

General Properties of AZ® / TI Photoresists



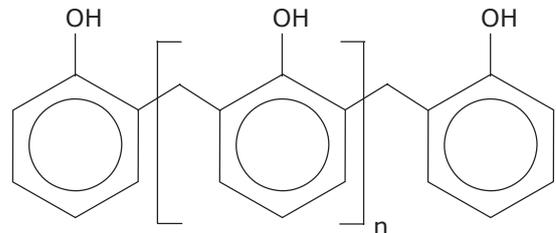
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The Resin

The resin of AZ® and TI resists is Novolak, a cresol resin that is synthesized from phenol and formaldehyde.

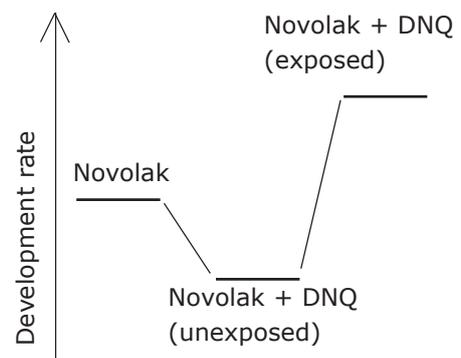
The molecular chain length adjusts important resist properties: Long chains improve the thermal stability, reduce the dark erosion but also the development rate, while short chains improve the adhesion. Thus photoresists are composed with a special mixture of resins dependent on the desired chemical and physical properties, typically 8 to 20 monomer units.



The Photo Initiator (Photo active Compound: PAC)

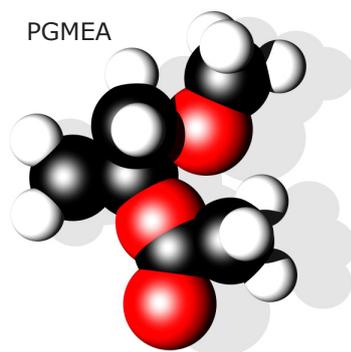
The photo active compound of AZ® and TI photoresists belongs to the group of diazonaphtho-quinones (DNQ). Their presence in photoresists reduces - as compared with pure Novolak resin - the alkaline solubility by more than one order of magnitude.

During exposure with UV-light (typically < 440 nm) the DNQ transforms (accompanied by the release of nitrogen and the absorption of water) into a carboxylic acid, and the alkaline solubility increases more than three orders of magnitude and is finally more than one order of magnitude higher as compared to pure Novolak.



Solvent(s)

The solvent of nearly all AZ® and TI photoresists is PGMEA (propylene-glycol-mono-methyl-ether-acetate), which is available as AZ® EBR Solvent (the former AZ® 1500 Thinner). Dependent on the viscosity, with approx. 55-85 % it is the main ingredient of our photoresists.



The high boiling point of PGMEA (145°C), and the low vapor pressure (2 mbar at room temperature) inhibits a fast vaporescence out of open bottles and during dispensation. As a 'safer solvent' it supports reproducible and safe working with a flash point of 42°C. It is a solvent that does not tend to particle formation even with high dilution ratios as compared to other solvents.

After softbake, the remaining solvent influences the chemical and physical resist properties: In developer, the PGMEA converts to acetic acid and increases the dark erosion. A high remaining solvent content also decreases the thermal stability in subsequent process steps and leads to a rounding of the resist structures.

Further Additives

Additionally to the above mentioned ingredients, photoresists may contain anti-oxidizing and leveling agents and adhesion promoters. Image reversal resists contain additives that make the exposed areas insoluble in the developer. Details to the safety, transport, storage, and to the disposal are given in the material safety data sheets (MSDS) that you will receive with each delivery, or per pdf upon request.

Thermal Stability

The **softening point** of AZ[®] and TI positive and image reversal photoresists of approx. 110 °C (e. g. AZ[®] 1500, 4500, 9200 series) to 135°C (e. g. AZ[®] 701MiR, 6600 series) depends on the resist series, the remaining solvent concentration, and (in case of image reversal resists) on the image reversal bake temperature. UV-hardening further enhances the softening point. Beyond this temperature, the developed resist structures start rounding.

From 120°C on, photoresists more and more react with oxygen from air (brownish coloring, embrittlement) promoting the formation of cracks. However, dependant from subsequent process steps, a baking at temperatures up to 170-180°C may nevertheless be useful to enhance thermal or chemical stability via thermal crosslinking.

Wet Chemical Resistivity

At room temperature, unexposed photoresist is sufficiently **alkaline stable** for many applications such as electroplating. Correctly applied hardbake (see chapter 13) can further increase alkaline stability. It has to be considered, that during electroplating the local pH-values near the regions of deposition may exceed the values measured in the bath. However, the alkaline stability of our AZ[®] and TI resists is insufficient for their usage as mask for KOH-based Si-etching. For this purpose hardmasks out of SiO₂ or SiN_x are recommended.

In **acids**, the resist stability depends more on the chemical nature of the medium than on the pH-value. Phosphoric and hydrochloric acid only weakly attack photoresist. Using hydrofluoric acid, in many cases the permeability of the resist film for HF determines process stability, heavily oxidizing acids such as sulfuric or nitric acid attack the resist film comparably strongly.

Polaric organic solvents dissolve AZ[®] and TI positive and image reversal resists to a certain rate. Cross-linking (via UV-hardening, high baking temperatures, or the usage of AZ[®] nLOF negative resists) increase the stability against organic solvents.

Dry Etching Stability

In general, the **plasma stability** of polymers depends on the principle chemical structure and is therefore comparable for all AZ[®] and TI resists based on cresol resin. In many cases, the **thermal stability** limits the dry etching capability, therefore the AZ[®] 6600 positive or AZ[®] nLOF 2000 negative resist help to prevent the resist structures from softening .

Optical Absorption

The optical absorption (fig. right-hand) of unexposed photoresist ranges from approx. 460 nm in the VIS to near UV, which is matched to the emission spectrum of Hg lamps in mask aligners. This absorption spectrum causes the typical reddish-brownish color of many photoresists. During exposure, photoresists almost completely bleach down to approx. 300 nm.

Viscosity

Depending on the solvent concentration, the resist viscosity ranges from < 10 (*thin resists* such as AZ[®] 1505) to > 500 cSt (*thick resists* such as AZ[®] 9260).

