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Band tail state related photoluminescence and photoresponse of ZnMgO solid solution nanostructured films

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Abstract

A series of $Zn_{1-x}Mg_xO$ thin films with the composition range x = 0.00–0.40 has been prepared by sol–gel spin coating on Si substrates with a post-deposition thermal treatment in the temperature range of 400–650 °C. The morphology of the films was investigated by scanning electron microscopy and atomic force microscopy while their light emission properties were studied by photoluminescence spectroscopy under excitation at 325 nm. It was found that annealing at 500 °C leads to the production of macroscopically homogeneous wurtzite phase films, while thermal treatment at higher or lower temperature results in the degradation of the morphology, or in the formation of ZnO particles embedded into the ZnMgO matrix, respectively. Local compositional fluctuations leading to the formation of deep band tails in the gap were deduced from photoluminescence spectra. A model for the band tail distribution in the bandgap is proposed as a function of the alloy composition. Thin films were also prepared by aerosol spray pyrolysis deposition using the same sol–gel precursors for the purpose of comparison. The prepared films were tested for photodetector applications.

Introduction

The ZnMgO solid solution system is of interest due to the possibility to tailor many important physical properties by varying their composition. This alloy system covers a wide ultraviolet (UV) spectral range between the direct bandgaps of 3.36 eV for ZnO and 7.8 eV for MgO at room temperature, making it very attractive for short-wavelength optical applications such as UV detectors [1-5] and light emitters [6-9].

Various techniques have been used for the preparation of ZnMgO films such as radio-frequency plasma-assisted molecu-