FIB modification of AFM tips for electrochemical applications

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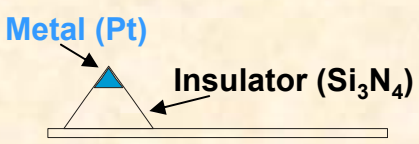
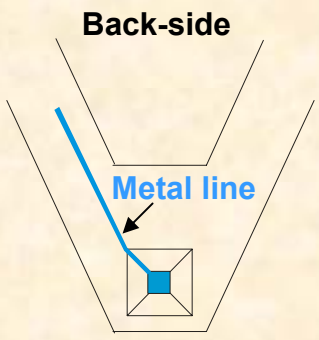
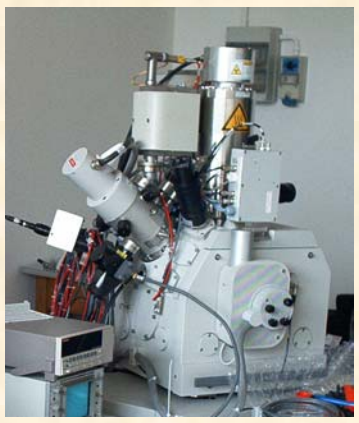
ElectroChemical Atomic Force Microscopy (ECAFM) operates by measuring current between a conductive tip and the sample. In a liquid environment standard probes, i.e. Si_3N_4 tips integrally coated with metal, cannot operate because current may flow trough all the cantilever area, making the electrical measurement useless.
Our goal is to metallize only the tip apex and to contact it from the back-side. This confines the electrically active region and should enable ECAFM in liquids.

