# Focused Ion Beam Induced Platinum Deposition with a Low Temperature Cesium Ion Source

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The deposition of material at a certain spot on a sample surface is a powerful and useful feature of Focused Ion Beam (FIB) systems. Initially, deposition was used for circuit editing and as protection layer before milling. Nowadays, the process is more far-reaching and 3D, magnetic or superconductive structures can be created. Also, specific mechanical structures on atomic force microscope (AFM) cantilevers can be made.

As ion species, most often Gallium (Ga) and Helium (He) are utilized. Besides these standard FIB systems new kinds of laser cooled ion sources (LoTIS) have been developed in the last few years. One strength of these ion sources based on laser-cooled atoms is that many elements, unavailable with conventional sources can be used. At least 27 elements, including both metals and non-metals, have successfully been laser-cooled. Among these elements, rubidium (Rb) and cesium (Cs) are more advanced with respect to source development due to their relatively low requirements for the cooling laser.

Li et al. already showed milling results and the deposition of Platinum (Pt) with a self-built prototype ultracold Rb+ source [1,2]. A Cs+ LoTIS has also been developed and characterized. Like the Rb+ source, the Cs+ LoTIS has also been incorporated in a ThermoFisher FIB column. ZeroK NanoTech Corporation has created commercially available Cs+ FIB systems based on the aforementioned construction. A disadvantage of using Cs is a possible surface modification. One aspect of this paper is to show if it is at all possible to deposit Pt with Cs+ ions or whether the surface modifications are dominating.

This work presents focused ion beam induced deposition (FIBID) experiments using a Cs+ FIB in comparison to results of layer deposition induced by Rb+ and Ga+. The Pt was deposited at different acceleration voltages and ion beam currents to evaluate the deposition rate and the specific resistance of the layer. To measure the grain structure and the material composition with Energy-dispersive X-ray spectroscopy (EDS) lamellas for Transmission electron microscopy (TEM) were prepared. In conclusion we show the differences in FIBID with a standard Ga+ FIB and the new kind of FIB with a LoTIS.

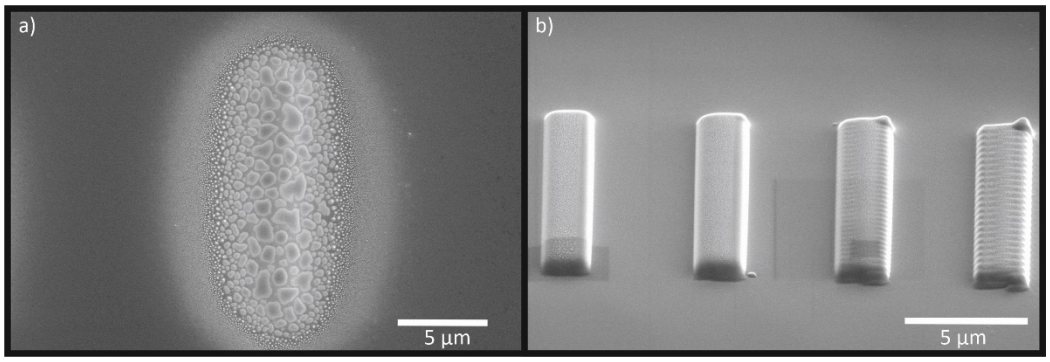


*Figure 1: (a) SEM images of FIBID Pt on Si with Cs+ ions at 2 kV showing a high amount of bubbles on the layer. (b) Pt deposited at 16 kV with different current densities and no bubbles. At specific beam parameters the Cs+ ions can induce surface modifications.*

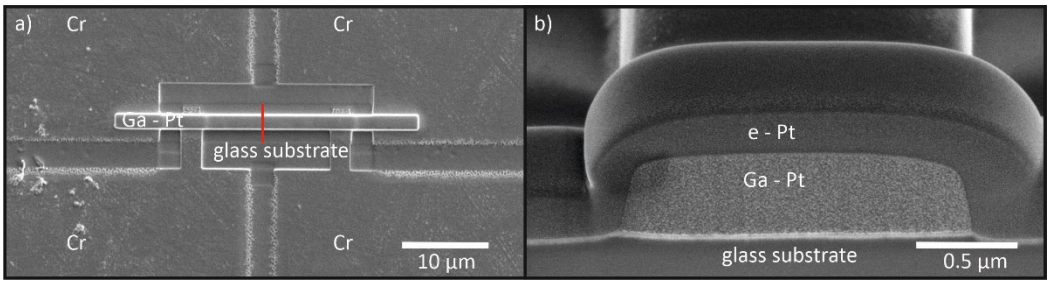


*Figure 2: (a) structure for the resistivity measurements consisting of four Cr electrodes and the 35µm by 1.5 µm Ga induced Pt deposit layer. The red line is indicating the position of the cross section. (b) SEM image of this cross section. Before the FIB cut for the cross section measurement was done an additional Pt layer was deposited with electron beam for protection.*

[1] Xu, S.; Li, Y.; Vredenbregt, E. J. D. *J. Vac. Sci. Technol. B* 2022, *40*, 042801.
[2] Li, Y.; Xu, S.; Sezen, M.; Misirlioglu, F. B.; Vredenbregt, E. J. D. J. Vac. Sci. Technol. B 2023, 41, 042803.