

DISSERTATION

Photolithography Simulation

ausgeführt zum Zwecke der Erlangung des akademischen Grades
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2.6.1 Contrast and Important Properties

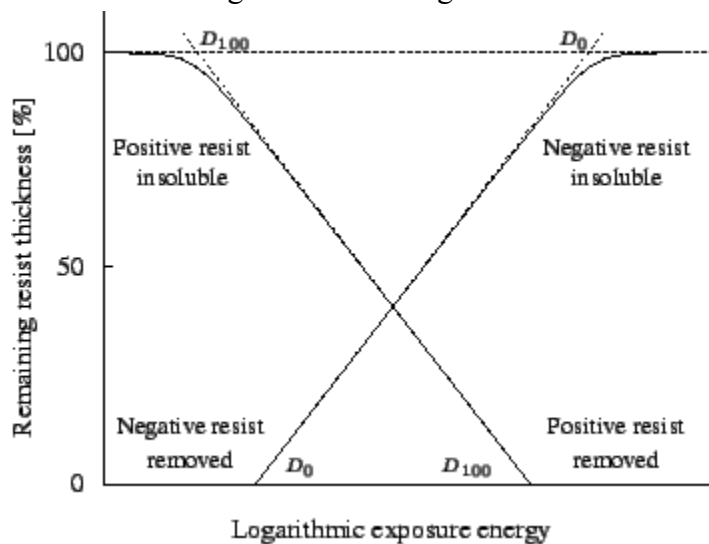
The performance of any photoresist can be characterized by its *contrast curve*. The contrast curve describes the remaining resist fraction of a uniformly illuminated resist versus the logarithm of the applied exposure dose. Idealized contrast curves for positive and negative resists are shown in Figure 2.7. The contrast γ is given by the expression [23, p. 187]

$$\gamma = \frac{1}{\log_{10} \frac{D_{100}}{D_0}}, \quad (2.6)$$

with doses D_{100} and D_0 defined in Figure 2.7. It is a simple measure of how well the resist can convert the distorted patterns of a "blurred" aerial image into a "sharp" binary stencil. Clearly, a high-contrast resist increases the resolution of the entire lithography process by reducing the parameter k_1 in (2.1). Typical values for γ range from 2-3. Hence, D_{100} is $10^{1/3}$ to $10^{1/2}$ times larger than D_0 , e.g., $D_0 \leq 50 \text{ mJ/cm}^2$ and $D_{100} \geq 150 \text{ mJ/cm}^2$. As the exposure dose depends on the exposure intensity as well as on the exposure time both quantities have to be chosen accordingly to transfer the pattern into the resist. The contrast crucially depends on all of the resist processing steps described in Section 2.6.3. The absorption spectrum and the bleaching behavior are also of great influence. Furthermore, second order effects like surface reflection and a non-uniform resist thickness have to be taken into account.

Figure 2.7: The contrast curve is a logarithmic sensitivity plot showing resist thickness versus exposure energy. The contrast γ is defined as the linear slope of

the transition region and describes the ability of the resist to distinguish between light and dark areas.



In the following list some important resist properties are summarized [[24](#), p. 204]:

- **Photospeed** is determined by the quantum efficiency of the resist, i.e., the ratio between the number of photoevents in the resist and the incident photon flux density.
- **Viscosity** affects the flow characteristics and film thickness, and depends on the solid content and temperature.
- **Adhesion** describes how strongly the film sticks to a broad range of substrate materials like silicon, oxide, nitride, polysilicon, and metals. Incomplete adhesion can cause a severe distortion or even the loss of a pattern.
- **Thermal stability** is necessary to withstand resist processing temperatures near 200 °C as well as additional plasma and UV treatment after the development.
- **Etch resistance** determines the ability of the film to protect the substrate from subsequent etching steps.
- **Contamination** of the resist by particulate and metal content increases the pinhole density.
- **Shelf-life** refers to the storage time of the resist before unacceptable changes of its properties occur.
- **Pinhole density** expresses the number of holes per unit area created in the resist due to contaminants or inherent properties. In a thinner resist the pinhole density increases.
- **Charging** becomes important during plasma etching or deposition processes and ion implantation steps. The conductivity of the resist plays an important role for the charging rate.
- **Ease of processing** generally describes the complexity and difficulties to apply, develop, and strip the resist.

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