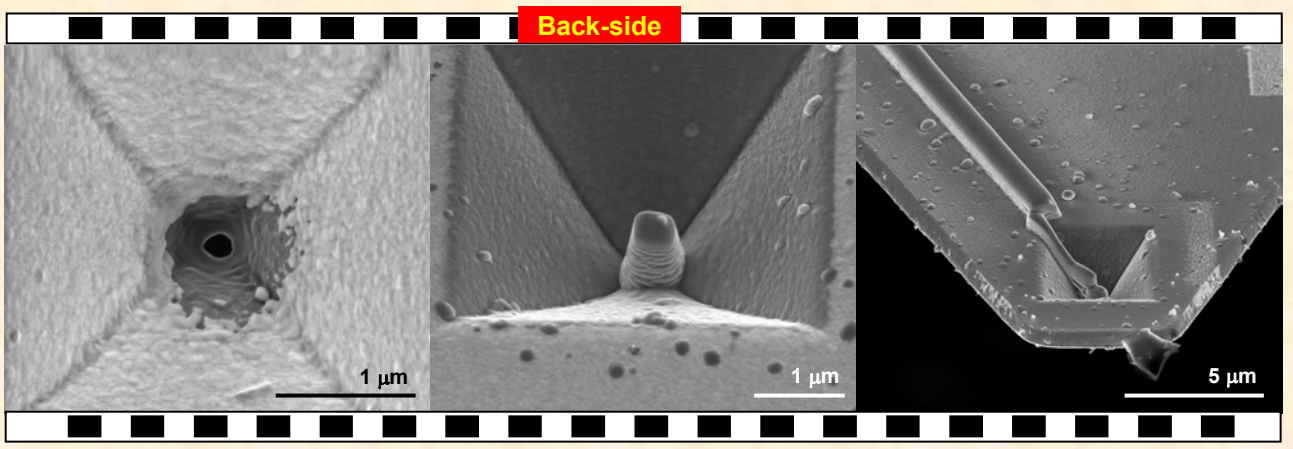
The idea... ...the tool







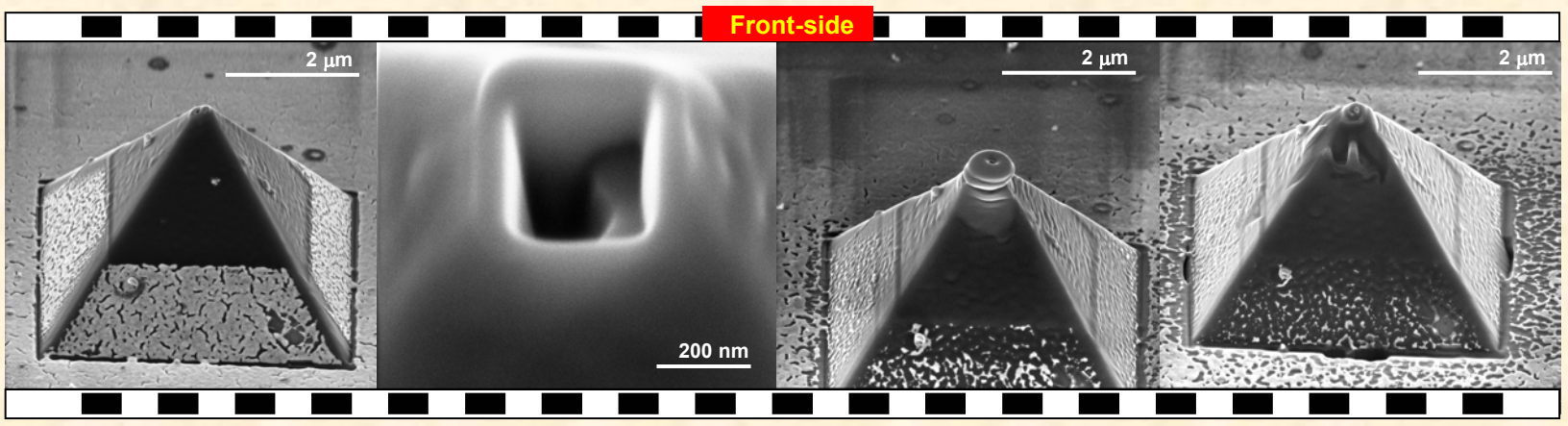
Fei Strata DB 235



1. A hole is milled at the centre of the tip to create the via between back and front side of the tip.

2. A Pt pillar is deposited to fill the hole and have a buffer of Pt below the tip.

3. A Pt line is deposited to connect the pillar and reach the cantilever level. A second line brings the contact along one of the cantilever arms.



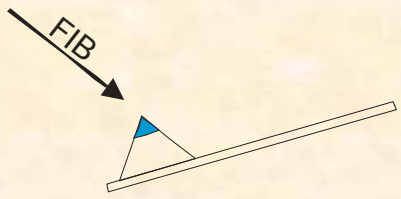
The modified tip is mechanically stable and the resolution, in topographical AFM, is comparable to that of a commercial tip.

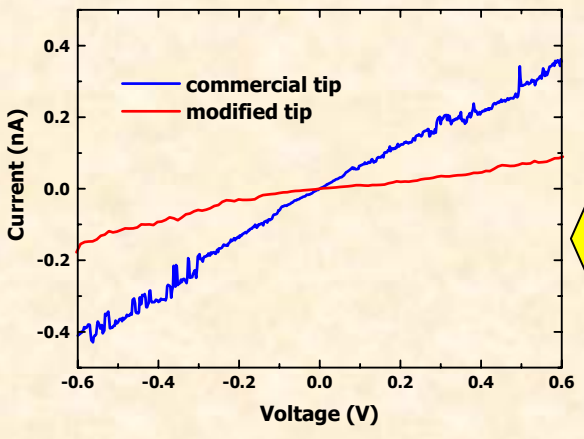
4. FIB cleans the tip from Au coating. The hole, filled with Pt, is visible at the top.

5. A trench is milled at the apex. The Pt buffer, i.e. the pillar of step 2, appears.

6. A Pt pillar, actually doughnut-shaped, is deposited onto the trench. It is the metal electrode.

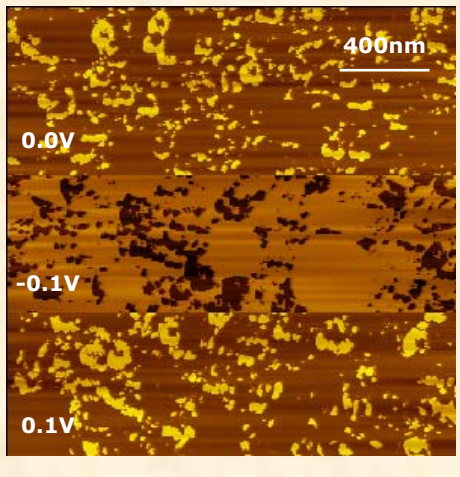
7. FIB is aligned along each of the pyramid sides to shape the metal electrode into a tip.





Preliminary electrical tests in air show that the tip is conductive. In the figure, I-V curves of a commercial tip and a modified one are reported. Measurements are performed by applying a bias between the conductive tip and a polycrystalline gold surface, after setting an opportune force set-point. Bias is continuously changed at a constant sweep rate.

With Current Sensing AFM (CSAFM) it is possible to probe simultaneously the topography and the conductivity of a surface. Here the conductivity image of a gold surface, probed by the modified tip, is reported. The image contrast changes, changing the sample bias. The current signal is shown as positive when sample surface is biased negatively.



Conclusions: by using FIB we are able to integrate a Pt microelectrode at the apex of an AFM tip. The electrical measurements show that the tip is conductive and is well suited for CSAFM.

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