

Identifying structures on a plasma-modified polymer surface

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Key Words

ESCALAB, Flexible Electronics, Imaging, Polystyrene, Retrospective Spectroscopy, XPS

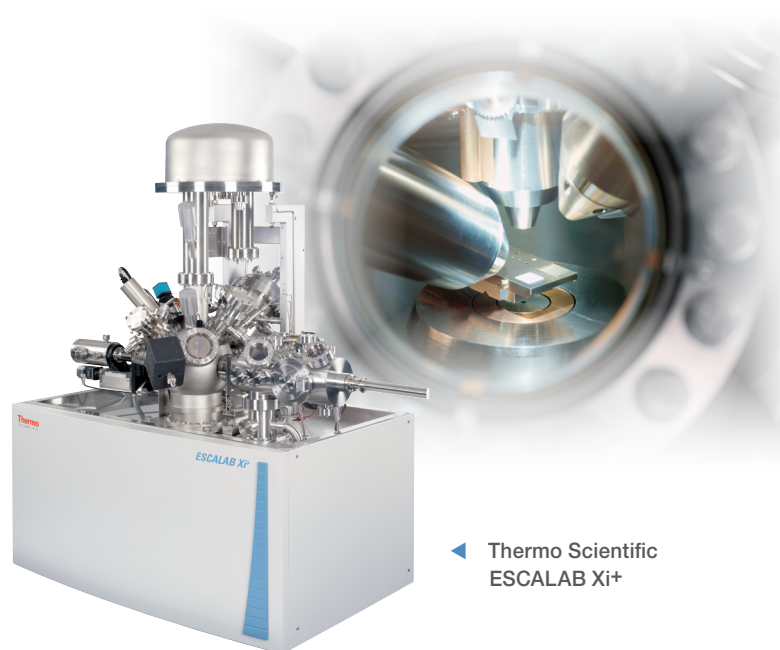
Identifying the chemical changes induced by plasma modification can be difficult, as they generally affect only the outer few nm of the surface. Here we demonstrate how the modification can be easily located and measured using XPS imaging.

Introduction

The worldwide market for lighter, cheaper and more convenient electronic devices is a strong driving force behind new developments in flexible electronics. Combined with medical requirements for cheap, disposable measurement platforms, the potential return on investment for step improvements in the base technology of these devices is very high. Polymers such as polystyrene (PS) present the characteristics desired for flexibility and mass production, as well as having high dielectric strength which is suited to manufacturing electronic devices. However, in order to create efficient electronic devices, the surface of these polymers needs to be finely tuned, to create not only the required conduction characteristics but also surfaces which readily accept any materials deposited on them. All this needs to be achieved without sacrificing or modifying significantly the bulk characteristics of the material.

Method

This tuning of the surface is where X-ray Photoelectron Spectroscopy (XPS) yields unique information suited to investigating the success of any surface treatments. XPS is a well established technique where the composition and chemical states of a surface can be probed by investigating the energy of photoelectrons escaping the



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ESCALAB Xi+

surface under soft X-ray illumination. For investigating the chemistry of small ($< 50 \mu\text{m}$) surface structures, Parallel Imaging XPS provides a higher resolution solution than possible by other XPS methods. Parallel Imaging XPS works by retaining the positional information of the photoelectrons emitted from the surface, and mapping these onto a two dimensional detector after energy selection, explained in Figure 1. By using this method, simultaneous information regarding photoelectron energy and distribution across the surface (at that energy) can be recorded. A Thermo Scientific™ ESCALAB™ Xi+ was used to collect XPS image data on a patterned polystyrene surface, prepared by exposure to oxygen plasma in defined areas, by masking off the surface sample.

