Direct-Write Fabrication of Electric and Thermal High-Resolution Nanoprobes on Self-Sensing AFM Cantilever

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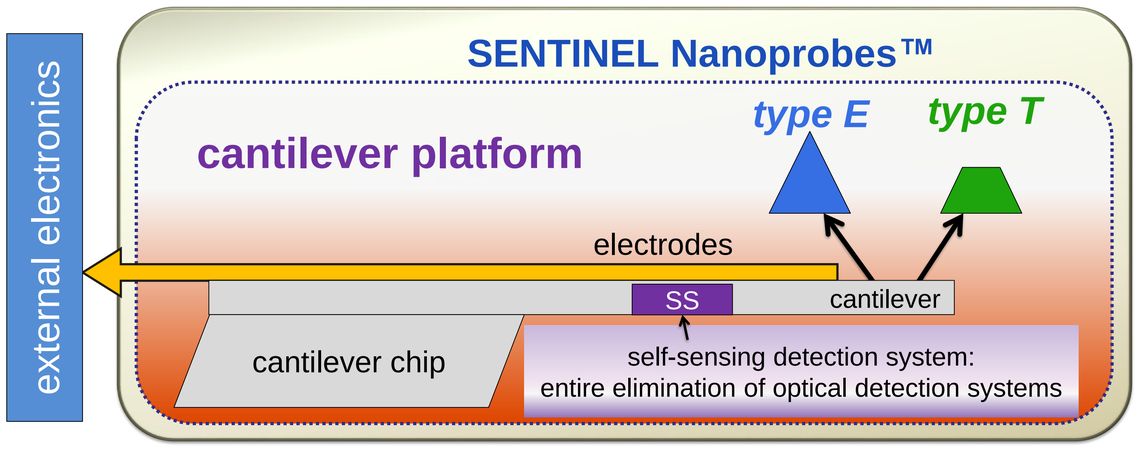
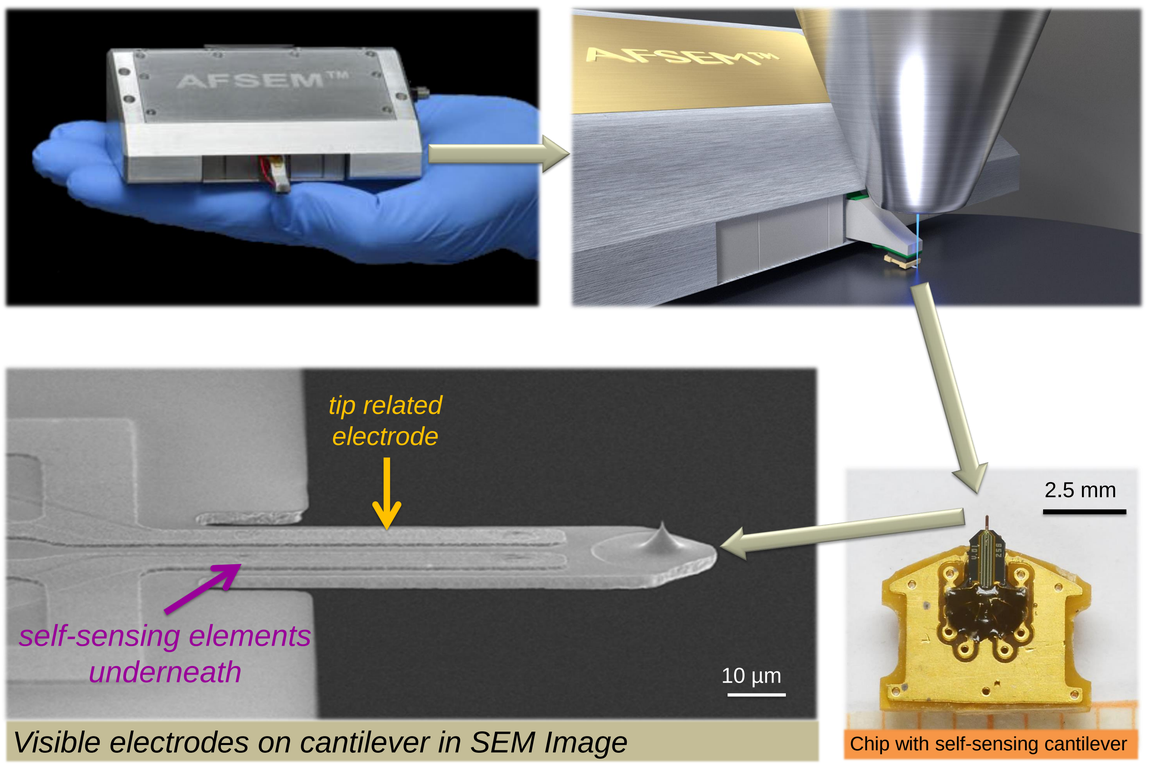
Introduction & Concept

