NiO Nanoparticle single doped with Ti and co-doped with Ti and Sn thin films: Enhancement of electrochromic properties

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Abstract

NiO nanoparticles doped with Ti (Ni1-xTixO) and co-doped with Ti and Sn (Ni1-xTix-ySnyO) have been prepared, on FTO/glass substrate, using solution method (dipping in a sol-gel). The Ti nominal molar concentration into Ni1-xTixO ranges from 0-30 %. Best electrochromic properties (contrast ratio, coloration efficiency, and stability) were observed for composition that has Ti nominal concentration of 25 % (Ni0.75Ti0.25O). This was evidenced from measurements of cyclic voltammetry (CV), transparency during CV, and photoluminescence (PL). The XRD measurements for Ni1-xTixO films reveal the amorphous structure, except for Ti contents of 30%, in which a peak corresponds to TiO2 was observed. SEM photographs confirm the amorphous structure of these films. It also showed a crystallite size of 6-17 nm for Ti contents of 10 %. The crystallite size for Ni1-xTixO was also observed by SEM to decrease to 3-9 nm when Ti contents increased to 20 %. The composition that gives best electrochromic properties (Ni0.75Ti0.25O) was chosen to prepare NiO nanocrystallite films co-doped with Sn (Ni0.75Ti0.25-ySnyO). The Sn molar concentration in these films varied from 1-5%. From CV and transparency during CV measurements, Co-doped NiO films showed better electrochromic performance than Ti single doped films. From co-doped films, the best electrochromic properties were observed for films that contains 3% of Sn (Ni0.75Ti0.22Sn0.03O). The thickness of the films, deduced from UV-visible scanned transparency, was found to be about 60 nm for single dipped films, and increased by 100 nm for extra dipping. The transparency spectrum was also used to deduce the optical energy band gap of the films in the bleach state. For all measured films, the optical energy band gap was found to have a value of about 4 eV.

Keywords: doping, co-doping, CV, transparency, electrochromic properties