

## STORAGE AND HANDLING OF PHOTORESISTS AND ANCILLARIES

*Photo chemicals are usually provided with an expiration date, within which they meet their specifications under the specified storage conditions. This chapter describes via which mechanisms and with which consequences on their properties different photo chemicals and ancillaries age in processing and what should be taken into account during storage and handling in order to be able to reproduce work with them over a period which is as long as possible.*

### Expiration Date

#### The Meaning of the Expiration Date

From the time of production, all chemicals are subjected to an ageing process where the composition of the product changes steadily. In the case of photoresists, this can mean the decomposition of the photo-active substances; in the case of negative resists, the cross-linking reactions of the resin and, in the case of developers, the neutralisation due to the penetration of CO<sub>2</sub> through the container walls. In addition, particles and metal ions can dissolve from the containers into the product affecting its purity.

By specifying the expiration date, the manufacturer specifies how long, under the specified storage conditions, the specifications of the product can be maintained with regard to its composition, its properties during processing and its degree of purity.

#### Process Management Before and after Expiry of the Expiration Date

Because in all ageing processes, continuous changes occur in the product properties, the expiration date does not mean that a product can be used until the expiration date unchanged and after the expiration date can no longer be used.

Rather, in the case of very critical processes with narrow parameter windows, or processes running at the edge of the optimum parameter window, it may be necessary to readjust certain parameters, such as the exposure dose or the development time, before the end of the expiration date.

Very uncritical processes, on the other hand, can make it technically possible to use products far beyond the stated expiration date without any significant effect on the result.

### Temperature Ranges during Storage

#### Storage Temperature and Ageing

The specified expiration date always refers to a specific temperature range during storage. Exceeding temperatures may cause certain parameters to be outside of the prescribed specifications prior to the end of the nominal shelf life. Cool temperatures, on the other hand, can slow the ageing process and thus slow the drift of the process parameters.

#### Photoresists

The effects on high storage temperatures of photoresists correspond to accelerated ageing. In the case of non-critical resists or/and processes with a wide parameter window, storage at room temperature is usually justifiable.

In the case of critical processes, particularly heat-sensitive photoresists or the requirement of being able to use the resist beyond the nominal expiration date, a storage temperature of 5 - 10°C should be aimed for (unless the manufacturer specifies lower temperatures). Chilled containers must be adjusted to the ambient temperature before opening (e.g. taken out of the refrigerator the evening before processing) in order to prevent the formation of water condensation in the resist bottle, which can damage the resist. In the case of continuous resist consumption, it can therefore be useful to store a separate filling in a smaller container at room temperature and to consume it while the larger original container is stored refrigerated.

#### Developer and Remover

In the case of aqueous developer solutions, only freezing should be prevented, while a moderate and not long-term exceeding of the recommended storage temperature does not generally adversely affect the

product properties.

### Cold-sensitive Products

The solvent DMSO (dimethyl sulfoxide) has a melting point just below room temperature, so it can possibly freeze in storage in cooler rooms. Thawing may require several days, but afterwards the product can still be used as it is.

Buffered hydrofluoric acid (BOE) crystallises in a cool environment, depending on the HF concentration. Here, too, use is possible to use the BOE after thawing. However, because of the small crystals still present days later, which can settle on the substrate and act as particle source, care has to be taken.

## Lighting Conditions

### Why Yellow Light?

The absorption bands of DNQ-based photoresists responsible for the photo reaction lie in the range of the 320-450 nm wavelength and thus also clear in the short-wavelength visible blue and - with already clearly lower sensitivity - green spectral range (Fig. 41).

Even with purely i-line (365 nm) resists, there is a certain sensitivity to blue light, which can be critical in the case of cross-linking negative resists or chemically amplified, correspondingly highly sensitive positive resists.

Therefore, not only the UV fraction of solar or blue sky light but also white artificial light from, for example, white fluorescent tubes can expose photoresist unintentionally if no suitable shielding is not done by means of corresponding filters with a sufficiently strong absorption for wavelengths below about 520 nm.

