A micro-manipulator system for characterization of irradiation induced thin film modifications at the in-situ high-resolution SEM at UNILAC*

C. Kiener, R. Ferhati, and W. Bolse#

Institute for Semiconductor Optics and Functional Interfaces, University of Stuttgart, Germany.

In order to be able to track the development of swift heavy ion (SHI) induced material modifications on surfaces and in thin films on a nm-scale, we have recently installed our in-situ high-resolution scanning electron microscope (HR-SEM) at the M-Branch of the UNILAC beam line [1]. The microscopy chamber is utilized for the ion irradiation as well as for SEM analysis and allows us to investigate the evolution of individual µm- and nm-sized objects from the first ion impact throughout the entire irradiation experiment. In a first extension stage an EDX-detector has been added to the system that enables us to also follow compositional changes besides the SHI induced structure formation. This way we were able to investigate SHI-induced dewetting of thin oxide films and to discover a dewetting mechanism, which is very similar to the spinodal dewetting of liquid films. But instead on capillary waves, the effect is based on a surface instability caused by irradiation induced mechanical stresses [2].

Here we present a new extension of our setup with a micro-manipulator (MM) system consisting of two MM3A devices from Kleindiek Nanotechnik [3]. The MM3A is a telescopic robotic arm, which can be rotated around its two perpendicular axes. It is attached to the microscopes 5-axes eutectic stage such that it follows the tilt and the up-down movement of the stage, but no lateral translation and azimuthal rotation. This way it can be assured that the tips of the MMs stay in the focus of the electron beam, while the sample can be adjusted on a nm-scale for precise handling (see also Fig. 1).

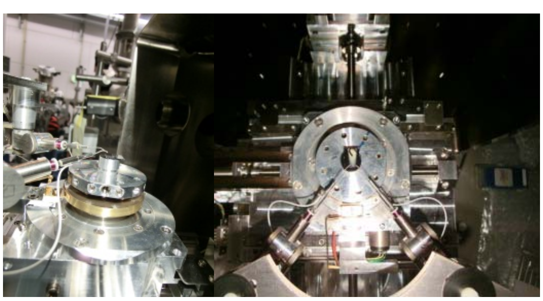

Figure 1: The micro-manipulators in the SEM.

Besides the prober tips (metallic needles with some tens of nm curvature radius), the MM3A can be equipped with various plug-in tools for different applications. The ROTIP device allows for axial rotation of the manipulator arms. For grabbing, removing and repositioning of µm and sub-µm sized particles a micro-gripper (MGS2) is available.

A force measurement system (FMS) allows for the investigation of (sub)micro-mechanical properties and a low current measurement kit (LCMK) can be used for electrical characterization on that length scale.

This system significantly enhances the potential of the in-situ setup, since it extends the possibility of in-situ tracking SHI-induced structural and compositional changes by simultaneous investigation of important other physical properties. Moreover, it will allow us to perform SEM- and EDX-analyses on submicron objects without the heavily disturbing substrate by separating them using the micro-gripper or glueing them on a prober tip. In combination with the ROTIP the object can then be inspected from any direction.

After installation of the MM system, first tests were performed. SiO_2 spheres with 3µm diameter were grabbed and repositioned on a Si-wafer (Fig.2). The FMS system was calibrated and a nano-indentation experiment was performed on a thin SiO_2-film on Si by measuring the indentation depth and force relationship. The LCMK was applied for conductivity measurements on gold-nanowires on NiO-lamellae formed by grazing incidence SHI irradiation of a Au-coated NiO-layer on oxidized Si. Publication of the results of these experiments is in preparation.

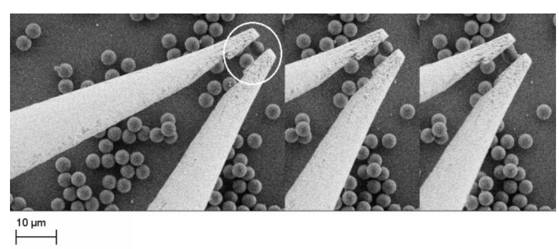

Figure 2: Test run of the MGS2 micro-gripper with microspheres.

We like to acknowledge GSI for hosting the experiment and especially M. Bender and D. Severin for valuable help.

References

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* Work supported by Deutsches Bundesministerium für Bildung und Forschung under contract 05K10VS1.

w.bolse@ihfg.uni-stuttgart.de