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Preparation of Thin InSb–Films

The possibilities to prepare thin films of InSb by evaporation technique were investigated. Good results were achieved when using the flash evaporation technique. The influence of substrate heating, temperature of the evaporator and the growth rate on the structure and composition of the films were investigated.

1. Introduction

Vacuum evaporation techniques are widely used for the preparation of thin films both of elements and compounds [1]. Such techniques are difficult to apply to compounds which decompose on heating, because the composition of the vapor is difficult to control. For example, many of the III-V compound semiconductors dissociate readily on heating in vacuo to yield a vapor which is initially rich in the more volatile component.

Vapor pressures of Indium and Antimony are extremely different. At 750°C the partial pressure of Indium is 10^{-5} torr while the partial pressure of Antimony is equal to 10^{-5} torr. Thus one component is almost completely vaporized before any appreciable evaporation of the other component takes place. The composition of the vapor produced the varies continously during the evaporation to yield a film which is completely inhomogenous.

2. Experimental

To overcome this decomposition there is the possibility of simultaneously evaporation of the components from two seperate sources [2] onto a substrate whose temperature is closely controlled, the so called three temperature method.

This method of preparation depends upon the fact that the compound has a vapor pressure intermediate to those of its constituents. The substrate must be held at an intermediate temperature below the decomposition temperature of the compound, but above the condensation temperature of the higher vapor pressure element. At a too high substrate temperature the compound will decompose, leaving only the lower pressure component, adhering to the substrate. The temperatures needed are 330°C for the substrate, 1025°C for the indium source and 650°C for the antimony source.

If, on the other hand, the evaporative technique is changed [3], so that the material to be evaporated is fed in the form of fine grains into a heater whose temperature is set as high as necessary to evaporate the least volatile component, then compositional changes in the vapor can largely be avoided. Because of its low thermal capacity, each grain evaporates rapidly and completely, and, especially in the case where a continuous feed is adopted, the vapor produced closely approximates in composition that of the starting material. Once the composition of the vapor can be controlled in this manner, this vapor can be condensed onto a substrate to form films which are stoichiometric with respect to the starting material.

The feeder used consists mainly of a material container with a spiral channel on the inner surface. The vibrations produced by a magnetic coil transport the coating materials, via the channel to the top of the container where it falls down the delivery tube to the evaporation source. The substrate temperature, delivered by a built in heater in the evaporation unit, was measured with a thermocouple.

3. Results

1. InSb-films prepared by means of the three temperature method are very badly reproducible in structure and composition.

2. Using the grain by grain ("flash") evaporation technique it was found that the crystalline nature of the deposited film is strongly dependent on the temperature of the substrate. Films deposited at low

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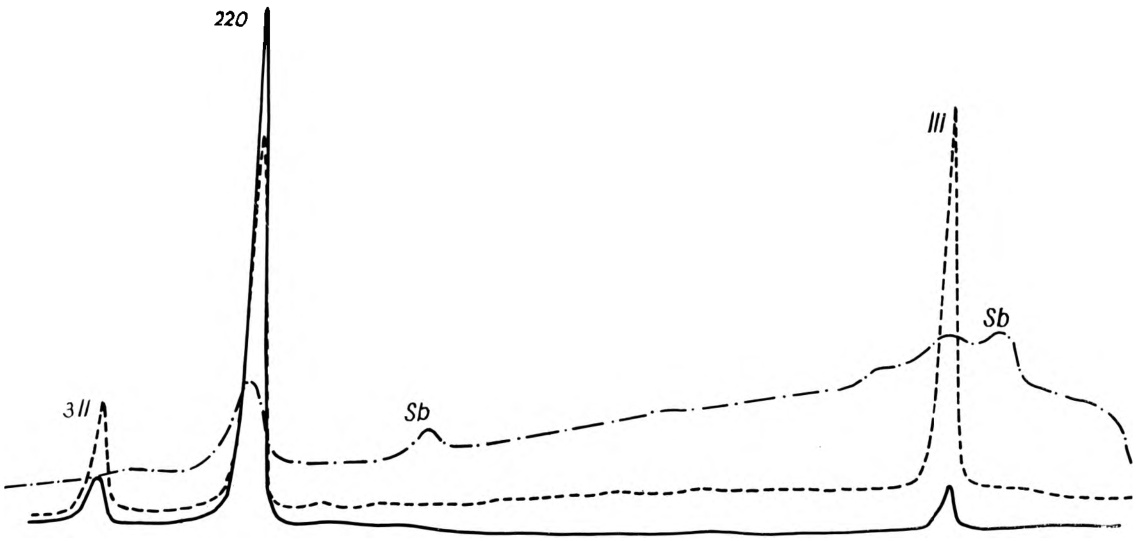

X-ray diffraction spectrum of three distinct InSb-films
— - — without substrate heating
——————— substrate heating, T_s = 395°C, growth rate 1 μm per min
——————— substrate heating, T_s = 395°C, growth rate 0.3 μm per min

substrate temperatures show *X*-ray diffraction patterns characteristic of a poorly crystallized and randomly oriented film (figure). At a higher substrate temperature the degree of crystallinity improves and the onset of some preferred orientation of the crystallites is seen. Further increase in the temperature led to re-evaporation of the group V element from the condensed film, leaving an excess of the group III metal on the surface.

3. Both the structure and composition of the deposited films were affected by the temperature of the evaporator. There was a minimum evaporator temperature below which the condition for flash evaporation no longer held. Below this minimum temperature the group III metal evaporates slowly to yield a film containing an excess of the group V element. Above this minimum temperature and with the substrate temperature held constant, structural differences were found in the deposited film which were dependent on the temperature of the evaporator. Films deposited from an evaporator whose temperature was set close to, but above the minimum temperature, were veıy rough in texture, with pits and hollows 10–20 μm in diameter. As the evaporator temperature was raised, the surface roughness decreased, untill at very high evaporator temperatures the film became smooth and almost structureless. In our case these temperatures ranged from a minimum at 1050°C up to 1500°C and higher, with which smooth deposits were obtained.

4. The crystalline nature is also strongly dependent on the growth rate. A slow growth rate, that means approximately 0.3 μm per minute delivers a film in which a relatively strong 220 line appears in the *X*-ray diffraction spectrum, while with increasing growth rate the 111 orientation is more preferred (figure).

4. Conclusion

Using the flash evaporation technique InSb-films were achieved, which were excellent in reproduction of both structure and composition. Best results were found with a temperature of the substrate (glass or quartz) of 395°C, a temperature of the evaporation boat (tantalum) of 1570°C and a growth rate of 0.3 μm per minute. These films, being n-type semiconductor, can be used as long pass filters or as room temperature infrared detectors. Resistances are between 80 and 300 Ω/sq. Thicknesses of the films, as measured with a "Talystep" apparatus, are up to 4 μm.

Получение тонких пленок InSb

Исследована возможность получения тонких плёнок InSb методом термического испарения. Хорошие результаты получены методом дискретного испарения. Исследовано влияние температуры подложки, температуры испарителя и скорости осаждения на структуру и состав получаемой плёнки.

References

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