Growth Characterization of Electron Beam Induced Silver Deposition from Liquid Precursor

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Electron beam induced deposition (EBID) using gas phase precursor molecules is an extensively studied fabrication technique. Liquid phase metal deposition has recently been shown to achieve higher purity levels than traditional gas phase deposition [1]. The goal of this investigation is to characterize liquid phase silver deposition for further studies in photonics. A Scanning Electron Microscope (SEM) (FEI Nova 600 NanoLab Dual Beam) was used to deposit silver on polyamide membranes from aqueous AgNO3 solution by accelerating electrons into the solution for silver ion reduction. Atomic Force Microscopy (AFM) and SEM were subsequently used to characterize the size dependence to electron dosage. Different electron beam dosages and patterns were used to understand how the electron energy influences the deposition. We observed granular silver deposits with sub-100 nm grain size and ~300nm total aggregate size. The results indicate that deposited silver ions were not reduced at the surface of the membrane but beyond the membrane within the solution, and that the solid silver was collected at the point of electron beam entry.

Our analysis of particle growth as a function of the electron beam acceleration voltage and dose shows that the diameter increases for low acceleration voltages (2 KV, 5 KV), but does not change at 20 KV (Fig 1). In addition the height of these particles increases from 2 KV to 5 KV, but then does not increase at higher acceleration voltage (20 KV). Assuming that the particle volume can be approximated to that of a sphere cap (Eq. 1), then the volume growth increases from 2 KV to 5 KV and then drops off to 20 KV, (Fig 2). This shows that there is an optimum acceleration voltage for particle deposition. Details of the particle growth and effect of liquid chemical composition are explored.

$$V = \frac{\pi h}{6}\left(\frac{3}{4}d^2 + h^2\right) \qquad (1)$$

V=volume, *h* = particle height, *d* = particle diameter

[1] G. Schardein, E.U. Donev, J.T. Hastings, Electron-beam-induced deposition of gold from aqueous solutions. Nanotechnology, 22(1), 015301

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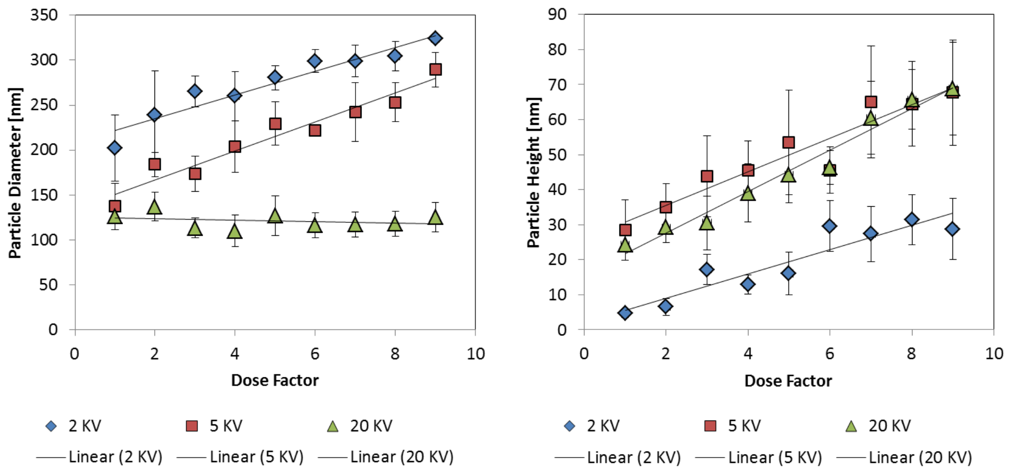

Figure 1: Graphs showing growth of silver deposited nanoparticles as a function of acceleration voltage and dose. (Left) particle diameter, (right) particle height. Particle height is much smaller than particle diameter.

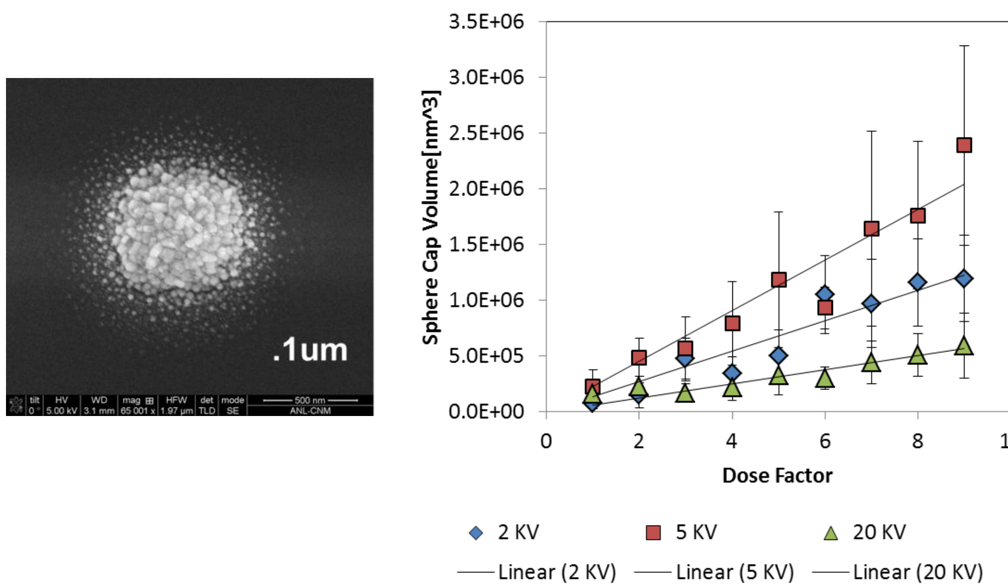

Figure 2: Graph showing volume of nanoparticle as a function of acceleration voltage and dose. (Left) Example of nanoparticle deposited at 2 KV. (right) Plot of particle volume vs dose assuming deposit shape is that of a spherical cap.

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