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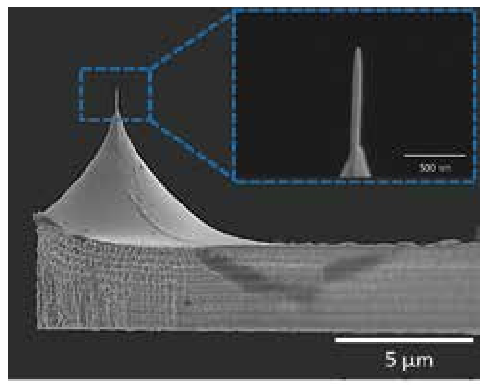
Application Note: In-Situ Magnetic Force Microscopy Analysis of Magnetic Multilayers and Duplex Steel with AFSEM®

Analyze magnetic properties of your sample with nanometer resolution using AFSEM

Magnetic compounds and multilayer structures are very promising for potential applications in spintronics, thermoelectrics, nanoelectronics and information technology. Currently, their most common use is for data storage. Magnetic force microscopy (MFM) is not only widely used in the quality control of magnetic data storage but has also been adopted to probe magnetic samples and differentiate between their magnetic domains. Additionally, the capability for in-situ analysis of magnetic nanostructures inside a SEM opens completely new possibilities for correlative in-situ analysis.

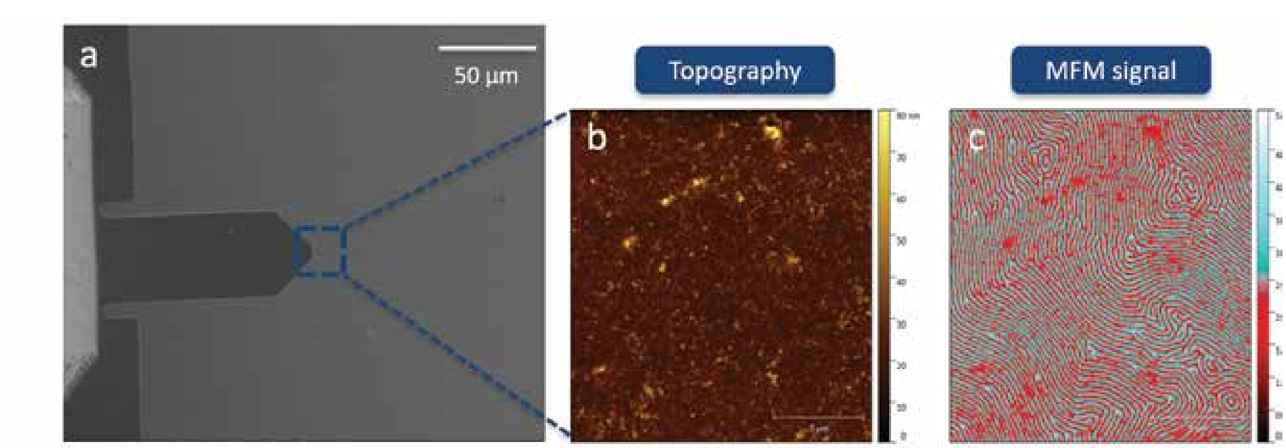
In combination with our in-situ AFM solution we use a novel 3D nano-printing technology for the fabrication of unique high-aspect ratio magnetic tips for MFM applications. A sharp magnetic tip is printed on a standard silicon tip resulting in a tip radius of approximately 10 nm, therefore allowing high-resolution magnetic imaging.

Measurements done on two different samples are presented here to illustrate the MFM capability of AFSEM.



Magnetic “super-tip” fabricated by 3D nano-printing for high resolution MFM imaging.

The first sample consists of several alternating layers of Pt and Co deposited on top of a Si/SiO2 substrate, showing a very distinct magnetic signal with high contrast.



Topography and MFM measurements on a multilayer sample provided by G. Hlavacek, O. Hellwig (HZDR, Germany). SEM guidance allows one to find the region of interest (a); AFM topography image of a smaller area (b); and the corresponding MFM signal measured with magnetic “super-tip” (c).

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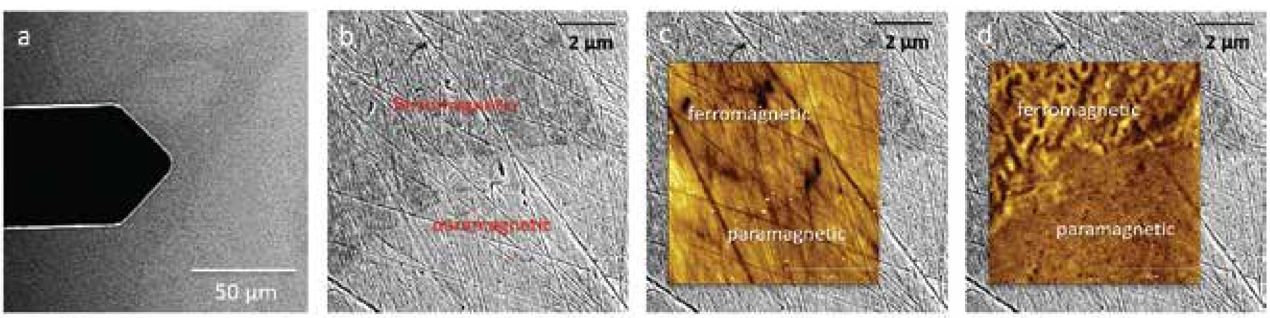
The second sample is a duplex steel consisting of paramagnetic and ferromagnetic phases distributed all across the surface. The different phases are visible in the scanning electron microscope (SEM) and the cantilever is easily positioned at the grain boundary of two distinct phases using the SEM guidance.

It is crucial to have the combination of SEM guidance and in-situ AFM in order to analyze distinct grain boundaries on the sample. AFM topography of the sample shows a flat surface with scratches due to prior polishing and does not distinguish between paramagnetic and ferromagnetic phases.

On the other hand, the MFM signal not only shows a clear boundary between two phases but also displays the sub domains within the ferromagnetic phase with high resolution.

In summary, AFSEM is the solution of choice to obtain magnetic properties of any magnetic sample inside the high-vacuum environment of SEM or FIB systems. SEM guidance makes the identification of the region of interest and cantilever positioning convenient and user friendly. The unique magnetic “super-tips” on self-sensing cantilevers enable a quantitative correlative 3D analysis in combination with high-resolution MFM imaging of magnetic nanostructures.



AFSEM measurements of duplex steel sample provided by M. Knyazeva, J. Rozo Vasquez (TU Dortmund). SEM guidance allows the positioning of the cantilever on the region of interest (a); SEM image with increased contrast shows ferromagnetic and paramagnetic phases (b); topography (c); and MFM signal (d).

- Fast and easy identification of your region of interest
- Correlative in-situ SEM & AFM analysis combined with magnetic properties
- Magnetic “super-tip” allows high resolution topography and MFM imaging

AFSEM® – The Leading Solution for AFM in SEM