DIP COATING

Dip coating is usually used if either the type or size of the substrates to be coated are neither suitable for spin-coating nor spray coating; or the photoresist represents a significant cost factor and requires a reduction of resist consumption per substrate.

This chapter describes the technology of dip coating and gives explanations and answers to common problems relating to this coating technique.

**Principle of Dip Coating**

**Basic Principle of Dip Coating**

During dip coating, the substrate is usually vertically lifted out of a cuvette filled with resist. The solvent-rich resist film just formed thins out in the solvent-saturated atmosphere above the resist level. In the saturated solvent atmosphere directly above the resist bath (Fig. 63), the formed resist film first flows downward. Only when enough solvent has evaporated from the resist film does the thinning end. Thus, the resist film thickness can be adjusted by means of the dwell time of the resist film in the saturated solvent atmosphere and thus the drawing speed of the substrate (high drawing speed = high resist film thickness).

**Possible Advantages**

Dip coating is a suitable coating technique when the substrate size, weight or geometry make spin coating difficult or impossible to realize.

The high resist yield of dip coating (100 % or, respectively, 50 % if only one substrate side needs to be coated with resist) may be important if resist consumption is a significant expense factor. However, one has to consider the fact that a certain resist volume is required to fill the cuvette the first time. Due to the high resist yield, an exchange of the resist volume in the tank might also be necessary when the resist in the tank expires before it's consumed.

**Limitations**

Dip coating is not suitable for applications where a double-side coating of the substrate or coating of holes or trenches in the substrate are undesirable which can hardly be avoided from a technical aspect.

Substrates with strong textures or macroscopic three-dimensional components on which larger amounts of resist can flow over the substrate which has just been coated are also problematic by means of a sufficiently high resist film homogeneity over the entire substrate.

**Dip Coating Techniques**

The vertical drawing out of a cuvette is an option in the case of separate, mechanically rigid substrates. A continuous roll-to-roll coating can also be used for the coating of films, in which the substrate is drawn from a roll through a basin filled with resist and is rewound onto a roll after subsequent drying.

**Requirements for the Equipment**

**The Tank**

In order to minimize the required resist volume and to maintain a constant solvent atmosphere above the liquid resist, the cuvette - the tank for the photoresist - containing the resist should be no more than a few cm larger (in all three directions) than the substrate to be coated. For this reason, flat substrates such
as metal sheets or wafers require a narrow cuvette design. Increasing the cuvette size does not affect the coating result but increases the resist volume required to start with as well as the lifetime of each filling. This also has to be taken into consideration if no large-scale series production is scheduled, thus the resist expired before consumed has to be exchanged.

In the case of a roll-to-roll coating, it is recommended for cost reasons to estimate in the definition of the resist volume in the tank what resist amount is needed within the resist expiry date for coating. The walls and seals must be permanently chemically stable against the solvents used in the resist, which is usually met by Teflon, HD-PE or stainless steel among other materials.

For longer breaks between the coatings, a tightly closing lid covering the resist tank minimises the evaporation of solvents from the cuvette or the entry of particles.

**Filling with Photoresist and Shelf Life**

After filling the tank with resist, wait at least a few hours (e.g. overnight) before the first coating step to outgas the air bubbles hereby incorporated into the resist. If the first coated substrates nevertheless show lots of defects, there are probably still bubbles in the resist.

Dip coating resists are often highly diluted, which – especially at room temperature – reduces the shelf life. 3 - 6 months after the cuvette has been filled with fresh resist, it might be necessary to exchange the entire(!) volume so as not to carry a part of the expired resist from one filling to the next.

A measurement of the concentration of the low-boiling, more volatile solvent, carried out in certain cycles, allows a timely addition of the amount lost by evaporation. Such a measurement or at least estimation can take place either via the viscosity of the resist or its density, since low-boiling solvents such as acetone or MEK usually have a significantly lower density than the resist in its original composition.

**Substrate Suspension**

The upper substrate suspension should not dip into the resist in the tank. Otherwise, the resist will drain off the suspension over the already-coated substrate and thereby cause strong inhomogeneities in the resist film thickness.

**Motor and Motor Control**

The motor lifting the substrate should operate continuously and work vibration-free. Otherwise the resist film thickness will show characteristic horizontal, line-like inhomogeneities. For the same reason, the entire dip coater should be vibration-free and the air stream around the dip coater remain constant. The realisable drawing speed should range from approx. 1 - 20 mm/s, typical drawing speeds are 3 - 10 mm/s for resist film thicknesses of several µm.

**Operational Safety from Particles**

The atmosphere in the room the dip coater is placed should be particle-free as possible, since any impurities accumulate in the cuvette over weeks and months, and even in the case of less critical processes can decrease the yield by defects in the coated film.

