Electrochemical Atomic Layer Deposition of CdS on Au substrates; An X-ray Diffraction and Reflectivity study

Snelgrove M[1]*, Carlà F[1], Morris A[1], Hussain H[1], Rawle J[1], Brearton R[1], Warne A[1].
*lead presenter: matthew.snelgrove@diamond.ac.uk
1. Diamond Light Source Ltd., Harwell Science and Innovation Campus, UK

The ability to deposit films to an angstrom level of thickness accuracy, while ensuring a high degree of conformality and stoichiometry control, has led to the wide use of atomic layer deposition (ALD) into areas such as the semiconductor industry and the renewable energy sector. However, conventional ALD processes typically require elevated temperatures to ensure a favourable deposition, which exasperates high costs associated with vacuum technology and volatile chemical precursors.

Classifying as a unique subcategory to the field, electrochemical-ALD (E-ALD) admits chemical precursors via the liquid phase, using an applied potential on the substrate instead of temperature to ensure a self-limiting deposition. The technique is based on electrodeposition and the phenomenon known as underpotential deposition (UPD). [1]. It has been demonstrated that E-ALD can produce highly ordered thin films on single crystalline substrates with well-defined crystallographic structure and epitaxial relation with the substrate [2]. This ability to deposit crystalline films at room temperature, and the potential low cost compared to the vapor phase alternatives, makes E-ALD an attractive field of study for thin film deposition.

This work will characterise the deposition and growth process of CdS on Au(111) single crystals at I07 – a surface and interface diffraction beamline that exploits the high brilliance of the 3rd generation synchrotron storage ring of Diamond Light Source. Particular emphasis will be placed on synchrotron X-ray reflectivity (XRR) and X-ray diffraction (XRD) techniques, harnessing the unique in-situ capabilities at the beamline. Whilst single crystal substrates provide an ideal benchmark for studying the deposition process, the high cost and small surface area of such a material negates the prospect of E-ALD being pursued for technological development. Consequently, the Au(111) single crystal results will be compared to a similar CdS E-ALD process that has been completed on thin film Au. The work will provide a detailed experimental insight into the CdS deposition on both substrate types with the aim of advancing this technique using more practical and economic substrate systems.

References

[1] Gregory BW and Stickney JL. Electrochemical atomic layer epitaxy (ECALE). J. Electroanal. Chem., 1991;300:543-561.
[2] Carlà F et al. Electrochemical atomic layer deposition of CdS on Ag single crystals: Effects of substrate orientation on film structure. J. Phys. Chem. C. 2014;118:6132-6139.