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Physical properties characterization of WO_3 films grown by hot-filament metal oxide deposition

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ABSTRACT

WO_3 is grown by hot-filament metal oxide deposition (HFMOD) technique under atmospheric pressure and an oxygen atmosphere. By X-ray diffraction obtains that WO_3 presents mainly monoclinic crystalline phase. The chemical stoichiometry is obtained by X-ray Photoelectron Spectroscopy (XPS). The IR spectrum of the as-grown WO_3 presents broad peaks in the range of 1100 to 3600 cm^{-1}. A broad band in the 2200 to 3600 cm^{-1} region and the peaks sited at 1645 and 1432 cm^{-1} are well resolved, which are originated from moisture and are assigned to ν(OH) and δ(OH) modes of adsorbed water and the corresponding tungsten oxide vibrations are in infrared region from 400 to 1453 cm^{-1} and around 3492 cm^{-1}, which correspond to tungsten–oxygen (W–O) stretching, bending and lattice modes. The Raman spectrum shows intense peaks at 801, 710, 262 and 61 cm^{-1} that are typical Raman peaks of crystalline WO_3 (m-phase) that correspond to stretching vibrations of the bridging oxygen, which are assigned to W–O stretching (ν) and W–O bending (δ) modes, respectively. By transmittance measurements obtains that the WO_3 band gap can be varied from 2.92 to 3.13 eV in the investigated annealing temperature range.

1. Introduction

Metallic oxides are important materials from the standpoint of both fundamental and applied science. Particularly, tungsten and molybdenum oxide films have been the focus of extensive scientific investigations due to their prospective technological applications in electrochromic devices [1], gasochromic sensors [2] and electrocatalysis [3]. However, their most intensively investigated property so far is the electrochromism. The characteristics of WO_3 films make them suitable for electrochromic (EC) devices or windows [4]. Depending on the deposition conditions and techniques, films may present considerably different structural, optical and electrical behaviours, and consequently different EC behaviours. The sputtering technique is the most widely investigated and large-scale deposition set available. Sputtered WO_3 films deposited on substrates are known to be amorphous or polycrystalline. Using tungsten (W) targets in direct current (D.C.) magnetron reactive sputtering, thin film properties can be improved by controlling the reactive gas atmosphere.

In recent years, there have been strong development efforts in the area of EC devices because of various potential applications such as architectural glazings, automobile and building sun-roofs, displays for light regulation and energy saving, etc. [5,6]. Electrochromic devices have therefore attracted extensive attention among researchers involved in thin film preparation [7].

As it is known, the structural quality and components of the material dominate the physical properties of the thin films. Both IR and Raman spectroscopy are very powerful tools to analyze the structure, phase and components of materials such as tungsten oxides. They are suitable to study the vibration and rotation of molecules. With these techniques, it is possible not only to identify different oxide phases but also to detect intercalated H_2O. Such studies allow obtaining fundamental information about WO_3 films for their applications. Granqvist had given brief statements about vibrations in the range of 400 to 1200 cm^{-1} [8]. The Raman vibration mode is related to the molecular structures by comparison with standard compound spectra or with Raman theoretical calculations. The use of Raman scattering to study thin film has

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