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58MHz Surface-Acoustic-Wave Video-Intermediate-Frequency Filter Using ZnO-Sputtered Film

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Introduction It has been pointed out that piezoelectric film layers overlying periodic interdigital metal structures provide a simple and efficient means for the generation and detection of surface elastic waves on nonpiezoelectric substrates, and that high coupling efficiencies and low propagation losses are obtained.[1-3] As one of the promising piezoelectric materials, ZnO oriented film has been studied and there have been published many results concerning fundamental studies on the growth of the oriented film[4-7] and the application to the acoustic devices,[8-17] among which surface-acoustic-wave (SAW) video intermediate frequency filters (VIF-filters) are of the present interest. In this technical paper, we shall report concerning fundamental study for the practical application of ZnO sputtered films as a 58MHz SAW-VIF filter which is up to TV standards in Japan. From the view point of the practical application it should be pointed out that ZnO targets sintered from 99% powder and glass substrates are not expensive and SAW-VIF filters composed of the ZnO films, electrodes and substrates are estimated to be of lower cost than the ones using $LiNbO_3$ or other single crystal bulk materials. Moreover as shown below, temperature coefficient of the frequency characteristic of the ZnO-glass SAW-VIF filter can be made smaller than that of $LiNbO_3$ SAW-VIF filter with -80ppm/°C for y-cut and z-propagation.

Experimental ZnO films were rf-sputtered from the target sintered from the powder of 99%. The sputtering atmosphere was Ar(50%)+O_2(50%) premixed gas at 7×10^{-2} Torr. The substrate temperatures were kept constant between 150°C-200°C. The sputtering rates were 0.2-0.4μm/hr and it was run 3 days to obtain film thickness of about 20μm. The substrate materials were fused quartz and several kinds of glasses. The Cr+Au interdigital electrodes were photoetched directly on the substrate and the ZnO film was sputtered covering these electrodes and the SAW propagation path on the substrate. There have been many papers concerning preparation of a highly oriented ZnO film as referred above. In our rf-diode-sputtering also, the films were highly oriented with c-axis almost perpendicular to the substrate surfaces with the average angle decline of 2° and the standard deviation less than 3° from the measurement of the locking curves of X-ray diffractometer (Fig.1). Figure 2 shows the unsealed appearance of a filter, which is composed of an industrial glass substrate for a thin

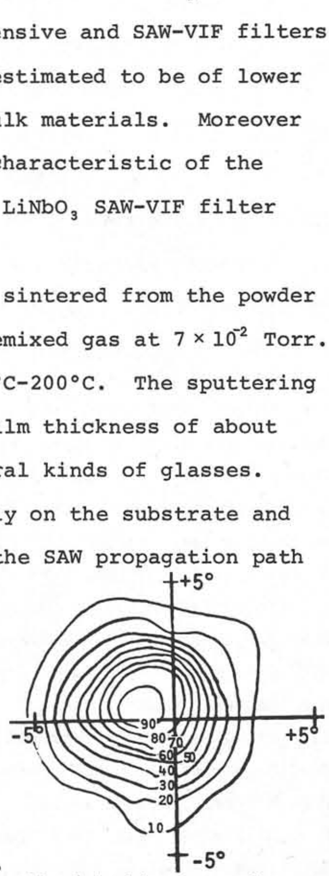

Fig.1 Locking curve for a usual grade of ZnO film. Parameter is X-ray intensity.

film resistor, a normal generation electrode with 15 finger pairs and an apodized one with 24 finger pairs, and a 20μm thick ZnO film. Both finger and space widths are 11μm. Figure 3 shows the electrical circuit for the measurement of the frequency characteristics of insertion loss and group delay time. Figure 4 shows the frequency response of the insertion loss and group delay of the filter. The tripple transit echo suppression is more than 35dB from the signal level. The temperature coefficient of the frequencies within the significant band is less than -30ppm/°C in the temperature range between -20°C and +80°C as shown in Fig.5. The aging characteristics has been measured for 500 days to give no significant change in the frequency characteristic of insertion loss. In Table I are shown the essential characteristics of the filter. The coupling coefficient which satisfies $k^2/2 = (v_\infty - v_0)/v_\infty$ was deduced from the frequency characteristics of the input impedance giving the value of k as 10-13.5%. The minimum insertion loss for the maximum coupling coefficient was 13.0dB.

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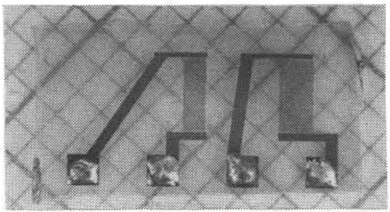

Fig.2 Unsealed appearance of a 58MHz SAW-VIF filter. 1mm/div.

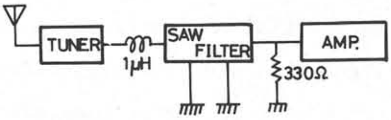

Fig.3 Measuring circuit for 58MHz SAW-VIF filter

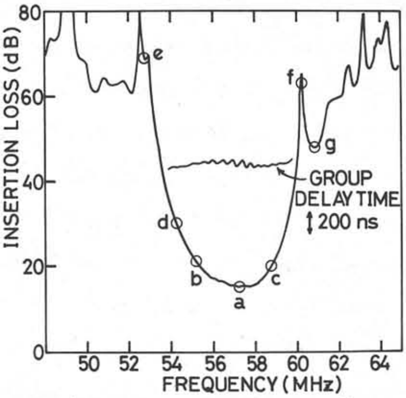

Fig.4 Frequency dependences of insertion loss and group delay time of a 58MHz SAW-VIF filter.

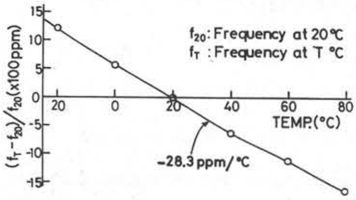

Fig.5 Temperature dependence of a specified frequency.

Table I Details of points a to g in Fig.4.

a; minimum insertion loss frequency,
b; chromatic signal carrier frequency,
c; picture signal carrier frequency,
d; sound signal carrier frequency,
e; picture signal carrier trap,
f; sound signal carrier trap,
g; maximum side lobe level frequency.

	Frequency(MHz)	Loss(dB)
a;	57.25	15
b;	55.17	6(+15)
c;	58.75	5(+15)
d;	54.25	15(+15)
e;	52.75	54(+15)
f;	60.25	45(+15)
g;	60.75	33(+15)