Towards high purity FEBID gold nanostructures – a comparison of purification approaches

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Gold is among the most promising materials deposited by focused electron beam induced deposition (FEBID). Gold stands out due to its high chemical stability, the excellent electrical conductivity and a dielectric function that is favorable for plasmonics. Early experiments on gold-FEBID from commercial precursors showed that deposited structures suffered from heavy carbon contamination. That is why purification of gold has been topic of interest for a long time.

This work reports on different purification approaches of FEBID gold nanostructures fabricated using commercial metalorganic precursors. We compare the results of (i) e-beam curing (ii) oxidation and (iii) a combination of e-beam curing and oxidation with respect to material purity and electrical conductivity. E-beam curing was performed in-situ either during deposition or as post-deposition process. As oxidant we have used oxygen and water activated by plasma or the electron beam. The purification process is described in Figure 1.

In order to purify, 500 × 500 nm planar gold nanostructures were deposited using an acceleration voltage 3 kV and a beam current of 1 nA. One subset of samples was additionally exposed to the electron beam for a defined, constant time. In a post-deposition step subsets of samples were exposed to an oxygen source - either in-situ or ex-situ. This oxygen treatment was activated by electron irradiation or by a plasma, both intended to trigger the oxidation of the carbonaceous contamination of the gold deposit. The composition and the height of the structures were measured using EDX. The AFM results presented in Figure 2 indicated that significant amount of material is removed in each step.

In another purification approach an oxidant such as water was injected simultaneously during gold deposition. The dosing behavior of water revealed that the precursor flow could be regulated precisely for precursors with comparable vapor pressure to water. The water vapor injection into the SEM chamber is (i) reproducibly (ii) quickly adjustable and (iii) can be kept stable as displayed in Figure 3. Gold deposited at under coinjection of water is shown in Figure 4. An influence of the co-injected water on the purity of the deposited gold was found. A systematic investigation of the obtained results will be presented and the underlying mechanisms will be discussed.

The metal content of various purification approaches will be thoroughly discussed and potential applications for nanoelectronic devices are elucidated.

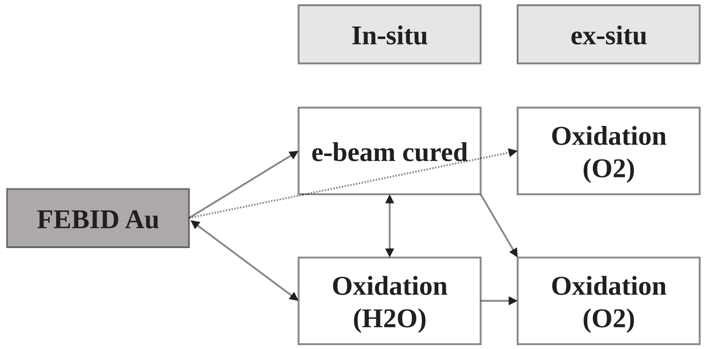

Figure 1: Different purification approach. Double arrow corresponds that both process were performed simultaneously.

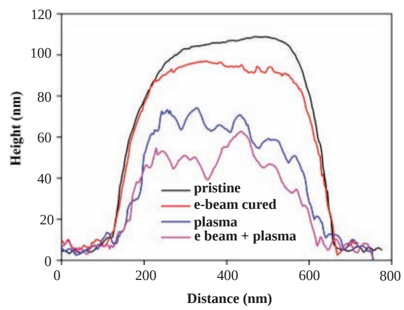

Figure 2: Comparison of structures height after different purification methods

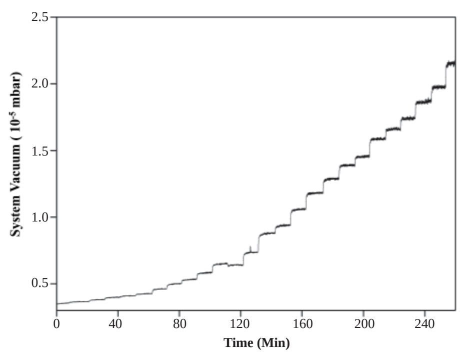

Figure 3: The graph reveals chamber pressure while water is injected at different doses

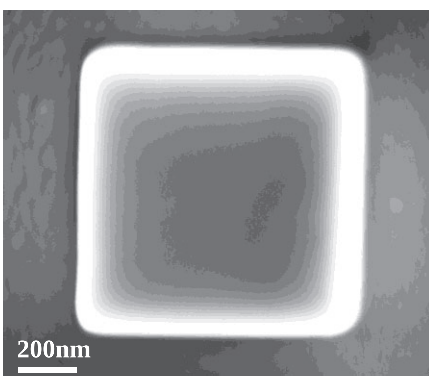

Figure 4: FEBID gold Au structures with the presence of water.