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ZnO 기반의 투명 박막 트랜지스터 제작을 위한 Active-layer의 최적화에 대한 연구

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Optimization of active layer for the fabrication of transparent thin film transistor based on ZnO

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Abstract - We have observed electrical properties of ZnO thin films for the fabrication of transparent thin film transistor. ZnO thin films were deposited on Al_2O_3(0001) substrate at various temperatures by pulsed laser deposition(PLD). The third of harmonic(355nm) Nd:YAG laser was used for pulsed laser deposition. X-ray diffraction(XRD), field emission-scanning electron microscope(FE-SEM) ,and photoluminescence were used to characterize physical and optical properties of ZnO thin film.. The results indicated the ZnO film showed good optical properties as increasing temperatures, with low FWHM of exciton-related peak and XRD(0002) peak.

Key word : ZnO thin film, Pulsed Laser Deposition

1. Introduction

ZnO is a II-VI compound semiconductor with a wide direct band gap of 3.37eV at room temperature, and can be grown as polycrystalline structure.[1-2] Especially, ZnO can be used for a light emitting devices cause it has a large exciton binding energy(60meV) at RT. Pulsed laser deposition(PLD) is one of the deposition techniques to make ZnO thin films. PLD[3-4] technique has the advantage of stoichiometric deposition, easy to use, and cold wall process. Parameters of ZnO thin film, such as substrate-temperature, ambient gas pressure, target-substrate distance, and laser energy density, have influenced on the crystal quality of ZnO thin films and cause a change in the optical and structural properties. In this paper, the ZnO thin films were grown on (0001)sapphire substrate by PLD method at various subtrate temperature. X-ray diffraction(XRD), and photoluminescence(PL) were used to confirm the quality of ZnO thin films and field emission-scanning electron microscope (FE-SEM) was used to observe the morphology of deposited ZnO films.

2. Experimental Details

ZnO thin films were deposited on (0001)sapphire substrate in a PLD system. A 1-inch ZnO disk target was used to make ZnO thin film in PLD system. The substrates were cleaned in an ultrasonic bath with acetone, methanol, and DI Water for 3 minutes before being loaded into the chamber. The substrate were placed parallel to the target surface at a distance of 50 mm. 355 nm Nd:YAG laser were used with the energy density of 1.4 J/cm^2 and 5Hz repetition rate. The deposition chamber was initially evacuated to $2x10^{-5}$ Torr, and the substrate was heated and ambient oxygen gas pressure was maintained of $3.5x10^{-1}$ Torr. Heated substrate holder was rotated for the uniformity of ZnO thin film. The deposition time was 10 minutes for each samples.

A FE-SEM apparatus was used to see the surface morphology of the films. The structural properties of the films were characterized by XRD. The PL spectra were measured by using a He-Cd Laser with wave length of 325nm at room temperature.

3. Results and Discussions

For the crystal-quality observation, we measured the FWHMs (Full-Width at Half Maximum) of ZnO XRD peaks and exciton-related peaks. The measured FWHMs of XRD peaks were shown in Fig. 1. The minimum FWHM of XRD peak was 0.37 degree at 700℃.