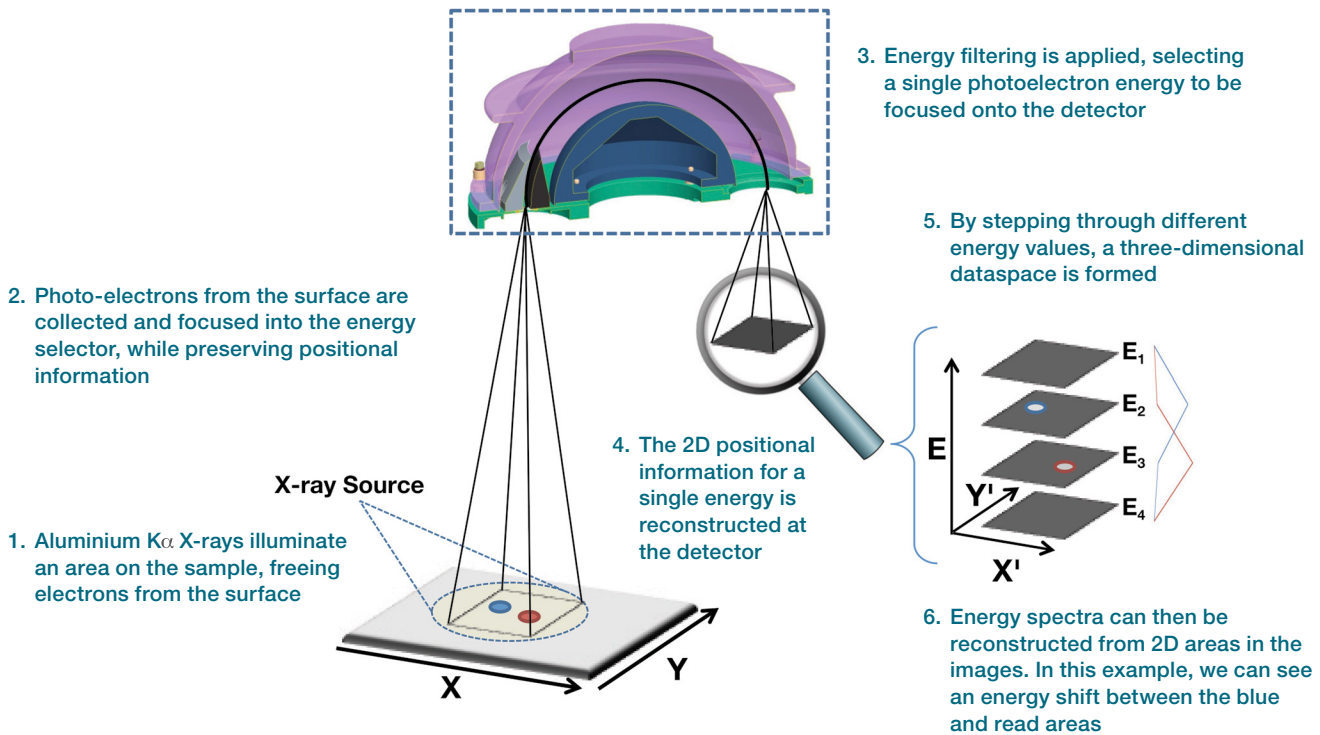


Figure 1: Parallel imaging XPS

Results

Both static (single kinetic energy) and quantified images (multiple discrete kinetic energies) from an area $150\ \mu\text{m}$ square were recorded for the C1s and O1s regions. The static imaging results, recorded in approximately 3 min 20s per region, show a clear correlation between the location of the oxygen (O1s) on the surface and a reduction in the carbon (C-C) signal, as shown in Figure 2. The clear contrast demonstrates successful and significant modification of the polystyrene surface in the unmasked treated areas.

Of particular interest in this case is whether the chemistry of the masked section is retained when the unmasked section is treated. For the quantified image, intensity data

is recorded for each pixel of the image, at each spectra to be reconstructed from one or more regions within the image, in this case from the treated and untreated areas of the surface. Figure 3 shows two spectra reconstructed from the highlighted areas on the image, the first is from the untreated area and demonstrates the π - π^* shake-up feature which is characteristic of a pure polystyrene spectrum, the second is from the treated area and shows some extra oxygen bonding and a loss of the π - π^* feature. From these data we can conclude that the masked area retains the surface properties of pure polystyrene, while the chemistry of the treated surface has been successfully modified.

