MBE 法による Al ドープ ZnCdO 薄膜成長時の酸素流量の効果

Influence of oxygen flow rate during the growth of Al-doped ZnCdO thin films by MBE.

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1. Introduction

Recently, a lot of studies have been performed to investigate low resistivity transparent conductive oxides (TCOs). Among TCO materials, CdO is taking attention as a potential material due to high mobility of 200 cm^2/Vs [1,2]. This characteristic enables a low carrier concentration that can extend a plasma reflection and the free carrier absorption effects to a much wider wavelength region over 2000 nm. Although the band gap of CdO is smaller than other TCOs materials, the band gap can be expanded by alloying with ZnO. In the previous study, we grew 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 (referred as “0.3 sccm-films”) and clarified Al-doping effect in ZnCdO. In this study, we have grown Al-doped ZnCdO thin films under high oxygen flow rate of 1 sccm (referred as “1 sccm-films”), and electrical and optical properties were compared and analyzed in detail.

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 0.76 and 0 to obtain various composition of ZnCdO thin films. Al flux was kept constant at 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

From XRD and RHEED analyses, the wurtzite (WZ) phase is observed in the composition $x \leq 0.5$ whereas the rocksalt (RS) phase is observed in for $x \geq 0.6$. A mixed phase of both the WZ and RS phases are observed inside the Cd composition range of $0.6 > x > 0.5$. Figure 1 shows comparisons of the resistivity, electron concentration and mobility of 1 sccm- and 0.3 sccm-films. An *n*-type conductivity was confirmed in all films. At $x < 0.6$, the resistivity of 1 sccm-films is almost similar to that of 0.3 sccm-films while lower resistivity was obtained in 1 sccm-films with $x \geq 0.6$. This is due to the higher electron concentration ($> 10^{21}$ cm^{-3}) in those films, indicating the increase of donor concentration by the growth under high oxygen flow rate.

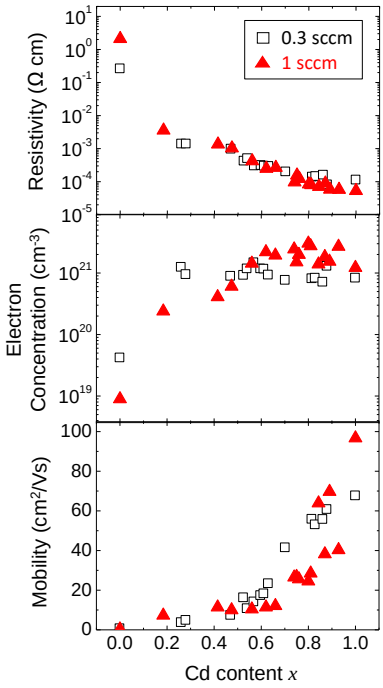

Figure 1. Comparison of electrical properties of 1 sccm- and 0.3 sccm-films.

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