

## **Spectroscopy Study of Amorphous Tungsten Oxide Films used in Electrochromic Multilayered Structures**

Hai-Ning Cui<sup>1</sup> and Vasco Teixeira<sup>1</sup>

<sup>1</sup>University of Minho-Physics Department,GRF-Functional  
Coatings Group  
Campus de Azurem  
Guimaraes PT-4800-058  
Portugal

Amorphous Tungsten Oxide ( $\alpha$ -WO<sub>3</sub>) film is one of the most studied electrochromic (EC) materials. It can be used as EC layer in EC devices. Electrochromism can be described as reversible change optical properties, by an applied external voltage. Here  $\alpha$ -WO<sub>3</sub> thin films were deposited onto glass and ITO substrates by reactive DC magnetron sputtering for EC application. Growth temperature, oxygen partial pressure, and total gas pressure have been varied to obtain the thin films. They were analyzed by spectroscopy in the range of near infrared (NIR), visible and ultraviolet (UV-vis) spectra. X-ray diffraction, X-ray photoelectron spectroscopy and atomic force microscopy were also used in order to characterize the film structure. We obtain information on the tungsten oxide optical properties, a percentage of void fraction, surface roughness and film thickness.

Raman spectra analysis of  $\alpha$ -WO<sub>3</sub> thin films were also studied. The Raman spectra of WO<sub>3</sub> films as deposited are the typical Raman spectra of mixing phase of monoclinic WO<sub>3</sub> and amorphous WO<sub>3</sub>. We notice that the phonon activity may be grouped in a set of two ranges: high at 600-1000 cm<sup>-1</sup> and low at 140-400 cm<sup>-1</sup>. The one strongest peak was located at 970 cm<sup>-1</sup>, which is assigned to a terminal W=O stretching mode of cluster and cluster boundaries. The W=O terminal stretching belong to the W-O bonds at the free surface of cracked grains. This remarkable relative intensity of the double W=O bond, typical of non bridging oxygen, caused by absorbed water molecules and are frequently seen in sputtered or evaporated films deposited at lower temperatures. From the study, it can be found that Raman spectroscopy can be used to distinguish the phase structure of  $\alpha$ -WO<sub>3</sub> thin films in developing of the EC devices.