AN 353
Physical and Chemical Characterization of Multilayer Thin Films

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Discussion

Thin film optical coatings serve many roles in semiconductor laser or other photonic applications. Some applications of thin film coatings include waveguides, anti-reflective (AR) coatings, or high reflectivity (HR) coatings for use in precision optics, LEDs and lasers. Generally the film compositions, as well as layer structure and thickness, must be precisely defined in order to provide the desired optical property.

A combination of analytical tools that can provide a nearly complete characterization of thin films is SEM (scanning electron microscopy) and XPS/ESCA (x-ray photoelectron spectroscopy/electron spectroscopy for chemical analysis). The utility of this combination of analytical tools was illustrated in the examination of an AR coating of unknown thickness and composition deposited on glass.

Figure 1 shows an SEM cross section of the AR coating. From the cross section, the number of layers as well as the layer thicknesses were determined. The AR coating was found to be composed of four layers with the following film thicknesses (from top to bottom): 2200 Å, 1900 Å, 390 Å and 830 Å. The thickness of each layer was measured with an accuracy of ±10% using the SEM data.

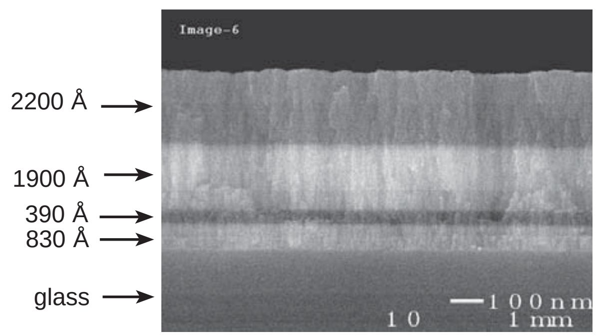

Figure 1. SEM cross section of AR coating on glass

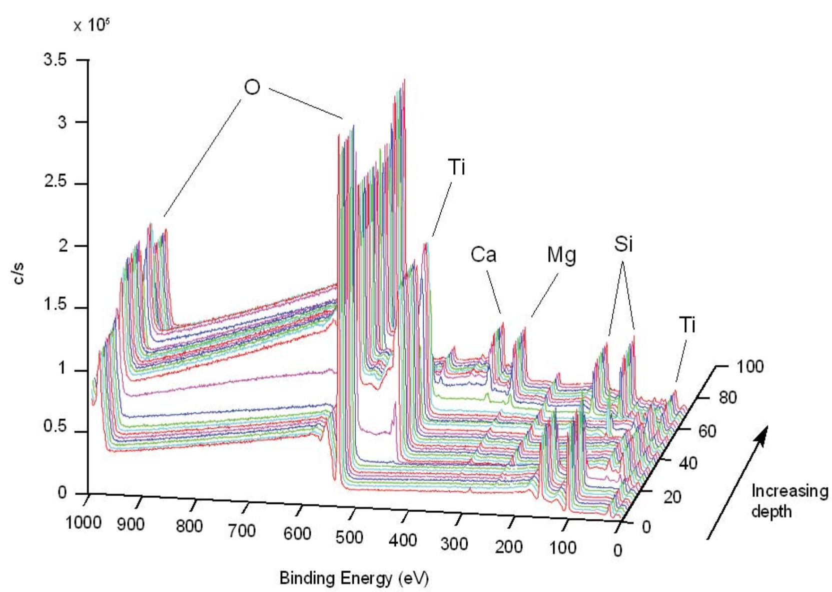

Figure 2. XPS survey depth profile of AR coating

A survey depth profile using XPS was obtained from the same sample. The advantages of an XPS depth profile in survey mode include the detection of all elements except H and He and the ability to provide atomic concentrations of the detected elements, even when present at matrix levels. Figure 2 shows a montage plot of the survey data as a function of sputter cycle, and Figure 3 shows the depth profile that was extracted from the elemental survey data. The XPS results show that the film is composed of alternating layers of SiO_2 and TiO_2. Ca and Mg, along with Si and O, mark the beginning of the glass substrate.

Table 1 provides a summary of the range of information obtained from the film by utilizing the combination of these two analytical tools.

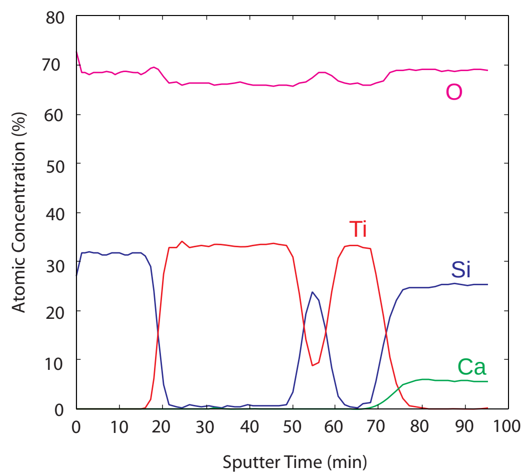

Figure 3. XPS depth profile extracted from survey data

Table 1. Film thickness and composition

Layer # (from top)	Thickness (SEM)	Composition (XPS/ESCA)
Layer 1	2200 Å	SiO_2
Layer 2	1900 Å	TiO_2
Layer 3	390 Å	SiO_2
Layer 4	830 Å	TiO_2

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