# Cd함량변화에 따른ZnO의 구조적,광학적 특성변화에 관한연구

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# Structural and optical properties of ZnO depending on Cd content

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**Abstract**

$Zn_{1-x}Cd_xO$ thin films were grown on (0001) sapphire substrates by pulsed laser deposition. The energy bandgap of $Zn_{1-x}Cd_xO$ films decreases withincreasing Cd content. An increase of Cd content also leads to the emission broadening and degraded crystallinity. The absorption edge and ultraviolet emission peak shift to lower energy from 3.357 eV to 3.295 eV and 3.338 eV to 3.157 eV, respectively, with increasing Cd content from 0.3% to 3%. The Stokes' shift between the absorption and emission indicates the increase of localization of exciton with Cd content.

**Key Words : ZnCdO, energy bandgap, emission broadening, localization of exciton, Stokes' shift**

## 1. Introduction

ZnO, a wide and direct band gap (about 3.37 eV) II-VI semiconductor, has found many applications in different fields. For example, it can be used as the material base for heterojunction laser diodes, ultraviolet (UV) lasers, UV solid-state emitters and detectors, transparent conductive contacts, thin-film gas sensors, varistors, solar cells, surface electro-acoustic wave devices, and others. Interest in short wavelength display devices based on ZnO has also been getting more attention recently[1-3]. An important step to design ZnO-based devices with high emitting efficiency is the band gap engineering in order to fabricate the quantum wells that are necessary in devices such as light emitting diode (LED) and laser diode (LD)[4]. Fabrication and characterization of alloys such as (Mg,Zn)O or (Cd,Zn)O are important from the viewpoint of band gap engineering as well as of a *p-n* junction[5]. Many results are reported related to ZnMgO[5-7] and Stokes' shift is investigeted [5-10]. However, ZnCdO has not been widely studied[2,5,8]. Moreover, the Stokes' shift in

ZnCdO is rarely reported. In this paper, we report the experimental results of band gap modulation, structural characteristics, spectral broadening and Stokes' shift in ZnCdO films as a function of Cd content.

## 2. Experimental

Thin films were grown on (0001) sapphire substrates by pulsed-laser deposition (PLD), using a pulsed XeCl laser operating at a wavelength of 308 nm and a repetition rate of 5 Hz. The target was a ceramic pellet which consists of 80 wt % ZnO and 20 wt % CdO. Cd content in ZnO depending on deposition temperature from 200 ℃ to 800 ℃ was changed from 0.3 % to 0.03 %. Thickness of $Zn_{1-x}Cd_xO$ films is 700 nm. The stoichiometry of thin films was estimated using Rutherford backscattering spectroscopy (RBS). The structural properties of the films were investigated by X-ray diffraction (XRD). The optical properties of the films were characterized by photoluminescence (PL) and absorption measurements, both at 4 K using a He-Cd laser as a light source at an excitation wavelength of 325 nm.

## 3. Results and Discussion

All of the films studied were preferientially oriented as indicated by the only(0002) diffraction. Figure 1 shows the full width at half-maximum (FWHM) values of the x-ray rocking curve from (0002) diffraction peaks and emission broadening from PL spectra as a function of Cd content. The FWHMs of the x-ray rocking curve from (0002) diffraction peaksand emission broaedenig increase with the Cd content x in $Zn_{1-x}Cd_xO$ films. This indicates the structural degradation of film as the Cd content increases.

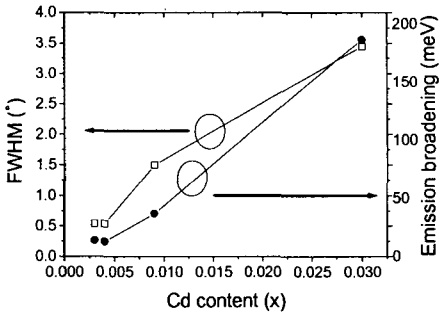


FIG. 1. The FWHM values of rocking curve from (0002) diffraction and emission broadening from PL spectra as a function of Cd content

A comparison of photoluminescence (PL) and absorption measured at 4K for $Zn_{1-x}Cd_xO$ films is shown in Fig. 2. The broadening of both emission energy and absorption edge increases as the emission peak energy decreases. This increase of broadening is mainly due to the increase of disorder in semiconductor, which leads to the appearance of localized electron and/or hole states[11]. The increase of localized states in semiconductor leads to the increase of emission and absorption broadening. This, in turn, causes the Stokes' shift.

The Stokes' shift, defined as the energy difference between energy band gap and the peak of the emission spectrum [9], is plotted as a function of the emission peak energy shown in Fig. 3. The increase of localized states in ZnCdO gives rise to the increase of Stokes' shift as a function of Cd content as shown in Fig. 3.

## 4. Conclusion

In summary, Ⅱ-Ⅵ semiconductor alloying $Zn_{1-x}Cd_xO$ thin films ( $0.003 \leq x \leq 0.03$ ) were grown by PLD. A systematic increase in emission broadening with decreasing emission peak energy is observed. The investigation on emission and absorption spectra of $Zn_{1-x}Cd_xO$

has enabled the demonstration of a linear dependence of Stokes' shift on emission peak energy, in which the Stokes' shift increases with Cd content caused mainly by the localized states in ZnCdO films.

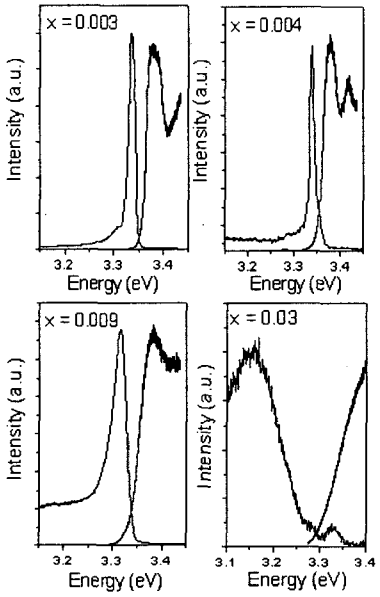


FIG. 2. Photoluminescence and absorption spectra at 4K from $Zn_{1-x}Cd_xO$.

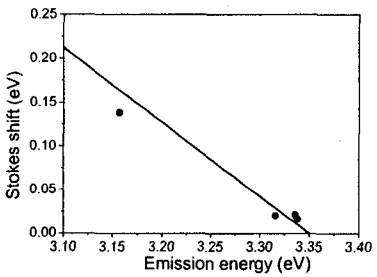


FIG. 3. Stokes' shift plotted as a function of emission peak energy for Zn1-xCdxO.

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