Three-Dimensional Focused Electron Beam Induced Deposition: Design, Simulation and Experiments

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A design environment specific to focused electron beam induced deposition (FEBID) will be described. The capability is used to design three–dimensional[1-4] FEBID experiments. A complementary simulation serves as a predictive tool geared toward aiding the design of more complex 3D deposits. The ultimate goal of this simulation is to predict the primary electron beam coordinates and beam dwell times required for experimental 3D FEBID. This process will be demonstrated for the deposition of 3D objects as complex as the truncated icosahedron[5] and triangular bipyramid[6] geometries. The 3D design environment facilitates the design of mesh objects[5] as opposed to solid object exposure using raster scanning.

Inelastic energy loss deposited in the object and substrate by transmitted, high energy primary electrons is converted into a secondary electron surface emission profile wrapping the surface of the 3D object. The emitted SE surface current function appears as a term in the differential equation describing precursor dissociation which is coupled into continuum simulation. The continuum simulation emulates the surface diffusion of adsorbed precursor, adsorption and desorption of precursor via the vapor phase and secondary electron induced precursor dissociation.

The presentation will cover electron beam exposure design. A constant beam speed model is used to exposure each segment, or edge, component of a mesh object. The role of simulation in design will be explained in the context of the proximity effect due to scattered electrons. Regarding experimental results, in the past morphology comparison has mostly been used to achieve the convergence of simulations and experiments. Initial results investigating the ability of the simulation to predict the experimentally observed sample current evolution[7-8] will also be presented (Figure 1) in the hope that dynamic feedback may be achieved during FEBID to modify designs during exposure.

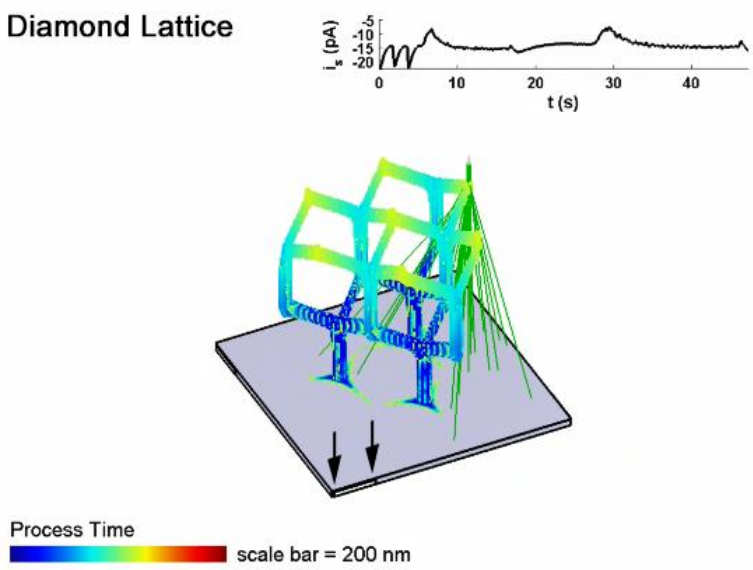

Figure 1: Diamond Lattice Deposition: Image capture of a simulation frame during the FEBID exposure of a diamond lattice. The diamond lattice consists of a platinum-carbon composite. Example electron trajectories (green lines) are shown in green for the beam impact point. The beam acceleration voltage was set to 30 keV. Deposit accumulates in simulation voxels during the process time; once filled the voxel faces are shaded to indicate the process time. The scale bar spans the indicated arrows. The sample current (i_s) evolution is tracked during deposition and depends on the primary electron impact, backscattered electron emission and secondary electron emission.

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