Rehydration of Photoresists

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www.microchemicals.com/downloads/application_notes.html

MicroChemicals

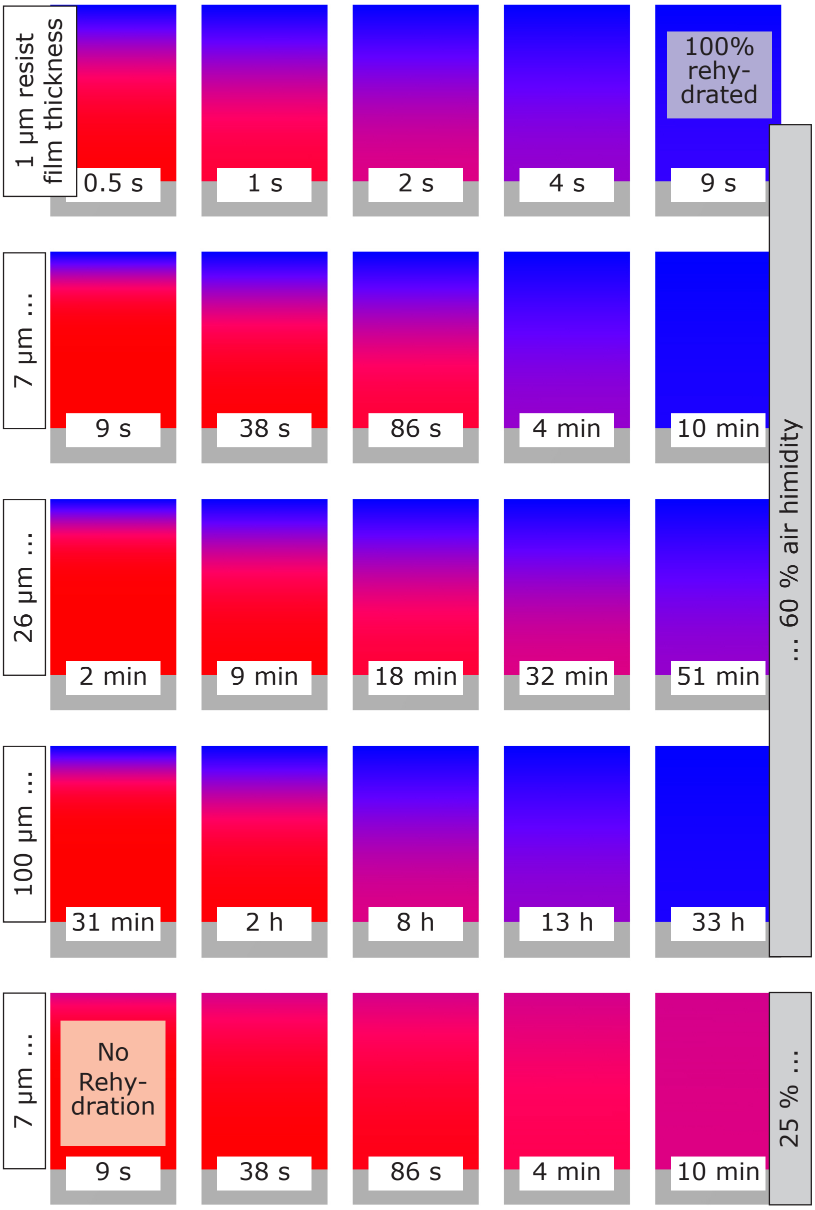
Theory

During Softbake or image reversal bake), the bulk **water concentration** of photoresist films drops. However, a certain water content in the resist during exposure is required to allow a reasonable high development rate and a high contrast.

This missing water has to diffuse from the air into the resist film. Therefore, a delay time between baking and exposure is necessary to rehydrate the complete photo resist film towards the substrate:

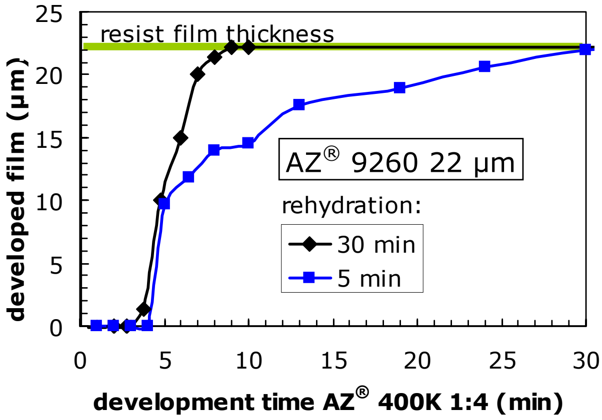
As the numerical simulation results right-hand show, thin films (few µm) completely rehydrate after a few seconds, while thick films (some 10 µm) need several hours for a complete rehydration. Beside the resist film thickness, the required rehydration time also depends on the temperature (water diffusion in the resist bulk is thermal activated) and the air humidity itself.