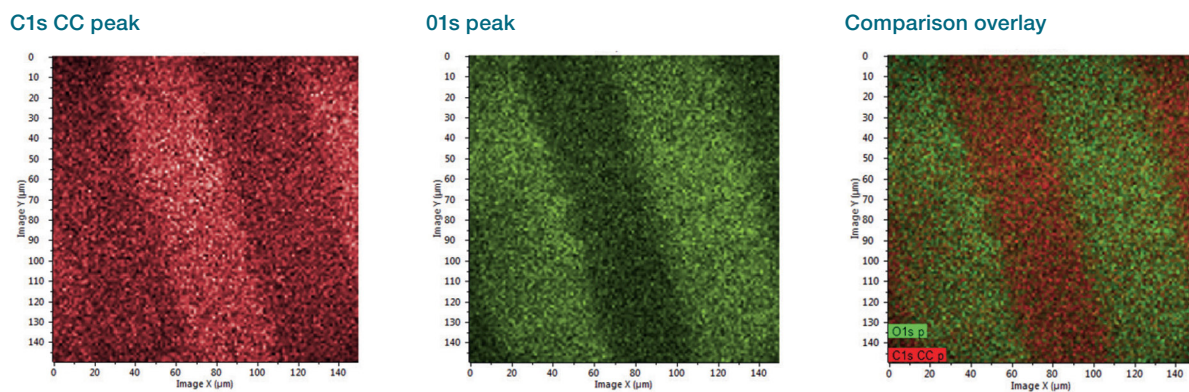


Figure 2: Static Images of Carbon and Oxygen regions, with overlaid comparison

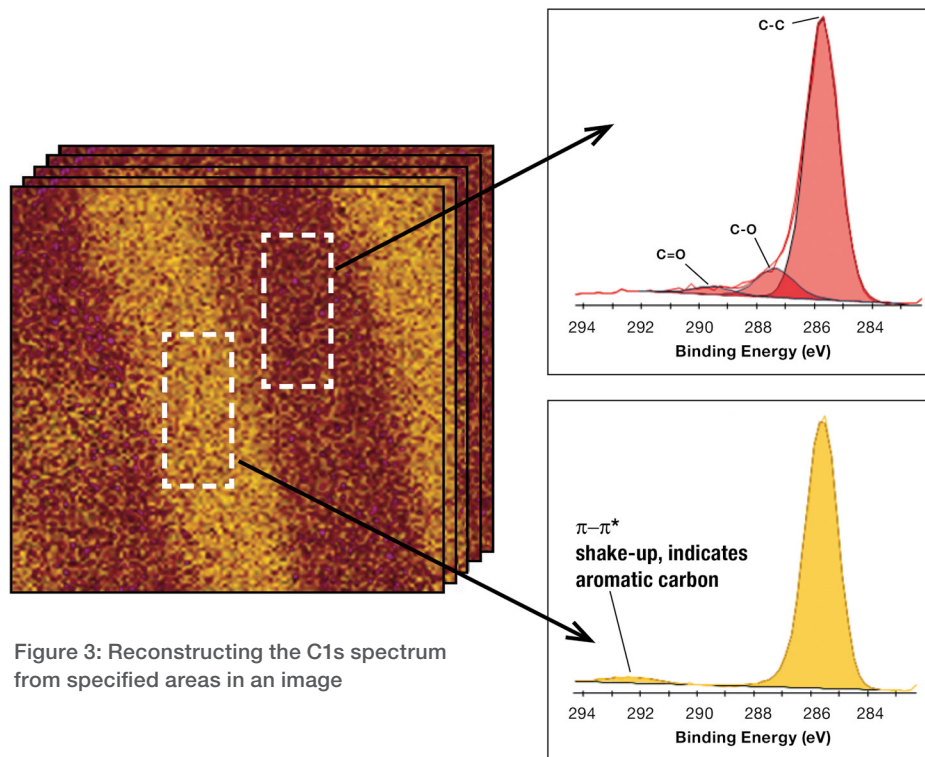


Figure 3: Reconstructing the C1s spectrum from specified areas in an image

Summary

Parallel Imaging XPS was used to identify chemistry changes on a polystyrene surface which had been patterned using a plasma treatment on a masked surface. This technique can be used to easily identify how much of a surface has been modified, or if desired structures needed for an end device have been created. By combining spatial and chemical information, it is possible to determine exactly how successful to production process has been.

Acknowledgements

We would like to thank the Rutgers University Laboratory for Surface Modification for providing the samples used to collect these data.

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