3D in SEM, (S)TEM, Ion Imaging, incl. FIB-SEM and SBF-SEM

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Examples of application an electron-ion scanning microscopy for research biological, quantum and solid-state materials in different areas of science and technology

Y. Anufriev[1,2], V. Galkov[1], A. Dudin[2], E. Eganova[2]

[1]JSC Nanopromimport, Moscow, Russian Federation
[2]Moscow State University, Faculty of Physics, Moscow, Russian Federation

hf_hf@newmail.ru

Recently, research techniques development in various fields of science leads to use the scanning electron microscopy. Although that this type of research provides detailed information about the surface morphology and material composition, single-beam systems loose to the functional capabilities of Dual-beam microscopes. The main problem of modern scanning electron microscopy is the incompatibility of some techniques and research facilities.

This article discusses the adaptation of scanning electron-ion microscopy for different objects of study. Provided results of work performed at the Physics Department of Moscow State University using a Quanta 3D FEG FEI workstation.

Originally, electron microscopy allowed to study only highly conducting metal or semiconductor materials at high energies of the primary beam. Modern electron microscopes allow us to investigate the dielectric and biological materials, as in a high vacuum, and in the natural environment mode (Figure 1,2). Choosing the right mode and method, you can minimize the damage to the sample surface to give the maximum information. For these purposes, the cryosystem or dew point mode are used.

Well-known application of ion microscopy is researching and editing electronic semiconductor circuits. However, the capacity of the gas chemistry with the FIB allows prototyping and creating the semiconductor quantum structures (Figure 3,4). One of the advantages of such systems is the possibility of gradually removing material from a localized area, thus obtaining 3D reconstruction of the object of study as shown in Figure 5. Equipping microscope with electrical testing system (Figure 6) allows you to record real-time processes of change in the surface morphology as a function of the applied voltage and current, monitor emission processes in nanostructures. Separate mechanical manipulators mounted directly on the microscope table and manipulators installed in the free port of the camera allows high-precision movement of micro-objects across the surface or to transfer them to the grid for analysis. In addition, the sharing of a scanning electron microscope and microprobe enhances diagnostic modern integrated devices. The opportunity to research nanostructures audit methodology current induced by the electron beam. Also, this technique allows you to search defects in the tracks of live circuits without thermal heating. The proposed research technique using nano-analytical equipment based on the precision of electron-ion scanning microscopy allow the study of almost any object of interest of modern nanotechnology.

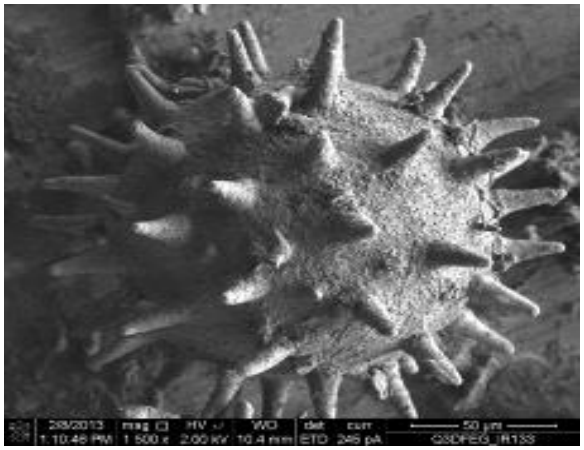

Figure 1. Tea rose pollen.

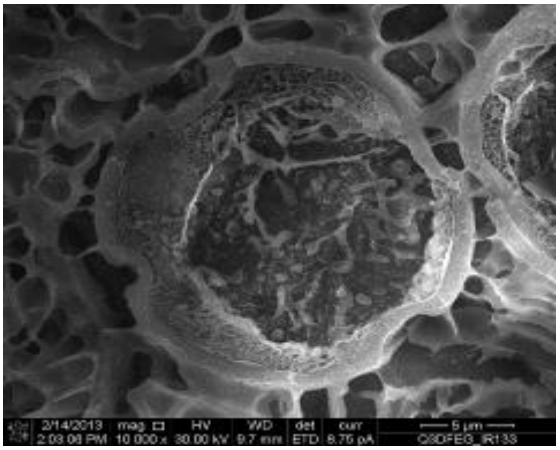

Figure 2. Fractured tobacco pollen cell.

