Enabling New In-Situ Nanofabrication Experiments Using Novel Electron And Ion-Beam Lithography And Nanoengineering Workstations

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E-Beam lithography (EBL) and focussed ion beam (FIB) techniques are common tools for R&D applications or master copy fabrication and are widely used in systems, which allow to generate lateral or 3D-structures even below 10 nm.

Due to its high resolution and flexibility, EBL is frequently used for prototype development, e.g. for microelectronic devices, for studies of quantum physics effects or recently also in nanobiotechnology. A large variety of different EBL systems exist, differing mainly in working principles, capabilities and price.

While conventional EBL tools focus on pure e-beam exposure capabilities, nowadays nanotechnology researchers´ needs and tasks gradually require more than just pure lithography capabilities, since nanstructures also have to be interfaced to the macroscopic world. Therefore, capabilities not only for pure fabrication, but also for sample relocation by applying intelligent sample navigation or for modification such as shaping, adding, subtracting features and materials - preferably in situ - are highly desired. Additional in situ measurements such as chemical, topographical or dimensional analysis as well as contacting to electrical probes can perfectly complement modern R&D nanotechnology tasks. This exactly describes the design concept of the new Raith e_LiNE e-beam-lithography system, which can be additionally equipped with a dedicated gas injection system (GIS) for e-beam induced deposition or etching (EBID/EBIE), with an EDX system and with up to four nanomanipulators for nanoassembly or probing experiments. Moreover, a new exposure mode called Fixed Beam Moving Stage (FBMS) was implemented in this tool. A collection of related applications will be presented, which may demonstrate the e_LiNE potential in an illustrative way. Fig.1 and 2 e.g. exhibit 3-dimensional structures deposited by EBID technique applying a special lithography "exposure " mode. In Fig.3 prestudies of in situ contacting MWCNTs by EBID of tungsten precursor for subsequent electrical probing measurements can be seen. EBID of nanostructures and manipulation thereof is shown in Fig. 4 and 5.

In a shorter second part, an overview about a newly developed ion-beam lithography, nanofabrication and engineering workstation, the Raith ionLiNE, will be given. Here, experiments will be presented, which require a highly selective probe combined with both low dose and large area patterning capabilities.

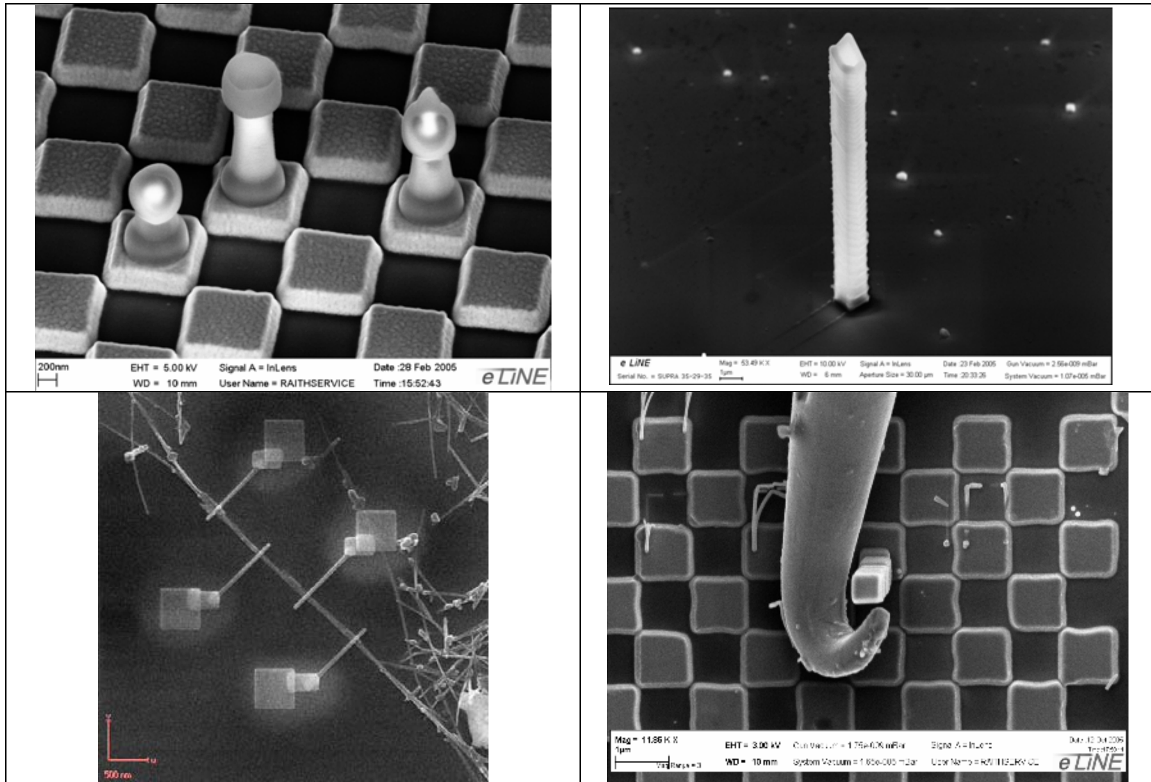

Fig.1: 3D "CHESS"-nanostructures, Fig.2: Chimney-like nanocapillary, Fig.3: EBID of conductive material on MWCNTs, Fig.4 and 5: Manipulation of EBID nanostructures