Atomic Force Microscopy (**AFM**) is an essential part in research and development thanks to its quantitative 3D surface characterization capability with spatial resolution in the sub 1 nm regime. Additional AFM modes can provide laterally resolved electric, magnetic, chemical, mechanical, optical, or thermal properties of the sample surface. A comparable new field is the combination of AFMs with Scanning Electron Microscopes (**SEM**), Focused Ion Beam (**FIB**) microscopes or SEM / FIB Dual Beam Microscopes (**DBM**). As the available space is limited, traditionally used optical detection concepts often fails. To overcome this limitation, *GETec Microscopy* has introduced a compact AFM system (**AFSEM™**) which combines a high-resolution tube scanner with self-sensing cantilever which entirely eliminates the optical detection system.

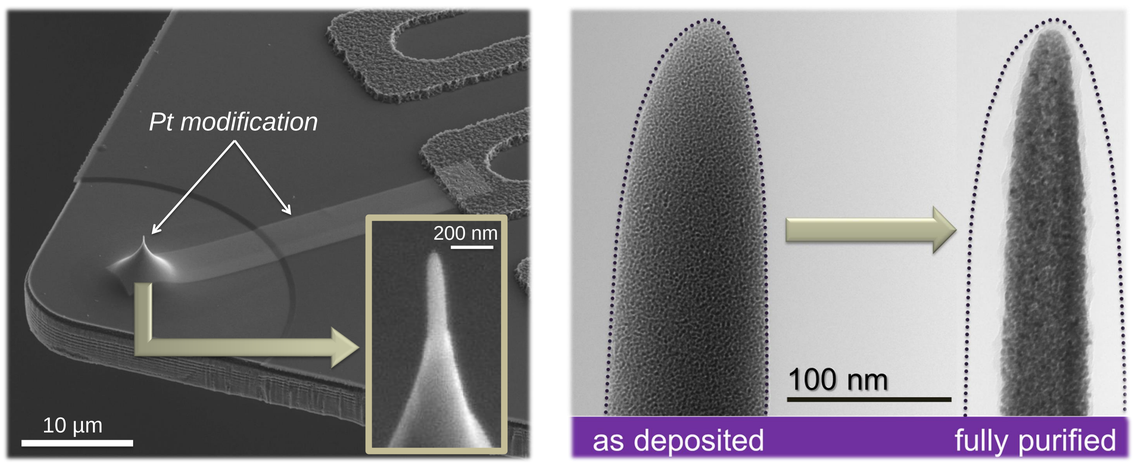


AFSEM™ powered by *GETec Microscopy*

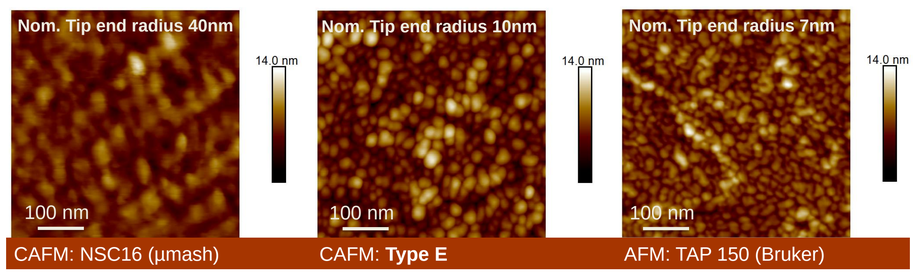


Conductive type E Cantilever

Modification of self-sensing cantilever with platinum (Pt) pillars via FEBID processing and post growth purification[1,2] to pure metal high-resolution type E tips.