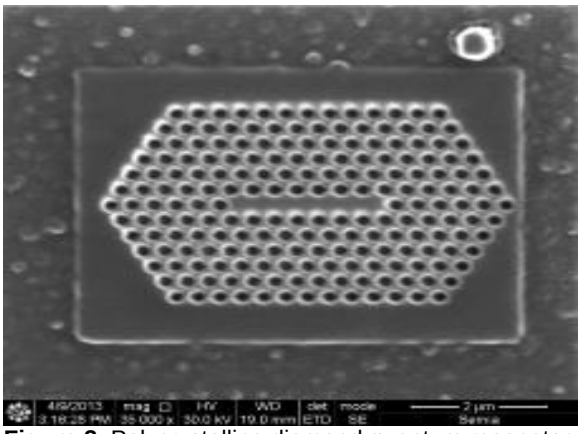

Figure 3. Polycrystalline diamond quantum resonator.

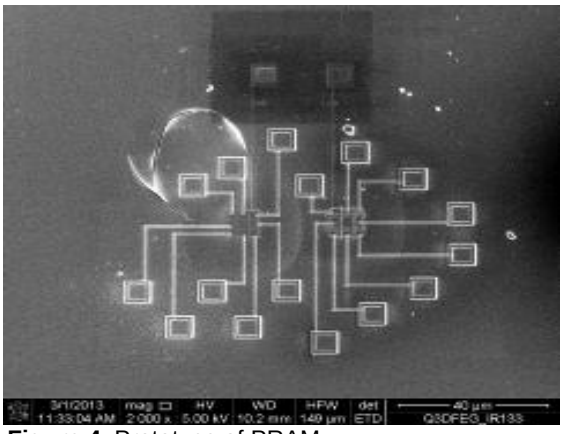

Figure 4. Prototype of PRAM.

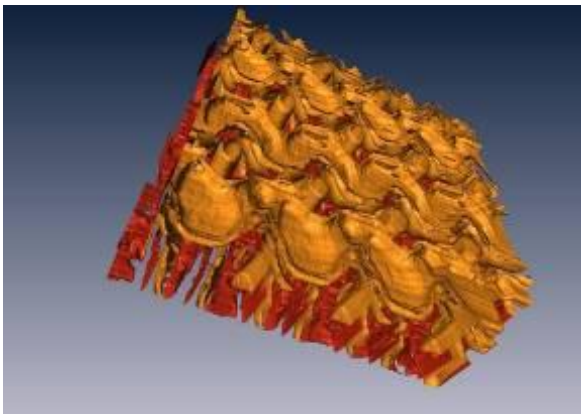

Figure 5. 3D reconstruction of microchip sample.

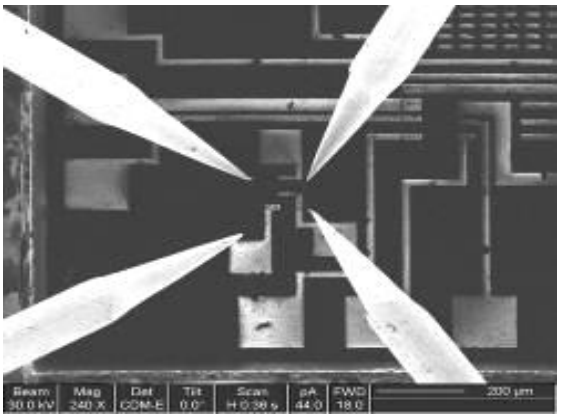

Figure 6. The process observation of contacting probes installed in the chamber.