Characteristics of the orientation distribution and carrier transport of polycrystalline Al-doped ZnO films prepared by direct current magnetron sputtering

Junichi Nomoto, Hisao Makino, Tetsuya Yamamoto

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Characteristics of the orientation distribution and carrier transport of polycrystalline Al-doped ZnO films prepared by direct current magnetron sputtering

Junichi Nomoto[1, a)], Hisao Makino[1] and Tetsuya Yamamoto[1]

[1] Research Institute, Kochi University of Technology,

185 Miyanokuchi, Tosayamada-cho, Kami-shi, Kochi 782-8502, Japan

[a)] Corresponding author: nomoto.junichi@kochi-tech.ac.jp
Tel: +81-887-57-2734, Fax: +81-887-57-2181.

Abstract

We investigated the influence of Al contents on the structural, electrical and optical properties of Al-doped ZnO (AZO) polycrystalline films with the columnar grain structures. In addition, we demonstrated an effective way for achieving improved Hall mobility AZO films at any given Al contents. We deposited 500-nm-thick AZO films on glass substrates at a substrate temperature of 200 ºC by direct-current magnetron sputtering with a direct-current power of 200 W. The oxide targets were high-density sintered AZO targets with Al_2O_3 contents from 0.5 to 3.0 wt.%. Analysis of the data obtained by X-ray diffraction and Hall effect measurements showed that an increase in the Al_2O_3 contents resulted in an increase in volume fraction of (0001) orientation ($V_{(0001)}$) from 85 to 98% and in carrier concentration of the AZO films. The use of a 10-nm-thick Ga-doped ZnO film deposited by ion plating with direct-current arc discharge as an interface layer between the glass substrate and a thick AZO film drastically changed the above behavior of the orientation distribution limited by the Al_2O_3 contents. We found the $V_{(0001)}$ of about 99% at any given Al_2O_3 content. The resulting well-defined (0001) crystallographic orientation led to very small contribution of grain boundary scattering to carrier transport. Hall mobility of AZO films with the very thin interface layer was improved with enhanced carrier concentration as a result.

Keywords: Carrier transport; Crystallographic orientation; Transparent conducting oxide; X-ray diffraction; Al-doped ZnO; Ga-doped ZnO; Magnetron sputtering; Ion plating;

1. Introduction

Al-doped ZnO (AZO) polycrystalline films have been developed as an alternative to Sn-doped In_2O_3 and F-doped SnO_2 films for use as the transparent electrodes of flat panel displays and in the window layers of solar cells [1-4]. One of the