

## Growth of the Violet-Luminescence-Emitted ZnO Films by Off-axis Pulsed Laser Deposition

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Abstract: Zinc Oxide related materials have possibility to be ingredient for near-ultraviolet light devices. In this study, The ZnO films were grown by off axis pulsed laser deposition on sapphire (0001) substrate. As a result, the film of off-axis was shown higher band gap energy of 2.94 eV than on axis of 2.72 eV. The off axis film was observed higher emission intensity than on axis by photoluminescence measurement. And the off axis film was confirmed high exciton emission of 380 nm.

### 1. Introduction

Zinc Oxide (ZnO) materials have possibility of near-ultraviolet light devices. Characteristics of ZnO that energy gap ( $E_g$ ) is 3.37 eV and exciton binding energy is high (60 meV)<sup>[1]</sup>. However, most growth ZnO films are n-type semiconductor because of oxygen ( $O_2$ ) defects. A p-type ZnO is obtained by displacing nitrogen ( $N_2$ ) on  $O_2$  parts. The p-type ZnO films are necessary for near-ultraviolet light devices. For growth the film, we choose a pulsed-laser-deposition (PLD)<sup>[2]</sup>. This method has many advantages, such as deposition in relatively high pressure, crystallization of films at lower temperatures because of the higher energy of the ablated particles in the laser-produced plume, and relatively high deposition rates. The film of low crystallization are grown by this technique of off-axis. Therefore, the ZnO of much  $O_2$  defects film are grown by off-axis PLD.

In this paper, we aimed to dope large quantities of  $N_2$  gas to the films by off-axis PLD for p-type<sup>[3]</sup>.

### 2. Experimental

Figure.1 shows an experimental apparatus of on-axis and off-axis PLD. ZnO thin films were grown on sapphire ( $Al_2O_3$ ) (0001) substrates ( $10 \times 10 \times 0.5$  mm) by PLD using a focused Nd:YAG laser beam (LOTIS TII, PS-2225M, wave length = 355nm, pulse width = 20 ns, repetition frequency = 10 Hz, laser energy = 360 mJ) for 60 min. ZnO bulks for the PLD target are obtained by pressing ZnO powder (99.99 %) at 80 kN for 30 min. The substrate and the bulk are installed at vaccumed chamber, and atmosphere pressure is adjusted at 40 mTorr by flowing in nitrogen gas. (flow rate: 600 sccm).

Transmittance of the ZnO thin films were measured by spectra analyze measurement (EPP 2000-UVN-SR-50). Crystal structure of growth films were measured by x-ray-diffraction (XRD) (RIGAKU RINT-2000).

Photoluminescence (PL) spectra of growth films were measured by He-Cd laser (KIMMON KR 1801C, wavelength: 325 nm, laser energy: 20 mW).

