Experimental study of energy distribution in ion-beam lithography

M. M. Myrzabekova[1], N.R. Guseinov[1], M.M. Muratov[1], M.T. Gabdullin[1], R. R. Nemkayeva[1], T. Tolkynbayeva[1], Ya. L. Shabelnikova[2], S. I. Zaitsev[2]

[1] *National Nanotechnological Laboratory of Open Type (NNLOT), Almaty, Kazakhstan*
[2]*Institute for Microelectronics Technology and High Purity Materials (IMT) RAS, Chernogolovka, Russia*

E-mail: *markizat.myrzabekova@gmail.com*

The paper reports two important results. Conducted a rigorous comparison of the sensitivity of the resist is polymethylmethacrylate (PMMA) to the irradiation of electron and ion beams. It is shown that, as in the case of electron irradiation, the resist shows both positive (at low doses) and negative (at higher doses) behavior of sensitivity. But compared with the electronic exposure, sensitivity of the resist is approximately a thousand times higher to the ion exposure, both the positive and negative areas.

The second series of experiments concerned the study of the etching depth (thick) of the resist depending on the dose. It was discovered that in contrast to irradiation by electrons, the energy distribution deposited by ions is strongly inhomogeneous in depth, which leads to strongly non-uniform dependence of the rate of etching to the depth and irradiation dose.

These data were the basis for attempts to quantitatively recover the spatial distribution of energy losses by fast ions in matter.

The process description is based on the formula (1), in which the dissolution rate of the resist V is associated with a density of absorbed energy $E_{exp}(z)$ irradiated with dose D and the contrast of the resist γ the following relation:

$$\frac{V}{V_0} = \left(\frac{\mathrm{D}\, E_{exp}(z)}{D_0}\right)^{\gamma} \qquad (1)$$

In ion-beam lithography compared to electron beam lithography, there is a strong dependence of the sensitivity of the resist thickness. When increasing the thickness from 10 nm to 70 nm sensitivity, measured in units of [μC / cm2], changes to the order, remaining, however, still high compared to the sensitivity to irradiation by electrons.

Thus, in addition to the practical significance of the measured characteristics (sensitivity, contrast), the technique presented by us opens an experimental way of studying the processes of interaction of fast ions with matter.

[1] Ya. Shabelnikova, S. Zaitsev. (ICMNE-2016) with the Extended Session "Quantum Informatics" (QI 2016) October 3-7, 2016, Moscow Region, Russia
[2] Ya. Shabelnikova, S. Zaitsev, Abstracts of MNE 2017, Sept 18-22, 2017, BRAGA, Portugal