The influence of lithographic parameters on EBID

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The fundamental challenge in the fast growing field of nanotechnology is the generation of nanostructures with high purity and defined shapes. Electron-beam induced deposition (EBID) is a method for size- and position-controllable lithography of two- and with restrictions for three-dimensional nanostructures. Our distinct approach is to conduct the deposition experiments under ultra-high vacuum (UHV) conditions in the low 10^{-10} mbar regime. This allows to minimize contaminations from the residual gas and to prepare a contamination-free surface. Under the influence of a focused electron-beam (Ø < 3 nm) from a UHV-compatible scanning electron microscope column, the dissociation of adsorbed organometallic precursor molecules is induced. While the volatile fragments desorb, the non-volatile ones are deposited.

In this contribution, we report our recent findings on how certain lithographic parameters can change the growth mode and thus the final morphology of an EBID deposit. An example is shown in Fig. 1 for the system titanium(IV) tetraisopropoxide (TTIP) on Au(111). The experiment was organized such that approximately the same accumulated electron line dose was realized with a different number of exposure loops, thus a different dwell time per pixel. It will be shown that shorter dwell times (i.e. µs) yield local height growth mainly at the position of primary electron impact, whereas broadened "flat" deposits were generated at higher dwell times (i.e. ms). The diameter of the flattened lines corresponds almost perfectly to the simulated backscattered electron (BSE) exit area, and is interpreted as due to the emission of secondary and BS electrons in this area. Clear-cut evidence will be presented that within the applied experimental conditions a shift from the electron limited regime at shorter dwell times to the precursor limited regime at higher dwell times occurs.

In addition, we present a method to fabricate very sharp and well defined lines for different systems, i.e. TTIP on Au(111) and $Fe(CO)_5$ on [SiO_x(300 nm)/Si]. The lines shown in Fig. 2 could be generated using low doses, very short dwell times, several hundred loops, and a waiting period between each line in the ms region. In this way, the BSE proximity effect was drastically diminished.

Supported by the DFG (MA 4246/1-1) and by COST Action D41.

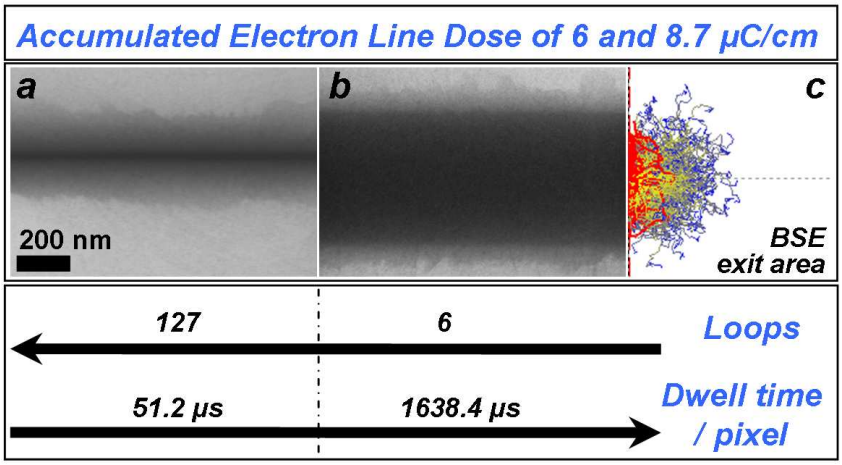

Fig. 1: *(a, b)* SEM micrographs of line deposits generated with the precursor TTIP on Au(111) using approximately the same accumulated electron line dose. Exposure parameters: I = 400 pA, U = 15 kV, $p(TTIP)$ = 3.0 x 10^{-7} mbar. *(c)* BSE exit area for Au substrate, simulated with the program CASINO V2.42. The diameter of the lines is for *(a)* ~ 239 nm, and for *(b)* ~ 600 nm. The Comparison of the simulated BSE exit area with the broadened line in *(b)* yields very good agreement.

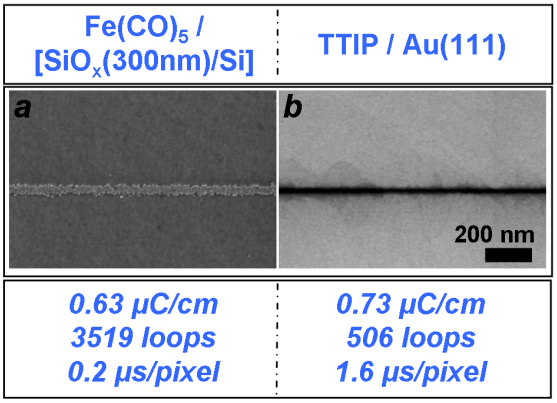

Fig. 2: SEM micrographs of line deposits generated with the precursor $Fe(CO)_5$ on [SiO_x(300nm)/Si] *(a)*, and TTIP on Au(111) *(b)* using approximately the same accumulated electron line dose. Exposure parameters: I = 400 pA, U = 15 kV, $p(TTIP, Fe(CO)_5)$ = 3.0 x 10^{-7} mbar. The diameter of the lines is for *(a)* ~ 40 nm and for *(b)* ~ 30 nm.