

DEPTH PROFILING ORGANIC FILMS

with the PHI 06-C60 Sputter Ion Gun

INTRODUCTION

Organic films are routinely applied to surfaces to provide lubrication, wetting, anti-static, and other surface properties for a wide range of industrial products. XPS has been used for a number of years to characterize very thin (< 50 Å) organic films such as perfluoroether lubricants on computer hard disks. However, for thicker organic films it has been only possible to characterize their outer surface, because of the chemical damage caused by traditional argon ion depth profiling methods that have been successfully applied to thick inorganic films. The PHI 06-C60 sputter ion gun uses C_{60} ions that have been shown to effectively sputter etch

many organic materials while causing minimal chemical damage. The example shown here demonstrates the ability to characterize the chemical composition of a 1 μm thick organic layer as a function of depth using the PHI 06-C60 sputter ion gun.

EXPERIMENTAL

A one micron thick perfluoropolyester film was deposited on a calcium fluoride substrate. A sputter depth profile was obtained using a PHI Quantera Scanning X-ray Microprobe to obtain XPS spectral data and a PHI model 06-C60 ion gun for sputtering. A 10 kV – 8 nA C_{60} ion beam was rastered over a 2 x 2 mm area to create the depth profile. The observed etch rate for the

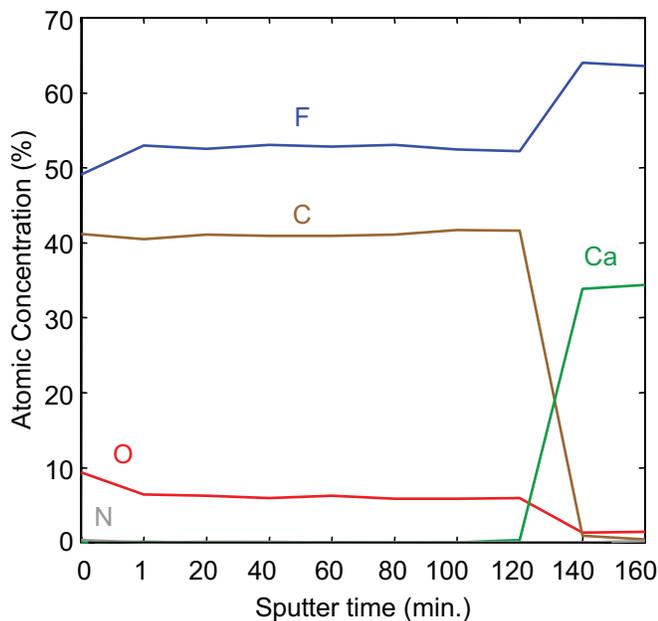


Figure 1: XPS depth profile of a 1 μm thick perfluoropolyester film on a calcium fluoride substrate obtained using the PHI 06-C60 sputter ion gun.

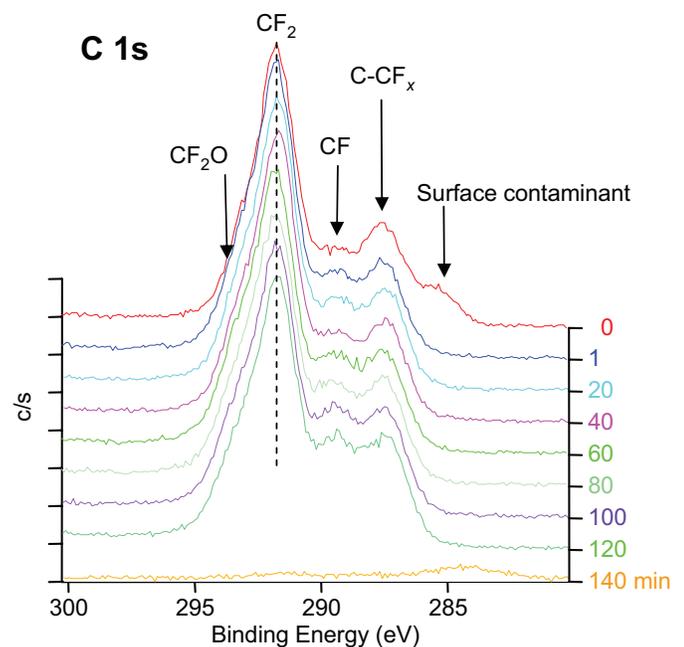


Figure 2: XPS spectra from the sputter depth profile show the removal of a surface contaminant and constant chemistry as a function of depth.

organic material was approximately 8 nm per minute. Charge neutralization was accomplished using PHI's patented dual beam charge neutralization method.