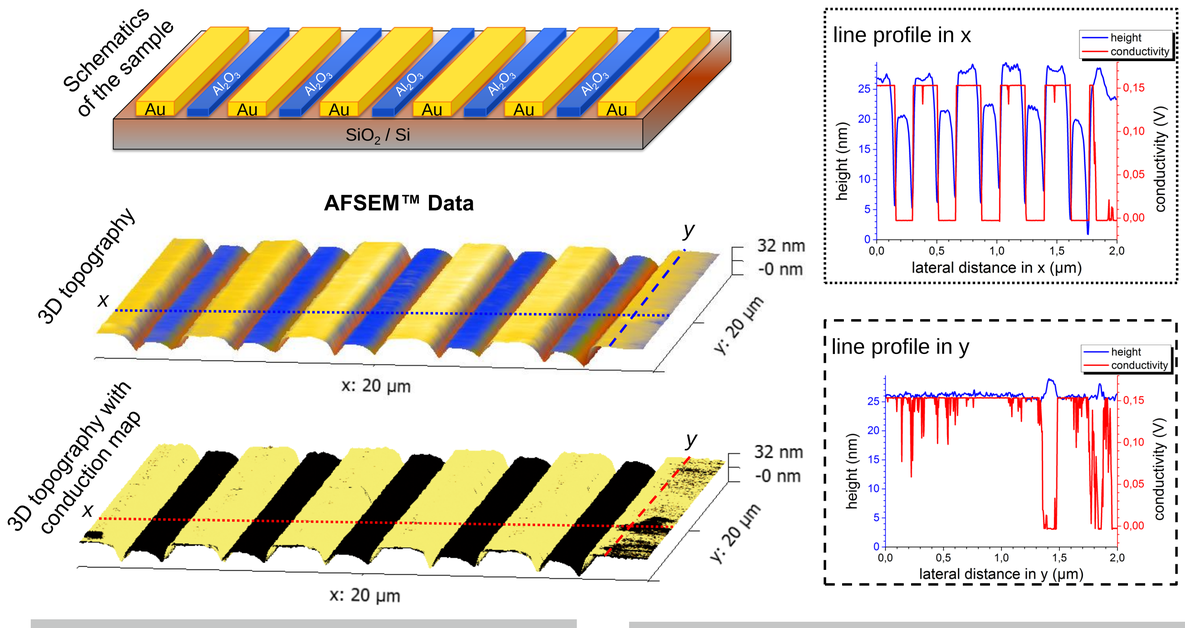


Resolution: Comparison of different cantilever in AFM height images of a granular gold layer on glass. Below a commercial available CAFM (left) and a standard AFM (right) cantilever are compared to a type E modified tip (middle).



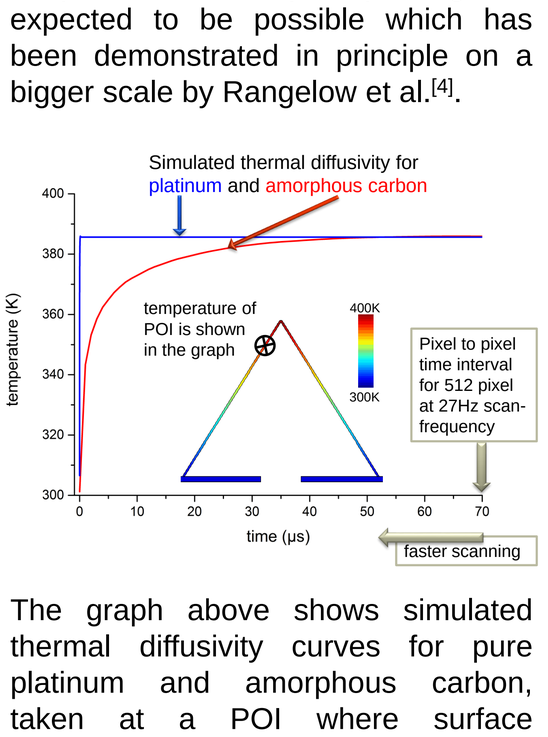
Advantages:
- better resolution
- stable imaging

