QUANTUM CONFINEMENT IN PbSe THIN FILMS FORMED BY ELECTROCHEMICAL ATOMIC-LAYER EPITAXY

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Electrochemical atomic-layer epitaxy (EC-ALE) is an approach to electrodepositing thin-films of compound semiconductors. It takes advantage of underpotential deposition (UPD), deposition of a surface limited amount (a monolayer or less) of an element at a potential less negative than bulk deposition, to form a thin-film of a compound--one atomic layer at a time.

Many II-VI and a few III-V compounds have been formed by EC-ALE. II-VI films such as CdSe, CdS, and CdTe have been successfully formed.[1-11] In addition, deposition of the III-V compounds InAs[12] and InSb[14] have been formed, along with initial studies of GaAs[13] deposition.

PbSe has a narrow band gap (0.26 eV) and is used in photodetectors, photoresistors and photoemitters in the infrared range. PbSe films have already been formed by electrodeposition.[15-18] In this abstract we report the first instance of formation of PbSe by EC-ALE.

The SeO_2 concentration was 0.2 mM with a pH of 5.5, buffered with 50.0 mM $CH_3COONa{\cdot}3H_2O$. The $Pb(NO_3)_2$ concentration was 0.2 mM, pH of 4.0. A pH 4.0 blank solution was used as well. Solution pHs were adjusted with CH_3COOH. The supporting electrolyte was 0.5 M $NaClO_4$. Solutions were made with water from a Nanopure water filtration system fed by the house-distilled water line. The potentials were measured relative to a Ag/AgCl reference electrode.

Films were typically deposited on gold substrates as follows: The cell is filled by a pump from a reservoir containing an electrolyte solution of the element of interest (Pb). A surface limited amount (~0.4 monolayers) of the element is deposited at –0.300 V. The cell is then rinsed with a blank electrolyte solution and filled with another electrolyte solution of the next element (Se). A stoichiometric amount of this element is then deposited on the previous element at –0.300 V and the cycle repeated.

The films were characterized using electron probe microscope analysis (EPMA) and atomic force microscopy (AFM). The optical properties of the films were studied via infrared absorption measurements. The ratio of Pb and Se atoms in the films were found to be stoichiometric by EPMA. Films were made with thicknesses of 10 nm to 30 nm, and a strong blue shift was observed spectroscopically for the fundamental absorption edge due to quantum confinement.

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