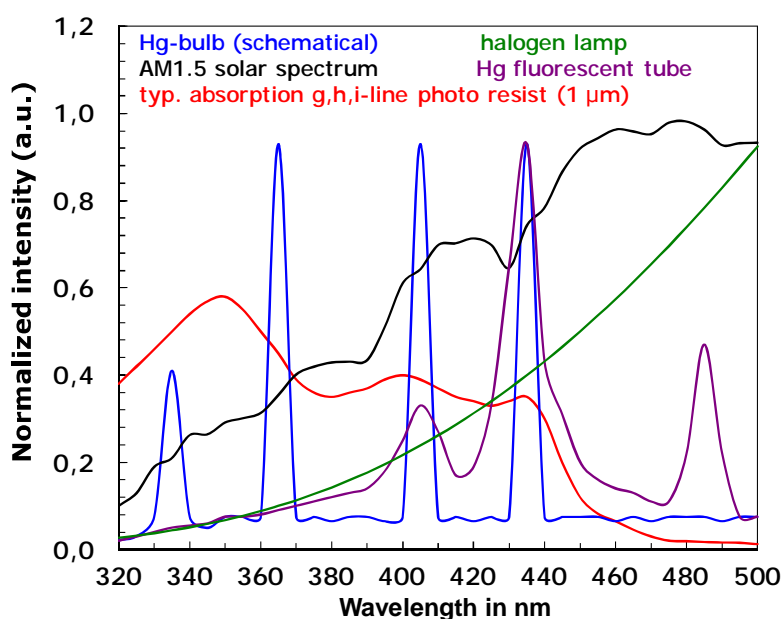


Fig. 42: The emission spectra of different light sources as well as the absorption spectrum of a broadband photoresist in the shortwave visible and near ultraviolet spectral range

### Storage of Containers

All AZ® and TI photoresists are shipped in light-protective bottles, so that the resist is protected against white light during transport and storage even when the outer packaging is removed. However, direct solar radiation should be avoided for reasons of the associated heating of the package and the resist contained therein.

In the case of developers, removers, solvents and etching chemicals, the lighting conditions are not critical, unless otherwise stated in the respective data sheets.

### Storage of Exposed Substrates

The handling and storage of coated substrates may only be carried out under suitable lighting conditions to avoid unwanted exposure. Positive resists would otherwise show an increased dark erosion in the developer at the locations which were protected during the actual exposure by the photo masks; negative resists are cross-linked where no cross-linking should take place.

Developed positive resist structures are then to be protected against unsuitable lighting conditions if a maximum alkaline stability of the photoresist mask is necessary for e.g. Wet-chemical etching or electroplating, since an (unintentional) exposure increases the solubility of these resist structures in alkaline media as it usually is the basis for the development process. The same situation applies to the use of image reversal resists processed in the positive mode.

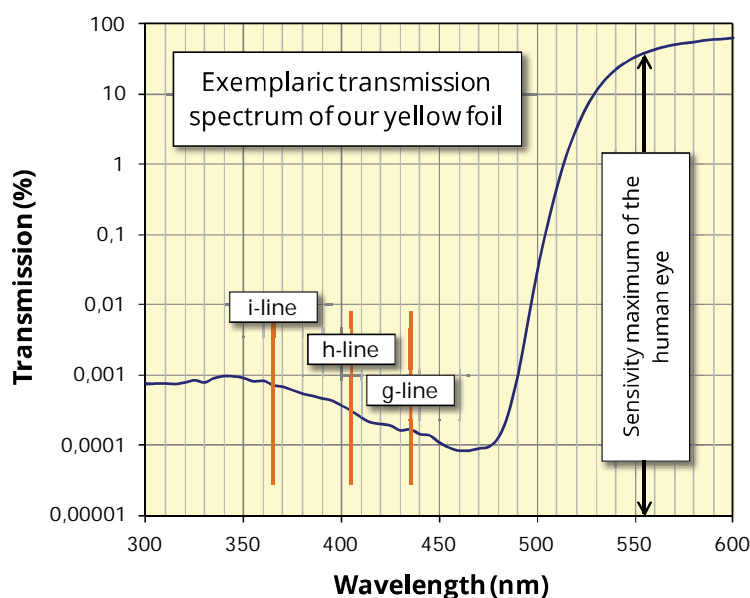
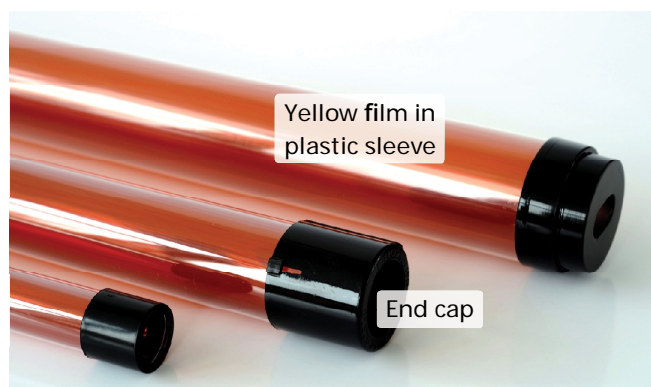
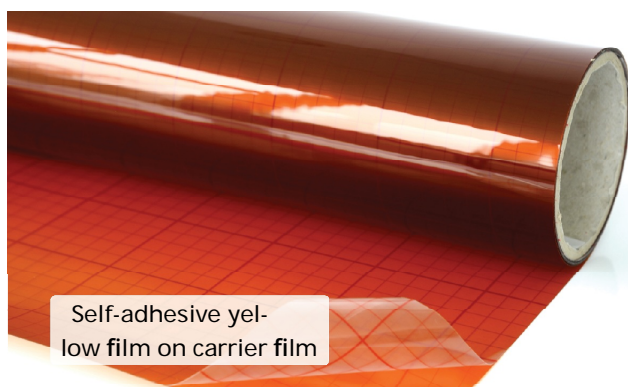


Fig. 43: Top left: Our self-adhesive yellow film with (temporary) carrier film for use on e.g. window panes or flat light sources.

