfolio

Plating

Plating solutions for e.g. gold, copper, nickel, tin or palladium: É www.microchemicals.com/products/electroplating.html

Solvents (MOS, VLSI, ULSI)

Acetone, isopropyl alcohol, MEK, DMCS, cyclopentanone, butylacetate, ... É www.microchemicals.com/products/solvents.html

Acids and Bases (MOS, VLSI, ULSI)

Hydrochloric acid, sulphuric acid, nitric acid, KOH, TMAH,... É www.microchemicals.com/products/etchants.html

Etching Mixtures

for e.g. chromium, gold, silicon, copper, titanium,... É www.microchemicals.com/products/etching_mixtures.html
Further Information


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
www.microchemicals.com/downloads/posters.html
Thank you for your interest!

Disclaimer of Warranty & Trademarks

All information, process descriptions, recipes, etc. contained in this document are compiled to the best of our knowledge. Nevertheless, we can not guarantee the correctness of the information. Particularly with regard to the formulations for chemical (etching) processes we assume no guarantee for the correct specification of the components, the mixing conditions, the preparation of the batches and their application. The safe sequence of mixing components of a recipe usually does not correspond to the order of their listing. We do not warrant the full disclosure of any indications (among other things, health, work safety) of the risks associated with the preparation and use of the recipes and processes. The information in this book is based on our current knowledge and experience. Due to the abundance of possible influences in the processing and application of our products, they do not exempt the user from their own tests and trials. A guarantee of certain properties or suitability for a specific application can not be derived from our data. As a matter of principle, each employee is required to provide sufficient information in advance in the appropriate cases in order to prevent damage to persons and equipment. All descriptions, illustrations, data, conditions, weights, etc. can be changed without prior notice and do not constitute a contractually agreed product characteristics. The user of our products is responsible for any proprietary rights and existing laws.

Merck, Merck Performance Materials, AZ, the AZ logo, and the vibrant M are trademarks of Merck KGaA, Darmstadt, Germany

MicroChemicals GmbH
Nicolaus-Otto-Str. 39
89079, Ulm
Germany
Fon: +49 (0)731 977 343 0
Fax: +49 (0)731 977 343 29
e-Mail: info@microchemicals.net
Internet: www.microchemicals.net