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Deposition of alumina film on ZnO/Glass substrates by electron beam evaporation to imrove the characteristics of surface acoustic wave devices

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Abstract

ZnO films with c-axis (0002) orientation have been successfully grown by RF magnetron sputtering on glass substrates. The alumina films were deposited on interdigital transducers/ZnO/glass substrates by electron beam evaporation. The phase velocity, and coupling coefficient of surface acoustic wave (SAW) device were increased when we increased the thickness of alumina film. The experimental result is beneficial to upgrade the performance of the ZnO thin film SAW devices on cheap glass substrate.

1. Introduction

ZnO (zinc oxide) is a member of the hexagonal wurtzite class and has a high electromechanical coupling factor, making it a useful material for surface acoustic wave (SAW) devices.[1] The ZnO thin films have been deposited on various substrates including GaAs,[2] sapphire,[3] InP,[4] Si,[5] diamond[6] and diamond. Among these substrate materials, glass is widely used due to its cheap price. In this paper, we fabricate the ZnO thin film on glass substrate with an electron beam (e-beam) evaporated alumina film overlaid for SAW device applications. The alumina film is expected to upgrade the performance of the ZnO thin film SAW devices on cheap glass substrate.

2. Experimental details

ZnO (doped with Li_2CO_3 (0.5-1 w.t. %)) ceramic discs, 4 inch in diameter, was used as the sputtering target. A Corning 7059 glass was used as the substrate. The deposition conditions of the ZnO thin films are RF power of 178 W, substrate temperature of 380 ^{o}C, sputtering gas ratio (Ar/O_2) of 1 under the fixed setting of total sputter gas pressure of 10 mTorr and distance between the 4 inch target and substrate of 40 mm. Interdigital transducers (IDTs) with 3 μm line-width and line-to-line spacing were fabricated on the ZnO film surface by a conventional photolithographic technique and the lift-off process. Each transducer has a 12 μm period and 1.2 mm aperture. The number of the finger pair is 64 and the propagation distance between the input and output transducers is 3 mm. The alumina thin films were then deposited on IDTs/ZnO/glass glass substrate using the e-beam evaporation. The Al_2O_3 pellet (99.99%) was used as the evaporation source. The deposition conditions are e-beam current of 70 mA, substrate temperature of 300 ^{o}C and distance between the evaporation source and substrate of 15 cm. The frequency response was measured by Agilent 8720ES network analyzer.

3. Results and discussion

Fig. 1 shows the frequency responses for IDT/ZnO/glass substrates. The center frequency of the SAW device without an Al_2O_3 overlayer was measured to be about 255.5 MHz, and the corresponding phase velocity ($v=f\times\lambda$) calculated from the center frequency is 2706 m/s.

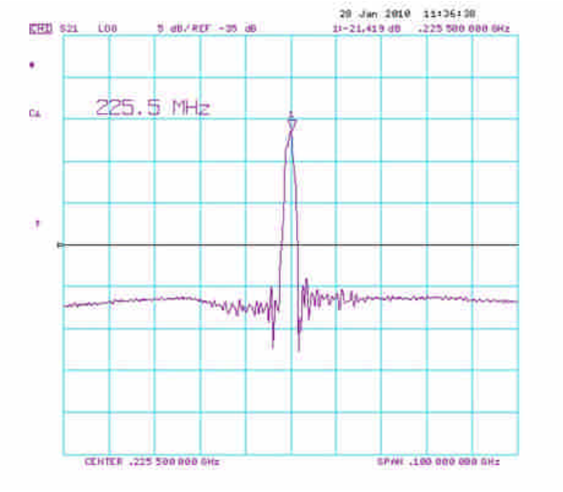

Fig. 1. Frequency response of the SAW filter for an IDT/ZnO/glass substrate with an electrode width of 3 μm.

Fig. 2 shows the dependence of the variation ratio of phase velocity of the fabricated SAW devices on the thickness of the alumina film. From Fig. 2, we can see that when we increased the thickness of alumina film, the phase velocity of the fabricated SAW devices were also increased.

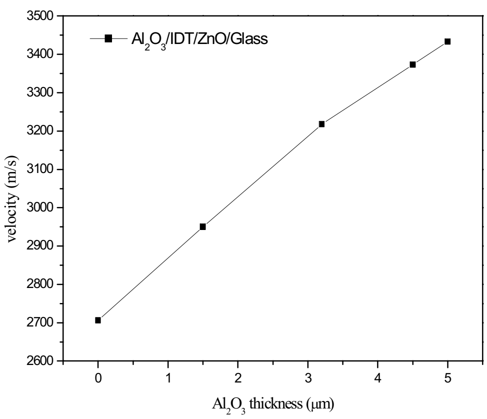

Fig. 2 Dependence of phase velocity of the fabricated SAW devices on the thickness of the alumina film.

Fig. 3 shows the dependence of the variation ratio of coupling coefficient of the fabricated SAW devices on the thickness of the alumina film. From Fig. 2, we can see that when we increased the thickness of alumina film, the variation ratio of coupling coefficient of the fabricated SAW devices were also increased.

4. Conclusions

ZnO thin film with highly (0002) preferred orientation was deposited on glass substrate by RF magnetron sputtering with an e-beam evaporated alumina film. The phase velocity and coupling coefficient of SAW device were increased when we increased the thickness of alumina film. The experimental result is beneficial to upgrade the performance of the ZnO thin film SAW devices on cheap glass substrate.

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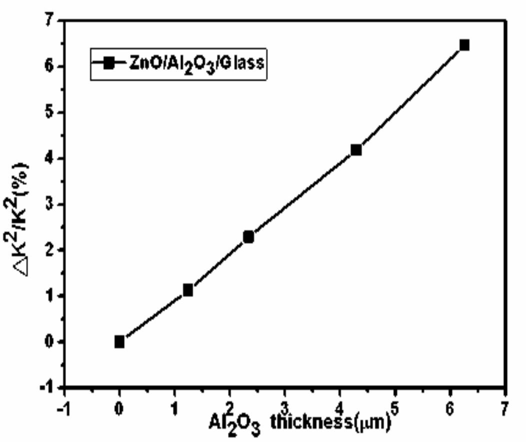

Fig. 3. Dependence of variation ratio of coupling coefficient of the fabricated SAW devices on the thickness of the alumina film.