Electron Stimulated Purification of Platinum Nanostructures Grown Via Focused Electron Beam Induced Deposition

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Electron Beam Induced Deposition (EBID) is a direct write method capable of fabricating highly precise nanoscale structures by employing a scanning electron beam to disassociate adsorbed precursor molecules which subsequently condense on a substrate. The major drawback of the EBID process is that high purity metallic deposition is difficult to achieve due to the incomplete dissociation of the precursor molecule by the electron beam during deposition. Thus, purification strategies for nanoscale EBID deposits has been a critically important research area as EBID is poised to impact many nanoscale science and technology applications. To this end, our recent work has been focused on the post-deposition purification of EBID structures. In this presentation we demonstrate the purification of platinum–carbon nanostructures deposited via EBID from $MeCpPt(IV)Me_3$ during a post-deposition electron exposure treatment in a localized oxygen ambient at room temperature. Time-dependent studies demonstrate that the process occurs from the top-down. Electron beam energy and current studies demonstrate that the process is controlled by a confluence of the electron energy loss and oxygen concentration. Furthermore, the experimental results are modeled as a 2nd order reaction which is dependent on both the electron energy loss density and the oxygen concentration. In addition to purification, the post-deposition electron stimulated oxygen purification process enhances the resolution of the EBID process due to the isotropic carbon removal from the as-deposited materials which produces high-fidelity shape retention.

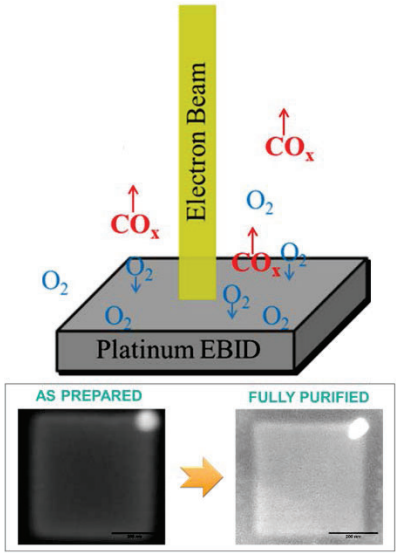

Figure 1: Experimental schematic for the purification process and SEM micrographs of the deposits before and after curing.

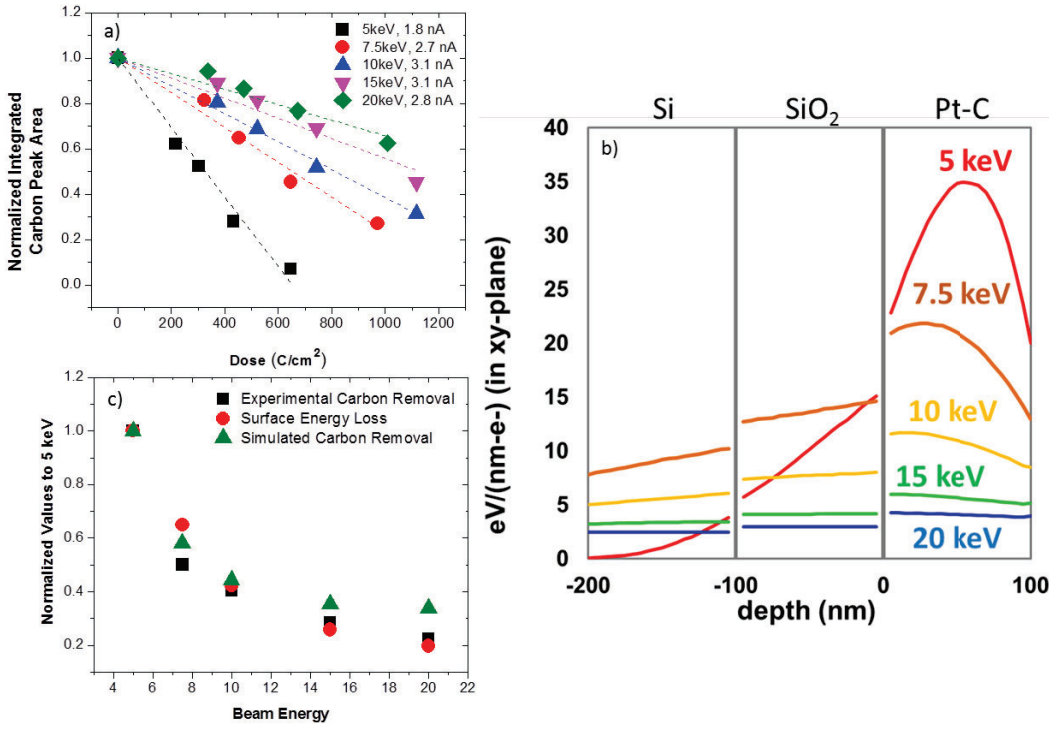

Figure 2: a) Normalized carbon peak area plotted as a function of dose for the beam energies shown. b) Monte Carlo simulation data depicting the electron energy loss over a 100 nm PtC_5 film on top of 100 nm SiO_2 as a function of height (thickness) at different beam energies. The gray vertical lines represent the Si-SiO_2 and SiO_2-PtC_5 interfaces. c) Comparison of the empirical purification rate to the simulated surface electron energy loss as normalized to the values at 5 keV.