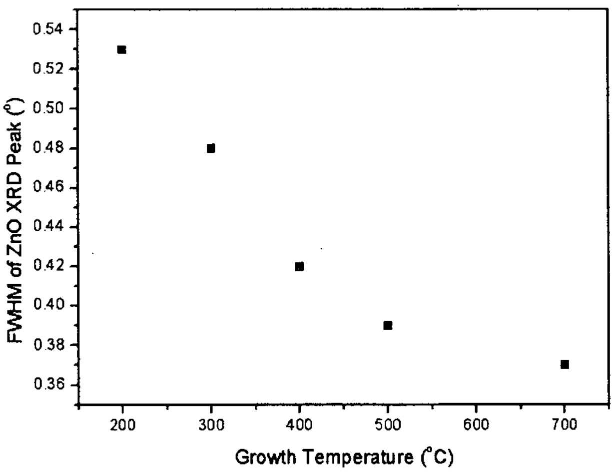

Fig. 1. Variation of the FWHM of ZnO Peaks

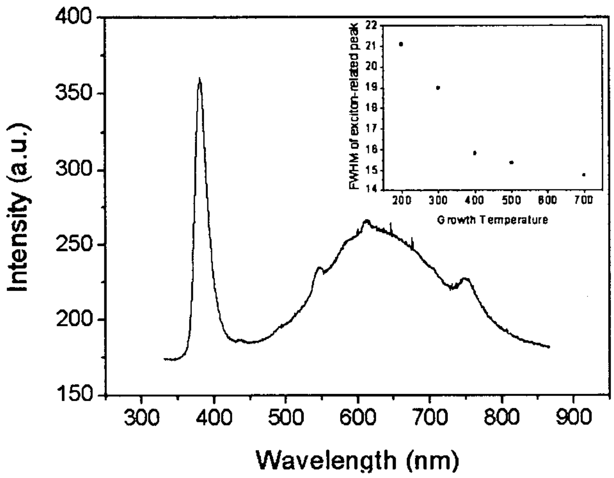

Fig. 2. Photoluminescence spectrum of ZnO prepared at 400℃. Inset: variation of the FWHM of Exciton-related Peaks

Fig. 2. shows the PL spectrum at 400℃. The exciton-related peak was shown near 380 nm and broad defect band peak was observed around 550-750 nm. As shown Fig. 1. and 2., the FWHM of XRD and PL peaks were decreased as increasing growth temperature. It means the crystal quality is improved as increasing growth temperature.

The FE-SEM images is shown in Fig. 3. It can be found that the grain size tends to be proportional to the growth temperature verified with the grain size analysis with the SEM images.

The migration of particles due to supplied thermal energy from the heater is the reason of increased grain size. In other words, thermal energy provides the migration energy to a particle, and a particle obtain kinetic-energy for migration. Thus the particle moves the surface of thin film. Finally the particles with the same species gather together. thereby the higer the growth temperature is, the larger the grain size is.

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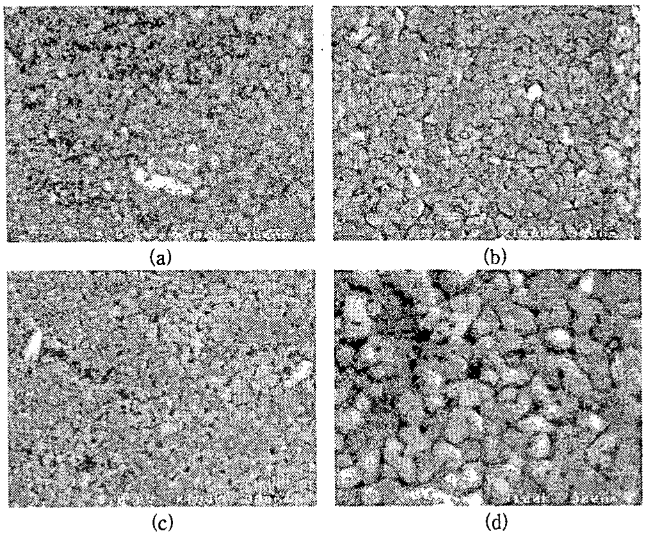

Fig. 3. FE-SEM Images : substrate temperatures of (a) 200℃, (b) 300℃, (c) 400℃, and (d) 500℃

<Table 1> FWHM of Exciton and XRD peak, and Grain size at various substrate temperature

Temp.	FWHM of ZnO Exciton Peak (nm)	FWHM of ZnO XRD Peak (°)	Average Grain Size (nm)
200	21.10	0.53	~40
300	18.99	0.48	~50
400	15.82	0.42	~60
500	15.37	0.39	~80
700	14.77	0.37	~90

In summary, crystal-quality of thin films was gradually improved as increasing growth temperature. Table 1. represents the important parameters of ZnO thin films.

4. Conclusion

In this paper, the ZnO thin films were grown by pulsed-laser deposition at various temperature, such as 200, 300, 400, 500, and 700.

The FWHMs of exciton-related peak, and XRD peak are decreased as increasing substrate temperature. It means that the crystal quality is improved. From the surface image, and summarized table, we can see that grain size of thin films are relied on substrate temperature. The increasing of the grain size according to the growth temperature is based on the migration of particles which were activated by thermal energy supplied from the heater. Indeed, thermal energy provides the migration energy to a particle, and particle move around the surface of thin film, finally the particle were gathered together with same species. therefore grain size was increased.

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