Application of Neon Ion Beam for Processing III-V Semiconductors and Atom Probe Sample Preparation of Ga sensitive materials

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Focused ion beam (FIB) milling using gallium ions is routinely used for the site-specific sample preparation of cross-sections, Transmission Electron Microscopy (TEM) lamella and Atom Probe Tomography (APT) tips. While the Ga FIB has been a versatile tool on a variety of materials, there are exceptions such as Al, In, Sn and III-V semiconductors where Ga irradiation and implantation causes detrimental effects. Artefacts from the Ga-FIB milling include near-surface implantation of gallium, eutectic alloy formation and intermixing, accumulation of gallium along grain boundaries and between phases, Ga droplet and pore formation due to selective sputtering of the atoms. With the advent of novel FIB sources, alternative ion species for precision milling are now available. For example, Ne-FIB-milling as the final polishing step in the preparation of electron-transparent samples for TEM has been demonstrated as an alternative approach for samples in which contamination effects from gallium cannot be tolerated [1]. In this contribution, we present results from the application of Ne ions in the milling GaAs and GaN and final polishing of APT tips from Aluminium/Aluminium oxide structures

Conventional processing of GaAs and GaN with Ga FIB-SEMs at room temperatures is well known to produce Ga-rich droplets and pores. Processing with non-Ga based ion sources has been explored using other ions species such Au and using broad ion beams and plasma ion sources with Ar for TEM lamella preparation. Here we employ the Ne ion beam for direct sputtering of GaAs to create trenches and structures as small as 20 nm. Optimization of the ion beam landing energy and current for preparing flat bottom trenches and side walls without Ga droplets will be presented.

The APT tips are extracted from bulk samples using Ga-FIB in situ lift out. The preliminary trimming is done using Ga FIB and the final polishing employs the Neon ions. Materials investigated include a titanium alloy and a sample comprising aluminum/aluminum oxide layers on a silicon substrate. High-resolution TEM analysis of Ne-FIB-milled tips reveals that implanted gallium from the previous steps is successfully removed. A thin amorphous layer of ~ 5nm is observed, beneath which the crystallinity of the tip is well-preserved. The experimental workflows for the Ne-FIB technique will be discussed and the 3D reconstructions from the APT measurements presented.

References:

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