3D in SEM, (S)TEM, Ion Imaging, incl. FIB-SEM and SBF-SEM

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3-dimenstional Processing and Imaging of Gold and Platinum Nanostructures with a SEM

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Nanofabrication techniques play an important role for numerous advanced applications. Controlling the atmosphere in a Scanning Electron Microscope (SEM) allows to perform dynamic experiments on the micro- and nanoscale including chemical reactions such as the focused electron beam induced deposition (FEBID). Direct write lithography technique produced by FEBID offers important benefits over classical resist based process. It is possible to deposit metals and dielectrics in situ with a single process step. This mask-free and resist-free technique has gained popularity due to its nanometer precision of material deposition [1,2].

FEBID is also a potential candidate for 2D and 3D Noble Metal nanostructures. 3D imaging with a SEM allows also investigation of physico-chemical properties as well as morphology of the fabricated micro- and nanostructures and facilitates to correlate between the microstructure of a material, its composition and its mechanical and electrical behaviour.

This work represents nano deposition of different noble metals with lateral feature size under 50nm. Different shapes of gold and platinum structures including nanopillars, nanospirals and nanosquares have been grown with different acceleration voltage ranging from 1KV to 20 KV.

The fundamental growth process of direct-write deposition has been imaged during different growth phases. The impact of process parameters (such as dwell time, refresh time, beam current, substrate temperature, precursor temperature) on the geometry and the chemical composition have been investigated. Approaches towards high purity depositions are discussed. Composition of Nanostuctures have been probed by the Energy Dispersive X-ray Spectroscopy (EDX).

Novel applications of patterned structures for electronic devices, photonic components and MEMS can be quickly realized by this technique. Potential applications of this rapid pattern fabrication process for nanoscale electronic devices and for photonic, magnetic or biofunctional structures are discussed in this work. Structural and morphological properties of the deposited structures have been investigated by High Resolution Transmission Electron Microscopy (HR-TEM).

With this work we have successfully demonstrated that SEM is a versatile tool for fabricating 3D structures on the nanoscale and is as well inevitable helpers for 3D analysis of these structures. The presented method is capable of mix-and-match fabrication of nanodevices which makes it attractive for a multitude of applications.

1. I. Utke, P. Hoffmann, and John Melngilis, J. Vac. Sci. Technol. B 26 (2008), 1197.
2. G. Hochleitner, M. Steinmair, A. Lugstein, P. Roediger, H. Wanzenboeck and E. Bertagnolli, Nanotechnology 22 (2011).
3. We kindly acknowledge European Community's Seventh Framework Programme (FP7/2007-2013) under grant agreement number ENHANCE-238409.
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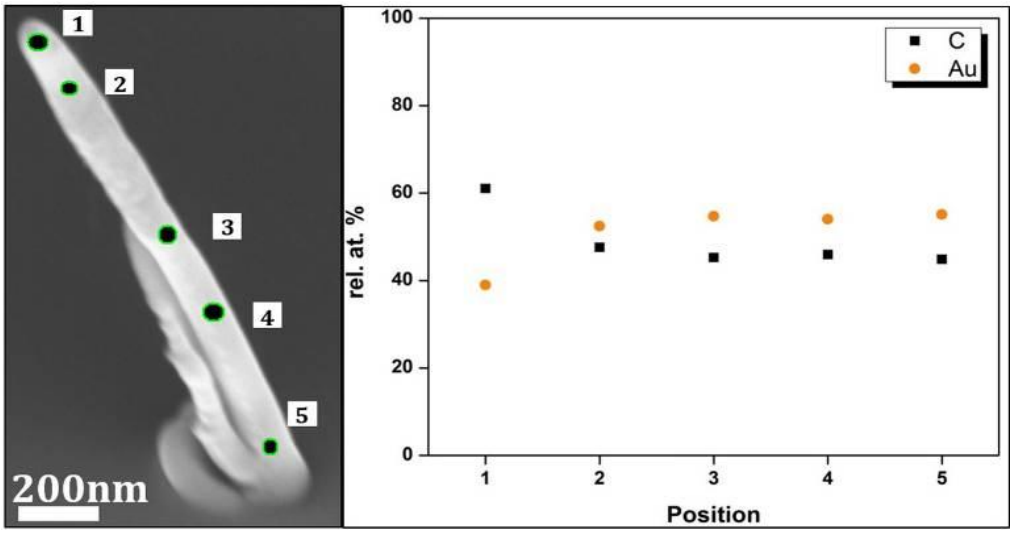

Figure 1. Gold nanopillars fabricated by FEBID and EDX analysis which shows the purity of the gold content.

