Nanochemistry in Chemically Amplified Resists Used for Extreme Ultraviolet Lithography

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Extreme ultraviolet (EUV) radiation, the wavelength of which is 13.5 nm, is the most promising exposure source for next-generation semiconductor lithography. The development of EUV resists has been pursued on a worldwide scale. Owing to its intensive development, the resist technology has already closely approached the requirements for the 22 nm node. The focus of the development has shifted to the 16nm node and beyond. In the development of resist materials, the trade-off relationships between resolution, line edge roughness (LER), and sensitivity are the most serious problem. Particularly, the reduction of LER is the most difficult task.

A highly sensitive resist, called chemically amplified resist, is an indispensable technology for EUV lithography. The role of chemically amplified resists is to convert the energy modulation to the real binary image as shown in Fig. 1. The photons from the exposure tool are absorbed by resist materials. Using the absorbed energy, acids are generated. The acids catalyze chemical reactions required for the solubility change of the polymer. By developing the generated latent image, a resist pattern is obtained. During these processes, the inhomogenity of chemical compounds which determine the solubility of the resist is generated. The chemical inhomogeneity at the boundary between soluble and insoluble regions leads to LER formation as shown in Fig. 2. The chemical reactions play an important role in not only image formation but also LER formation.

We have investigated the sensitization[1] and reaction[2] mechanisms of chemically amplified EUV resists. In particular, our efforts have been recently focused on the stochastic effect.[3] Figure 3 shows the relationship between LER and the standard deviation of protected units connected to a polymer. This result was obtained by analyzing the dependence of line width and LER on exposure dose and pattern pitch on the basis of the sensitization and reaction mechanisms. The chemistry induced in nanoscale regions is discussed in the presentation. Also, the design strategy for the resist materials used for 16 nm node and beyond is discussed on the basis of nanochemistry.

Acknowledgment

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References

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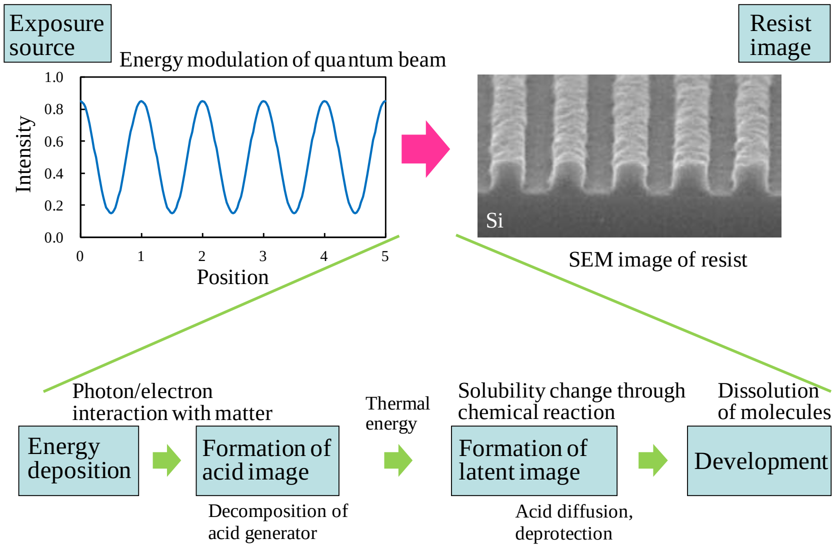

Figure 1: Formation of resist image

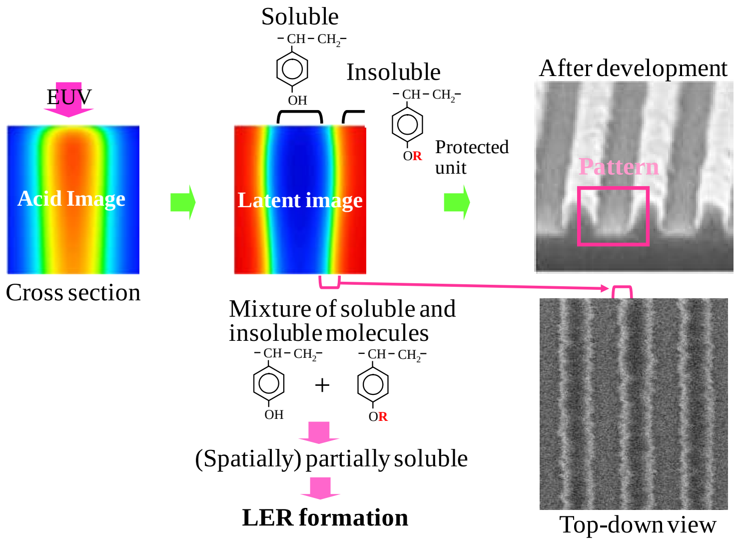

Figure 2: Formation of LER[2]

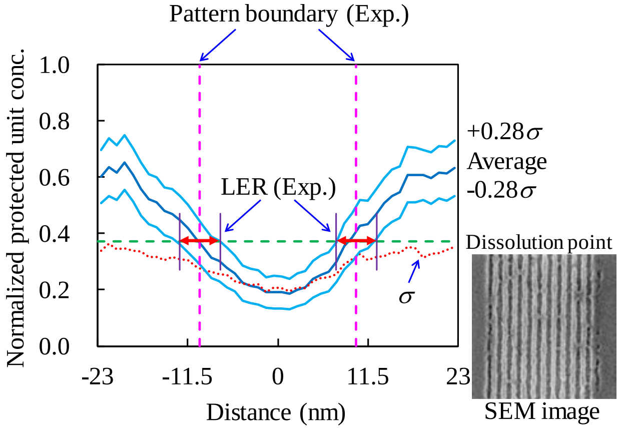

Figure 3: Distribution of protected units at half the height of resist patterns:[3] The vertical axis represents the number of protected units per polymer normalized by its initial value. The exposure dose was 16.0 mJ cm^{-2}. σ is the normalized standard deviation of protected units.