High-Fidelity Shapes and Disruption Mechanism during Focused Electron Beam Induced Deposition

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During recent years, focused electron beam induced deposition (FEBID) attracts increasing attention due to its mask-less, additive direct-write capabilities with spatial nanometer resolution. This techniques relies on the highly localized nano-synthesis of functional precursor molecules via a nanometer sized, focused electron beam on even non-flat surfaces where classical resist based lithography is complicated or even impossible. While the long lasting purity issues by means of carbon contamination have been recently be solved for Pt- and Co-based deposits, highly accurate morphology control is still subject of investigations. However, as emerging applications for nanoscale materials like plasmonics, thin film multilayer devices or high resolution sensor gaps demand precise deposit shape retention from design to deposition, a fundamental understanding for disruption mechanism is indispensable to enable specific control over morphology during FEBID processes.

In this contribution, we discuss limiting factors regarding lateral resolution, proximity deposition and surface shape fidelity. In more detail, we start with fundamental processes influencing the achievable widths of quasi-1D single lines on industrially relevant bulk substrates. We then expand the considerations to 3D deposits and discuss side wall broadening effects together with proximity deposition on the meso-scale (see Fig. 1). Finally, we focus on the surface properties of 3D deposits by means of flatness and disruption effects (see Fig. 2). By that this contribution gives a comprehensive insight in the complex interplay between electron trajectories, precursor dynamics as well as process parameters together with its morphological consequences on FEBID deposit from a fundamental point of view. Finally, the presentation demonstrates how ideal shapes can be achieved which is essential for controlled fabrication of highly defined structures from the micro- to the nano-scale.

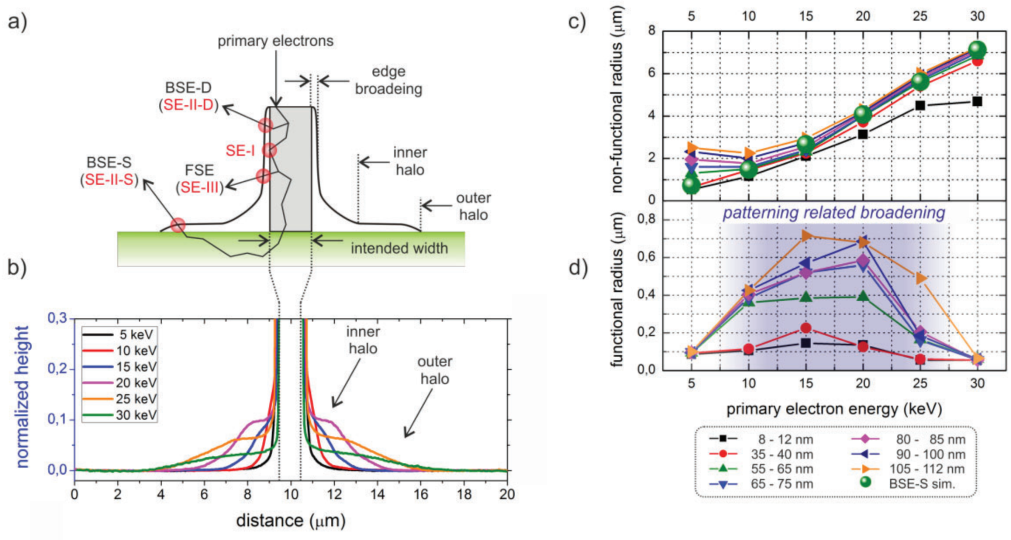

Figure 1: side wall broadening, proximity deposition and its origins: involved electron species (a) together with real AFM height profiles (b) for different primary energies. (c) and (d) give the proximity deposition for non-functional and functional properties, respectively, by means of electric conductivity which also reveals a patterning related influence for intermediate electron energies (d).

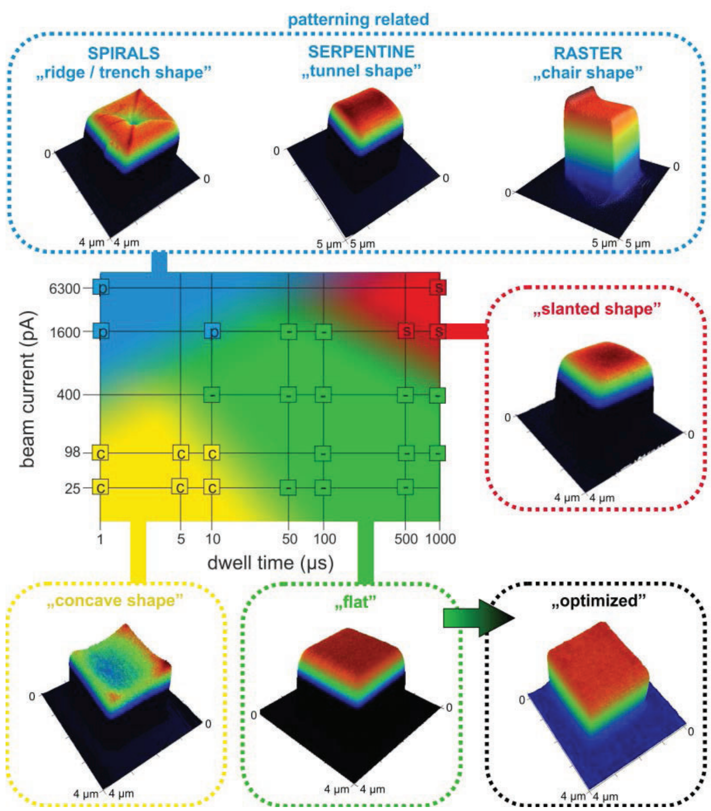

Figure 2: parameter dependent shape variations which can be explained by lateral gradients in the growth regime as will be discussed in the presentations. The bottom right image shows further optimized deposits by means of increased edge sharpness.