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Application Notes

SPM methodology

IN-SITU AFM VISUALIZATION OF ION TRACKS IN SILICON DIOXIDE USING SELECTIVE WET ETCHING

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Preliminary investigations showed that the selective chemical etching is effective to study the internal structures of materials, composed of micro- and nanofragments with different etching rates. The development of the atomic force microscopy (AFM) has given the possibility to obtain a three-dimensional image of the surface of solids with the nanometer-scale resolution in liquid and thus to observe the transformation of the surface etching in-situ in the real-time scale. This allows one to obtain the data about the structure of an undersurface layer.

Here we demonstrate the AFM visualization of the local radiation-damaged regions in SiO2 induced by heavy-ion bombardment with low dose. In the experiment, SiO2 films with thickness from 100 to 300 nm formed on a crystalline Si substrate were used as initial samples.

The samples were irradiated at a dose of about 109 ion/cm2 with 710 MeV Bi51+ ions in Joint Institute for Nuclear Research, Dubna by Dr. V. A. Skuratov. The weak HF aqueous solutions with the volume concentration of HF from 0.25 to 1 % were used for chemical etching. It is essential for our experiments that the Si substrate does not dissolve in such solutions. The measurements were carried out with a Solver-P4-18RM scanning probe microscope made by NT-MDT. The description of the liquid cells used in this work and of the respective methods of AFM measurements was published in [1]. The AFM measurements were made in a contact mode directly in-situ in the acid solution obtaining the AFM images from the same surface area one-by-one during its chemical modification.

Craters or hillocks due to single single-ion impacts were not found just after implantation of the SiO2 surface with Bi ions. This is probably caused by the relatively high roughness of the SiO2 surface of the initial sample and the "tip - sample surface" convolution effect. The selective etching method was successfully used for the AFM visualization of the latent tracks formed in SiO2 by Bi. The scheme of etch is presented in Fig. 1 a - c. Fig.2 shows the time sequence of AFM images obtained in-situ during etching. This experiment reflects the formation of such pit structure in the real-time scale and will allow us to estimate the etching rate of SiO2 in latent tracks containing implantation-induced damages.

It is shown that the AFM on the basis of the selective liquid etching can be successfully used to study SiO2 with the local regions with high concentration of radiation damages induced by single heavy-ion bombardment. These investigations allow one to delineate implanted bulk regions in the undersurface layer and to measure the lateral pit size during etching.

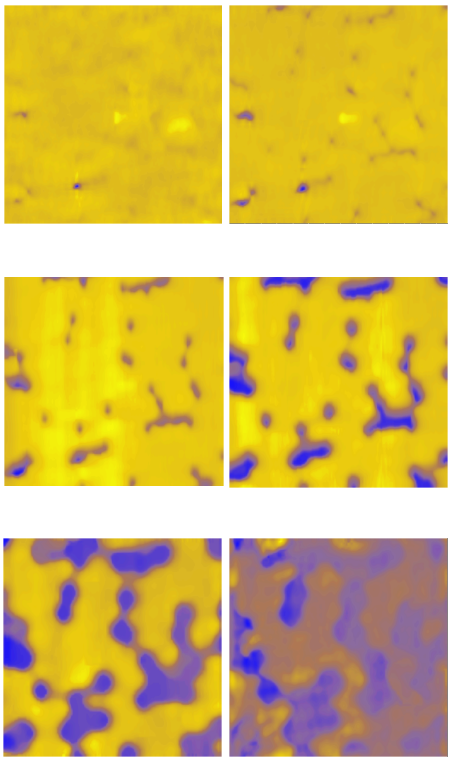

Fig. 1. Time sequence of AFM the images of the same area of the SiO_2-Si sample containing latent tracks obtained in-situ during liquid etching.

References

1. Bukharaev A.A., Nurgazizov N.I., Mozhanova A.A., Ovchinnikov D.V. Russian Microelectronics 28 (1999) 330.

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