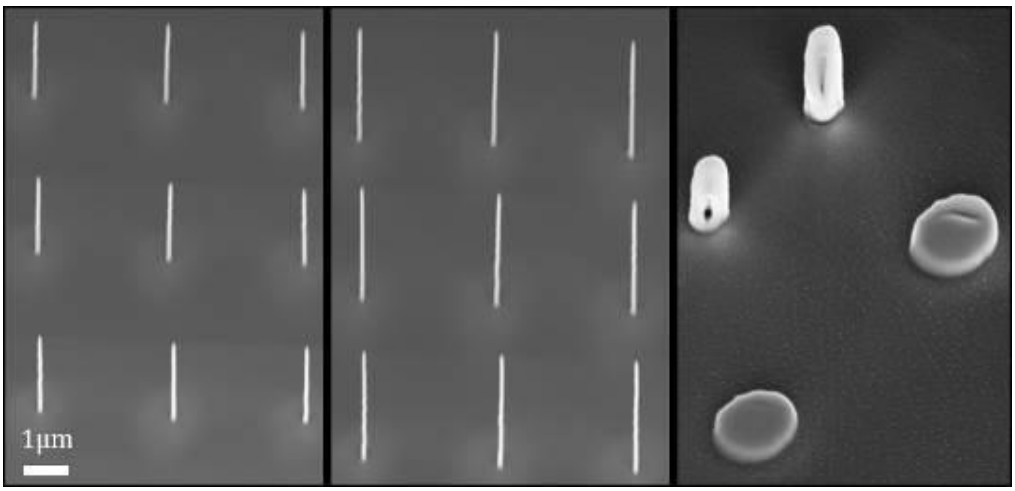

Figure 2. Platinum nanopillars deposited by FEBID for 30 sec, 60 sec and defocusing.

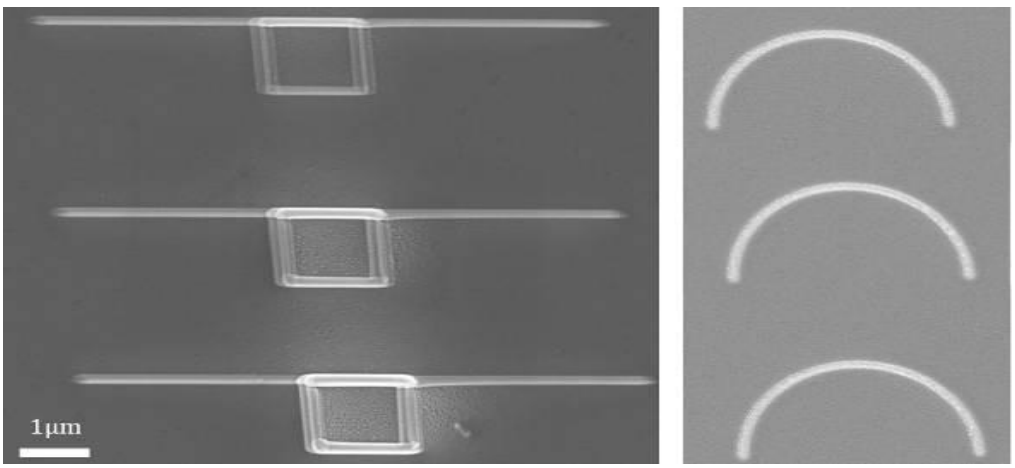

Figure 3. Different shapes of gold nanostructures deposited by FEBID.