IPL :
Ion Projection Lithography

White Paper

prepared for International SEMATECH

November 1999

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4. Acid and quencher diffusion
5. Solubility in developer: chemical transformation of polymer through reaction with acid
6. Developer reaction kinetic

Two simulation models have been developed based on a detailed microscopic study of ion interaction with resists which started in 1985 [Mladenov, 1985a; Vutova, 1991a,1992a,1994a]. One simulation model was developed to describe steps (1) and (2) to obtain the latent image and use then step (6) to get a resist structure. This model is perfect to understand the impact of the incoming aerial image properties (ion-optical blur etc.) and the basic resist-ion energy deposition reaction to the imaging process. Thus it can describe accurately an imaging process for non-chemical amplified resists (i.e. acid generation is not taken into account) [Kaesmaier 1999a]. A second model has been developed which also takes into account the effects of chemically amplified resists (steps 3-5).

5.2.1. Aerial image formation

The aerial image at the resist surface is computed by convoluting the ideal current density with the Gaussian image blur. The ideal current density is equal to the exposure dose multiplied by the characteristic function (equal to unity inside the pattern and zero outside) of the mask pattern, scaled by the demagnification ratio of the IPL tool. The nominal line width of a feature is defined as the corresponding width of the ideal current density function. The Gaussian image blur is just the ion-optical point-spread function, which is assumed to have a Gaussian shape. Beam blur is defined as the Full Width at Half Maximum (FWHM) of the point-spread function, which is equal to 2.355 times the standard deviation σ.

5.2.2. Latent image formation

The 3-dimensional (3-D) energy distribution in exposed resist is obtained by convoluting the surface current density with the 3-D energy distribution of a point source of ions. The Monte-Carlo ion scattering simulator SRIM is used to compute this distribution. An advantage of ion beam exposure is the presence of very little lateral scattering. Figure 5.1 shows the FWHM of the deposited energy distribution as a function of depth for 75 keV He^+ ions in 400 nm thick resist. Clearly, lateral scattering contributes a maximum blur of only 30 nm, which should be quite controllable for 100 nm critical dimensions. This can be seen more clearly in Figure 5.2, showing the actual lateral image as described before. The slope is not dominated by the ion-scattering but by the energy absorption as in optical lithography. In order to get steep profiles, high contrast resists with $\gamma \cong 10$ are needed, which are commercially available to date (i.e. chemically amplified resists).