CHAPTER THIRTEEN

Electron beam recrystallisation of InSb.
15.1. INTRODUCTION:

Among the III - V semiconductors InSb is perhaps the best studied. Among the striking properties which have attracted so much attention are, very high electron mobility (80,000 cm²/V.Sec) which magnifies all magnetic effects permitting wide applications such as the use of Hall effect for power amplification. The small energy gap (0.17 ev at Room temperature), which makes it suitable for radiation detection in the infra-red through the photo voltaic, photo conductive, photo electro magnetic effects. Its almost complete degeneracy (in n-type samples) at all temperatures is due to the exceedingly small value of the electron effective mass; The conduction band on pure samples, be filled upto an appreciable level with electrons to cause a shift in the absorption edge.

InSb is very easily formed by the direct reaction of the two elements and is very stable. It melts at about 523°C. Similar to homologous compounds, the solubility of the elements in the compound is very small, so that almost perfect stoichiometry is reached automatically.

It is f.c.c. like all other III - V compounds, with a lattice constant of 6.48Å.

InSb films have been grown by a number of methods. Reimer prepared InSb films by rapid evaporation of $10^{3}$Å/sec bulk charge on to SiO substrates. But the films showed dissociation of InSb to some extent. He partly succeeded in growing epitaxial films on NaCl heated to 300°C.
Dale and Senecal\textsuperscript{214} have observed recrystallisation of InSb when the films were annealed. They observed such recrystallisation when the films were exposed to the electron beam in the microscope. Williamson\textsuperscript{215} made a detailed investigation of various annealing procedures of InSb films. Richards, Herst and Muller\textsuperscript{216}, flash evaporated the material on to heated Germanium substrates to get epitaxial film. Juhasz and Auderson\textsuperscript{217} got the epitaxial film by flash evaporation on to heated mica. Gruenther has grown stoichiometric films of InSb by his famous three temperature method on a variety of substrates. Pagria\textsuperscript{218} has grown InSb films by the same technique on to glass substrates pre-coated with SiO.

Recrystallisation by melting and controlled solidification of previously deposited InSb films appeared promising because of the low melting temperature of this compound and relatively low vapour-pressure of Sb at the m.p. Wieder and Clawson\textsuperscript{210} have grown two phase (InSb + In) films by the recrystallisation of non stoichiometric liquid films. Wieder\textsuperscript{219} could grow monophase InSb by a similar technique taking more Sb initially. David and Wieder\textsuperscript{211} have grown large parallel InSb dendrites by electron beam microzone melting of vacuum deposited composite film of In and Sb. Teede\textsuperscript{220} repeated the same technique to grow InSb films having mobility very close to that of bulk material. Thus though a lot of work is done, it was thought worthwhile to see whether InSb films also could be grown by the simple
electron beam irradiation method, the details of which are
described in this chapter.

13.2. Experiment:

Successively deposited In - Sb films were prepared in
a way exactly similar to Al - Sb films described in chapter
eleven.

13.3. Results:

It was observed that the reaction due to the beam
irradiation was slow compared to the Al-Sb films. The re­
crystallisation proceeded slowly and needed heavy beam cu­
rrents (200 µamps.).

Figs. 13.1, 13.2 and 13.3 show the electron diffrac­
tion patterns of the film irradiated by electron beam. In
the case of InSb also, the (110), (111) and (211) orienta­
tions were observed, quite frequently. It is interesting
to note that the (100) orientation was practically never
observed in the case of InSb films. Table 13T.1 shows
the InSb 'd' values (standard) taken from A.S.T.M. data and
the calculated 'd' values for the recrystallised film. The
two are in good agreement there by confirming the formation
of InSb. Fig. 13.4 shows the electron micrograph of a
recrystallised film, similar to the one observed for AlSb
films (Chapter 11). The extra ring patterns observed in
some diffraction patterns are due to the tetragonal Indium
left over with the formation of InSb.

Table 13T.1:

(6 - 0208 ASTM)

<table>
<thead>
<tr>
<th>Standard 'd' value</th>
<th>Calculated 'd' value</th>
<th>hkl</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.740</td>
<td>3.720</td>
<td>(111)</td>
</tr>
<tr>
<td>2.290</td>
<td>2.230</td>
<td>(220)</td>
</tr>
<tr>
<td>1.953</td>
<td>1.942</td>
<td>(311)</td>
</tr>
<tr>
<td>1.620</td>
<td>1.610</td>
<td>(400)</td>
</tr>
<tr>
<td>1.486</td>
<td>1.479</td>
<td>(331)</td>
</tr>
<tr>
<td>1.323</td>
<td>1.329</td>
<td>(422)</td>
</tr>
</tbody>
</table>

As observed for AlSb films, near stoichiometry of the composite elements with slightly excess of Sb was the best condition for the alloy formation. Though highly non-stoichiometric films did not favour the formation of the alloy, the tolerance for non-stoichiometry was more in InSb films than in AlSb films. An intense irradiation resulted in the dissociation of the compound, since the melting point of the compound is quite low. The former observations are in accordance with the fact that solubilit
of elements in the molten InSb is very small as mentioned.

13.4. Conclusions:

InSb also can be recrystallised when the successively deposited composite film of In and Sb is exposed to the electron beam. The films show the typical f.c.c. orientations like $\langle 110 \rangle$, $\langle 111 \rangle$ and $\langle 211 \rangle$ orientations frequently.