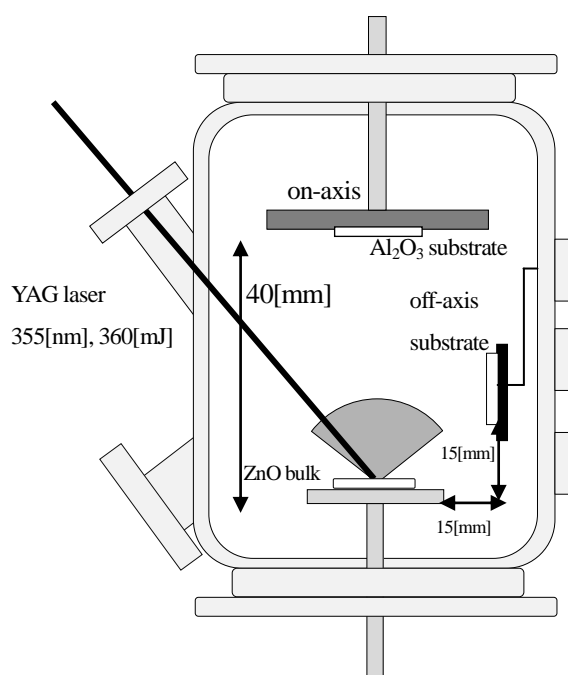


Figure 1 on-axis PLD and off-axis PLD

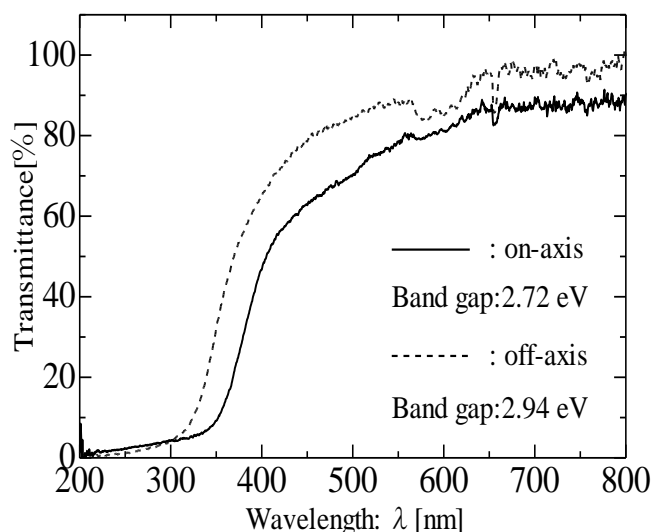


Figure 2 Optical transmittance spectra of ZnO films

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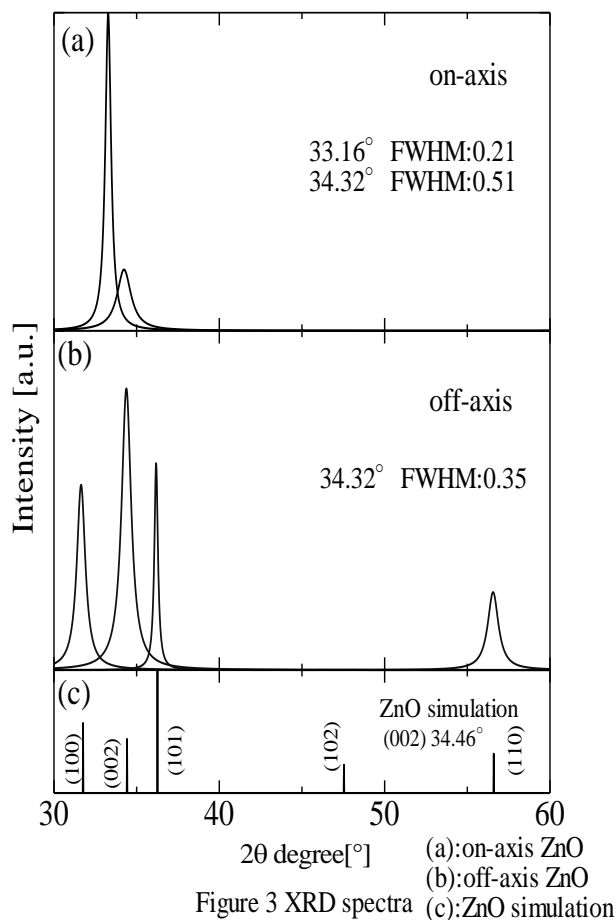


Figure 3 XRD spectra (c):ZnO simulation

### 3. Result

Figure 2 shows optical transmittance of growth films. The transmittance of off-axis ZnO was observed above 80 % from 400 to 800 nm area, furthermore 200-340 are below 20 %. The ZnO film of band gap energy calculated it from transmittance. As a result, the off-axis films were obtained higher band gap energy of 2.94 eV than on-axis of 2.72 eV.

Figure 3 shows the XRD spectra of the films. Four peaks of (100), (002), (101) and (100) axis peak, which due to crystalline of ZnO, were observed at off-axis film. However, the narrow full-width-half-at-maximum (FWHM) of (002) axis peak were observed at off-axis.

PL spectra of growth films are shown in Figure 4. Typical two emissions of a clear and sharp exciton peak at 380 nm, and a broad defect-related band at about 550 nm were observed<sup>[4]</sup>. The off-axis film spectrum was obtained high exciton emission (380 nm). However, O<sub>2</sub> defect-related spectrum also were observed with high intensity. The exciton emission intensity of off-axis ZnO had the count of 2266 higher than on-axis ZnO the count of 18.

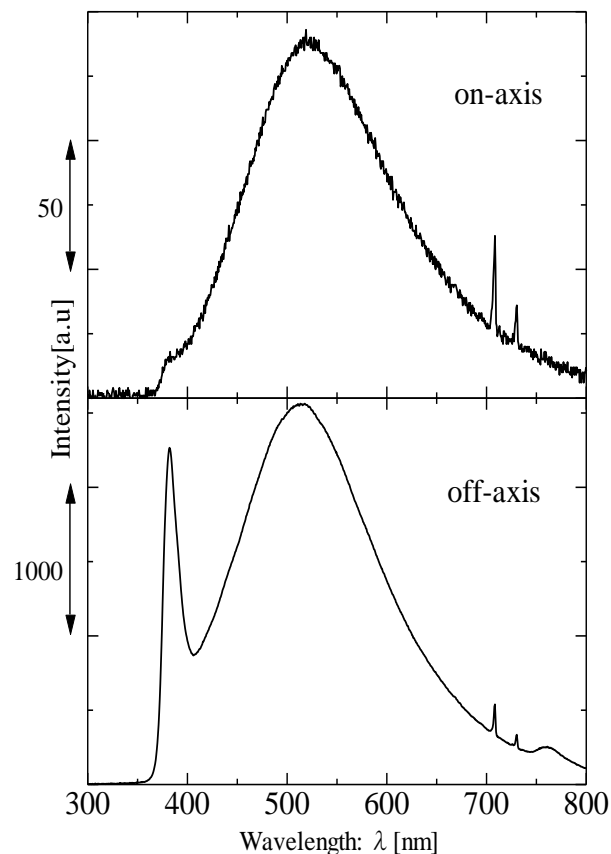


Figure 4 Room temperature (300k) PL spectra

### 4. Conclusion

We have attempted to grow the ZnO films on sapphire substrate by on-axis or off-axis PLD. The ZnO film was obtained high band gap energy by off-axis PLD. The films of off-axis were observed high exciton emission of 380 nm by PL spectra. The films are not performed hall measurement for high-value resistance.

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