Helium Ion Microscope Invasiveness study for Semiconductor Applications

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Helium ion gas field ion sources (He-GFIS) is a novel charged particle source technology with potentially greater capabilities than electron beam based tools for imaging and nanomachining applications. Primary benefits are smaller virtual source size, higher brightness, smaller intrinsic energy spread, and smaller interaction volume. However, unlike SEM, high energy helium ions are potentially invasive due to their mass and charge properties. We have completed a series of ion irradiation experiments and modeling to characterize the physical and electrical impact of using this technology in semiconductor microscopy, metrology, nanomachining, and in-line inspection applications.

Our study focused on 3 primary areas: 1) Impact of He+ on silicon lattice; 2) Impact on device threshold voltage and timing; 3) Novel SE and RBS imaging for mask and semiconductor substrates. Acceleration voltage for these experiments ranged between 20keV to 50keV, with dose ranging between 1E+14 to 5E+17 ion/cm^2. Figure 1 shows a TEM cross section of a silicon substrate irradiated with a high dose (1E+15 ions/cm2). In this sample, it appears that most of the discernable defects are concentrated near the surface (<35 nm), far shallower then the SRIM model predicted and is likely a function of the TEM sample prep.

In this paper we will present our latest results on dislocation analysis and charge related device invasiveness for various dose and acceleration voltage combinations. We will also present preliminary image resolution and charge neutralization capabilities analysis for mask and semiconductor materials.

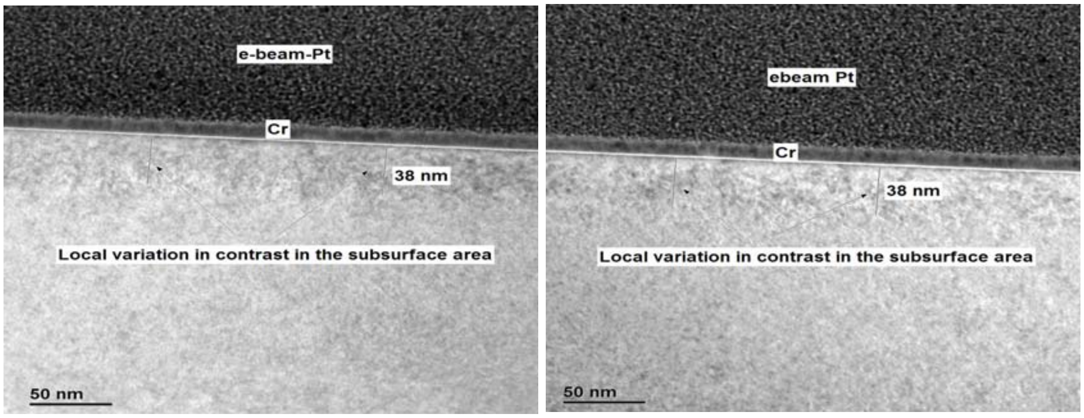

Figure 1: TEM cross section of damage study sample. The micrograph on the left is an area irradiated with helium ions with a dose of 1E+15 ions/cm2 at an energy of 22keV. The area on the right is the control area that had not undergone any form of helium microscope implant. Modeling completed under similar conditions predicts a dislocation depth of ~ 300nm with a defect density of ~5E+18 dis/cm3. However, our preliminary TEM analysis show no sign of defect over that range and shows little to no difference in the helium implanted sample when compared to the control area. More experiments at higher doses and energies underway –results will be presented in final manuscript.

References:

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