마이크로파 통신소자용 ZnO 압전 박막의 구조적 전기적 특성

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Structural and Electrical properties of Piezoelectric ZnO Films Grown by Pulsed Laser Deposition for Film Bulk Acoustic Resonator

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Abstract : The characteristics of ZnO films are reported depending on different deposition conditions for film bulk acoustic resonators (FBARs). The ZnO films have been deposited on Al films evaporated on p-type (100) silicon substrate by pulsed laser deposition (PLD) technique using a Nd:YAG laser. These films exhibit an electrical resistivity higher than 10^7 Ωcm. X-ray diffraction measurements have shown that ZnO films are highly c-axis oriented with full width at half maximum (FWHM) below 0.5°. These results show the possibility of FBAR devices using by PLD.

Key Words : FBAR, acoustic resonator, PLD, ZnO thin film

1. Introduction

ZnO thin films are promising materials for high frequency band FBAR because of their high piezoelectricity. In order to use ZnO thin films as a GHz-band piezoelectric devices, ZnO thin films must need high c-axis orientation, highly electrical resistivity. In this study, we have investigated the c-axis orientation and the electrical resistivity of ZnO films deposited on Al bottom electrode by PLD as functions of deposition conditions for FBARs, also discussed the potential of FBAR devices using by PLD.

2. Experiments

Piezoelectric ZnO films with 1㎛ thickness were deposited on Al bottom electrode by the PLD with a wavelength of 355 nm, and laser energy density of 2.5 J cm^{-2}. A substrate holder was placed in the position of 5 cm from the target. The detailed deposition parameters are summarized in Table 1.

3. Results and Discussion

To study the performance of ZnO films deposited under deposition temperature, oxygen pressure and laser frequency were fixed at 6.7 Pa, 5 Hz. Figure 1 shows the XRD patterns of ZnO samples prepared with different deposition temperature from 100 to 400℃. The intensity and the FWHM of ZnO (002) peaks were shown in Fig. 2. The (002) peak intensity of the ZnO films markedly increased up to 400℃, and FWHM of the (002) peaks decrease strikingly. Figure 3 shows the electrical resistivity of ZnO films as functions of different temperatures. As deposition temperature increased, the resistivity of ZnO samples drastically decreased. It means that quality of ZnO films was improved rather than that deposited at 100℃ by increase of deposition temperature.

The ZnO films prepared with increasing substrate temperature had highly preferred orientation toward c-axis. But, the electrical resistivity of these films was lower than that of piezoelectric films (> 10^6 Ωcm).[1]

Table 1. Deposition conditions of ZnO films.

Parameters	Value
Target	ZnO (99.999%)
Substrate	Al/Si
Substrate to target distance	50 mm
Substrate temperature	100℃ 200℃ 400℃
Base pressure	1.3×10^{-3} Pa
Laser power	0.7 W
Laser energy density	2.5 J cm^{-2}
Laser frequency	1 Hz, 2 Hz, 5 Hz

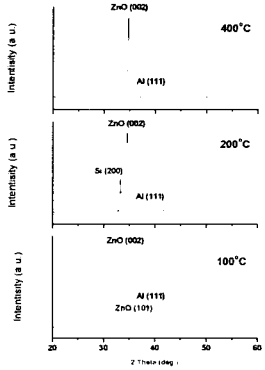

Fig. 1. XRD patterns of ZnO films deposited as functions of deposition temperatures.

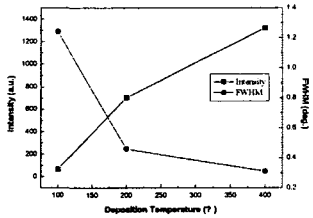

Fig. 2 Variations of XRD peak intensity and FWHM with deposition temperatures.

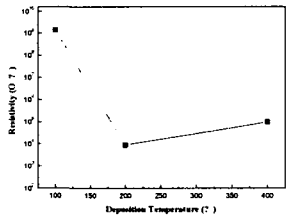

Fig. 3 Variations of electrical resistivity of ZnO films depositied as functions of deposition temperatures.

So, ZnO films were deposited to investigate quality of films as functions of various laser frequencies (1, 2, 5 Hz). Figure 4 shows the XRD patterns of ZnO samples prepared with different laser frequencies from 1 to 5 Hz, The (002) peak intensity of the ZnO films markedly decreased up to 5 Hz, and the FWHMs of (002) peaks were increased greatly as shown in Fig. 5.

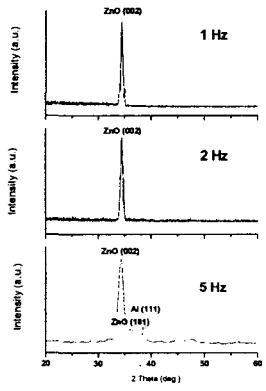

Fig. 4 XRD patterns of ZnO films deposited as functions of laser frequencies.

It was known that the short of the time interval of successive laser shot led to supersaturation effect in films.[2] Supersaturation could affect grain size in ZnO films seriously. The effects are estimated by XRD FWHMs of ZnO films as functions of laser frequencies from 1 to 5 Hz.

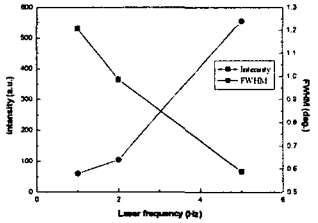

Fig. 5 Variations of XRD peak intensity and FWHM with laser frequencies.

Also, the resistivity of films lowered with decreasing time interval of laser shot as shown in Fig. 6. It was attributed to diminish of electron trap effects caused by defects too.

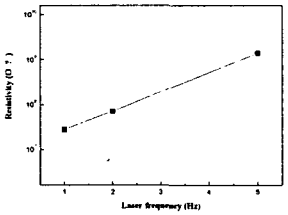

Fig. 6 Variations of electrical resistivity of ZnO films depositied as functions of laser frequencies.

4. Conclusions

We have fabricated the piezoelectric ZnO films with high electrical resistivity and high orientation toward the c-axis on Al bottom electrode by PLD as functions of deposition temperatur and laser frequencies for FBARs. It was found that optimized parameters for FBARs was at 100℃, 6.7 Pa, 1Hz. At this point, ZnO sample has XRD FWHM of 0.58°,and the electrical resistivity of 2.77×10^7 Ω cm. It indicates that the ZnO film has high resistivity like insulator and highly c-axis orientation and is suitable for FBARs.

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