Top right: The same yellow film, assembled in a plastic sleeve with end caps for the filtering of white fluorescent tubes.

Left: An exemplary measurement of the spectral transmission of our yellow film shows a sufficient transmission from wavelengths to which the human eye is particularly sensitive, at the same time, a blockade of wavelengths which could expose g-, h- and i-line sensitive photoresists by many orders of magnitude close to the detection limit.

### Evaluation of Various White Light Sources

Table 3 shows under which lighting scenarios after which periods of time photoresist films receive more or less critical exposure doses. Both the absorption of an exemplary selected, 2  $\mu\text{m}$  thick broadband resist sensitive to g-, h- and i-line as well as the spectral distribution and intensity of the irradiation of the listed light sources are only a rough approximation to assess the effect of non-optimal lighting:

Direct sunlight as well as the blue sky light can expose resist films already after a few seconds, white fluorescent tubes with their high blue light content after only a few minutes with a critical dose, that is, the order of magnitude of the light doses necessary for a desired exposure.

| Light source (r.) and time | Type 350 W mask aligner | Direct sunlight         | Skylight (noon)         | 80 W Hg fluorescent tube, 2 m distance | 100 W halogen lamp (2600 K), 2 m distance |
|----------------------------|-------------------------|-------------------------|-------------------------|--|---|
| 1 second                   | 25 mJ/cm <sup>2</sup>   | 12 mJ/cm <sup>2</sup>   | 1.2 mJ/cm <sup>2</sup>  | 0,075 mJ/cm <sup>2</sup>               | 0,009 mJ/cm <sup>2</sup>                  |
| 10 Seconds                 | 250 mJ/cm <sup>2</sup>  | 116 mJ/cm <sup>2</sup>  | 12 mJ/cm <sup>2</sup>   | 0.75 mJ/cm <sup>2</sup>                | 0,092 mJ/cm <sup>2</sup>                  |
| 1 minute                   | 1.5 J/cm <sup>2</sup>   | 0.70 J/cm <sup>2</sup>  | 72 mJ/cm <sup>2</sup>   | 4.5 mJ/cm <sup>2</sup>                 | 0.55 mJ/cm <sup>2</sup>                   |
| 10 minutes                 | 15 J/cm <sup>2</sup>    | 7 J/cm <sup>2</sup>     | 0.72 J/cm <sup>2</sup>  | 45 mJ/cm <sup>2</sup>                  | 5.5 mJ/cm <sup>2</sup>                    |
| 1 hour                     | 90 J/cm <sup>2</sup>    | 42 J/cm <sup>2</sup>    | 4.3 J/cm <sup>2</sup>   | 271 mJ/cm <sup>2</sup>                 | 33 mJ/cm <sup>2</sup>                     |
| 24 hours                   | > 100 J/cm <sup>2</sup> | > 100 J/cm <sup>2</sup> | > 100 J/cm <sup>2</sup> | 6.5 J/cm <sup>2</sup>                  | 0.79 J/cm <sup>2</sup>                    |

Table 3: An estimate of the exposure doses of typical positive photoresist films absorbed under different lighting conditions for different times. The colour scheme ranges from green (uncritical for conventional resists and processes) to yellow and orange to red (exposed).

### Possible Causes of Insufficient Yellow Light

Many conventional yellow films block short-wave light only inadequately: Even a transmission of short-wavelength visible radiation of only 0.1% is sufficient to allow herewith filtered direct sunlight to expose resist films in less than an hour.

With regard to their transmission properties, optimal filter films can age mechanically and chemically: When unsuitable carrier materials are used, films can get the finest cracks due to the heat development of the light sources, which hereby start to transmit short-wave light. UV radiation from aged Hg fluorescent tubes or daylight can decompose insufficiently stable dyes in the yellow film and thus also increase their transmission for short-wavelength light.

### Quick Test for Suitable Yellow Lighting Conditions

Do blue objects in your yellow room look blue instead of grey or black? This is already a clear indication of insufficient yellow lighting conditions.

The following test provides resilient results: Coat a substrate with a broadband photoresist and, after the softbake, cover half with a, e. g. black film. Store this partially shielded substrate in the yellow room at an exposed location under a fluorescent tube or near a window for one day. Then place the substrate in a developer suitable for this resist for 5 - 10 minutes. If the resist film in the unprotected half of the substrate shows a (higher) resist removal rate than the shielded half, this indicates an insufficient yellow light.

