World Academy of Science, Engineering and Technology
International Journal of Materials and Metallurgical Engineering
Vol:9, No:06, 2015

Doped TiO2 Thin Films Microstructural and Electrical Properties

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Abstract : In this work, the doped TiO2 (dopants – Ca, Mg) was investigated. The comparison between the physical vapour deposition methods as electron beam vapour deposition and magnetron sputtering was performed and the structural and electrical properties of the formed thin films were investigated. Thin films were deposited on different type of substrates: SiO2, Alloy 600 (Fe-Ni-Cr) and Al2O3 substrates. The structural properties were investigated using Ambios XP-200 profilometer, scanning electron microscope (SEM) Hitachi S-3400N, X-ray energy-dispersive spectroscope (EDS) Quad 5040 (Bruker AXS Microanalysis GmbH), X-ray diffractometer (XRD) D8 Discover (Bruker AXS GmbH) with glancing angles focusing geometry in a 20 – 70° range using the Cu Kα1 λ = 0.1540562 nm radiation). The impedance spectroscopy measurements were performed using Probostat® (NorECs AS) measurement cell in the frequency range from 10-1-106 Hz under reducing and oxidizing conditions in temperature range of 200 °C to 1200 °C. The investigation of the e-beam deposited Ca and Mg doped-TiO2 thin films shows that the thin films are dense without any visible pores and cavities and the thin films grow in zone T according Barna-Adamik SZM. Substrate temperature was kept 600 °C during the deposition and Ts/Tm ≈ 0.32 (substrate temperature (Ts) and coating material melting temperature (Tm)). The surface diffusion is high however, the grain boundary migration is strongly limited at this temperature. This means that structure is inhomogeneous and the columnar structure is mostly visible in the upper part of the films. According to XRD, the increasing of the Ca dopants' concentration increases the crystallinity of the formed thin films and the crystallites size increase linearly and Ca dopants act as prohibitors. Thin films are comprised of anatase TiO2 phase with an exception of 2 % Ca doped TiO2, where a small peak of Ca arise. In the case of Mg doped-TiO2 the intensities of the XRD peaks decreases with increasing Mg molar concentration. It means that there are less diffraction planes of the particular orientation in thin films with higher impurities concentration. Thus, the crystallinity decreases with increasing Mg concentration and Mg dopants act as inhibitors. The impedance measurements show that the dopants changed the conductivity of the formed thin films. The conductivity varies from 10-3 S/cm to 10-4 S/cm at 800 °C under wet reducing conditions. The microstructure of the magnetron sputtered thin TiO2 films is different comparing to the thin films deposited using e-beam deposition therefore influencing other structural and electrical properties.

Keywords : electrical properties, electron beam deposition, magnetron sputtering, microstructure, titanium dioxide
Conference Title : ICTFTA 2015 : International Conference on Thin Film Technology and Applications
Conference Location : Copenhagen, Denmark
Conference Dates : June 11-12, 2015