PHYSICAL ELECTRONICS
A DIVISION OF ULVAC-PHI

XPS Depth Profiling of
Organic Photovoltaic Films

Overview: X-ray Photoelectron Spectroscopy (XPS) offers great potential for the analysis of the components in organic photovoltaic (PV) films due to its ability to obtain quantitative elemental and chemical information for each component. To characterize elemental and chemical changes as a function of use, it would be useful to obtain compositional depth profiles of the layers in these organic devices. It is widely accepted that sputter depth profiles of organic materials using low energy (500 eV) argon ion beams destroys the very chemical structures that are being investigated. Recent experiments using an ion beam of 2,500 argon atom clusters have demonstrated the ability to obtain XPS depth profiles of organic PV materials while retaining chemical information.

Experimental: All spectra were taken on a PHI Model 5000 *VersaProbe* Scanning XPS Microprobe equipped with a gas cluster ion beam (GCIB) source. The GCIB source produced a 10 kV cluster beam with approximately 2,500 argon atoms per cluster and the beam was rastered over a 2 mm by 2 mm area. The model organic PV films used for this study were composed of two proprietary organic layers deposited, in sequence, on a glass substrate.

Results: Shown in figure 1, is the depth profile of the “as deposited” organic PV film stack. Note that the interface between the two organic layers is not sharp and that the S 2p plot associated with S-C bonding varies in intensity over the entire course of the depth profile, in both layers. Shown in figure 2, is a depth profile of the same film stack after annealing. The S-C peak intensity is flat in the first layer and persists at about half the concentration through the second layer to the glass interface. Furthermore, the shape of the carbon plot substantiates the sharpening of the interface observed in the sulfur 2p plots. This data demonstrates the ability of the GCIB to profile through the entire model PV film, to quantify with XPS the elemental and chemical state compositions of the two layers, and the ability of GCIB depth profiling to differentiate the layered structures before and after annealing the model PV films.

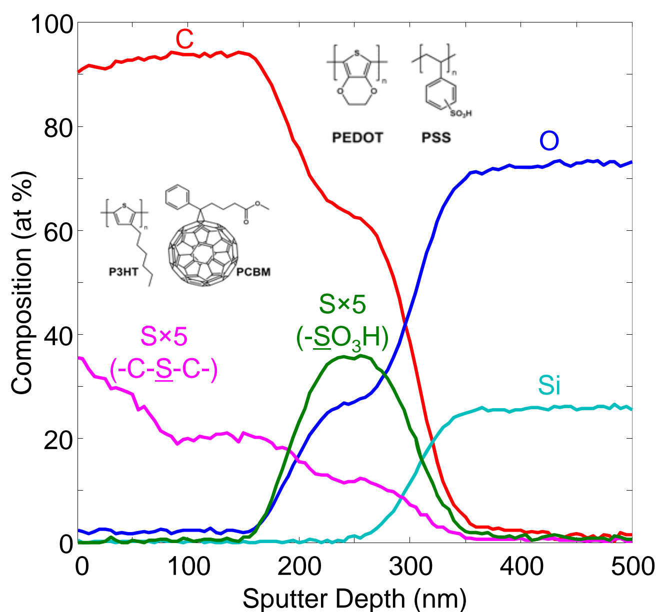

Figure 1. As deposited organic PV film stack

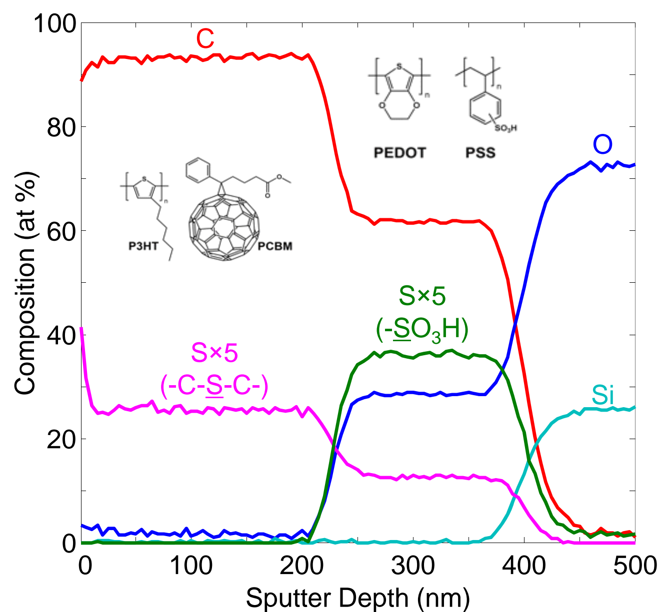

Figure 2. Annealed organic PV film stack

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