Plasma Deposition and X-ray Reflectivity Characterization of Graded Ultra High Barrier Coatings

by

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ABSTRACT

A variety of water vapor and oxygen barrier coatings are currently being developed to extend the lifetimes of moisture sensitive devices, such as flexible organic light emitting diodes (OLEDs). In this thesis, graded inorganic/organic ultra high barrier (UHB) coatings were investigated due to their potential to satisfy the requisite barrier, optical and flexibility requirements over the large areas needed to enable OLED lighting and display applications.

Graded UHB coatings were deposited with the commercially-viable deposition technique of plasma enhanced chemical vapor deposition (PECVD). Since many OLED devices will be fabricated on polymers, an added advantage of PECVD is its capability to reproducibly deposit conformal and compositionally graded coatings at or near room temperature.

In the UHB coatings studied in this thesis, PECVD was used to continuously deposit compositionally graded coatings that consisted of inorganic, organic and transitional *zones* rather than distinct layers of each material. The graded barrier coating was deposited in a single, continuous process by gradually mixing inorganic and organic precursor gases.

X-ray photoelectron spectroscopy and spectroscopic ellipsometry analysis indicated the properties of the transitional zones in the graded barrier coating were organic-like. To guide selection of the critical deposition parameters that control the gradation in coating properties, a growth model was developed. By using this growth model, a barrier coating with a sinusoidal-like variation in composition was fabricated. This demonstrated the capability of the growth model and characterization methodology to advance the development of graded UHB coatings satisfying the barrier, optical and flexibility requirements for OLEDs.

To enable monitoring of the barrier structure during manufacturing and over time, an x-ray reflectivity (XRR) methodology was developed that enabled fast characterization of the different composition zone thicknesses. Fundamental theoretical analysis as derived in this thesis showed that several distinct periodicities should be measurable in the XRR spectra of multi-component UHB coatings. These periodicities allow fast identification of the inorganic, organic, and under certain circumstances,

transitional zone thicknesses for graded UHB coatings. Experiments reported in this thesis demonstrated the feasibility of using XRR to detect grading that occurs over tens of nanometers.