### Our Yellow Film and Filter Tubes

Our yellow film (as a window film or finished in filter tubes for fluorescent tubes, see Fig. 43) reliably blocks the spectral range below 520 nm wavelength and simultaneously shows a sufficiently high transmission with larger wavelengths, which makes it suitable for use in clean rooms for processing all conventional, photoresists which are sensitive between 320 and 440 nm wavelength.

## Refilling and Dilution of Photoresists

### Refilling of Photoresists

Besides original sales units, we offer almost all photoresists also in 250 ml, 500 ml and 1,000 ml containers from some resists, also 100 ml containers. If the resist should nevertheless be refilled into smaller containers yet, consider a prior two-step cleaning process of the containers by means of 1. acetone (removes organic impurities) and 2. isopropanol (rinses off contaminated acetone residues). The comparatively slowly evaporating isopropanol damages the photoresist and has to be evaporated from the container without residue before filling with resist.

Only suitable plastics (unstained Teflon, HD-PE without plasticizer) or low-sodium glass containers may be used to store, transfer and dispense photoresists. Between filling and coating of resists, a waiting period of up to a few hours depending on the viscosity is recommended in order to allow introduced air bubbles to degas which would form defects in the coated resist film.

### Dilution of Photoresists

We offer different viscosities from most resist families, and ready-to-use dilutions for spray or dip coating. If a resist is nevertheless to be further diluted, consideration must be given to the use of suitable solvents. Due to their low vapour pressure and their compatibility with photoresists, PGMEA (= AZ® EBR Solvent), butyl acetate or ethyl lactate are recommended. If low-boiling solvents are to be added for spray or dip coating, acetone or MEK are generally suitable, while isopropanol is not recommended for resist dilution.

Not all resists can be thinned easily. Low-viscosity, photoinitiator-rich resists such as the AZ® 1505, 1512HS or 6612 react with rapid particle formation, whereas an even higher dilution is generally not critical with thick coatings such as the AZ® 4562 or 9260.

Since dilution also accelerates ageing of "uncritical" resists, it is generally advisable to dilute only the quantity of resist which can be consumed in a reasonable period of time. In order to avoid a too rapid particle formation of diluted resists, it is important, when diluting, to allow the highly diluted boundary

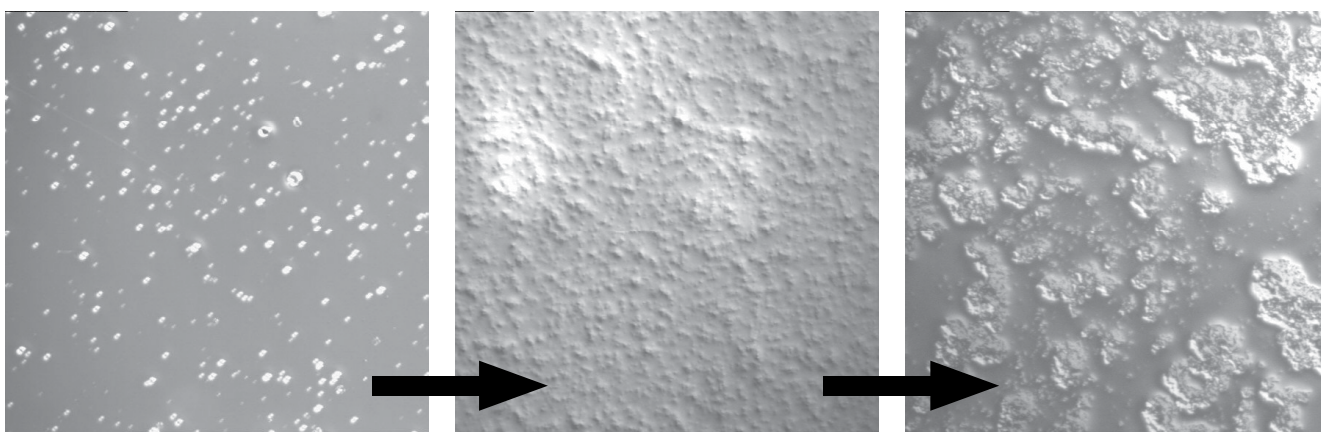


Fig. 44: Appearance of more and more (from left to right) aged photoresist coated on a substrate: With increasing concentration and size, particles conglomerate to clusters (each picture 500 x 500  $\mu\text{m}$ ).

layer of the photoresist and solvent to be as short as possible through rapid mixing. After dilution, the resist should rest for a few hours to allow introduced air bubbles to degas, which would lead to defects in the resist film.

## Ageing of Photoresists: Effects

### Particle Formation

DNQ-based positive and image reversal resists tend to gradually form particles when strongly diluted. After the coating, the naked eye shows a rough resist surface until the resist becomes progressively inhomogeneous (strong ripple, resist cracking behind larger particles, as shown in Fig. 44) in a later stage.

