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

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Atomic Force Microscopy (AFM) has evolved into an essential part in research and development due to its quantitative 3D surface characterization capability and additional AFM modes, which provide laterally resolved electric, magnetic, chemical, mechanical, optical, or thermal properties of the sample surface. Our Partner GETec Company has introduced an AFM system (AFSEM®) providing a high-resolution AFM tube scanner, which can be integrated into standard Scanning Electron Microscopes (SEM) / Focused Ion Beam Microscopes (FIB) / Dual Beam Microscopes (DBM). The use of self-sensing cantilever eliminates an optical detection system as it uses stress-strain elements for the electric readout according to the cantilever motion. The application of the self-sensing technology, however, prevents traditional tip fabrication or subsequent modification such as large area coating with conductive or magnetic materials. Hence, a method is needed to allow the highly localized, functional tip fabrication and / or modification according to AFM mode related requirements.

Based on this motivation we here demonstrate a concept, which aims on the Focused Electron Beam Induced Deposition (FEBID) based fabrication of specialized AFM tips for electric and thermal nano-probing via the AFSEM®. A common self-sensing cantilever (SS-CL) platform as substrate will be modified via FEBID towards two different functionalities. For electric nano-probes, Pt-C nano-pillars are first fabricated and then purified by our gas assisted purification approach as demonstrated by Geier et-al.[1] This contribution discusses chemical / structural aspects of the FEBID high-resolution tips together with Conductive-AFM (C-AFM) measurements to demonstrate the capabilities of this approach. For thermal nano-probes we take advantage of platinum resistivity response on varying temperatures. While basically shown in the past [2], our approach uses our recently developed simulation approach for 3D architecture [3] to enable highly precise, freestanding tri- and tetrapod architectures. To maximize the mechanical stability in X-Y-Z during scanning, finite element simulations using COMSOL® have been applied and finally fabricated via FEBID. This contribution discusses the current development state of the thermal probes ranging from simulation driven geometry optimization over detailed 3D characterization, post-growth curing, [4] and purification towards nano-mechanic characterization.

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[2] I.W. Rangelow, T. Gotszalk, N. Abedinov, P. Grabiec, K. Edinger; Thermal Nano-Probe; Microelectron Eng (2001); 737

[3] J. Fowlkes, R. Winkler, B. Lewis, M. Stanford, H. Plank., P. Rack; Simulation Guided 3D Nanomanufacturing via Focused Electron Beam Induced Deposition; ACS Nano (2016); in revision

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