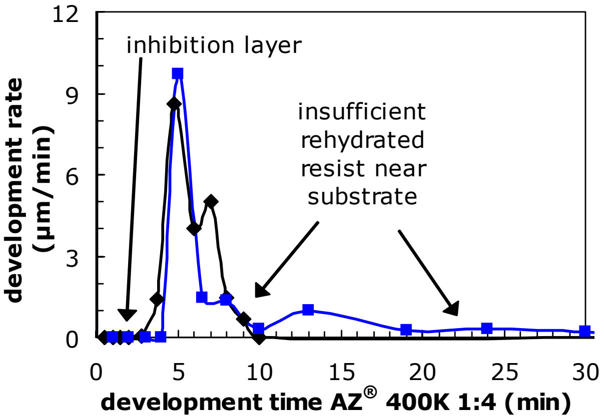
If the air humidity is too low, even a long rehydration cannot provide a sufficient water content, since the equilibrium (adsorbtion and evaporation) H_2O concentration in the resist film keeps below a required value.



Rehydration and Development Rate

The two plots on the next page (top) give a detailed view on the **spatial development rate** through a 22 µm AZ® 9260 resist film (again softbaked at 100°C for 20 minutes). In case of insufficient rehydration (5 minutes, blue symbols), especially the substrate-near resist keeps H_2O-depleted and therefore reveals a significantly lower **development rate** as compared to the rehydrated part on top of it. So the development starts at a reasonably high rate, but slows

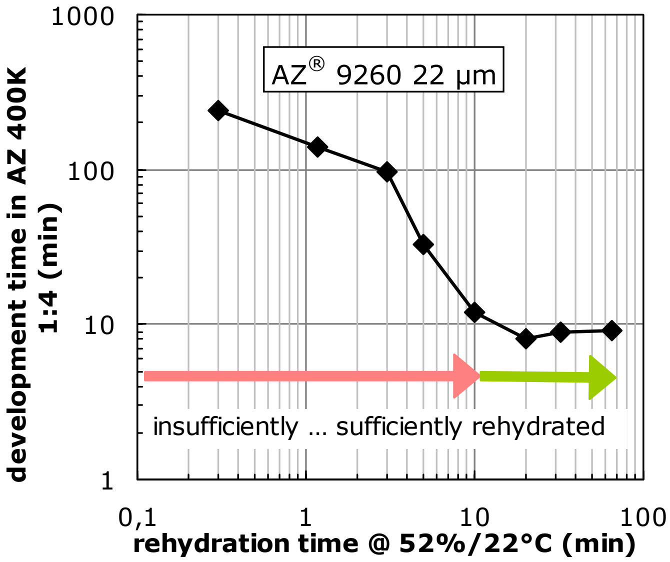




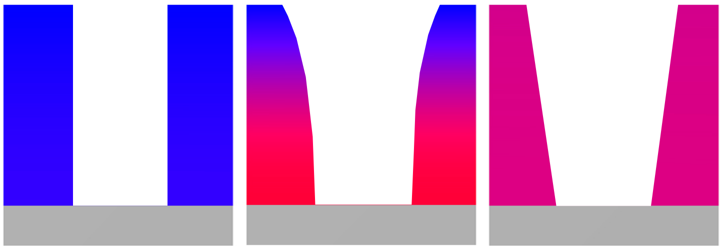
down towards the H_2O-depleted substrate-near part of the resist film. If the rehydration time is high enough (30 minutes, black symbols), the development rate is more constant at a high level throughout the entire resist film.

The plot right-hand shows how strong the necessary time for through-development increases in case of insufficient rehydration:

A 22 µm film AZ® 9260 (softbaked at 100°C for 20 minutes) requires a development time orders of magnitudes higher as compared to a complete rehydration (conditions: humidity 52 %, temperature 22°C).



Rehydration and Resist Profile



Besides a higher development rate, a sufficient rehydration also improves the resist **profile**:

The total dark erosion near the upper part of the already developed structures is reduced, when a high development rate allows a low development time.

Fig. top: An optimum (left), too short (middle) and sufficiently long, but with an air humidity too low (right) performed rehydration impacts on the developed resist profile via the parameters development rate and dark erosion. The resist water content increases from red via pink towards blue.

Optimum Rehydration Parameters

The numerical studies on the previous page give a rough estimation on the required rehydration time.

Since a high air humidity is also required (and can not be compensated by a prolonged rehydration time), one has to make a compromise between rehydration and resist adhesion (low air humidity). Generally, an air humidity of 45 ... 50 % is a good choice.