Some low-viscous and photoinitiator-rich thin resists such as the AZ<sup>®</sup> 6600 or 1500 series are significantly more affected by this ageing phenomenon than thick resists.

Since the resist is missing the photoinitiator due to its deposition, the development rate decreases or the dark erosion increases during the development, which is why a filtration of the photoresist with the particles formed does not lead to the same result as a fresh photoresist.

### Loss of the Photoinitiator in Positive Resists

The photoinitiator of positive, image reversal and some negative resists also gradually decomposes at the recommended storage temperature over months and years.

In the case of positive resists, this loss of photoinitiator means a lower rate of development and a higher dark erosion (because an unexposed photoinitiator as an inhibitor reduces the alkaline solubility), thus a lower contrast. Not only do the dimensions and sidewall slopes of the developed resist structures suffer, but also narrow structures are harder and harder to open during development. The  $\text{N}_2$  released from the photoinitiator dissolves in the resist and can form bubbles during coating when the resist bottle has been closed for an extended period of time and the  $\text{N}_2$  has thus been allowed to accumulate.

With image reversal resists in the negative mode and negative resists, the image reversal or cross-linking is less pronounced with a lower concentration of photoinitiator, causing the exposed resist areas are stronger dissolved in the developer. The resist structures can thereby change in various ways: With image reversal and negative resists which are completely exposed up to the substrate, vertical or undercut resist sidewalls are increasingly positive due to the greater degradation by the developer. In the case of weakly exposed image reversal and negative resists, the reverse reaction or cross-linking especially close to the substrate can be so weak, that the erosion of the resist in the developer is increased and can cause the separation of smaller or narrower structures in the developer.

### Cross-linking Reactions with Negative Resists

In expired negative and image reversal resists (e.g. the AZ<sup>®</sup> 5214E), the cross-linking agents present may begin to cross-link the resin during storage, thereby decreasing the development rate of the unexposed

negative resist or flood-exposed image reversal resist. Not only do the dimensions and sidewall slopes of the developed resist structures suffer, but also narrow structures are harder and harder to open.

The partial cross-linking of the resin reduces the removability of the resist film at the end of the litho process: In expired AZ® 5214E, difficult to dissolve residues can sometimes be detected after stripping.

#### Discolouration

In the case of a batch change of positive and image reversal resists, a different (usually brighter) colour of the new resist is occasionally apparent.

The gradual darkening of photoresist is due to the formation of highly absorbing dyes through the esterification of the photoinitiator with the resin but has no significant effect on the processing and performance of the resist: Already minimal traces of such converted photoinitiators strongly dye the resist in the visible range, which does not however significantly affect the UV absorption which is decisive for the exposure.

#### Resist Adhesion

A resist adhesion loss which can take place in case of expired resists is based on gradual chemical changes of the resin, which can be compensated within limits in some processes via optimised substrate pre-treatment and / or a hardbake.

Because other ageing phenomena of the resist are also likely to worsen the litho result at this stage, the use of a fresher resist batch is recommended in the case of an adhesion deterioration caused by resist ageing.

#### Viscosity

A small amount of the solvent evaporates when resist containers are opened. Already 1% solvent loss significantly increases the viscosity and therefore the film thickness attained by spin coating (Fig. 45). As a result, the exposure doses necessary for an exposure and subsequent complete development can be increased.

Due to the low vapour pressure of the commonly used solvents, however, this effect only occurs theoretically after several 100 bottle openings, each with a complete exchange of the solvent atmosphere therein, and can even be compensated in this case by means of higher spin speeds during spin coating.

### Developer: Ageing and Development Rate

#### Neutralisation by CO<sub>2</sub>

The ageing of aqueous alkaline, NaOH, KOH or TMAH-based developer is based on CO<sub>2</sub> absorption from the air, which decreases the rate of development. Therefore we recommend storage in well closed original containers.

In open developer baths, a N<sub>2</sub> curtain minimises the CO<sub>2</sub> intake. Without such a N<sub>2</sub> barrier, the shelf life of a developer basin depends primarily on the ratio of the surface area of the developer to its volume which is why the activity of small (litre-sized) developer beakers can already be reduced after a few hours.

The CO<sub>2</sub> insertion, due to the dead volume of a developer container that is exposed to air when a container is opened, can usually be disregarded: Approx.  $1.7 \cdot 10^{-5}$  mol/L CO<sub>2</sub> of air face approx. 0.25 mol/L OH<sup>-</sup> ions which are neutralized by the CO<sub>2</sub> only with very frequent opening of the container and / or a very small remaining developer volume.

