Tip-based electron beam induced deposition (TB-EBID) with active cantilevers

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Electron beam induced deposition (EBID) is a direct- nanofabrication technique capable of creating three-dimensional nanoscale structures using electron-induced reactions of diverse organometallic precursors. EBID can operate in the single digit nanometer regime for realization of single electron devices [1]. In conventional SEM based EBID, the higher energy electron beam (above 0.1 kV) interacts with the substrate and generate backscattered electrons and low energy secondary electrons which could influence the resolution [2]. Tip-based electron beam induced deposition (TB-EBID) [3] is an alternative technique, using low energy electrons (<50eV)[4] field-emitted from the tip of an active cantilever [5]. In this work we will present TB-EBID experiments done with an atomic force microscope tool integrated with in a scanning electron microscope. The tool has been developed by nano analytik GmbH [Figure 1]. The integrated AFM enables an easy analyzation and measurement of deposited features due to fast switching between electron-field emission from the cantilever tip, to non-contact AFM imaging. The writing and imaging processes are performed with the same cantilever tip. In our previous work [4,5], we could not observe significant tip wear in the AFM images taken in the AFMinSEM before and after EBID, using reference samples with rectangular profile shape. Another important issue is that the placement of deposited features can be chosen very precisely using the AFM for navigation and placement of the EBID features with very high positioning accuracy. The lateral resolution of the AFM stage is better that 0.2nm (closed loop mode). This allows features-placement, AFM-navigation, and CD-metrology of the deposits with very high precision. We will present systematic investigation of the size of deposits versus electron energy, exposure dose and placement accuracy.

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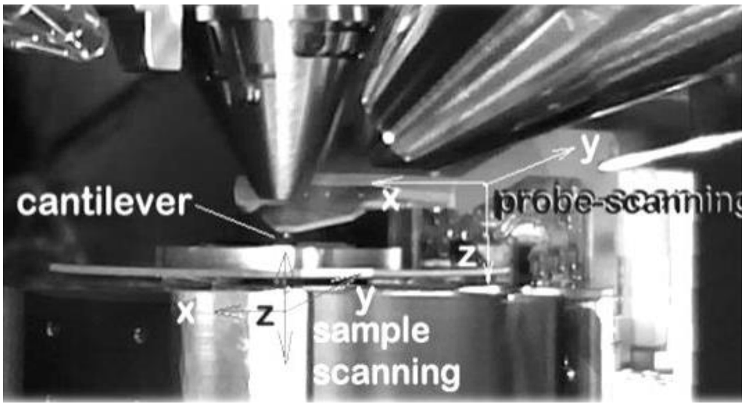

FIG. 1. Image of the AFMinSEM taken with the infrared camera of the SEM/FIB tool.

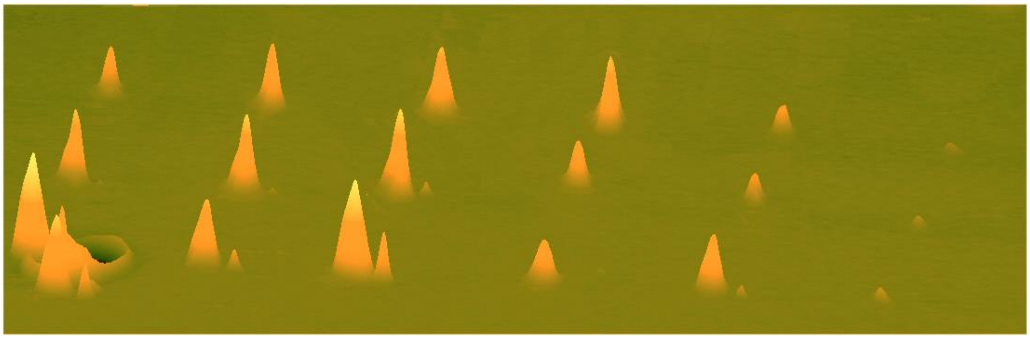

FIG. 2. TB-EBID with trimethyl (methylcyclopentadienyl) platinum of single digit nanometer features using field-emitted low energy electrons (40 eV) and different exposure dose. The dots are imaged after EBID using the same tip for deposition and AFM. The smallest dot is 2.2 nm (see right upper corner of the image).

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