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

J. Sattelkow, J. Fröch, H. Plank
Institute of Electron Microscopy and Nanoanalysis, Graz University of Technology, Graz, Austria
harald.plank@felmi-zfe.at

R. Winkler, U. Radeschnig
Graz Centre for Electron Microscopy, Graz, Austria

C. Schwalb, M. Winhold, A. Deutschinger, T. Strunz, E.G. Fantner
GETec Microscopy Inc. & SCL Sensor.Tech. Fabrication Inc.,
1220 Vienna, Austria

V. Stavrov
AMGT, Botevgrad, Bulgaria

G.E. Fantner
Laboratory for Bio- and Nano-Instrumentation, EPFL, Lausanne, Switzerland

Atomic Force Microscopy (**AFM**) has evolved into an essential part in research and development due to its quantitative 3D surface characterization capability with spatial resolution down to the sub-nm range. Beside this precise height information, additional AFM modes provide laterally resolved electric, magnetic, chemical, mechanical, optical, or thermal properties of the sample surface. Depending on the application, different types of probes and therefore fabrication tools get necessary. Furthermore, to satisfy the general tendency of *in-situ* experiments the integration of the AFM into SEMs or Dual Beam Microscopes gets increasingly important. For that purpose, the GETec company has introduced an AFM system (**AFSEM®**) providing two main advantages: ***1)*** application of a high-resolution tube scanner enabling AFM access from top which means that standard SEM / FIB / DBM sample stages can be used; and ***2)*** the application of self-sensing cantilever which entirely eliminate space consuming, optical detection systems as they uses electric readout of the cantilever motion via stress-strain elements. However, to exploit the full potential of the AFSEM® concept, dedicated nano-probes are required, which fulfil the high demands on spatial dimensions, overall shapes and required materials. Based on this motivation we here demonstrate a Focused Electron Beam Induced Deposition (**FEBID**) based, on-demand fabrication approach for AFM tips, dedicated for electric and thermal nano-probing. For the former, Pt-C nano-pillars are initially fabricated with FEBID and then chemically transferred into pure Pt via a gas assisted post-growth purification (Fig. 1). We discuss chemical / structural aspects of FEBID high-resolution tips together with conductive-AFM (**C-AFM**) measurements to demonstrate the added value of the entire system. For thermal nano-probes we take advantage of platinum´s thermoelectric properties as transducing element together with FEBIDs true 3D fabrication capabilities to realize free-standing nano-bridges (Fig. 2). The small active volumes and end radii down to 5 nm are ideal for fast thermal response and high-resolution capabilities, respectively.

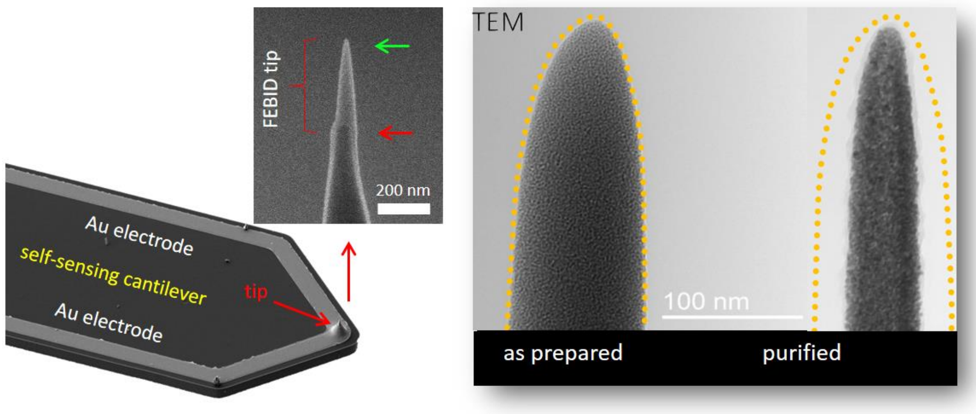

Figure 1: On-demand fabrication of electrically conductive, high-resolution Pt nano-probes. FEBID is used for initial fabrication of Pt-C nano-pillars on pre-structured self-sensing cantilever (left) yielding clearly improved tip shapes compared to the original situation (compare red and green red arrow in the SEM side view image). After purification the carbon is removed, tip dimensions are further decreased (right comparison) and tip radii down to 5 nm can be achieved.

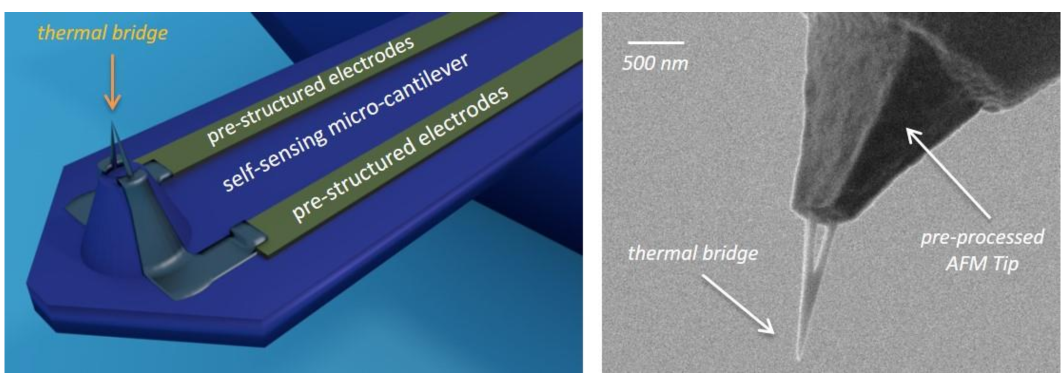

Figure 2: Concept scheme of our thermal probe approach (left) consisting of a pre-structured self-sensing cantilever further modified by a freestanding nano-bridge for thermal measurements using Pt's thermoelectric properties as transducing element. The right Image shows the first successful prototypes, which have been proven to be applicable in real AFM measurements.