RESULTS

The elemental sputter depth profile in Figure 1 shows a constant ratio of C, O, and F throughout the thickness of the film indicating that chemical damage was minimal. The carbon 1s spectra in Figure 2 show the presence of the perfluoropolyester and a surface contaminant. After the first sputter cycle the surface contamination was removed and the spectra from the perfluoropolyester remained unchanged throughout the thickness of the film, indicating that minimal chemical damage was caused by sputtering with C_{60} .

In a similar manner the fluorine spectra in Figure 3 are at a binding energy for an organic fluorine bond throughout the thickness of the

film indicating minimal chemical damage. If chemical damage had occurred, a loss of fluorine and peak shift to lower binding energy would have been detected. The chemical state depth profile shown in Figure 4 was created by curve-fitting the data in Figures 2 and 3 with PHI MultiPak. It shows that the chemical composition remained constant throughout the 1 μm thick layer as material was being removed with C_{60} sputtering

SUMMARY

We have shown that a PHI Quantera Scanning X-ray Microprobe equipped with a PHI 06-C60 ion gun can successfully be used to characterize thick organic films such as the perfluoropolyester film shown in this example. Surface contamination was removed and the entire film sputter depth profiled with minimal chemical damage. As a result, a complete chemical characterization of the entire thick film structure was obtained.

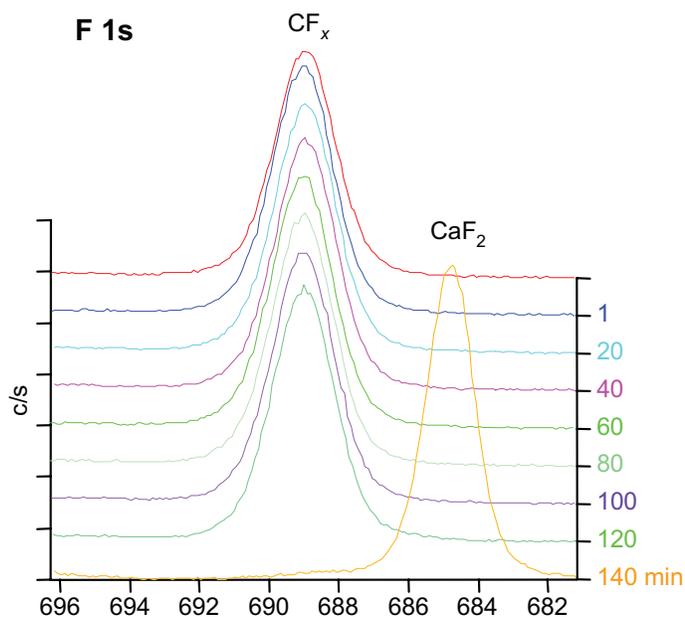


Figure 3: XPS spectra of fluorine show the stable presence of the organic F species throughout the organic layer and the fluoride species detected when reaching the CaF_2 substrate.

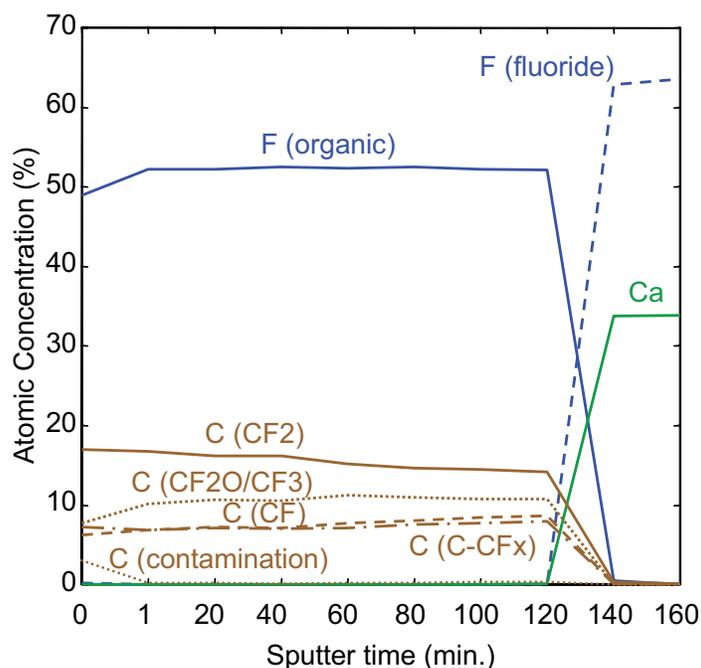


Figure 4: Depth profile plots of the detected C and F chemical species show the chemical stability of the organic film under C_{60} bombardment.

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