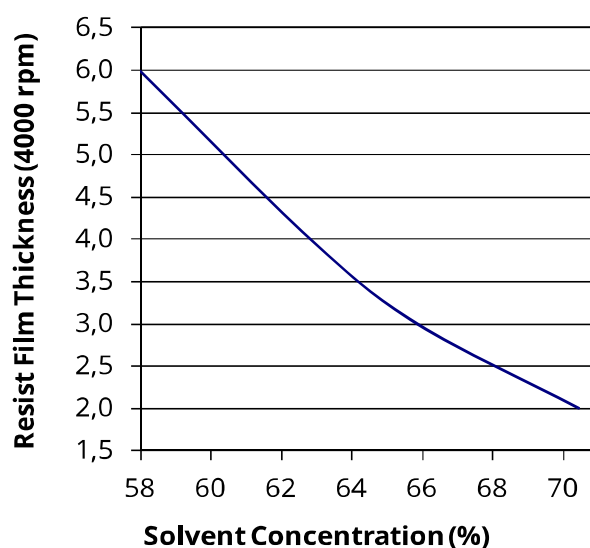


Fig. 45: The resist film thickness attained by spin-coating used in relation to the solvent concentration.

## Chemical Buffer

Some developers (such as AZ® 400K or AZ® 351B) contain chemical buffers, which reduce the decrease of the pH value through the CO<sub>2</sub> absorption achieving a constant long-term development rate - compared to pure NaOH/KOH dilution. The exhaustion of the developer by the resist dissolved during the development process itself is not stopped.

## Air Temperature and Humidity During and after Coating

### Temperature

Higher temperatures reduce the viscosity of the resist and accelerate its drying by means of an increased evaporation rate of the solvent, which has an effect on the resist film thickness attained by spin or dip coating.

The duration of the rehydration of positive resists (Chapter 14) and their development rate, which is decisive between softbake and exposure especially in the case of thicker resist films, are likewise temperature-dependent and have an effect both on the development time as well as on the resist profiles attained.

For reproducible litho processes, if applicable, a clean room temperature in the range of 18 to 23°C, which is kept constant at 1 - 2°C or better, is therefore recommended.

### Humidity

A high relative humidity accelerates the H<sub>2</sub>O adsorption on the substrates to be coated, which can worsen the wetting and adhesion of the photoresist.

After the coating and softbake have been completed, a humidity that is too low prevents the rehydration (chapter 14 on page 65) required for many DNQ-based positive and image reversal resists which can result in a greatly reduced development rate up to incomplete development. As a reasonable compromise for most applications, we recommend a constant relative humidity of approx. 45 - 50%.

## Storage of Exposed Substrates

### Unexposed Substrates

The storage of coated substrates is basically not critical even over months as long as they are protected adequately from particles and chemical contaminants from air. As described in detail in section 7.3, coated substrates must also be protected against insufficient light conditions such as white light. The sensitivity of DNQ-based photoresists do not only lie in the near-ultraviolet range but also in the short-wave, visible spectral range, which is why daylight as well as artificial light sources have to be shielded by corresponding filter films with a complete absorption of wavelengths < 520 nm.

### Exposed Substrates

The time between exposure and development is more critical with respect to a homogeneous development rate. For most resists, waiting times of hours or days are possible, although not recommended. With the AZ® 15 nXT which is comparatively critical in this regard, the development should not take place any longer than a few minutes after the post exposure baking step.