Between the coatings, a lid minimises the evaporation of solvents from the cuvette or the entry of particles.

**Photoresist for Dip Coating**

When selecting a dip coating resist that is most suitable for a specific application, the essential criterion is whether a positive, image reversal or negative resist is to be applied and with which resolution for which application the developed resist mask is to be used.

The solvent composition of the resist is decisive for the coating result: Low-boiling solvents increase the viscosity of the just formed resist film within seconds and thus prevent too much flow of the resist over the substrate. High-boiling solvents prevent a too rapid complete drying and thus allow smoothing of the resist film within minutes at room temperature.

We offer optimised photoresists for different applications for dip coating - please contact us if you are interested!
### Our Photoresists: Application Areas and Compatibilities

#### Recommended Applications

<table>
<thead>
<tr>
<th>Resist Family</th>
<th>Photosists</th>
<th>Resist Film Thickness (µm)</th>
<th>Recommended Developers</th>
<th>Recommended Removers</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Positive</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Improved adhesion for wet etching, no focus on steep resist sidewalls</td>
<td>AZ® 1500</td>
<td>≥ 0.5</td>
<td>AZ® 351B, AZ® 326 MIF, AZ® 726 MIF, AZ® Developer</td>
<td></td>
</tr>
<tr>
<td>AZ® 4500</td>
<td>AZ® 4533</td>
<td>≥ 3 - 5</td>
<td>AZ® 400K, AZ® 326 MIF, AZ® 726 MIF, AZ® 826 MIF</td>
<td></td>
</tr>
<tr>
<td>AZ® 4562</td>
<td>AZ® P4110</td>
<td>≥ 1 - 2</td>
<td>AZ® 400K, AZ® 326 MIF, AZ® 726 MIF, AZ® 826 MIF</td>
<td></td>
</tr>
<tr>
<td>AZ® P4330</td>
<td>AZ® P4620</td>
<td>≥ 3 - 5</td>
<td>AZ® 400K, AZ® 326 MIF, AZ® 726 MIF, AZ® 826 MIF</td>
<td></td>
</tr>
<tr>
<td>AZ® P4903</td>
<td>AZ® 4984 PL 177</td>
<td>≥ 10 - 30</td>
<td>AZ® 351B, AZ® 400K, AZ® 326 MIF, AZ® 726 MIF, AZ® 826 MIF</td>
<td></td>
</tr>
<tr>
<td>AZ® 4999</td>
<td>Dip coating</td>
<td>AZ® 351B, AZ® 400K, AZ® 326 MIF, AZ® 726 MIF, AZ® 826 MIF</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Spray coating</strong></td>
<td>MC Dip Coating Resist</td>
<td>≥ 2 - 15</td>
<td>AZ® 351B, AZ® 400K, AZ® 326 MIF, AZ® 726 MIF, AZ® 826 MIF</td>
<td></td>
</tr>
<tr>
<td>Steep resist sidewalls, high resolution and aspect ratio for e.g. dry etching or plating</td>
<td>AZ® ECI 3000</td>
<td>≥ 0.7</td>
<td>AZ® 351B, AZ® 326 MIF, AZ® 726 MIF, AZ® Developer</td>
<td></td>
</tr>
<tr>
<td>AZ® ECI 3012</td>
<td>AZ® ECI 3027</td>
<td>≥ 1.0 - 1.5</td>
<td>AZ® 351B, AZ® 326 MIF, AZ® 726 MIF, AZ® Developer</td>
<td></td>
</tr>
<tr>
<td>AZ® 9200</td>
<td>AZ® 9245</td>
<td>≥ 3 - 6</td>
<td>AZ® 400K, AZ® 326 MIF, AZ® 726 MIF</td>
<td></td>
</tr>
<tr>
<td>AZ® 9260</td>
<td>AZ® 701 MIR (14 cPs)</td>
<td>≥ 5 - 20</td>
<td>AZ® 351B, AZ® 326 MIF, AZ® 726 MIF, AZ® Developer</td>
<td></td>
</tr>
<tr>
<td>AZ® 701 MIR (29 cPs)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Image Reversal</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Steep resist sidewalls, high resolution and aspect ratio for e.g. dry etching or plating</td>
<td>AZ® XT</td>
<td>≥ 3 - 6</td>
<td>AZ® 400K, AZ® 326 MIF, AZ® 726 MIF</td>
<td></td>
</tr>
<tr>
<td>AZ® 12 XT-20PL-05</td>
<td>AZ® 12 XT-20PL-10</td>
<td>≥ 10 - 30</td>
<td>AZ® 351B, AZ® 326 MIF, AZ® 726 MIF, AZ® Developer</td>
<td></td>
</tr>
<tr>
<td>AZ® 12 XT-20PL-20</td>
<td>AZ® 40 XT</td>
<td>≥ 15 - 50</td>
<td>AZ® 351B, AZ® 326 MIF, AZ® 726 MIF, AZ® Developer</td>
<td></td>
</tr>
<tr>
<td>AZ® IPS 6050</td>
<td></td>
<td>≥ 20 - 100</td>
<td>AZ® 351B, AZ® 326 MIF, AZ® 726 MIF</td>
<td></td>
</tr>
<tr>
<td><strong>Negative (Cross-linking)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elevated thermal softening point and undercut for lift-off applications</td>
<td>AZ® 5200</td>
<td>≥ 1</td>
<td>AZ® 351B, AZ® 326 MIF, AZ® 726 MIF</td>
<td></td>
</tr>
<tr>
<td>AZ® 5214</td>
<td>T1 35ESX</td>
<td>≥ 3 - 4</td>
<td>AZ® 351B, AZ® 326 MIF, AZ® 726 MIF</td>
<td></td>
</tr>
<tr>
<td>T1 xLift-X</td>
<td></td>
<td>≥ 4 - 8</td>
<td>AZ® 351B, AZ® 326 MIF, AZ® 726 MIF</td>
<td></td>
</tr>
<tr>
<td><strong>Negative Resist Sidewalls in Combination with No Thermal Softening for Lift-off Application</strong></td>
<td>AZ® nLOF 2000</td>
<td>≥ 1.5 - 3</td>
<td>AZ® 351B, AZ® 326 MIF, AZ® 726 MIF, AZ® 826 MIF</td>
<td></td>
</tr>
<tr>
<td>AZ® nLOF 2035</td>
<td>AZ® nLOF 2070</td>
<td>≥ 3 - 5</td>
<td>AZ® 351B, AZ® 326 MIF, AZ® 726 MIF, AZ® 826 MIF</td>
<td></td>
</tr>
<tr>
<td>AZ® nLOF 5500</td>
<td></td>
<td>≥ 0.7 - 1.5</td>
<td>AZ® 351B, AZ® 326 MIF, AZ® 726 MIF, AZ® 826 MIF</td>
<td></td>
</tr>
<tr>
<td><strong>Improved adhesion, steep resist sidewalls and high aspect ratios for e.g. dry etching or plating</strong></td>
<td>AZ® nXT</td>
<td>≥ 2 - 3</td>
<td>AZ® 351B, AZ® 326 MIF, AZ® 726 MIF, AZ® 826 MIF</td>
<td></td>
</tr>
<tr>
<td>AZ® 15 nXT (115 cPs)</td>
<td>AZ® 15 nXT (450 cPs)</td>
<td>≥ 5 - 20</td>
<td>AZ® 351B, AZ® 326 MIF, AZ® 726 MIF, AZ® 826 MIF</td>
<td></td>
</tr>
<tr>
<td>AZ® 125 nXT</td>
<td></td>
<td>≥ 20 - 100</td>
<td>AZ® 351B, AZ® 326 MIF, AZ® 726 MIF, AZ® 826 MIF</td>
<td></td>
</tr>
</tbody>
</table>

