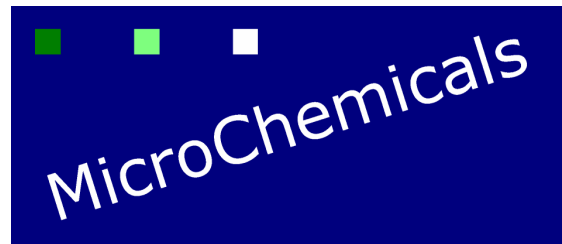


# Baking Steps in Photoresists Processing



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Source: [www.microchemicals.eu/technical\\_information](http://www.microchemicals.eu/technical_information)

## General

This document aims for an understanding of the purpose of the various baking steps in photoresist processing, and how the baking parameters temperature and time impact on the individual process.

## Substrate Heating before Resist Coating

Heating the substrate before resist coating can improve the resist adhesion in two ways:

From 100°C on, H<sub>2</sub>O present on all surfaces desorbs, so we recommend a baking step of 120°C for few minutes for this purpose. A two-step cleaning process with acetone, followed by isopropyl alcohol, has the same effect.

From 150°C on, also OH bonds apparent on any oxidized surfaces such as silicon, glasses, quartz, or ignobel metals, are thermally cracked. These OH bonds otherwise form a hydrophilic surface with inferior resist adhesion. Applying adhesion promoters such as HMDS or TI PRIME gives a similar result.

The coating should be performed directly after cooling down of the substrates in order to avoid re-adsorption of water. However, the substrate should again have room temperature before resist coating since otherwise the resist film thickness homogeneity will suffer.

The document [Substrate Cleaning and Adhesion Promotion](#) gives more details on this topic.

## Softbake

After coating, the resist film contains a remaining solvent concentration depending on the resist, the solvent, the resist film thickness and the resist coating technique.

The softbake reduces the remaining solvent content in order to:

- avoid **mask contamination** and/or **sticking** to the mask,
- prevent **popping** or **foaming** of the resist by N<sub>2</sub> created during exposure,
- improve resist **adhesion** to the substrate,
- minimize **dark erosion** during development,
- prevent dissolving one resist layer by a following **multiple coating**, and
- prevent bubbling during subsequent **thermal processes** (coating, dry etching).

A softbake too cool or/and short may cause the above mentioned problems. A softbake too hot or/and long will thermally decompose a significant fraction of the photo active compound in positive resists, with a lower development rate and higher dark erosion as a consequence. Negative resists will suffer from thermal cross-linking during baking, which lowers the development rate or makes through-development impossible.

Generally, we recommend a softbake at 100°C on a hotplate for 1 minute per µm resist film thickness. In an oven is used, it is recommended to add some minutes softbake time. If softbake is applied at 110°C, one should halve the softbake time, while for each 10°C below 100°C the time should be doubled in order to sufficiently decrease the remaining solvent concentration.

The document [Softbake of Photoresist Films](#) gives more details on this baking step.

## Post Exposure Bake

The post exposure bake PEB (performed after exposure, but before development) can be applied above the softening point of the resist without destroying the structures to be developed due to the still closed resist film. There are various different possible reasons for the application of a PEB:

### Chemically Amplified Resists

In chemically amplified resists, the PEB catalytically performs and completes the photoreaction initiated during exposure. Most of the AZ<sup>®</sup> and TI resists supplied by MicroChemicals<sup>®</sup> do not belong to chemically amplified resists, and therefore do not require a PEB for this purpose. Typically, 110°C for 2 minutes are recommended for this baking step.

### Crosslinking Negative Resists

In the case of many crosslinking resists such as the AZ<sup>®</sup> nLOF 2000 series or the AZ<sup>®</sup> 15 nXT, the PEB is essential for the crosslinking mechanism initiated during the exposure. The negative resist AZ<sup>®</sup> 125 nXT does not require a PEB, since the cross-linking already takes place at room temperature. Details on these negative resist can be found [here](#).