## Our Photoresists: Application Areas and Compatibilities

| Recommended Applications <sup>1</sup> |   | Resist Family             | Photoresists   | Resist Film Thickness <sup>2</sup>                             | Recommended Developers <sup>3</sup>   | Recommended Removers <sup>4</sup>  |
|---------------------------------------|---|---------------------------|--|--|---|--|
| Positive                              | Improved adhesion for wet etching, no focus on steep resist sidewalls                             | AZ <sup>®</sup> 1500      | AZ <sup>®</sup> 1505<br>AZ <sup>®</sup> 1512 HS<br>AZ <sup>®</sup> 1514 H<br>AZ <sup>®</sup> 1518                        | ≈ 0.5 µm<br>≈ 1.0 - 1.5 µm<br>≈ 1.2 - 2.0 µm<br>≈ 1.5 - 2.5 µm | AZ <sup>®</sup> 351B, AZ <sup>®</sup> 326 MIF, AZ <sup>®</sup> 726 MIF, AZ <sup>®</sup> Developer                     | AZ <sup>®</sup> 100 Remover,<br>TechniStrip <sup>®</sup> P1316<br>TechniStrip <sup>®</sup> P1331                                     |
|                                       |   |                           | AZ <sup>®</sup> 4533<br>AZ <sup>®</sup> 4562   | ≈ 3 - 5 µm<br>≈ 5 - 10 µm                                      | AZ <sup>®</sup> 400K, AZ <sup>®</sup> 326 MIF, AZ <sup>®</sup> 726 MIF, AZ <sup>®</sup> 826 MIF                       |  |
|                                       |   | AZ <sup>®</sup> P4000     | AZ <sup>®</sup> P4110<br>AZ <sup>®</sup> P4330<br>AZ <sup>®</sup> P4620<br>AZ <sup>®</sup> P4903                         | ≈ 1 - 2 µm<br>≈ 3 - 5 µm<br>≈ 6 - 20 µm<br>≈ 10 - 30 µm        | AZ <sup>®</sup> 400K, AZ <sup>®</sup> 326 MIF, AZ <sup>®</sup> 726 MIF, AZ <sup>®</sup> 826 MIF                       |  |
|                                       |   |                           | AZ <sup>®</sup> PL 177   | AZ <sup>®</sup> PL 177   | ≈ 3 - 8 µm  |  |
|                                       | Spray coating   | AZ <sup>®</sup> 4999      |  | ≈ 1 - 15 µm  | AZ <sup>®</sup> 400K, AZ <sup>®</sup> 326 MIF, AZ <sup>®</sup> 726 MIF, AZ <sup>®</sup> 826 MIF                       |  |
|                                       | Dip coating   | MC Dip Coating Resist     |  | ≈ 2 - 15 µm  | AZ <sup>®</sup> 351B, AZ <sup>®</sup> 400K, AZ <sup>®</sup> 326 MIF, AZ <sup>®</sup> 726 MIF, AZ <sup>®</sup> 826 MIF |  |
|                                       | Steep resist sidewalls, high resolution and aspect ratio for e. g. dry etching or plating         | AZ <sup>®</sup> ECI 3000  | AZ <sup>®</sup> ECI 3007<br>AZ <sup>®</sup> ECI 3012<br>AZ <sup>®</sup> ECI 3027   | ≈ 0.7 µm<br>≈ 1.0 - 1.5 µm<br>≈ 2 - 4 µm                       | AZ <sup>®</sup> 351B, AZ <sup>®</sup> 326 MIF, AZ <sup>®</sup> 726 MIF, AZ <sup>®</sup> Developer                     |  |
|                                       |   |                           | AZ <sup>®</sup> 9245<br>AZ <sup>®</sup> 9260   | ≈ 3 - 6 µm<br>≈ 5 - 20 µm                                      | AZ <sup>®</sup> 400K, AZ <sup>®</sup> 326 MIF, AZ <sup>®</sup> 726 MIF  |  |
| Positive (chem. amplified)            | Steep resist sidewalls, high resolution and aspect ratio for e. g. dry etching or plating         | AZ <sup>®</sup> XT        | AZ <sup>®</sup> 701 MiR (14 cPs)<br>AZ <sup>®</sup> 701 MiR (29 cPs)   | ≈ 0.8 µm<br>≈ 2 - 3 µm   | AZ <sup>®</sup> 351B, AZ <sup>®</sup> 326 MIF, AZ <sup>®</sup> 726 MIF, AZ <sup>®</sup> Developer                     | AZ <sup>®</sup> 100 Remover,<br>TechniStrip <sup>®</sup> P1316<br>TechniStrip <sup>®</sup> P1331                                     |
|                                       |   |                           | AZ <sup>®</sup> 12 XT-20PL-05<br>AZ <sup>®</sup> 12 XT-20PL-10<br>AZ <sup>®</sup> 12 XT-20PL-20<br>AZ <sup>®</sup> 40 XT | ≈ 3 - 5 µm<br>≈ 6 - 10 µm<br>≈ 10 - 30 µm<br>≈ 15 - 50 µm      | AZ <sup>®</sup> 400K, AZ <sup>®</sup> 326 MIF, AZ <sup>®</sup> 726 MIF  |  |
| Image Re-verseal                      | Elevated thermal softening point and undercut for lift-off applications                           | AZ <sup>®</sup> 5200      | AZ <sup>®</sup> 5209<br>AZ <sup>®</sup> 5214   | ≈ 1 µm<br>≈ 1 - 2 µm   | AZ <sup>®</sup> 351B, AZ <sup>®</sup> 326 MIF, AZ <sup>®</sup> 726 MIF  | TechniStrip <sup>®</sup> Micro D2<br>TechniStrip <sup>®</sup> P1316<br>TechniStrip <sup>®</sup> P1331                                |
|                                       |   | TI                        | TI 35ESX<br>TI xLift-X   | ≈ 3 - 4 µm<br>≈ 4 - 8 µm                                       |   |  |
| Negative (Cross-linking)              | Negative resist sidewalls in combination with no thermal softening for lift-off application       | AZ <sup>®</sup> nLOF 2000 | AZ <sup>®</sup> nLOF 2020<br>AZ <sup>®</sup> nLOF 2035<br>AZ <sup>®</sup> nLOF 2070                                      | ≈ 1.5 - 3 µm<br>≈ 3 - 5 µm<br>≈ 6 - 15 µm                      | AZ <sup>®</sup> 326 MIF, AZ <sup>®</sup> 726 MIF, AZ <sup>®</sup> 826 MIF   | TechniStrip <sup>®</sup> NI555<br>TechniStrip <sup>®</sup> NF52<br>TechniStrip <sup>®</sup> MLO 07                                   |
|                                       |   | AZ <sup>®</sup> nLOF 5500 | AZ <sup>®</sup> nLOF 5510  | ≈ 0.7 - 1.5 µm   |   |  |
|                                       | Improved adhesion, steep resist sidewalls and high aspect ratios for e. g. dry etching or plating | AZ <sup>®</sup> nXT       | AZ <sup>®</sup> 15 nXT (115 cPs)<br>AZ <sup>®</sup> 15 nXT (450 cPs)   | ≈ 2 - 3 µm<br>≈ 5 - 20 µm                                      | AZ <sup>®</sup> 326 MIF, AZ <sup>®</sup> 726 MIF, AZ <sup>®</sup> 826 MIF   | TechniStrip <sup>®</sup> P1316<br>TechniStrip <sup>®</sup> P1331<br>TechniStrip <sup>®</sup> NF52<br>TechniStrip <sup>®</sup> MLO 07 |
|                                       |   |                           | AZ <sup>®</sup> 125 nXT  | ≈ 20 - 100 µm  | AZ <sup>®</sup> 326 MIF, AZ <sup>®</sup> 726 MIF, AZ <sup>®</sup> 826 MIF   |  |

