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A5-1 Effect of Overcoating SiO Thin Films on Monolithic Elastic Surface Wave Amplifiers

Kazuhiko Yamanouchi, Tetsuro Konno, and Kimio Shibayama
(Research Institute of Electrical Communication, Tohoku University)
2-chome Katahira, Sendai, Japan.

Variations in conductance of thin films of InSb with thickness of vacuum-deposited overlay of SiO thin film indicate surface depletion or enhancement in semiconfuctors by substrate temperatures. These films are applied in the construction of monolithic elastic surface wave amplifiers.

Thin film structures several hundred angstroms thick of InSb on $LiNbO_3$ substrate have been applied in the construction of monolithic elastic surface wave amplifiers.[1,2] We report herein that vacuum-deposited SiO causes an enhancement of layers at the substrate temperatures of about 95 °C and a depletion of layers at about 300 °C on the surface of InSb thin films. Also, monolithic elastic surface wave amplifiers with useful gain and output power were obtainable by using this new method.

To demonstrate charge depletion or enhancement by substrate temperatures, a series of InSb films about 500Å thick were vacuum deposited by source temperature-programed evaporation[2] from high-purity, n-type InSb ($N_D=10^{14}/cm^3$) onto a mica plate which was maintained at a temperature of 280 °C during deposition and annealed in a vacuum at 340 °C. The evaporation equipment has a mesh between the source and the substrate because of removing a rich In gas.

The variation of σh of the InSb film with thickness of an SiO insulating layer is shown in Fig.1 with the substrate temperature as a parameter, where σ is conductivity and h is film thickness. We found that σh decreased at the substrate temperature of about 300 °C and that it increased at about 95 °C . A similar phenomenon has been explained from the variation of the depth and amount of charge depletion at the surface of an InSb thin film semiconductor by SiO and CaF_2[3]; however, our phenomenon cannot be explained by this theory since it was caused by variations of the substrate temperature.

These films are applied in monolithic elastic surface wave amplifiers. First, a thin barrier layer of SiO was deposited on a 131°-rotated, Y-cut, X-propagation $LiNbO_3$ substrate (effective electromechanical coupling coefficient, $K^2=0.055$). The InSb film was then evaporated by source temperature-programed evaporation[2]. Finally, the structure was overcoated with SiO by the method formerly described.

The sample without an overcoating by SiO thin film in Fig.2 has a small value of $\sigma h=12.3\mu\mho$ and rather small value of hole mobility, $\mu_h=792cm^2/V\cdot sec$, and reveals a small gain only at the frequency of 39.5MHz. By overcoating SiO thin film at the substrate temperature of about 95°C, the electric properties of InSb thin film were extremely improved; that is, the σh changes in $40.2\mu\mho$ from $12.3\mu\mho$, and the hole mobility changes in $2068cm^2/V\cdot sec$ with a drift mobility of $1600cm^2/V\cdot sec$ from $792cm^2/V\cdot sec$. Further, a net terminal gain of 40dB with an electronic gain of 70dB was obtained at 195MHz.

Figure 3 shows the characteristic of another sample. The σh of InSb thin film without overcoating by SiO thin film was rather large for the device and was $145\mu\mho$. By overcoating SiO thin film at the substrate temperature of about 300°C, the σh of InSb thin film decreased in $93\mu\mho$ and the gain was improved.

The sample without overcoating by SiO thin film in Fig.4 has a very small value of $\sigma h=8.7\mu\mho$, and indicates only interaction between a hole carrier and the elastic surface wave. The σh increases in $16.5\mu\mho$ by overcoating SiO thin film at around 95°C, and the device shows interaction between an electron carrier and surface wave.

In conclusion, we have shown that the effect of overcoating SiO thin films at various temperatures can be useful in producing monolithic elastic surface wave amplifiers, although we cannot yet fully explain this phenomenon physically.

Reference

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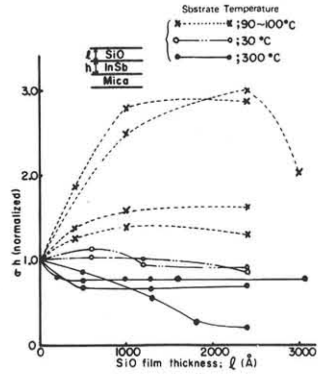

Figure 1 Variation of thin film semiconductor σ-h vs thickness of SiO overcoat with substrate temperature as a parameter

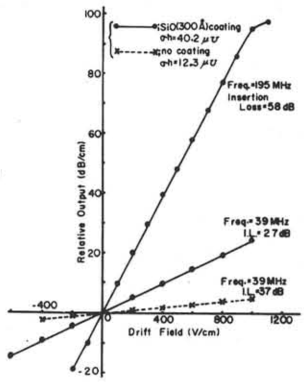

Figure 2 Relative gain vs drift voltage for a sample without and with overcoating by SiO thin film

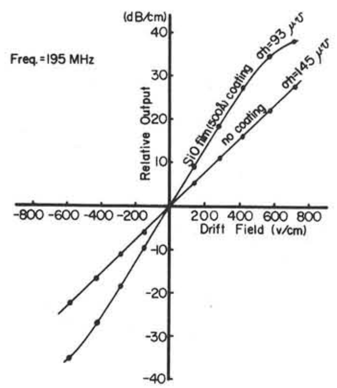

Figure 3 Variation of the electronic gain by overcoating SiO thin film

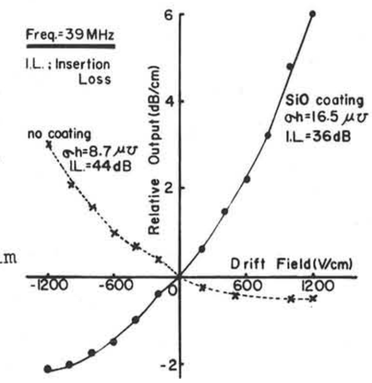

Figure 4 Variation of interaction for a sample without and with overcoating by SiO thin film