Determination of Base Dose and Scattering Coefficients for Proximity Effect Correction in Electron Beam Lithography

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In electron beam lithography, it is often necessary to correct for proximity effects caused by scattering of the electron beam through its interaction with the resist and substrate. Failing to make these corrections leads to non-uniform doses, which propagates through subsequent process stages, resulting in reduced device performance. Most methods to determine the starting dose and scattering factors involve very precise critical dimension (CD) measurements with many exposure samples, which is painstaking and expensive. In this work, we employ a method that uses a test pattern with 250nm features that can be analyzed in a modest SEM without making detailed CD measurements to determine the base dose and scattering parameter η for four positive-tone electron beam resists: Polymethyl Methacrylate (PMMA in anisole), ZEP 520A (methyl styrene, chloro methyl acrylate copolymer in anisole), SML 2000 and SML 100 resist [1].

One of the most powerful advantages of PEC during fracture is that the base dose is fixed after one time calibration to a resist process. The influence of the stack and the layout is corrected by PEC assigning the required relative doses. We have used the 25% dose sensor that was developed in reference [2]. Results of the corrected exposure in the center and at the corners of the pattern are shown in Figures 1 and 2, respectively, on SML 100 resist (100 nm thick) when exposing at 100 keV and 1 nA beam current. Calculated values of base dose (D_B) and scattering parameter η are shown in Table 1 for each resist studied here. In that table, we show that the base dose does not vary beyond 2σ for SML 100, SML 2000, or PMMA, but that η varies inversely with thickness in SML resist.

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2. N Unal, Y Wang, U Waizmann, T Reindl, Microelectronic Engineering 2011;88(8):2158-2162.

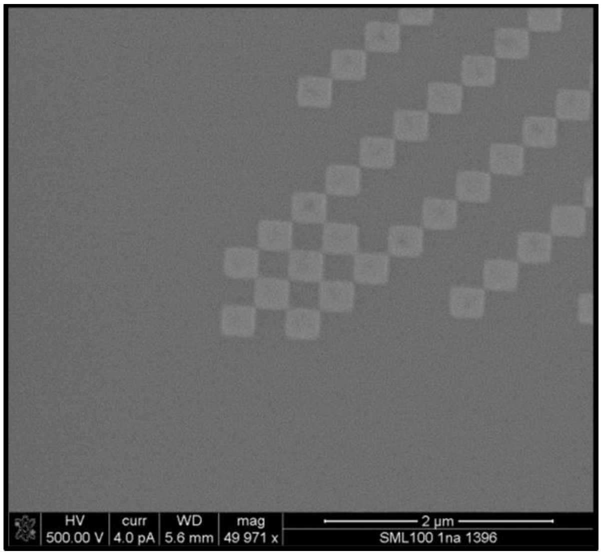

Figure 1. PEC-corrected “best” dose at corner for SML100 resist on Si

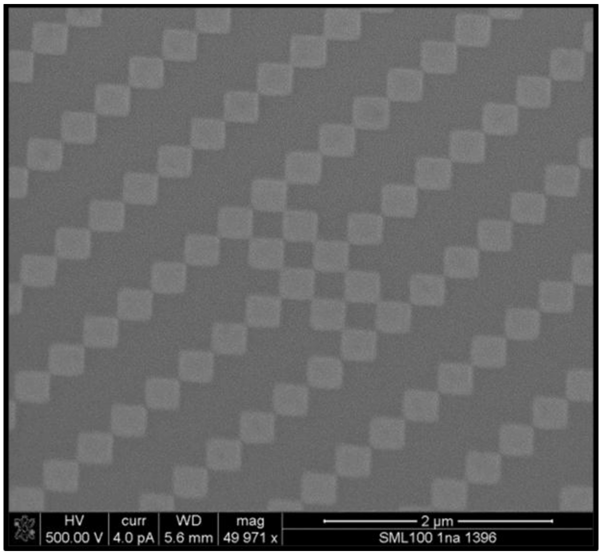

Figure 2. PEC-corrected “best” dose in center for SML 100 resist on Si

Resist	D_B (µC/cm^2)	η	Beam current (nA)	Thickness (nm)
SML 100	1395± 35	0.28 ± .04	1.0	100
SML 100	1382 ± 36	0.25± .04	0.083	100
SML 2000	1488 ± 41	0.09± .04	1.0	2000
ZEP 520A	152 ± 8	0.32 ± .09	5.0	350
PMMA	1436 ± 35	0.26 ± .04	1.0	1500

Table 1. Calculated results of PEC parameters for four electron beam resists on silicon at 100 keV.