<sup>1</sup> 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.

<sup>2</sup> 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.

<sup>3</sup> 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<sup>®</sup> 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<sup>®</sup> 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<sup>®</sup> 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<sup>®</sup> 303** specifically for the AZ<sup>®</sup> 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<sup>®</sup> 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 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 SiO<sub>2</sub>, main criterion is the crystal orientation (e. g. X-, Y-, Z-, AT- or ST-cut)

Fused silica wafers consist of amorphous SiO<sub>2</sub>. 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: [⇒ 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: [⇒ www.microchemicals.com/products/electroplating.html](http://www.microchemicals.com/products/electroplating.html)

### Solvents (MOS, VLSI, ULSI)

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

### Etching Mixtures

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

## Further Information

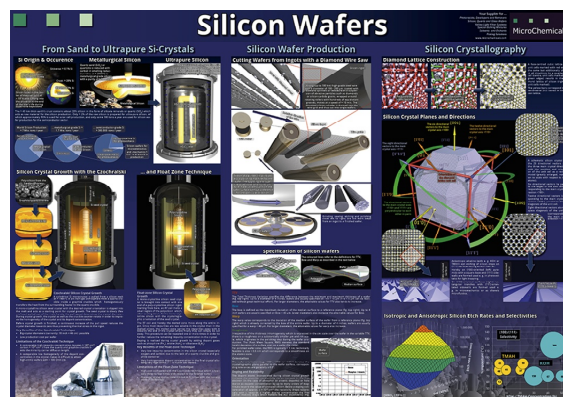
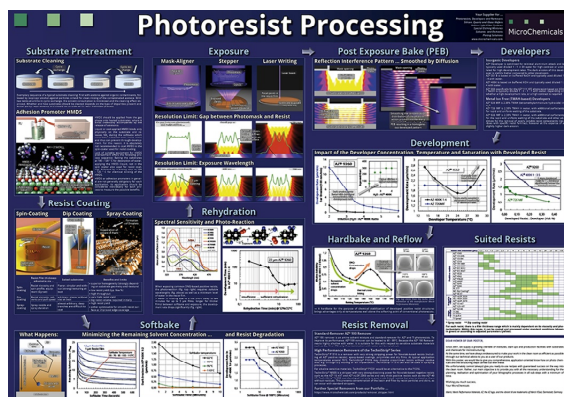
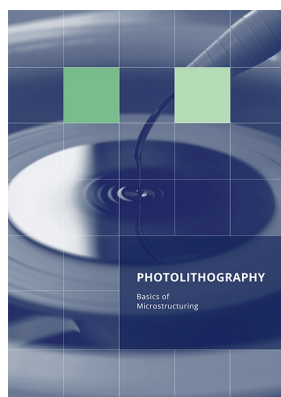
Technical Data Sheets:

[www.microchemicals.com/downloads/product\\_data\\_sheets/photoresists.html](http://www.microchemicals.com/downloads/product_data_sheets/photoresists.html)

Material Safety Data Sheets (MSDS):

[www.microchemicals.com/downloads/safety\\_data\\_sheets/msds\\_links.html](http://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](http://www.microchemicals.com/downloads/brochures.html)

[www.microchemicals.com/downloads/posters.html](http://www.microchemicals.com/downloads/posters.html)

Thank you for your interest!

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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.

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