MBE 法による低抵抗 Al ドープ ZnCdO 薄膜の特性改善

Improved properties of low-resistive Al-doped ZnCdO thin films by MBE.

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1. Introduction

Recently, a II-VI semiconductor material based on CdO (band gap energy of 2.3 eV) is expected to realize low resistive thin films at a low carrier concentration which can suppress a free carrier absorption and a plasma reflection, leading to a high transparency in long wavelength up to infrared region [1,2]. Although the band gap of CdO is small for a transparent conductive oxide (TCO) application, it can be expanded by alloying with ZnO which has a band gap of ~3.3 eV. However, because CdO has a rocksalt (RS) structure (a=4.70 Å), whereas ZnO has a wurtzite (WZ) structure (a=3.25 Å, c=5.21 Å), the crystal structure of $Zn_{1-x}Cd_xO$ (ZnCdO) is expected to change at a certain Cd composition.

In the previous study, we have grown Al-doped ZnCdO thin films on MgO (100) substrates by radical-source molecular beam epitaxy (MBE) under the oxygen flow rate of 0.3 sccm, and found that the phase transition takes place at the Cd composition x~0.69 and the largest band gap is ~3.23 eV in RS structure. The oxygen flow rate affects to the growth properties of ZnCdO. Here, we have grown Al-doped ZnCdO thin films on MgO (100) substrate under the oxygen flow rate of 1.0 sccm and found improved optical and electrical properties by increasing oxygen flow rate.

2. Experimental

Al-doped ZnCdO thin films were grown on MgO (100) substrates at the substrate temperature of 250 °C by a conventional MBE system with a radio frequency radical cell for O. The Cd flux ratio (f_{Cd} = [Cd]/[(Cd]+[Zn])) was changed from 1 to 0.78 to obtain various composition of ZnCdO thin films. Al flux was kept constant to 1.5×10^{-7} Pa. In this study, oxygen flow rate was set to 1.0 sccm by a mass flow controller. The films were characterized using x-ray diffraction (XRD), energy dispersive x-ray spectroscopy (EDX), reflection high-energy electron diffraction (RHEED), hall-effect measurement, and transmittance and reflectance measurements.

3. Results and discussion

Figure 1 shows comparison of the resistivity, electron concentration and mobility of Al-doped ZnCdO thin films by hall-effect measurement. 1.0 sccm films show lower resistivity (~4×10^{-4} Ω) with higher mobility (~80 cm^2/Vs) were achieved at high Cd content which have rocksalt structure. Those properties are suitable for TCO application.

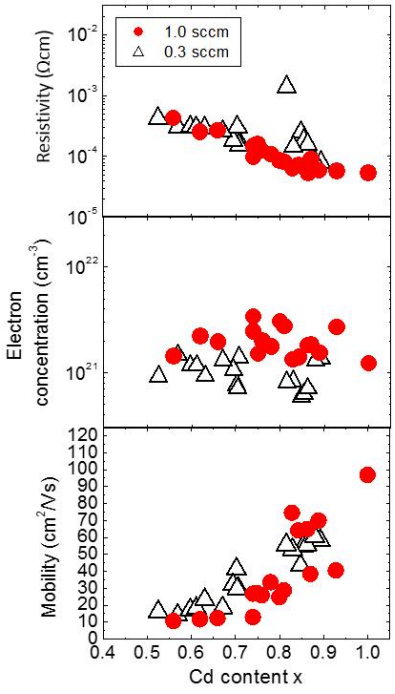

Figure 1. Comparison of the electrical properties of resistivity, electron concentration and mobility of Al-doped ZnCdO thin films.

Reference

[1] K. M. Yu et al. J. Appl. Phys. 111 (2012)123505. [2] D. M. Detert et al. Appl. Phys. Lett. 102 (2013)232103