Analysis of a Dry Film Photo-Resist

The Thermo Scientific K-Alpha X-ray Photoelectron Spectrometer (XPS) System was used to analyze the interface between a dry film photo-resist layer and its protective polypropylene layer.

Introduction
Dry film photo-resists are increasingly used in photolithography applications, such as the manufacture of integrated circuit boards. The photo-resist often forms part of a laminated stack, with a polymer substrate (such as PET) and a protective layer (such as polypropylene). The protective layer is peeled away during use, but the efficacy of this process will depend on the properties of the dry film-protective layer interface. These properties, in turn, can be investigated by analyzing the surfaces of the dry film and protective layers after peeling. X-ray photoelectron spectroscopy (XPS) is the ideal analytical technique for this purpose, combining surface sensitivity with chemical selectivity.

To fully characterize the polymer surfaces after peeling, it may be necessary to detect and distinguish subtle differences in carbon and oxygen bonding states. Additionally, since the polymers are insulators, it is necessary to neutralize the electrical charge that builds as a result of X-ray analysis. This requires an XPS tool that combines turn-key charge neutralization with high sensitivity and excellent energy resolution.

The K-Alpha XPS System was used to investigate the surfaces formed by peeling the polypropylene protective layer from a dry film. The dry film was mounted on a PET substrate, as shown in Figure 1. The chemistry of the dry film was also investigated with K-Alpha XPS System.

Experiment
The photosensitivity of the dry film means that the XPS analysis must be carefully controlled if accurate chemical information is to be obtained. Once the protective layer has been removed and the dry film exposed, the sample must be transferred to the analysis chamber as quickly as possible. This will minimize any possibility of chemical degradation in the surface by exposure to ambient UV light. The K-Alpha XPS System enables rapid transfer of samples from atmosphere to the analysis chamber. Most polymer samples can be transferred within ten minutes, which maximizes throughput and productivity, as well as protecting the sample.
Components due to the dry film were observed in the carbon spectrum acquired from the peeled polypropylene surface (Figure 5). The Avantage Data System was used to quantify the relative proportions of dry film residue and polypropylene.

The peak fitting protocol for the dry film was applied to the carbon spectrum from the peeled propylene surface. Two further components were added, with relative binding energies, peak widths and peak intensities appropriate for pure polypropylene. The Avantage Data System then allowed the XPS spectrum to be fitted in terms of the total area for pure polypropylene and the total area for the dry film. The composition of the surface was found to be four parts polypropylene to one part dry film.

**Results**

**Dry film photo-resist surface**

XPS analysis of the dry film surface after the polypropylene layer had been peeled away showed that it was composed of carbon and oxygen; no other elements were detected. A high-energy resolution XPS spectrum of carbon (Figure 3) reveals the chemical bonding states in the surface.

Peak fitting of the raw data in the Thermo Scientific Avantage Data System (the integrated software solution for all of our XPS systems) indicates that the dry film surface could be a mixture of partially esterified cellulose (giving rise to the C-C*=O, C-O and C*=C=O components) and aliphatic carbon (C-C).

**Protective layer (polypropylene) surface**

The carbon spectrum of a pure polypropylene surface should have a single asymmetric peak, which can be deconvoluted into contributions from CH₂ and CH₃ groups. The surface of the protective layer, which was formerly in contact with the dry film, was analyzed (Figure 4), and it was found that the carbon spectrum was not that of pure polypropylene.