Characterization of Barrier Layers by Spectroscopic Ellipsometry for Packaging Applications

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Materials such as the plastics and papers used in flexible packaging are permeable to different gases (O_2, CO_2, etc.), humidity and odours unless treated. Without the addition of barrier layers to the packaging, food or beverage contents spoil more quickly. Additionally layer transparency, to allow viewing of the contents and microwave compatibility are further performance parameters needed in an ideal, modern barrier layer.

This has lead to a new generation of materials and coatings, usually oxide based, being developed to meet the high-performance specifications required for today's packaging. The oxide coated PET films are used as a barrier material for food packaging and deliver completely transparent coatings. For standard grade barrier coatings, a coating thickness of 40-60 nm is deposited on the PET film.

Spectroscopic ellipsometry is the ideal technique for very fast, reliable and non-destructive characterization of these barrier coatings. This application note details the ability of the UVISEL Spectroscopic Ellipsometer to accurately monitor in real-time both the thicknesses and quality of the transparent coatings that are applied using high speed reel to reel machines running at up to 10m/s and handling web widths of 1-3 m. Based on the methodology provided by Prof. S. Logothetidis, Aristotle University of Thessaloniki Coordinator of FP5-GROWTH Project, G1RD-CT-2000-00334 "TransMach-Transparent Films Vacuum Coatings Machine with Integrated In-line Monitoring and Control" during which, this ability of UVISEL Spectroscopic Ellipsometer was verified.

Experimental

The experimental data were acquired at an angle of 70° across the spectral range 1.5 – 6.5 eV using the UVISEL FUV spectroscopic ellipsometer.
The characterization of the sample was performed in two steps:

- Characterization of the PET substrate
- Characterization of the barrier coating deposited on PET

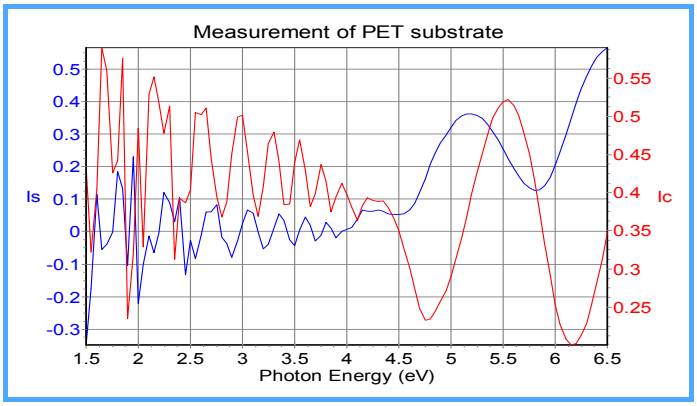


Figure 1

PET substrate characterization

In the visible region from 1.5 – 4 eV the PET substrate is transparent introducing interference fringes caused by reflections from the backside of the substrate film. At higher photon energies the substrate becomes completely absorbing and this feature may be exploited to avoid reflections from the backside of the substrate film, as shown in the figure 1.
The region from 4 to 6.5 eV was therefore used to perform the analysis of the barrier coating.
The PET optical constants in this range are directly extracted from the raw data measurements of the substrate (figure 2).

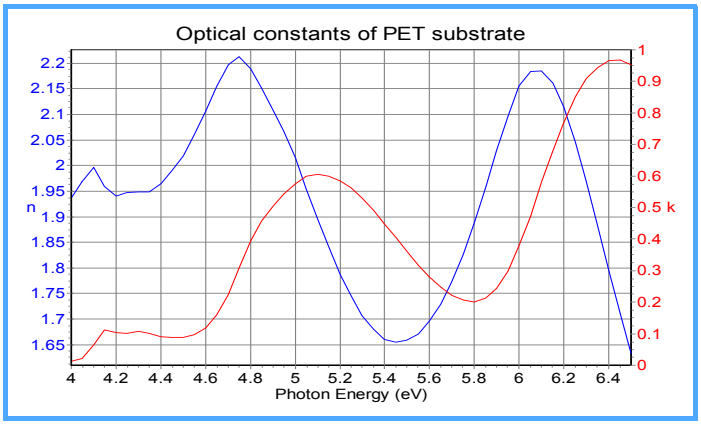
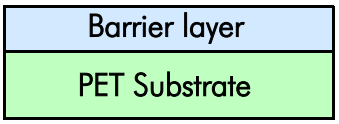


