

# CHARACTERIZATION OF NANOSTRUCTURED COMPOUND SEMICONDUCTORS DEPOSITED ON SILVER SINGLE CRYSTALS BY ECALE

M.L. Foresti<sup>1</sup>, M. Innocenti<sup>1</sup>, F. Loglio<sup>1</sup>, G. Pezzatini<sup>1</sup>  
and M. Cavallini<sup>2</sup>

<sup>1</sup>Dipartimento di Chimica, Università di Firenze

Via G. Capponi 9, 50121 Firenze, Italy

<sup>2</sup>Istituto di Spettroscopia Molecolare - CNR

Via Gobetti 101, 40129 Bologna Italy

In the present communication, we shall report on the growth of nanolayered semiconductors deposited on silver single-crystal substrates by Electrochemical Atomic Layer Epitaxy (ECALE) and on their characterization by surface science techniques. The ECALE technique is used to grow structurally well-ordered II-VI and III-V compound semiconductors. A monolayer of the compound is obtained by alternating the underpotential deposition of the metallic element with the underpotential deposition of the non metallic element in a cycle. When the upd is performed on single crystals, the atomic layer is epitaxial; namely, it is strongly affected by the crystallographic orientation of the substrate. The ECALE cycle can be repeated as many times as necessary to obtain deposits of practical thickness. The thickness of the deposit is determined by the number of cycles.

The ECALE method was proposed by Stickney and coworkers [1] and was extensively applied to polycrystalline, as well as to single crystal gold substrates. In our laboratory, it was employed to grow cadmium and zinc chalcogenides, as well as indium arsenide and ternary compounds on silver single crystal substrates. Once the deposit is formed, the amount of the elements deposited was estimated from the charge involved in their stripping. These investigations always confirmed an almost stoichiometric ratio of the element forming the compound. Moreover, the charge is a function of the number of deposition cycles, thus indicating layer-by-layer growth.

In order to determine the characteristics of composition, morphology and structure, the deposited films were examined by different surface science techniques. In particular, the composition was determined by X-ray photoelectron spectroscopy (XPS). Measurements were performed ex-situ by transferring the samples after deposition to the XPS spectrometer in ultra-high vacuum. The results obtained so far indicate that all compounds examined have the desired composition. The structural analysis was performed by X-ray photoelectron diffraction (XPD), still in ultra-high vacuum. For CdS and ZnS deposited on Ag(111), it was evidenced the formation of an ordered ultrathin layer of the compound. The structure is that of wurtzite with the (0001) plane parallel to the surface plane and the Cd type termination.

The morphology of samples formed with 25, 50, and 100 deposition cycles was investigated by Atomic Force Microscopy (AFM) to study the evolution from the bare silver single crystal to deposits of different thickness. It can generally be observed that the thinnest deposits exactly reflect the underlying silver surface. As the deposit's thickness increases, the formation of some crystallites and some clusters are observed, but the surface remains homogeneous. The high homogeneity is also indicated by the very low roughness factor of all samples examined. In the case of CdS, the crystallites of samples formed with 100 deposition cycles appear to lengthen along a preferential direction up to more than

100 nm. Magnification of AFM images of the thickest samples shows that the growth takes place along large terraces, layer-by-layer and not with cusps. Thus, strongly suggesting the epitaxial growth.

The high order found by AFM, as well as by XPD measurements, points to a high quality of the compound obtained. Hence, ECALE technique hold the promise of being able to provide low-cost, structurally well-ordered solids whose composition can be controlled at the nanoscopic level along the direction perpendicular to the substrate.

## REFERENCES

- (1) (a) Stickney, J.L. *J. Electroanal. Chem.*; **300**, 543 (1991). (b) Huang, B.M.; Colletti, L. P.; Gregory, B.W.; Anderson, J.L.; Stickney, J.L., *J. Electrochem. Soc.*, **142**, 3007 (1995).