3D FEBID magnetic nanostructures for scanning probe microscopy

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3D magnetic nanostructures often present novel magnetic phenomena induced by scale reduction and geometry, which is often absent in bulk materials. This opens new possibilities of applications in high-density nanoelectronic devices, data storage and sensing. However, the patterning of 3D nanomagnets is still challenging and only a limited number of synthesis techniques are well suited for this purpose. Among them, Focused Electron Beam Induced Deposition (FEBID) has emerged as a powerful direct-write nanofabrication method enabling the growth of complex three-dimensional nanostructures with almost arbitrary geometry, and is being extensively used to explore novel magnetic phenomena induced by topology, as well as for device prototyping. 3D FEBID magnetic nanostructures have been successfully applied in the magnetic functionalization of scanning probe microscopy tips, which has enabled the design of magnetic probes for magnetic force microscopy (MFM) and nanoscale magnetic sensing with enhanced spatial resolution and sensitivity.

In this lecture, the fundamental mechanisms of the FEBID process, based on electron-beam-induced dissociation of precursor molecules, will be briefly introduced, highlighting key challenges related to the control of geometry, composition and microstructure in 3D magnetic nanostructures. Strategies for improving the magnetic performance of FEBID-grown structures, including deposition optimization and post-growth treatments, will be addressed. An overview of application of 3D FEBID functionalized cantilevers for magnetic force microscopy techniques will be reviewed, demonstrating their superior performance of FEBID-functionalized tips compared to commercial probes.