### Highly Reflective Substrates

The PEB promotes the thermally activated diffusion of carboxylic acid formed during exposure from the photoactive compound. This diffusion step smoothens out the rippling effect of the periodic carboxylic acid concentration. This rippling effect is due to standing light waves during monochromatic exposure, especially in case of highly reflective substrates. These patterns otherwise would transfer to the resist profile thus e. g. reducing the spatial resolution of the resist and the desired aspect ratio.

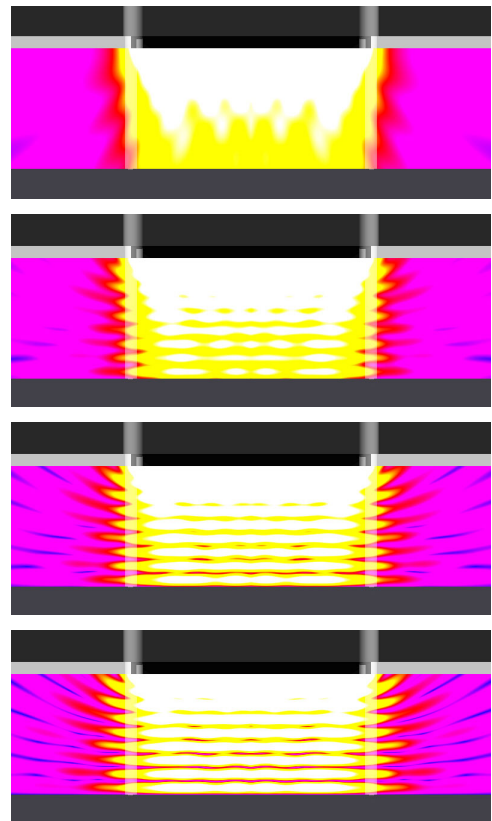
Alternatively, or additionally, bottom-layer anti reflective coatings such as AZ<sup>®</sup> Barli improve the resolution and resist profile on highly reflective substrates under monochromatic exposure. Details on anti-reflective-coatings are summarized in the document [Anti-Reflective Coatings for Photoresists](#).

### Mechanical Relaxation

A PEB performed near the softening point of the photoresist reduces mechanical stress formed during soft-bake and exposure of especially thick resist films due to the expanding nitrogen and therefore improves resist adhesion and reduces under-etching in subsequent wet chemical etching. However, a certain delay between exposure and PEB is required to outgas N<sub>2</sub>. Otherwise, during PEB the N<sub>2</sub> in the resist will expand and increase mechanical stress in the film. This delay strongly depends of the resist film thickness.

### PEB Required?

If none of the previously mentioned effects are relevant, a PEB is generally not necessary and can be skipped.



The spatial incident light intensity distribution in a resist film as a function of the substrate reflectivity increasing from 0 % (top) to 100 % (bottom).

## Hardbake

A hardbake can be performed after development in order to increase the thermal, chemical and physical stability of developed resist structures for subsequent processes (e. g. electroplating, wet-chemical and dry-chemical etching). Hereby the following mechanisms have to be considered:

- Embrittlement of the resist film with crack formation
- Reflow of the photoresist
- The need for an improved resist adhesion
- The need for an improved chemical stability of the resist mask
- A decreased removability of the stabilized resist after processing

These points are detailed in the document [Hardbake of Photoresist Structures](#).

### Hardbake - Yes or No?

The intrinsic high alkaline stability of AZ<sup>®</sup> and TI resists, together with an optimum substrate pretreatment, in many cases make the hardbake redundant, which simplifies the processing and arranges following wet-chemical processes more reproducible.

In most cases, an optimized resist helps to avoid a hardbake: For electroplating, the negative resists AZ<sup>®</sup> 15 nXT and 125 nXT show an improved adhesion and stability against most electrolytes. The AZ<sup>®</sup> ECI 3000 series has an optimized adhesion for wet etching, and the AZ<sup>®</sup> 6600 series as well as the AZ<sup>®</sup> 701 MiR an elevated thermal stability for dry etching.

However, for harsh attack (e. g. mesa etching with HNO<sub>3</sub>), however, a hardbake at > 130-140°C is sometimes inevitable.

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