Metal Depositions Induced by Helium and Neon Ion Beams

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The dimensional shrinkage of integrated circuits, data storage and biological/medical devices requires continual improvements to conventional technologies and innovations for new nanofabrication technologies. Gallium - focused ion beams (Ga-FIB) and electron beams (e-beams) have been established to fabricate mico or nanoscale structures and widely used for circuit editing and repair. However, the limited feature size that Ga-FIB can fabricate (> 50 nm) and Ga implantation cannot meet the needs for further dimensional shrinkage. E-beams can provide smaller feature size than Ga-FIB, but normally lack the power to completely decompose the precursors and have low sputter yields, which also limit e-beam applications. Consequently, there is a surging need for the development of novel nanofabrication methods that can address these needs.

The Orion-NanoFab microscopy provides both helium and neon ion beams with a smaller probe size relative to both the electron beam and Ga-FIB and has the capability of fabricating sub-10 nm patterns at high densities, providing a possible solution for future nanofabrication. Here, we will present the beam chemistry with He and Ne ion beams to induce metal deposition. We will discuss the differences between the dimensions and resistivities of metal lines deposited by helium and neon ion beams. We will also compare our results with those fabricated by Ga-FIB and e-beam using similar precursors reported in the literature. We will discuss the factors that determine the ultimate line width using He and Ne ion beams. Last, we will discuss the underlying mechanisms of the beam chemistry that influences the choice of gas precursors for a particular procedure and how to select between the helium and the neon ion beams to achieve the best result.

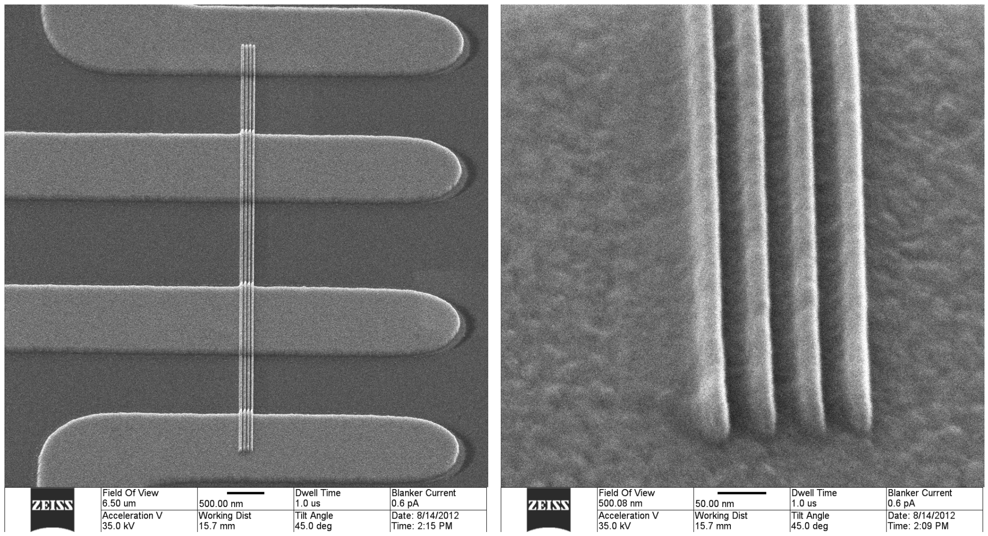

Figure 1: A 45^o tilted He ion image of 4 metal lines deposited across a 4 point probe structure for measurement of resistivity (left) and a high resolution He ion image (right): lines have been deposited using a 1.5 pA helium gas field ion source. A 4-line pattern with an average width of 25 nm and a pitch of 50 nm is shown here. Electrical property measurement shows the average resistivity of these metal lines is less than 100 μΩcm.