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Determination of certain sol-gel growth parameters of nickel oxide films

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Abstract

In present work, NiO thin films were fabricated by sol-gel spin coating technique depending on precursor concentration, annealing temperature and solvent type. Crystallographic, morphological and optical features of films were inquired by XRD, AFM and UV/VIS measurements. The XRD studies pointed that films had nickel oxide cubic structure with (200) preferential orientation and the crystallinity of films depended on deposition conditions. The AFM pictures showed the films were composed of well-formed nano particles. From AFM analysis, it was also found that deposited films had quite smooth surfaces. The optical measurements indicated that the transmittance and optical band gap values continuously decreased with the increasing precursor molarity, however they initially increased with the annealing temperature up to 550 °C and then dropped off with more increasing annealing temperature. For 2-methoxyethanol, methanol and water solvents, the highest optical transmittance and optical band gap values were found for methanol solvent. The findings in our study suggest that the characteristic properties of NiO films strongly depend on the deposition conditions of sol-gel spin coating. NiO films with good structural, morphological and optical properties can be also used in various technological applications.
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Keywords: XRD; Nickel oxide; Annealing; Molarity

1. Introduction

In recent years, nickel oxide (NiO) which is a member of transition metal oxides has been greatly used in many apparatus [1] such as magnetic materials, catalysts, smart windows, solar cells [2–5] as well as electrochromic devices [6] because of its thermal and chemical insistence, low cost, superior electrical, optical and antiferromagnetic properties [7–9]. NiO, one of a few p-type metal oxide semiconductors, has a large band gap varied between 3.6 to 4.0 eV [10]. In the stoichiometric structure, NiO has insulator property with resistivity of about $10^{13}\,\Omega\,cm$ [11], however non-stoichiometry resulted from Ni^{2+} vacancies and oxygen interstitials in NiO structure makes it a p-type semiconductor material [1,12].

In thin film form, NiO can be deposited by various thin film growth techniques such as electrochemical deposition, sputtering techniques, spray pyrolysis and sol-gel spin coating etc. [13–16]. Among these, spin coating is more functional technique owing to its simplicity, safety, low cost and ability to deposit homogenous and good quality films [7,17]. In a sol-gel spin coating deposition process, the properties of studied material may be tailored by growth parameters such as sol-gel chemistry, spin velocity, drying and annealing temperature and deposition ambient. [18]. In the literature, NiO thin films have been grown as functions of spin layer number [7,14,19], sol-solution pH [20], annealing temperature [4,9,14,21], solvent type [22] and annealing ambient [14] in order to understand the effect of sol-gel spin coating growth parameters on the features of NiO films. However, according to our best knowledge, there has been no report on the fabrication of NiO film depending on sol-gel precursor solution molarity and there is only one study on effect of solution solvent type. Therefore, we have aimed to determine the effect of precursor molarity, annealing temperature and solvent type on the structural, morphological and optical features of NiO thin films. For this purpose, nickel oxide thin films have been deposited via sol-gel spin coating technique for different

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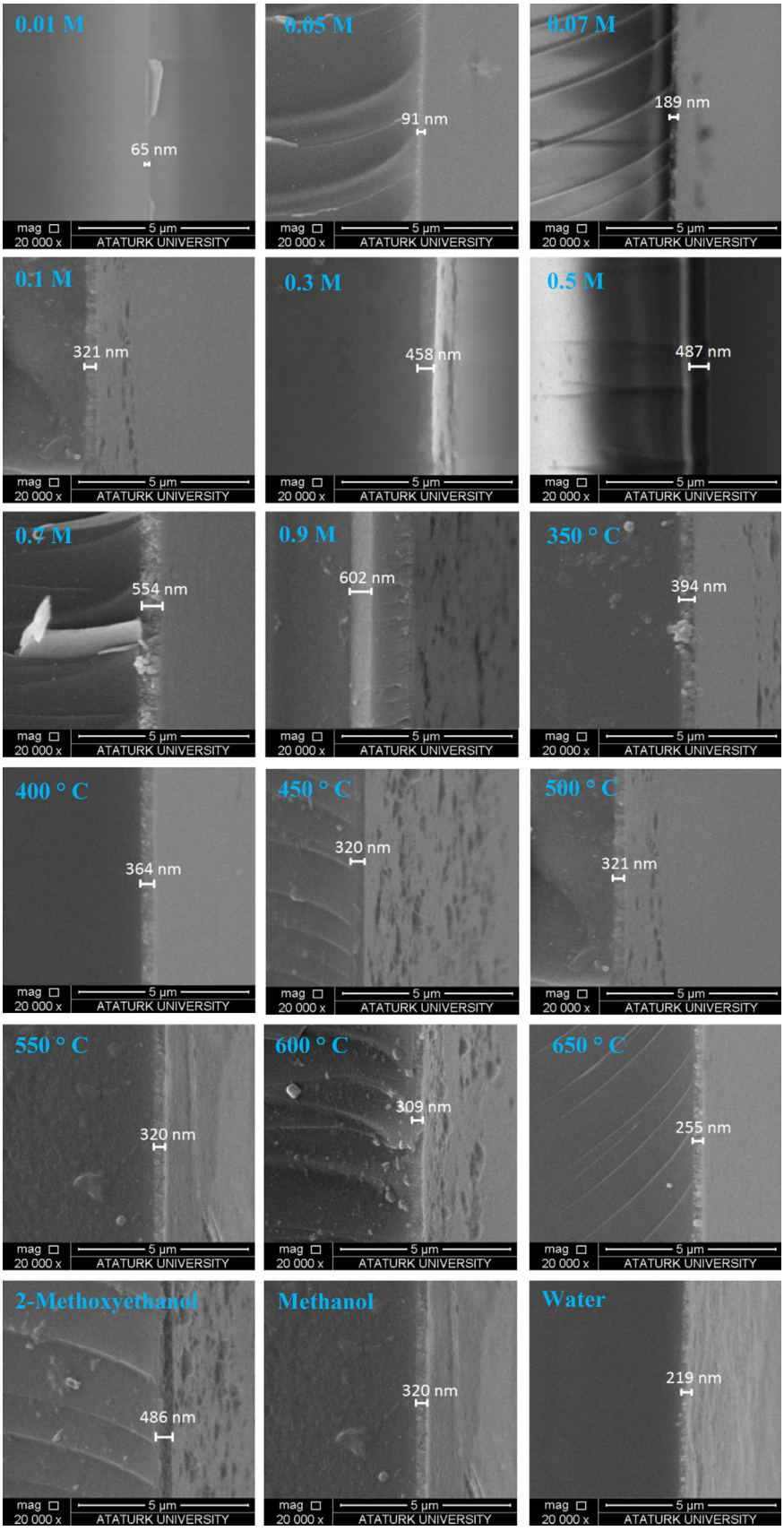

Fig. 1. The cross-sectional SEM images of NiO films.

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