Nanofabrication by means of defect engineering with a focused helium ion beam

Yu.V. Petrov[1], E.A. Grigoyev[1], T.V. Sharov[1], E.V. Ubiyvovk[1], A.P. Baraban[1], O.F. Vyvenko[1]

[1] Saint-Petersburg state university, Saint-Petersburg, Russia
y.petrov@spbu.ru

A helium ion microscope is quite promising tool for nanoimaging and nanofabrication. Focused helium ion beam can be used for local modification of material properties by means of defect engineering especially in a case of thin films or 2D structures, such as graphene [1], superconductive thin films [2], quantum wells [3] and so on. In this work we present a review on our results obtained in this area during last few years, particularly in ion irradiation enhancement of chemical etching of silicon nitride and silicon dioxide, few examples are presented in figure 1.

In our work we use helium ion microscope Zeiss Orion. Irradiated samples were investigated by several methods, including transmission electron microscopy (TEM) with Zeiss Libra 200, atomic force microscopy (AFM) with NT-MDT Ntegra, and scanning electron microscopy (SEM) with Zeiss Auriga. The concentration of ion-induced defects can be estimated using Monte-Carlo simulation with SRIM software. Our results show that effect of irradiation with 30 keV helium ions on most of material properties is negligible, if the ion fluence is less than 10^{13} cm^{-2}, and it tends to saturation, if the ion fluence is above 10^{16} cm^{-2}. The exception is electron transport properties, which are quite sensitive to the concentration of defects in the case of non-metals. Most of observed effects can be explained by the correlation between investigated properties of the material and the concentration of ion-induced defects.

Investigation was performed using the equipment of Interdisciplinary Resource Centre for Nanotechnology of SPbSU.

References

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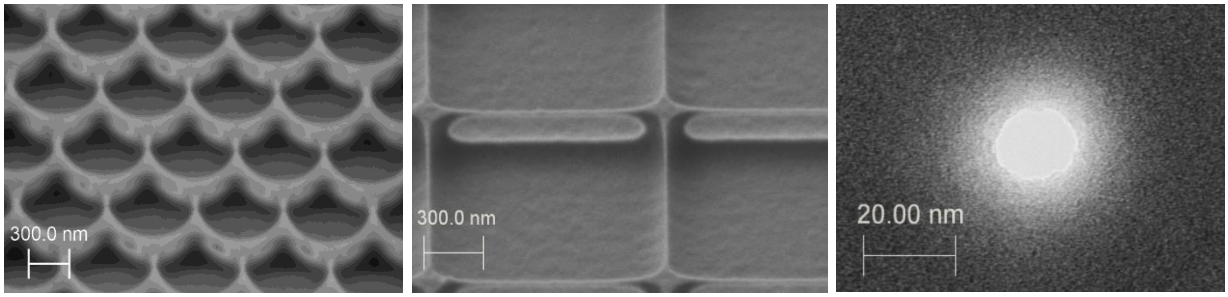

Figure 1. Images of examples of the nanostructures fabricated by means of ion beam enhanced etching. (a) SEM image of honeycomb type structure; (b) SEM image of suspended nanostrings; (c) TEM image of single nanopore in silicon nitride