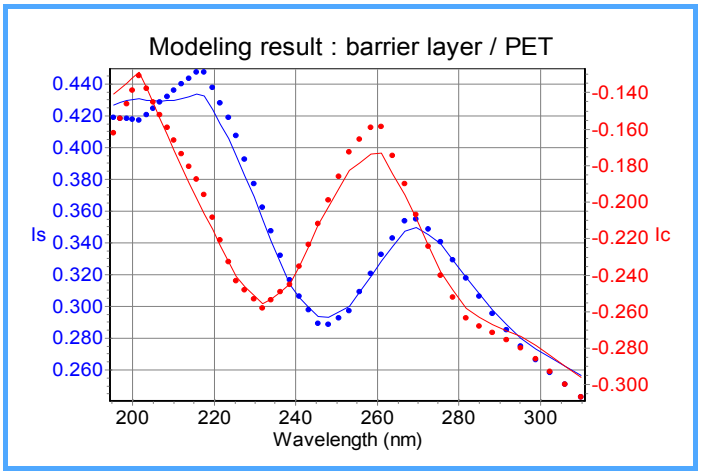
Figure 2

Barrier coating characterization

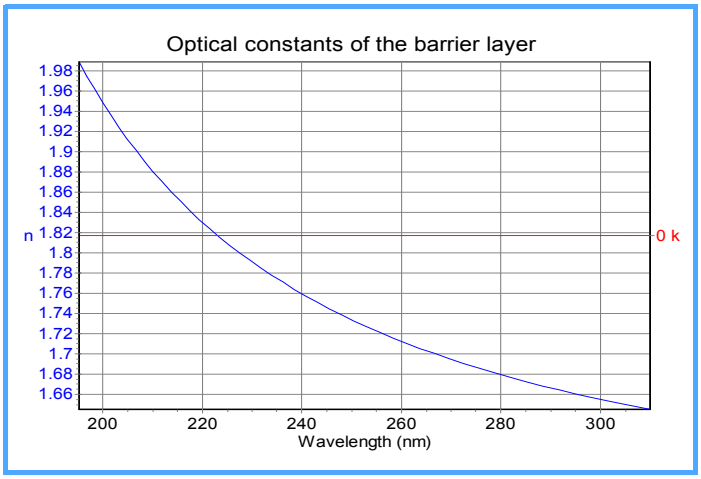
The barrier coating is accurately described using a single layer model.



Both the refractive index and film thickness were obtained from the data analysis without ambiguity.



The classical Lorentz oscillator formula was used to model the refractive index of the barrier layer which is completely transparent in the FUV range.

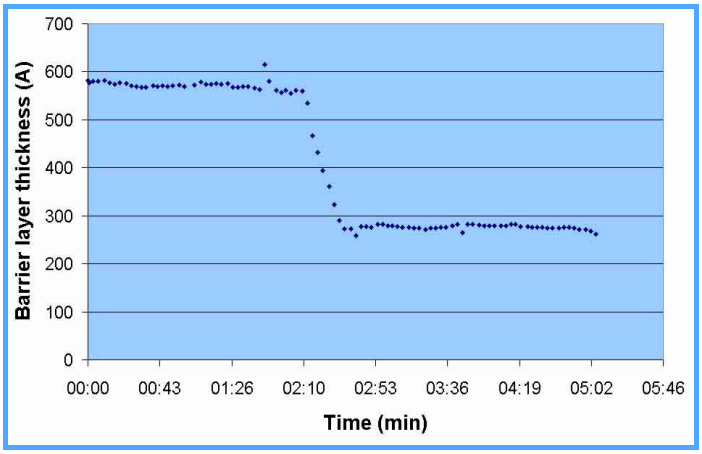


Production Readiness

The UVISEL FUV Spectroscopic Phase Modulated Ellipsometer was mounted on a web coater to measure coating parameters in real-time. The challenge of this task is to provide accurate real-time monitoring of these parameters on a fast moving and vibrating surface.

The UVISEL FUV when combined with a multiwavelength detection system allows ultra fast measurements every 20 ms enabling data to be collected at intervals of a few centimetres along the web length, with the measured thickness and optical values being fed back to the coating system controller for immediate process adjustment.

The graph below shows the simultaneous coating and measuring results for two different thicknesses around 570 and 270 Angstroms.



The verification of the UVISEL FUV Spectroscopic Phase Modulated Ellipsometer was performed during FP5- GROWTH Project, G1RD-CT-2000-00334 "TransMach" using the methodology provided by Prof. S. Logothetidis, Aristotle University of Thessaloniki.

Plastic films mounted on the coater

Conclusion

The UVISEL FUV combines high-speed acquisition, high accuracy and versatility with a straightforward recipe mode for automated tasks. This powerful combination allows the UVISEL spectroscopic ellipsometer to be used for monitoring the production of barrier coatings for packaging applications in real time.

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