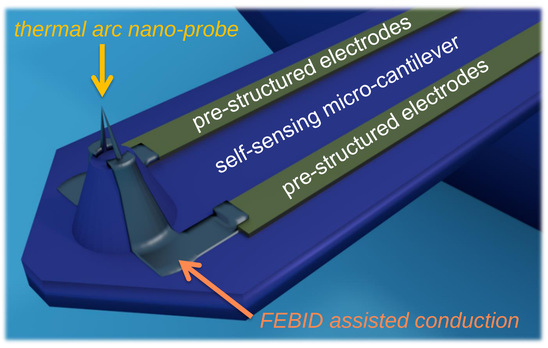
Performance testing has been done on structured surfaces revealing alternating lines of insulating (Al_2O_3) and conducting material (Au). This sample was then measured with the AFSEM™ equipped with a type E tip.



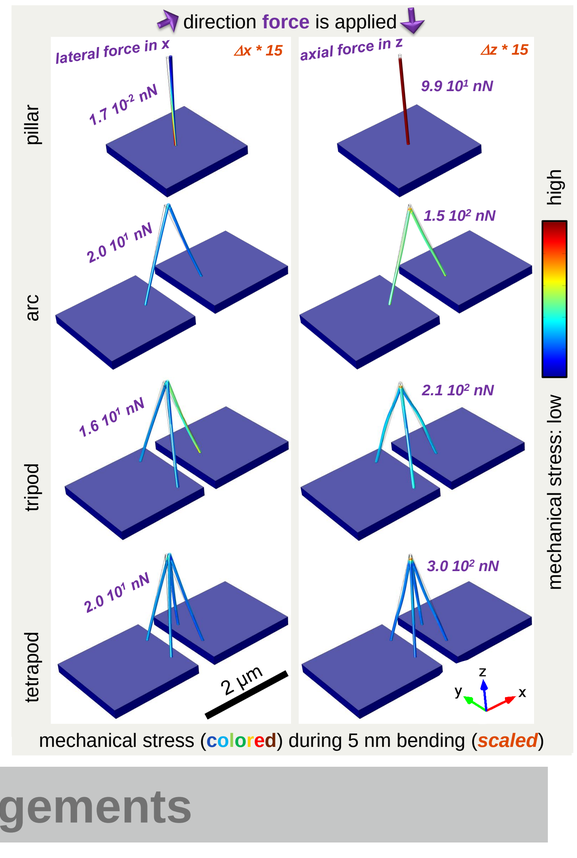
Thermal type T Cantilever

For thermal probing we aim on the temperature dependent electric properties of Pt and / or Pt-C (to be evaluated) using a nanoscale electric bridge as schematically shown below. First pre-tests demonstrates the capability to fabricate such structures as shown at the right. The fact that any 3D nano-scale structure can be realized [3] allows different geometries.





Finite element simulations are used for geometry optimization as shown below. The simulation shows mechanical stress tests with 5 nm displacement in lateral (x) and axial (z) dimension scaled 15 times for visibility. The force needed for bending is of interest to help to prevent excessive experimental mechanical testing.



First finite element simulation suggests a very fast response of Pt / Pt-C structures on surface temperatures due to the small volume. By that temporal resolved point-probing are expected to be possible which has been demonstrated in principle on a bigger scale by Rangelow et al.[4].

The graph above shows simulated thermal diffusivity curves for pure platinum and amorphous carbon, taken at a POI where surface temperature changed significantly till equilibrium. The equilibrium state is shown with POI inside the graph. The graphs endpoint in x marks a scan frequency of 27 Hz at 512 pixel per line. In respect to the jet unknown thermal behaviour of the final type T cantilever this simulations give very promising results.

Reference

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Acknowledgements

We gratefully acknowledge Prof. Dr. Ferdinand Hofer, Franz Hofbauer and NANOSURF for supporting work. We also thank the FFG Austria (base project Nr. 850652), the European Union (EUROSTARS Project E! 8213 and 7th Framework Programme [FP7/2007-2013] under Grant Agreement no. 312483 (ESTEEM2)), and the COST funding (CM 1301) for financial support.

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