Investigation of ultracold Rb ion beams for FIB applications

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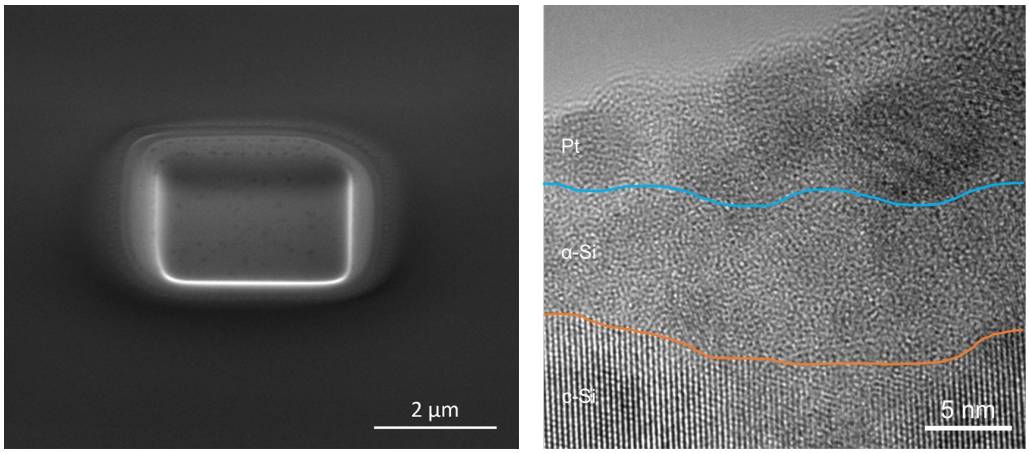
Focused Ion Beams (FIBs), with applications for circuit editing and microscopy, are important tools for material science and semiconductor industry. Here a prototype FIB system is described that uses Rb^+ ions. The essential innovation is the use of a cold-atom ion source based on photoionization of a laser-intensified and cooled atomic Rb^+ beam. The whole source is mounted onto a FEI FIB200 column. Some first sample millings and platinum deposition experiments have been performed.

Currently, the Rb^+ FIB can deliver an 8.5 keV beam with maximum current up to 45 pA. Using a selecting aperture to cut down the current close to 10 pA, we currently achieve a resolution in the 100 nm range. Different energies and currents are also available with the beam.

Transmission electron microscopy (TEM) inspection of the Si milled by Rb^+ (Fig.1) reveals a damage layer of around 8.6 nm, which is comparable to that milled by Ga^+ ions. The Rb^+ FIB demonstrates advantage over Ga^+ FIBs in that it mills more evenly on several samples. For instance, atomic force microscopy scans of milling results on Au shows that the roughness of the milled pattern decreased by 76% switching from Ga^+ to Rb^+. In Fig 2, the Rb^+ milled pattern on GaAs contains smaller droplets compared to that made by Ga^+. From the milling experiments, Rb^+ sputter yields and secondary electron yields have also been measured.

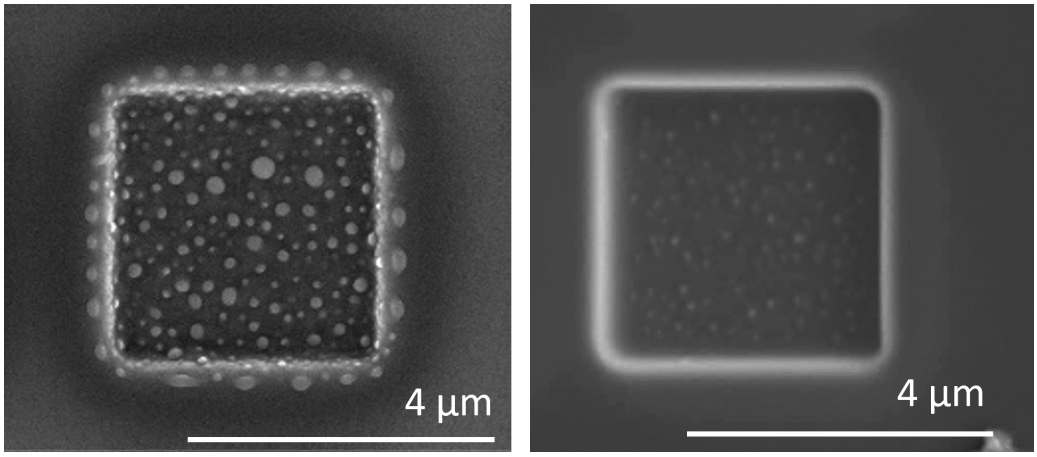
A first Rb^+ induced Pt deposition was made. The surface the deposited Pt includes cluster structures. These dark clusters are believed to be Rb oxides formed during sample transportation since the deposition imaged in situ in the sample chamber lacks such structure. EDX analysis also states that these clusters have a higher Rb content than the surrounding Pt deposition layer.

The current focus of the research is to optimize the system performance and to study ion-sample interactions including ion implantation and damage range on different samples. Future work will also investigate the yield and resistivity of Rb^+ induced deposition.



(a) (b)

Figure 1: Si samples: *(a)* milled pattern by Rb ions, *(b)* high-resolution TEM image of a lift-out lamella taken from the bottom of a pattern



(a) (b)

Figure 2: GaAs samples: *(a)* square milled by Ga^+, *(b)* square milled by Rb^+