Mesoporous silica film for electron-scattering-suppression in electron-beam lithography

Chun-Hung Lin [1], Sheng-Jung Hung [2], Cheng-Tung Chou [2], Hsu-Chun Cheng [1]
[1] National Nano Device Laboratories, Hsinchu 300, Taiwan
[2] Department of Chemical and Materials Engineering, Nation Central University, Taoyuan 320, Taiwan

Multi-electron-beam direct-write (MEBDW) technology is a potential successor to optical lithography and an attractive candidate for the 32-nm node and beyond. [1-2] Maskless lithography eliminates the need for masks and results in cost and cycle-time reduction. In the electron-beam lithography, the proximity effect is the most serious problem to the critical dimension (CD) control. The scattering of electrons in substrate and resist cause the proximity effect. Electrons will not only expose the resist at the position they are applied, but also in their neighborhood. The non-uniform background electron dose coming from the scattered electrons leads to the pattern displacement and distortion. Conventionally, proximity effect correction (PEC) should be applied to address to this issue. However, more accurate PEC should be employed especially for fine and dense patterns. Here, we proposed to add an electron-scattering-suppression layer (ESSL) between resist and substrate as shown in Fig. 1. This is similar to use bottom anti-reflective coating (BARC) in optical lithography for eliminating the reflected light. In this work, porous oxide [3] as an ESSL is demonstrated.

We use the simple and commonly used two-Gaussian equation to model the proximity effect.

$$f(x,y)=\frac{1}{\pi(1+\eta)}\left[\frac{1}{\alpha^2}e^{-\frac{x^2+y^2}{\alpha^2}}+\frac{\eta}{\beta^2}e^{-\frac{x^2+y^2}{\beta^2}}\right] \tag{1}$$

where α, β are forward and backward scattering ranges respectively; η is the deposited energy ratio of back-scattering over forward scattering. After introducing the porous oxide as an ESSL on silicon substrate, the parameter η was found to be reduced from 0.74 to 0.48. Therefore, back-scattering electrons are suppressed with the ESSL. To see the influence of ESSL on the lithographic performance, the CD deviation between measured and designed CD of 1:1 dense-line patterns are demonstrated in Fig. 2 with respect to various pitches. The CD deviation was reduced when introducing the porous oxide as the ESSL. After applying the PEC with PROXECCO [4], the CD deviation can be further reduced. The etching selectivity between resist and porous oxide was also investigated. Detailed analyses and results will be further reported.

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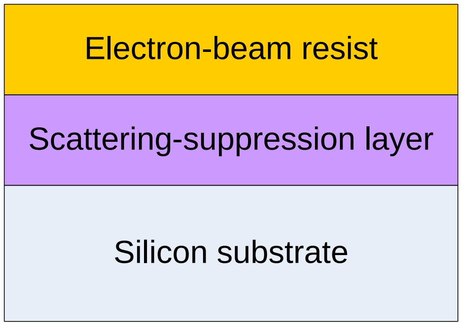

Fig. 1 Scheme of ESSL structure.

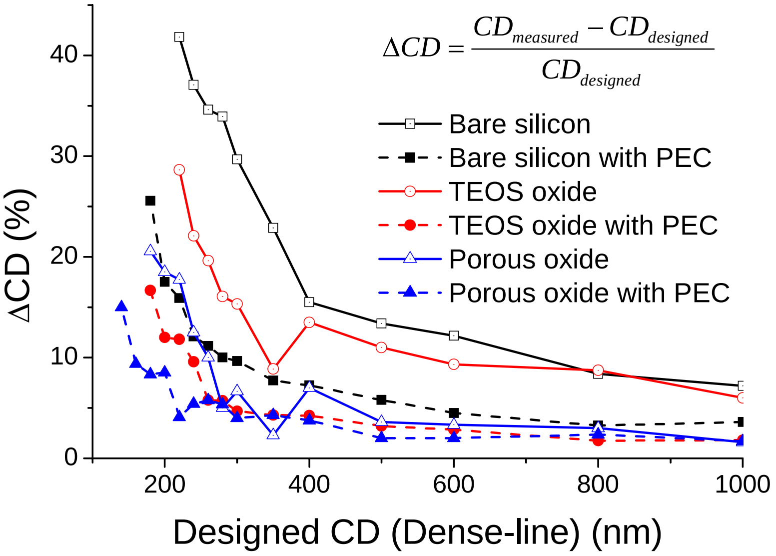

Fig. 2 CD deviation due to the proximity effect in dense-line (line:space = 1:1)