3D Nano-Printing via Focused Electron Beams: A Perspective

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Additive manufacturing of 3-dimensional objects is currently on a success route in research and development. While manufacturing down to the (sub)micron-scale has already reached a reliable status with impressive examples, downsizing to the real nanoscale is still a challenging task. Within the pool of techniques with the potential for controlled 3D nanoscale fabrication, Focused Electron Beam Induced Deposition (FEBID) is a highly promising candidate. This not only relies on the fact that predictability, reliability and precision have strongly progressed but also bases on its true direct-write character, which allows fabrication on almost any material and substrate morphology in a single-step process. Together with achievable feature dimensions down to 20 nm and an increasing availability of precursors with different functionalities, FEBID has advanced from a trial-and-error laboratory method to a predictable 3D nano-printing technology, which opens up new opportunities for advanced applications.

In this talk, the audience is first introduced to the basic principles of 3D printing via FEBID, complemented by simulations for deeper insights in their fundamental processes. Next, we present two software packages, which allow comfortable upfront design of even complex 3D objects, as indispensably needed for a generic 3D nano-printing technology. In the following, we review several application examples, which strongly benefit from the here presented 3D nanofabrication possibilities. We start with scientifically oriented nano-applications in the field of resonant optics, magnetics and mechanical sensor concepts. To highlight the industrial relevance of this technology, we also present concepts of advanced nano-probes for application in scanning probe microscopy. In more detail, we start with magnetic probes, go over to electrically conductive probes and end the discussion with a new concept for thermal probing on the nanoscale. We close the talk with a view on remaining challenges, current activities and future perspectives.

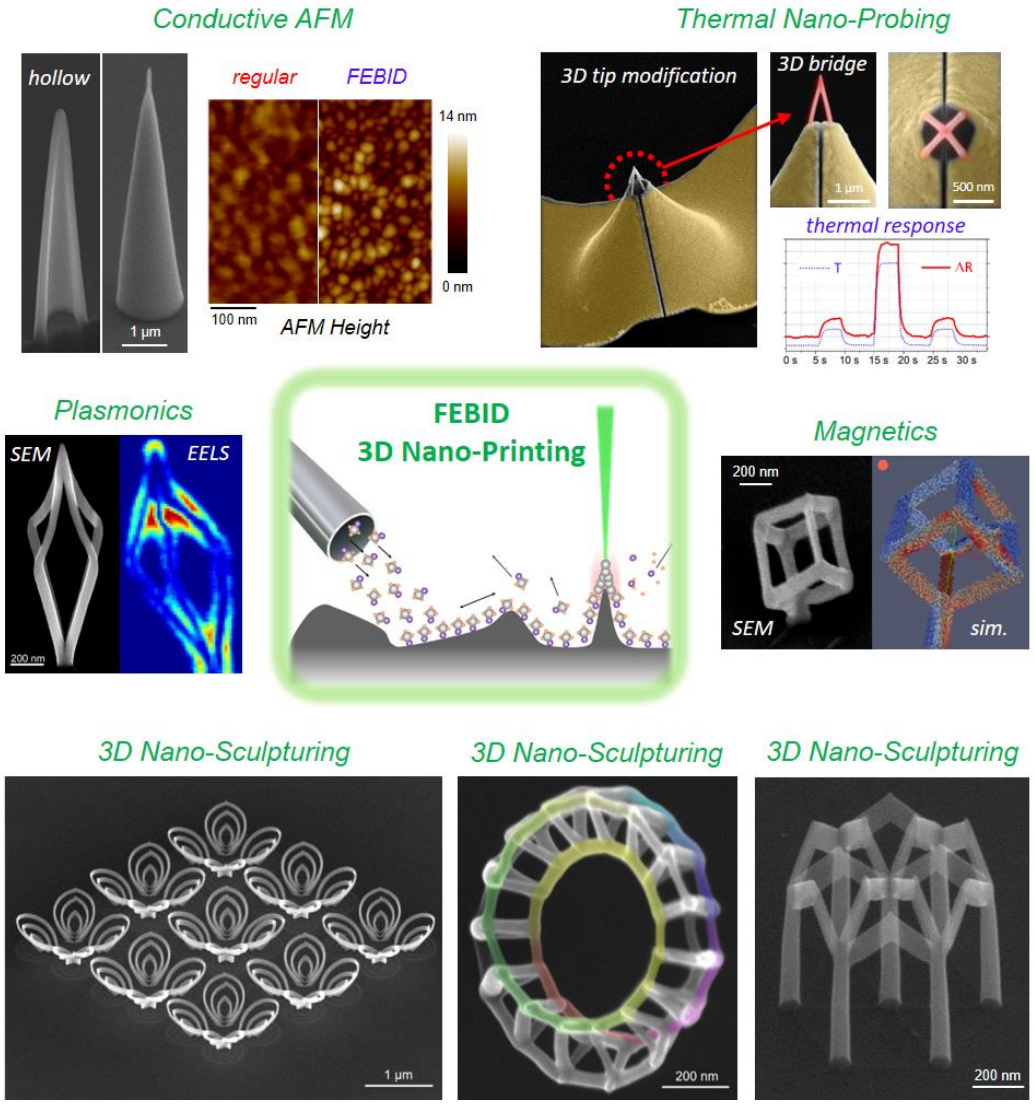

Figure 1: Selected applications based on 3D nano-printing via Focused Electron Beam Induced Deposition (FEBID, schematically shown in the center), as discussed in this talk. Aside of precise 3D nano-sculpturing (bottom row, including a freestanding Moebius strip in the center), applications from plasmonics (electron energy loss spectroscopy map at the right), artificial frustrated magnetic systems (micro-simulations at the right), hollow cone tips for conductive AFM (imaging comparison at the right) and thermal nano-probes (temperature response at the bottom) are discussed.