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IT-13-P-1712 Sample preparation using Xenon IC-Plasma FIB: benefits and problems.

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For many types of specimens it is necessary to remove a large amount of material in order to provide an electron transparent region or a needle structure for atom probe tomography (APT). This is particularly true in the case of 3D Integrated Circuit development and manufacturing. This requirement has become sufficient to bring to the market a new generation of commercially available focused ion (FIB) tools that are equipped with inductively coupled Xenon plasma ion sources. This technology allows the generation of beam currents that are twenty times higher than those available using conventional FIBs that use a liquid metal (gallium) ion source. The use of xenon ions to prepare samples such as scanning electron microscope (SEM) cross-sections, transmission electron microscope (TEM) lamellae or even APT needles is attractive because of the theoretical reduced damage of xenon when compared to gallium. Figure 1 shows SRIM simulations of Xe, Ga and Ar ions with different energies in silicon at an angle of incidence of 5° normal to the specimen surface [1]. The simulations suggest that the range of the ions is significantly less for Xe ions. Although the simulations do not account for effects such as channeling in a crystalline specimen, the link between specimen damage and the SRIM simulations has been verified [2]. In this presentation we will introduce the Xe plasma milling system and present measurements of the implantation of Xe ions in Silicon compared to Ga and Ar. For example Figure 2 shows amorphisation and ion implantation profiles have been measured using TEM and APT measurements as a function of the accelerating voltage on silicon and compare to TRIM calculations. We will show the results of specimen preparation using Xe ions, for example of materials that are sensitive to gallium like GaAs and InP which tend to form eutectic compounds that precipitate under Gallium implantation and local heating. Scanning spreading resistance microscopy (SSRM) measurements on InP/GaAs samples cross sectioned with Xenon ions have been compared to Ga-FIB prepared samples in order to compare the sample surface in terms of roughness and dead layer for electrical measurements. Xenon Plasma-FIB specimen preparation also has drawbacks due to the large beam size diameter that has been quantified in this study. We believe that using Xe plasma FIB could open up applications for site specific time of flight (ToF)-SIMS, Auger and XPS analysis, for which the use of a Ga-FIB is impracticable for the production of large enough surface areas, i.e. few hundreds of micrometers.

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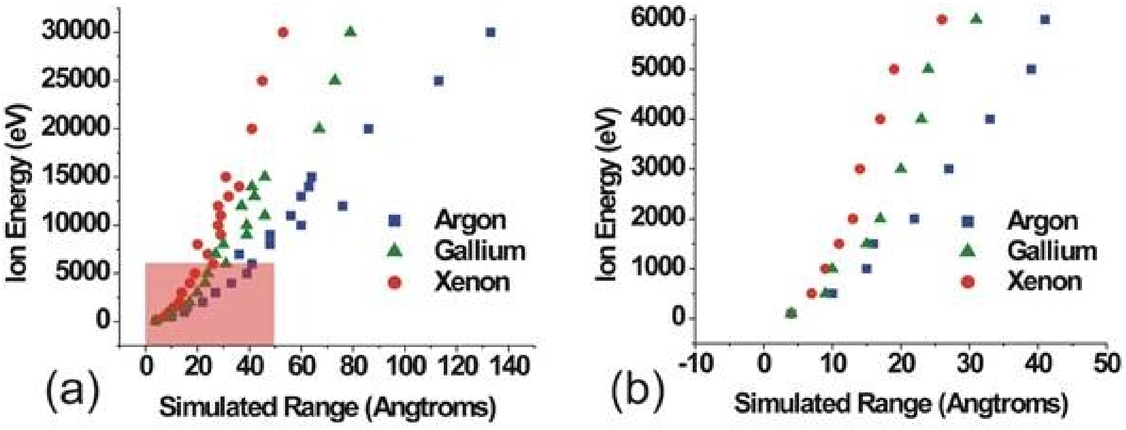

Fig. 1: Figure 1(a): SRIM simulation of Ar, Xe, and Ga range in silicon as a function of the energy for an angle of incidence of 5°. (b) Magnified plot indicated in (a) by the red shaded region.

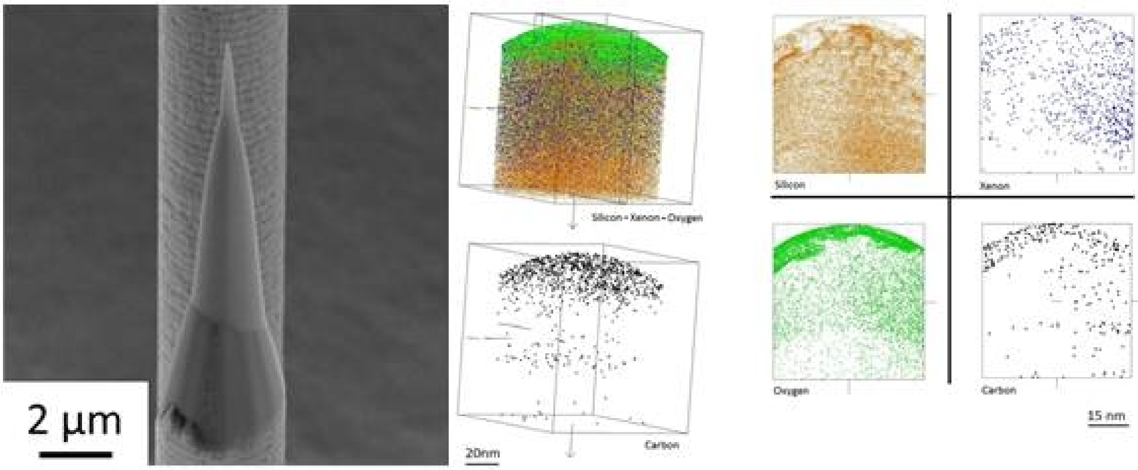

Fig. 2: Figure 2: SEM view of an APT needle of silicon milled with 30kV xenon ions and a reconstructed volume showing the Xenon penetration.