9-7 Amplification of Rayleigh Surface Waves and Leaky Surface Waves in Structure of InSb Thin Film

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The characteristics of Rayleigh and Leaky surface wave acoustic amplifiers are described. Using InSb vacuum deposited on rotated Y-cut $LiNbO_3$, the electronic gain of 36dB/cm has been obtained at 228MHz, and electric field of 1.3KV/cm.

Various types of acoustic surface wave amplifiers[(1)~(4)] have been proposed and experimented, and that of amplifier with a film deposited directly onto the piezoelectric plate is most promising. The amplifiers with CdSe[(5)] and InSb[(6)] thin films are experimented, but in these amplifiers high electric field are required for large electronic gain because of low values of mobilities and electromechanical coupling coefficient(K^2).

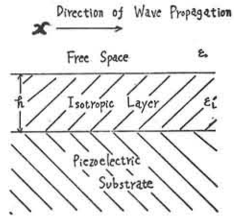

Fig. 1 Co-odinate System

This paper show that the considerable large electronic gain at low electric field has been obtained with leaky surface waves propagating along X-axis of a 64° rotated Y-cut on $LiNbO_3$ having large K^2 and InSb thin film prepared by temperature programed evaporation method.

Figure 1 shows the co-ordinate system. The h is the thickness of semiconductor and the surface waves propagate along the X-axis direction.

Figure 2 and 3 show the velocity dispersion and attenuation value caused by radiating into the solid, in the case of leaky surface waves propagating along X-axis on the 64° rotated Y-cut $LiNbO_3$ with InSb layers. These figures show that the electromechanical coupling coefficient(K^2=0.12) is large and the attenuation constant (0.030dB/λ) is small in the range of $\omega h < 500$. The K^2(=0.055) of Rayleigh waves of a 131° rotated Y-cut is also larger than one of Y-cut, Z-propagation (K^2=0.049) conventionally used in the range of $\omega h < 1000$. The amplification equaation of the leaky surface waves with semiconductor layers is given as follows, in the case of $\omega_c \omega_s > \omega^2$,

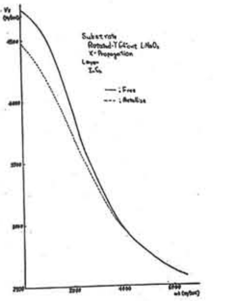

Fig.2 Dispersion Curves of Leaky Surface Waves vs. ωh

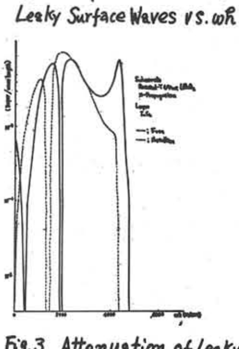

Fig.3 Attenuation of Leaky Surfase Waves vs. ωh

$$G = 54.6N\left[-\frac{K^2}{2}\varepsilon_p\frac{r}{\alpha h} - (V_{fi} - V_{mi})\left(\varepsilon_p V_{mr}\cdot\frac{r}{\alpha h}\right)^2 - V_{mi}\right] \ \mathrm{dB/cm} \quad (1)$$

where, α is conductivity, V_{fi} and V_{mi} are imaginary parts of velocities of free and metalized surfaces.

Figure 4 shows the calculation value of the amplification value of the amplification characteristics of the 64° cut leaky surface waves and the 131° cut Rayleigh waves in the case of $\mu_0 = 10^3 cm^2/V.sec.$ and $n = 7.0 \times 10^{16}/cm^3$. This figure shows that gains of the leaky surface waves are larger than ones of Rayleigh waves. InSb thin films on $LiNbO_3$ are prepared by temperature programed vacuum evaporation method. Source materials are InSb added 15% Sb of carrier density of $2 \times 10^{14} cm^{-3}$ and mobility of $2 \times 10 cm^2/V.sec.$.

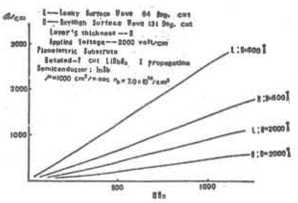

Fig. 4 Electronic Gain of Surface Waves vs. Frequency

Figure 5 shows evaporation apparatus.

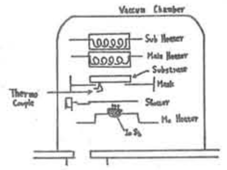

Fig. 5 Evaporation apparatus

From eq.(1), we can see that InSb thin film semiconductors are most effective to obtain a large gain when the mobility is larger and h is smaller. From the above, we put the evaporation conditions as follows, (1) substrate temperature is kept at 265°C, (2) programed source temporatures are kept at 950°C for 2 sec. and at 1015°C for 3 sec..

The film is 500Å thick, σh is 122μ℧ and mobility is $700 cm^2/V.sec.$, respectively.

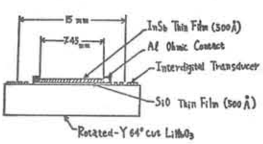

Fig. 6 Surface Wave Amplifier

Figure 6 shows the structure of amplifier elements of leaky surface waves. The piezoelectric plate is the 64° rotated-Y cut $LiNbO_3$. The layer of SiO between InSb thin film and $LiNbO_3$ surface wave is deposited to prevent damage to the InSb caused by oxygen sublimation from the $LiNbO_3$.

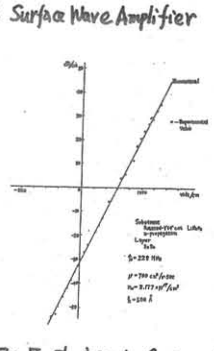

Fig. 7 Electronic Gain of Leaky Surface Wave vs. Electric Field

Figure 7 shows the measurement value of amplification characteristics comparing with theoretical value. From this figure, we obtained 36dB/cm electronical gain at 228MHz and 1.3KV/cm and found measurement value agreed with thoretical one.

Photograph 1 and 2 show the variation of amplitude vs. drift electric field at 228 MHz.

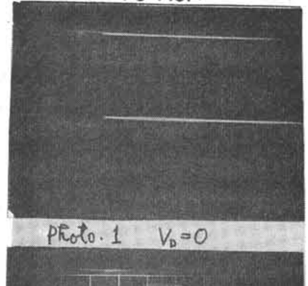

Photo. 1 $V_D = 0$

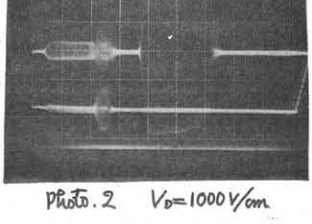

Photo. 2 $V_D = 1000 V/cm$

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