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Structural study of NiO_x thin films fabricated by radio frequency sputtering at low temperature

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Spectroscopic ellipsometry, Nickel oxide, RF sputtering, Orientation factor

Abstract:

Structure and crystal growth of nickel oxide thin films (10-300 nm) prepared by low-temperature sputtering have been investigated by scanning electron microscopy (SEM), X-ray diffraction, and spectroscopic ellipsometry. Very thin films are compact and homogeneous and are made of almost randomly oriented crystals. A preferential growth direction is then observed following the (111), (220) and (311) planes to the detriment of the (222) and (200) planes, inducing a growth of the materials in columns perpendicularly to the substrate. An optical model able to account for this particular structure has been created from the spectroscopic ellipsometry measurements, and correlates well with the structure observed by SEM. Moreover, it enables an accurate estimation of the thickness without damage to the substrate.

Introduction

Nickel oxide, herein referred as NiO_x with x close to 1 due to its imperfect stoichiometry, is a material with various interesting properties, such as wide band gap (3.6-4.0 eV), excellent chemical stability and controllable transmittance for visible light [1,2,3]. Due to those characteristics, NiO_x thin films are studied in many fields such as lithium ion batteries, antiferromagnetic layers, electrochemical capacitors, chemical sensors and electrochromic coatings [4-9]. In recent years, its electron-blocking property attracted a great attention from the field of solar cells such as organic photovoltaic cells [10], hybrid organic-inorganic perovskite solar cells (HOIP-SCs) [11-13] and dye-sensitized solar cells [14], to be used as a hole-transporting layer (HTL) and compact layer. The