Liquid phase electron beam induced deposition of CdS

M. Bresin, N. Reddy, V. Singh, and J. T. Hastings
Department of Electrical and Computer Engineering, University of Kentucky, Lexington, KY 40517
hastings@engr.uky.edu

Liquid phase electron beam induced deposition (LP-EBID) is a site specific and maskless process where an electron beam drives chemical reactions in liquid precursors. Previous work in LP-EBID has shown the successful deposition of a variety of metals from aqueous precursors, resulting in high purity gold, silver, and platinum deposits.[*] However, deposition of compounds such as semiconductor materials remains a challenge for both gaseous and liquid EBID. In this work, the authors report the successful deposition of CdS from a precursor mixture of cadmium chloride ($CdCl_2$) and thiourea ($SC(NH_2)_2$), demonstrating the ability to induce multi-reagent chemistry with an electron beam. The ability to deposit semiconductor materials with site specificity may impact a variety of nanoelectronic and nanophotonic applications, and is particularly exciting given the limited gas phase EBID processes for semiconductor deposition.

The liquid precursor consisted of 10 mM $CdCl_2$ and 50 mM $SC(NH_2)_2$. The precursor was contained within a QuantomiX QX-102 WETSEM capsule. Deposition was performed with a Raith e-LiNE electron beam lithography system using 20 keV beam energy and 300 pA beam current. The deposition process and liquid cell are illustrated in Figure 1, where the electron beam penetrates the thin membrane and induces deposition on the precursor reservoir side. Figure 2 shows a top-down view (2a) and 45^{o} tilted view (2b) of a 5x5 array of CdS deposits, with diameters of approximately 250 nm and heights of 600-800 nm. EDX measurements from the deposits in Fig. 2 indicate the presence of both Cd and S (Figure 3), and have an atomic percentage of 55 and 45 respectively. The approximately stoichiometric ratio may indicate a two-step reaction mechanism. Possible reaction mechanisms, methods for deposit geometry control, as well as TEM crystallographic data will also be presented.

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[*] G. Schardein et al., *Nanotechnology*, vol. 22, p. 015301, 2011; E. U. Donev and J. T. Hastings, *Nano Letters*, vol. 9, pp. 2715-2718, 2009; A. W. Chamberlain et al. EIPBN 2011.

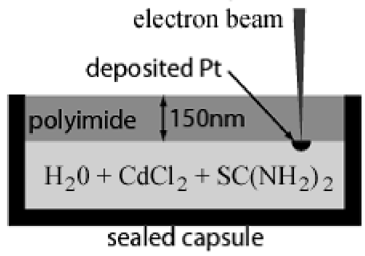

Figure 1: Schematic illustration of the LP-EBID process. Deposition occurs on the underside of the polyimide membrane.

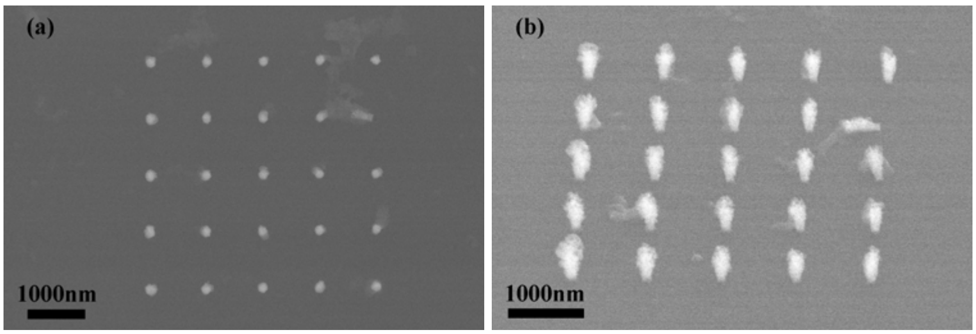

Figure 2: (a) Top-down view of 5x5 CdS array showing isolated deposits with a diameter of approximately 250nm (b) 45^o tilted view of array, illustrating the rod-like nature of the deposits with heights between 600-800 nm.

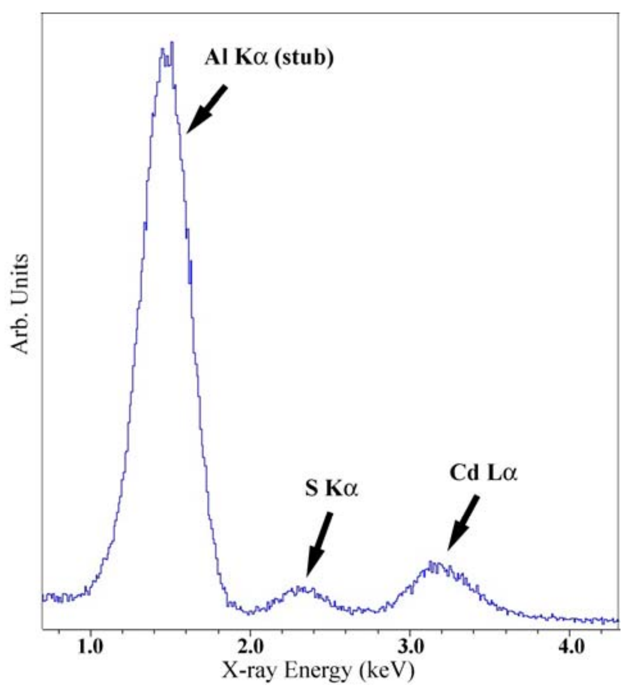

Figure 3: EDX spectra of CdS deposits from Fig. 2. The atomic percentage of Cd and S is approximately stoichiometric at 55 and 45 respectively.