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Structural characteristics and properties of nanocrystalline WO_3/TiO_2-based powders and thin films for humidity sensors

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Abstract – Nanocrystalline WO_3/TiO_2-based powders and thin films have been prepared by the polymeric precursor method using titanium isopropoxide and tungstic acid as reagents. The WO_3 concentration ranged from 1 to 20 mol % and its influence on samples properties was studied. The samples were treated at temperatures ranging from 450°C to 600°C for 2 h and their structural and microstructural characteristics were evaluated by X-ray diffraction and transmission electron microscopy measurements. Grain size decreased as the WO_3 content increased. The surface morphology of films was observed by atomic force microscopy. Good sensor response was obtained for samples with at least 5 mol% WO_3.

TiO_2-based nanostructured powder is technologically interesting for a variety of applications, such as photocatalysts, optically transparent UV-filters, and sensors [1]. TiO_2 nanomaterials are promising candidates for gas sensing, such as CO, methanol and ethanol sensing and has also been tested for humidity sensing. Titanium dioxide has different crystalline phases, brookite, anatase and rutile, being rutile the most stable. Titanium dioxide may have its crystallization influenced by doping with transition metal oxide, such as tungsten oxide, which can alter the transformation of anatase to rutile phase [2]. Moreover, the TiO_2 sensing properties have been enhanced by adding tungsten as dopant.

In this study, nanocrystalline WO_3/TiO_2-based powders and thin films have been prepared by the polymeric precursor method using titanium isopropoxide and tungstic acid as reagents. The WO_3 concentration ranged from 1 to 20 mol % and its influence on samples properties was studied. The samples were treated at temperatures ranging from 450°C to 600°C for 2 h and their structural and micro-structural characteristics were evaluated by X-ray diffraction (XRD) and transmission electron microscopy (TEM) measurements. The influence of WO_3 concentration on the specific surface area was evaluated.

The morphology of thin films surface was analyzed by atomic force microscopy and revealed a decrease in grain size with the increase of WO_3 content. The same behavior was observed for powder samples. Also, the sensing characteristics of WO_3/TiO_2 ceramics and films as a function of the relative humidity, obtained by the capacitance/resistance measurements at 1 kHz frequency, were evaluated.

XRD of the samples calcined at temperatures from 400 to 600°C for 2 h showed anatase as the main crystalline phase. It was observed that the increase in WO_3 concentration avoids the crystallization of the rutile phase, even for samples treated at 600°C. The crystallite and particle mean sizes ranged from 5 to 18 nm and from 10 to 100 nm, respectively. Good sensor response was obtained for samples with at least 5 mol% WO_3. These results indicate that WO_3/TiO_2 ceramics and films can be used as a humidity sensor element.

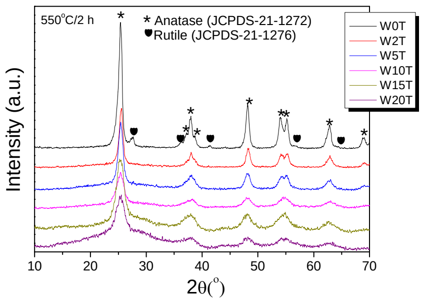

Figure 1: XRD patterns of WO_3/TiO_2 samples heat treated at 550°C/2 h

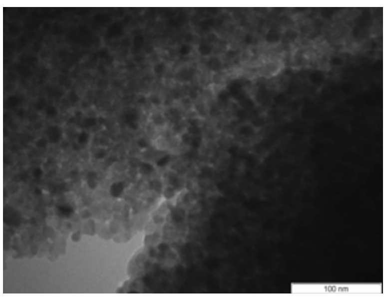

Figure 2: MET image of a WO_3/TiO_2 sample with 5% WO_3 heat treated at 600°C for 2 h.

References

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