A Comparison of Xe^+ Plasma FIB Technology with Conventional Gallium LMIS FIB: Resolution, Milling Acuity, and Gas-Assisted Applications.

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Focused Ion Beam (FIB) tools incorporating Xe plasma ion sources have recently been introduced, and applications development on prototype systems has made significant progress. Typical applications for the semiconductor industry have already been presented, including bulk silicon trenching, Through-Silicon Via (TSV) cross sectioning, and package-level deprocessing.[1,2,3] In this work, we present a detailed comparison between Xe plasma FIB and conventional gallium Liquid Metal Ion Source (LMIS) tools. Specifically, we investigate imaging resolution, milling acuity, and gas-assisted operations including metal deposition and silicon etching.

The beam current range of the plasma FIB (few pA to > 1 uA) is approximately two orders of magnitude larger than a typical gallium LMIS FIB (1 pA to 20 nA). At low currents, the gallium FIB resolution is superior to the plasma FIB resolution, but at high currents the situation is reversed. Due to differences in the angular intensities of the two sources, the performance of the plasma FIB begins to outperform Ga LMIS at currents above ~20 nA. “Milling Acuity” is examined by measuring line burn widths on a thin chrome-on-glass substrate, and is compared for both source technologies in the low current and high current regimes.

Gas-assisted deposition and etching have also been examined. XeF_2-assisted silicon removal rates of $1.5x10^6$ μm^3/min were measured with the plasma FIB, in contrast to the previous Ga LMIS record of $2x10^5$ μm^3/min.[4] The results for metal deposition are mixed. Volumetric deposition rates for Pt films were three times higher for the plasma FIB, but the resistivity of the Ga-deposited films was significantly lower. The differences in resistivity are attributed to the contributions of implanted primary ions and differences in the density and porosities the deposited films.

[1]R. Young et al, presentation at International Wafer-Level Packaging Conference, 2010; [2]S. Kellogg et al, presentation at Microscopy and Microanalysis Conference, 2010; [3]C. Rue, presentation at European FIB User Group Meeting, 2010; [4]C. Rue et al, presentation at ISTFA 2008.

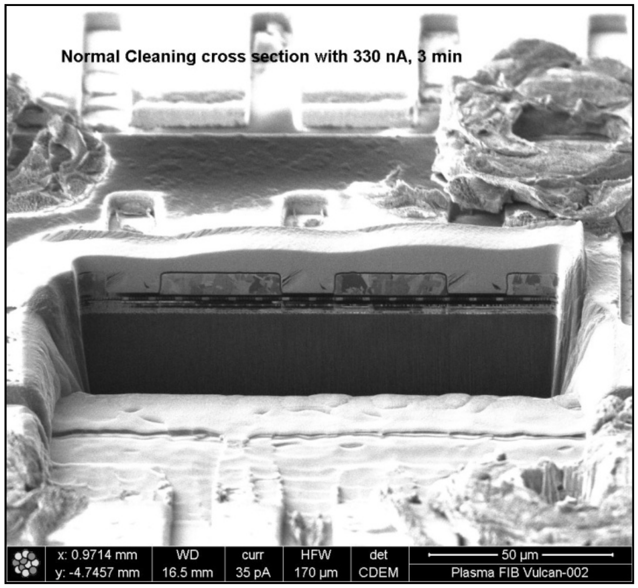

Fig 1. Large cross section on an integrated circuit device prepared using the Xe^+ plasma FIB. A thick layer of Pt was deposited as a sacrificial cap prior to sectioning. The Pt thickness varies from 7 to 15 um. Despite the enormous volume of metal deposited, the process required just minutes to complete.

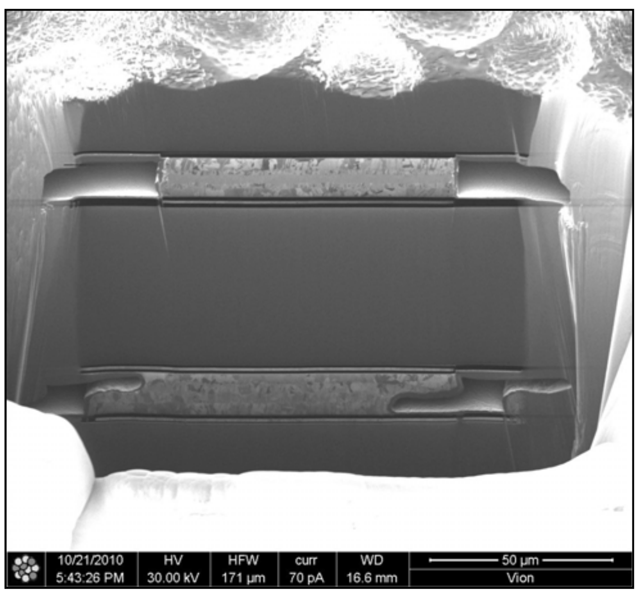

Fig 2. Cross section of a device with stacked die. XeF_2-assisted silicon removal ("trenching") was used to remove the bulk of the overlying substrate silicon prior to sectioning.