### Our Developers: Application Areas and Compatibilities

**Inorganic Developers**

AZ® Developer is based on sodium phosphate and –metsilicate, 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 photosist 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.

AZ® 100 Remover, TechniStrip® P1316, TechniStrip® P1331

AZ® 726 MIF, TechniStrip® P1316, TechniStrip® P1331

AZ® 826 MIF, TechniStrip® P1316, TechniStrip® P1331, TechniStrip® MLO 07

AZ® 1531, TechniStrip® P1316, TechniStrip® P1331, TechniStrip® MLO 07

Metal ion free (TMAH) developers are significantly more expensive, and reasonable if metal ion 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 (resides 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. Not compatible with Au.

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

TechniStrip® N1555 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® N1555 was developed not only to peel cross-linked resists, but also to dissolve resists without residues. This prevents contamination of the basin and filter by resist particles and skins, as can occur with standard strippers. TechniStrip® N1555 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:  E  www.microchemicals.com/products/wafers/waferslist.html

Further Products from our Portfolio

Plating

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

Solvents (MOS, VLSI, ULSI)

Acetone, isopropyl alcohol, MEK, DMSO, cyclopentanone, butylacetate, ...  E  www.microchemicals.com/products/solvents.html

Acids and Bases (MOS, VLSI, ULSI)

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

Etching Mixtures

for e. g. chromium, gold, silicon, copper, titanium, ...  E  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 book are compiled to the best of our knowledge. Nevertheless, we cannot 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 cannot 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