

Advantage of IBL over EBL:

Comparative measurement of sensitivity and contrast of PMMA

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ABSTRACT

1. In the present work the first and rigorous sensitivity comparison of the most used positive-tone resist (PMMA 950K) exposure to both electrons and gallium ions in a wide range of exposure doses at the same beam energy was carried out. It was found that the PMMA 950K resist has a positive sensitivity of 0.15 C/cm², which is more than three orders of magnitude more sensitive to gallium ions than to electrons, all at the same conditions. At high Ga exposure doses, as well as with electron exposure, negative sensitivity is measured resulting to ~2000 ratio of sensitivities. See Table 1.

2. The depth of the resist after etching in a solvent depending on the exposure dose (dose curve) was also studied. But absorbed dose is essentially inhomogeneous in resist and the dissolution rate is strongly dependent on depth. So the common procedure of resist contrast determination cannot be applied anymore. In the present work a new method for resist contrast determination considering the relation between dissolution rate and deposited energy density is suggested and realized. By using it for PMMA resist irradiated by 30 keV Ga⁺ ion beam the value of contrast was determined to be 3.1 and ions Bethe range (energy length) was estimated to be 42 nm. See Figure 1.

3. Note that a new parameter ion trajectory length (the Bethe range) now can be extracted from experimental data on residual resist thickness-exposure dose. It is important because Bethe range is closely related to interaction cross sections of incident ions and atoms of target (resist)

4. Now the set of advantages specific for IBL: sub-10 nanometer resolution achievable, very high energy efficiency and almost complete absence of proximity effect could be qualitatively understood. The feature of the promising tool of lithographic nanostructuring based on selective exposure of polymer resist by ion beam is very compact (of about tens of nanometers) beam interaction volume. Herewith the main part of beam energy is deposited in the resist and is spent to its modification.

Table 1.

Comparison
of ion beam
sensitivity
and electron
beam one

	Positive, [uC/cm ²]	Negative, [uC/cm ²]	Ratio, Pos/Neg
Electrons (30keV)	150	~5000	33
Ions (Ga, 30keV)	0.15	2.2	15
Ratio, Ion/Electr	1000	2200	

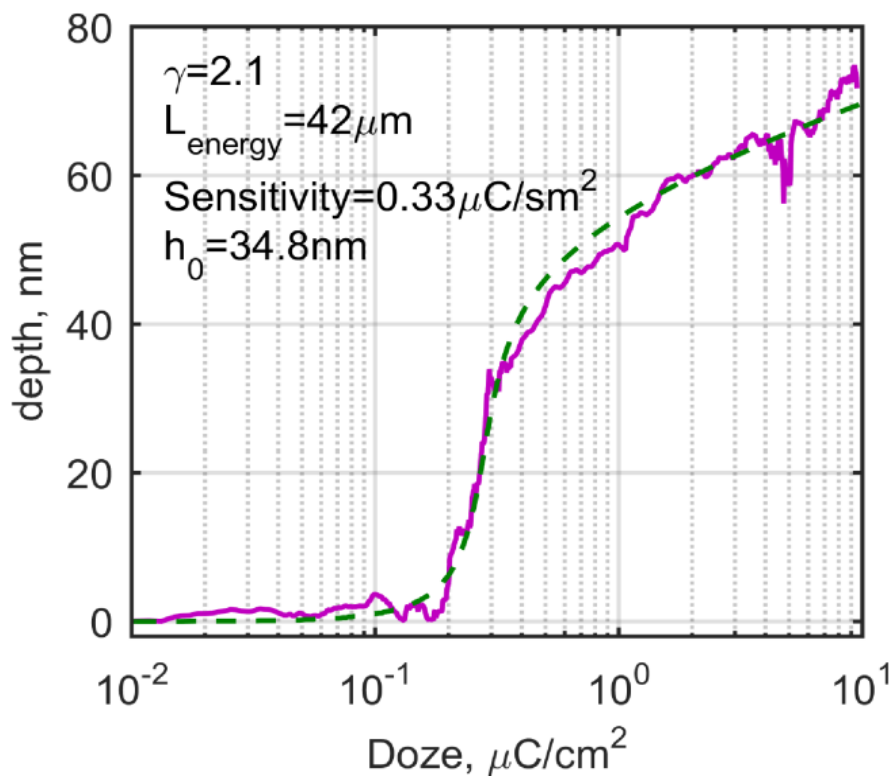


Figure 1. Measured etching depth profile (pink curve) and fitted one (green curve).

