Characterization of Engineered Nanomaterials by Spectroscopic Ellipsometry

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Introduction

For many emerging applications, nanocrystals are surface functionalized with polymers to control self-assembly, prevent aggregation, and promote incorporation into polymer matrices and biological systems. The hydrodynamic diameter of these nanoparticle-polymer complexes is a critical factor for many applications, and predicting this size is complicated by the fact that the structure of many grafted polymers at the nanocrystalline interface is not generally established.

One parameter that helps to elucidate the surface structure is the polymer film thickness. In this study Polystyrene on CdSe nanocrystals has been evaluated by Spectroscopic Ellipsometry, a non-destructive optical technique dedicated to the characterization of thin film structures. Spectroscopic Ellipsometry (SE) will routinely determine film thickness, optical constants (n, k), information on layer inhomogeneity and material structure.

Experimental

A HORIBA Scientific UVISEL Spectroscopic Phase Modulated Ellipsometer has been used to characterize three samples including: Polystyrene/c-Si, CdSe nanoparticules/c-Si and Polystyrene/CdSe/c-Si.

Ellipsometric measurements were performed at an angle of incidence of 70°, across the spectral range 248-826 nm (1.5-5 eV), with a beam size of 1mm.

For the CdSe samples a micro spot of 100 μm, a standard feature of the UVISEL, was used in order to overcome the poor quality of the sample surface state.

The DeltaPsi2 software used for the analysis, provides advanced measurements, modelling and reporting capabilities for accurate and versatile characterization of thin film structures.

UVISEL Spectroscopic Ellipsometer

Ellipsometric Modelling and Results

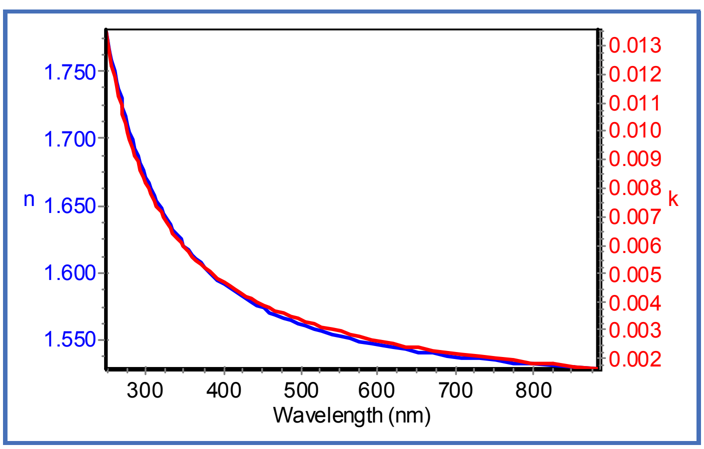
The characterization of the first two single layer samples aims to provide the film thickness and optical constants of both polystyrene (PS) and CdSe materials separately. This methodology simplifies the characterization of the bilayer structure, and improves the accuracy of the determination.

1st Sample

356.6 Å PS
Si

For this sample a single, homogeneous layer of polystyrene of thickness 356.6Å was found. The polystyrene optical constants were found to be slightly absorbing across the whole range 1.5-5 eV (248-826 nm). The optical constants were determined using the classical dispersion formula (see TN08 "Lorentz dispersion formula" for details of this formula).

Polystyrene Optical Constants

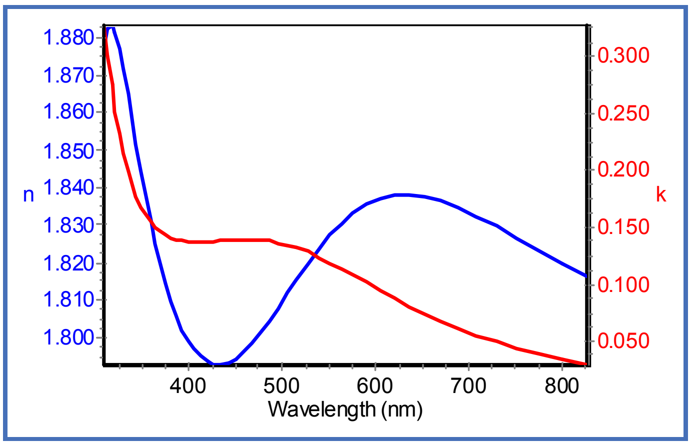


2nd Sample

309.5 Å CdSe
Si

The 2nd sample consists of a single, homogeneous CdSe nanoparticle layer. An excellent fit agreement was found across the spectral range 1.5-4 eV (310-826nm) by adjusting the thickness and optical constants of the CdSe layer. The optical constants were determined using the double new amorphous dispersion formula (see TN12 "New amorphous dispersion formula" for details of this formula).

CdSe Optical Constants

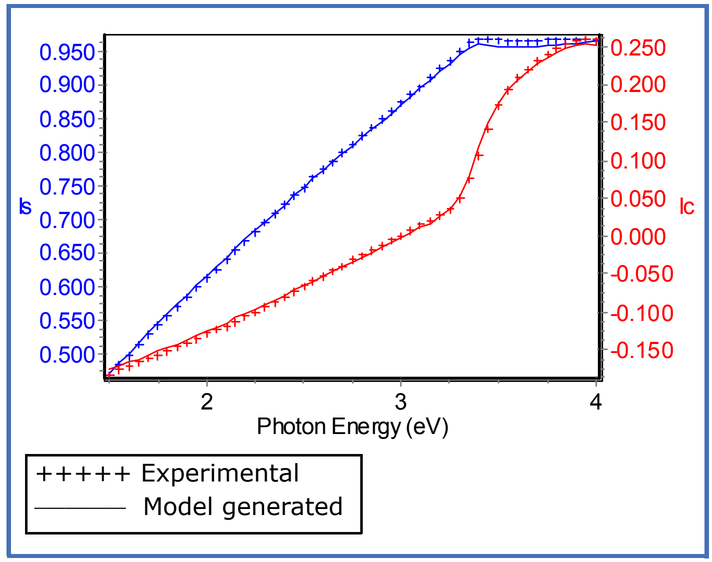


3rd Sample

The bi-layered structure was successfully characterized across the spectral range 1.5-4 eV (310-826nm). In the model structure the individual film optical constants were fixed to those previously determined, and only the layer thicknesses were calculated.

L2	PS	269.9 Å
L1	CdSe nanoparticle film	89.5 Å
	Si	

SE Fit Agreements



Conclusion

The UVISEL spectroscopic ellipsometer is a powerful instrument for characterizing nanostructures with high accuray and reliability. The analysis of polystyrene on CdSe nanoparticle provides precise and simultaneous information on both thin film thicknesses.

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