Growth and characterization of ZnCdO thin films by molecular beam epitaxy on MgO substrates for transparent conductive oxides

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II-VI semiconductor material, CdO, has a band gap of 2.3 eV, and because of its high mobility, it 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 as a transparent conductive oxide (TCO), it can be expanded by alloying with ZnO which has a band gap of ~3.3 eV. However, because ZnO has a wurtzite structure (a=3.25 Å, c=5.21 Å) whereas CdO a rocksalt structure (a=4.70 Å), the crystal structure of $Zn_{1-x}Cd_xO$ (ZnCdO) is expected to change at a certain Cd composition.

In previous experiments, we studied the growth and characterization of ZnCdO on sapphire substrates, and found that the phase transition takes place at the Cd composition x~0.5 and the largest band gap is ~2.95eV. The phase transition composition may be extended to a lower Cd composition by using the substrate with a rocksalt structure, which will result in the expansion of the band gap. In this study, we report the growth of ZnCdO films on MgO substrates with a rocksalt structure.

The ZnCdO films were grown on MgO substrate by molecular beam epitaxy (MBE). The Cd flux ratio was changed to control the Cd composition in the films. The band gap of the films was determined by a square plot of absorption coefficient (α) obtained from transmittance and reflectance measurements.

Figure 1 shows the variation of the optical band gap of ZnCdO films on the MgO substrates as a function of Cd composition. The band gap of ZnCdO changes largely at the Cd composition x~0.4, indicating the phase transition from wurtzite to rocksalt structure. The largest band gap of the rocksalt ZnCdO is 3.12 eV. Figure 2 shows the electrical properties of ZnCdO on MgO substrates determined by Hall measurements. The rocksalt ZnCdO showed a low resistivity of the order of 10^{-4} Ωcm with the highest mobility of ~60 cm^2/Vs. These properties are suitable for the application of TCO. The phase transition composition was shifted to a lower Cd composition side by using MgO substrate.

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

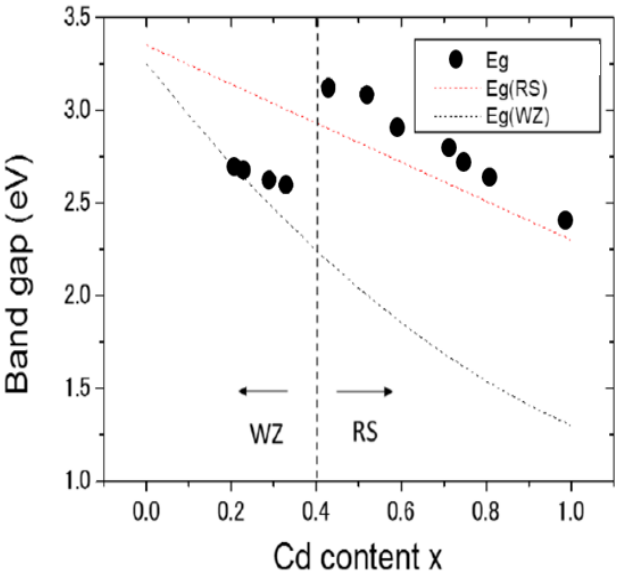

Fig. 1. Variation of band gap of ZnCdO films on MgO substrates as a function of Cd composition.

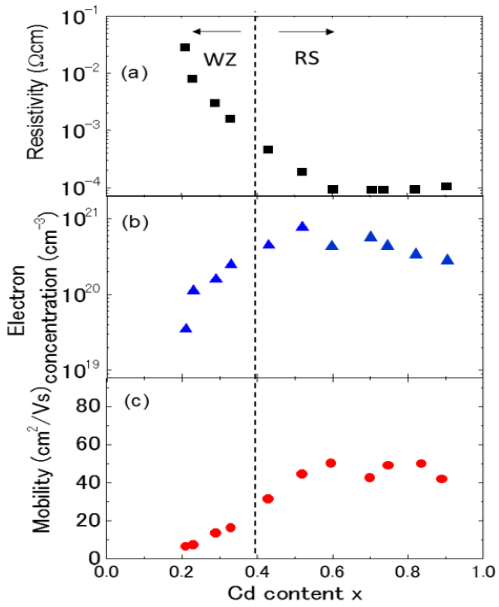

Fig. 2. Electrical properties of ZnCdO films on MgO substrates.