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Monolithic Elastic Surface Wave Amplifiers of Continuous Operation

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Introduction The InSb thin films of width of about 97μm and length of 7mm were evaporated on 131° rotated Y-cut X-propagation $LiNbO_3$. We obtained the thin films with drift mobility of 1000cm²/V·sec and observed an electronic gain of 11.5 dB/7mm at the continuous operation.

1\. Theoretical Gain Equation for Rayleigh Waves(1),(2)

In Fig.1, under the conditions of $\varepsilon_s > \varepsilon_0$, $\beta h \ll 1$ and $\omega^2 \ll \omega_c \omega_D$ the amplification gain, G is given as follows :

$G=54.6 \cdot (-K^2 \varepsilon_p V/2\sigma h)\gamma N$ (dB/cm)·····(1). where β is the propagation constant, ω_c and ω_D are the dielectric relaxation and diffusion angular frequency, $\gamma = 1 - v/V$, ($v = \mu E$, μ is the mobility, E the electric field and V the surface wave velocity), K the effective dielectric constant, σ conductivity, h the film thickness, N the wave-number/cm, and K the electromechanical coupling coefficient, respectively.

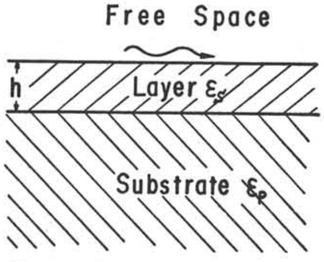

Figure 1 Monolithic type of amplifiers

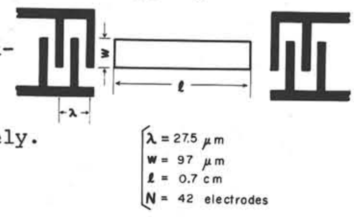

Figure 2 Stripe type of continuous operation amplifiers

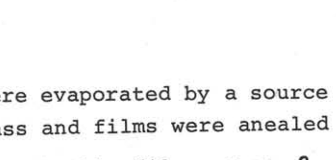

Figure 3 Heat sink

In order to obtain a large amplification gain, we should make the thin film having a large mobility and small conductance σh . In the case of InSb thin films having a large carrier density, proper thickness, h is about 500Å to obtain a large mobility.

In the continuous operation, Joule heat from InSb thin films should be reduced and the stripe type of thin films is proper, as shown in Fig. 2. Moreover, it is effective to put a heat sink on the films, as shown in Fig. 3.

2\. Experimental results and Discussion

First, a series of InSb thin films about 500Å thick were evaporated by a source temperature-programed evaporation system onto a pylex glass and films were anealed in vacuum at 350°C. Figure 4 shows the characteristics of InSb thin films, μ_H vs σh.

We need the thin films of large μ and large slope $\tan\theta = \mu/\sigma h$. By overcoating a SiO thin film(3) at substrate temperature of about 95°C, the electric properties of InSb is improved. An example of the variation of σh during the SiO overcoating is shown in Fig.5. It is fixed by first attaching thin layer of SiO. These are new phonomena. Arrow lines in Fig.4 show results of SiO overcoating effects.

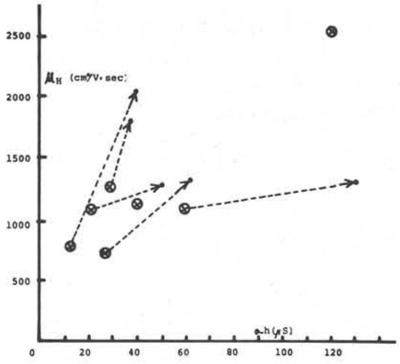

Figure 4 Characteristics of InSb thin films on Pylex glass and SiO overcoating effects

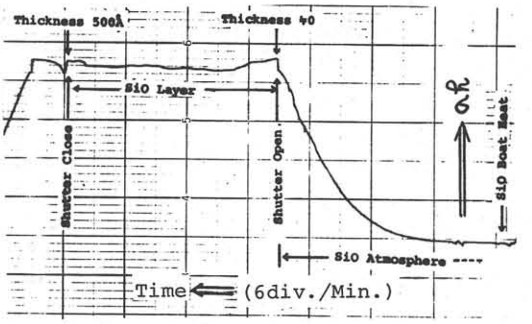

Figure 5 Variation of σh during SiO overcoating

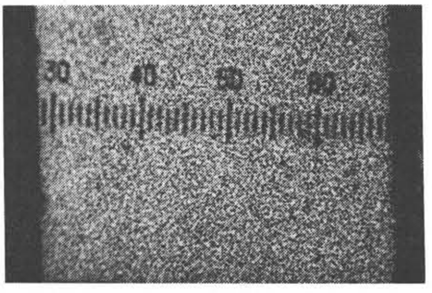

Figure 6 Photo of InSb thin film surface (x800)

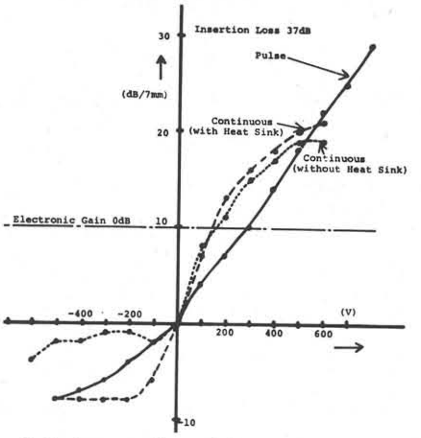

Figure 7 Pulse and continuous operations

Fig.2 shows the structure of monolithic type of continuous operation elastic surface wave amplifiers. These are fabricatied by using the photo-etching techniques. Fig.6 shows the photo of surface of InSb thin films (x 800). We can see the grain size of InSb.

Fig.7 shows gain-drift characteristics of thin films with Hole mobility of 1320 cm²/V·sec and σh of 62μS in the case of the pulse and continuous operations. The drift mobility, μ_D equals to about 1000cm²/V·sec. The limitation of the applied electric field in the continuous operations was 600V/7mm without heat sink and 740V/7mm with heat sink made of an AlN ceramics and copper metal, as shown in Fig. 3. The gain characteristics is different from pulse operations. We think that it depends on the irregularity of InSb thin films, hole carriers effects and heating effects etc. But we cannot yet fully explain this phonomenon. We obtained the electronic gain of 11.5dB/7mm at 144MHz in the continuous operation.

Conclusion: We found the new phonomena about the overcoating effect of SiO layer and are now investigating about the details of them. We obtained the electronic gain of 11.5 B/7mm at 144 MHz in the continuous operation. We will be able to obtain the larger gain in near future, as we can fabricate the better InSb thin films on $LiNbO_3$.

(Reference)
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(2) K.Yamanouchi,K.Abe and K.Shibayama,IEEE SU-22,No.5 Sept.(1975)369
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