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Optical Characterization of Magnesium Doped Indium Antimonide Bulk Crystal Using VDS Technique

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Abstract: ***Vertical directional solidification (VDS) technique is used to produce quality semiconductor crystals such as InSb and GaSb. Using this technique, magnesium doped Indium antimonide bulk crystal is grown. The Stoichiometric solution of Indium, Antimony and Magnesium were sealed in a quartz ampoule. The growth is carried out at 5mm/hour in an inert atmosphere and reduced pressure. During crystal growth, the temperature at the center of the furnace was held at 550^0C and ampoule was lowered below melting point. The resultant ingot was found detached from the ampoule wall. The metallic smooth appearance of the crystal, uniform diameter across the length and other studies confirms the superior quality of the crystal. The crystal was cut in 2mm wafers and polished to mirror finish before characterization. The powder X - ray diffraction pattern shows a single peak dominating over other peaks of small intensity which indicate preferential orientation of the crystal. The absorption measurements were carried out using FTIR. The absorption edge was shifted from 0.16eV to 0.156 eV. Hence the material is suitable for band gap modification of InSb. The tilt angle of the absorption edge is smaller than 90^0 which indicate presence of large number of charge carriers.***

Keywords: Vertical Directional Solidification, Indium Antimonide, Magnesium Doping, Crystal Growth, Band Gap Modification

1. Introduction

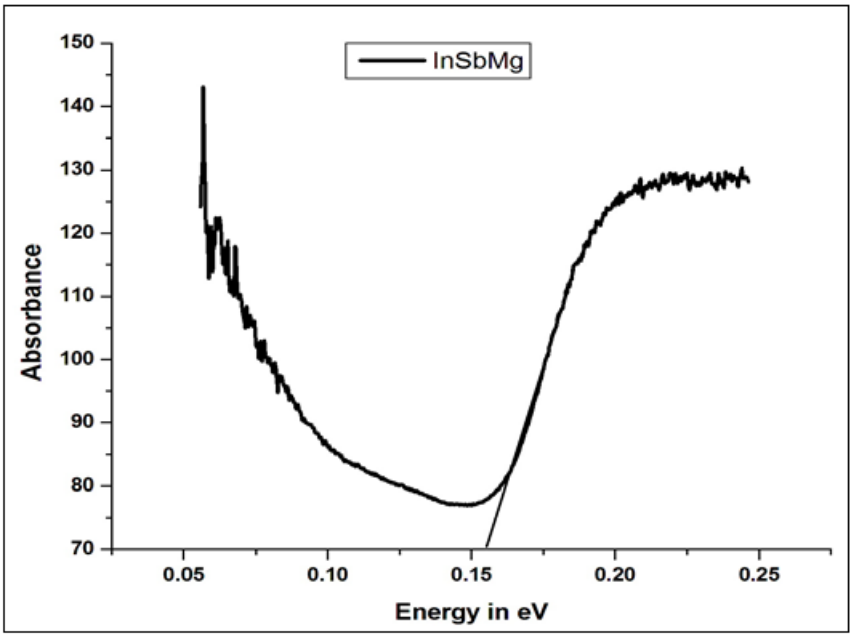
Indium antimonide is infra red sensitive material which can be grown with large surface area, low defect density. The detectors made from InSb can be stable. The infra red detectors are useful for infrared imaging, infrared astronomy and detection of various gases. The growth of bulk crystals was carried out using vertical directional solidification (VDS) process. The material band gap and characteristics are suitably modified for a particular application by doping it with variety of materials. The devices with sensitivity in LWIR window are used in thermal imaging, Infra - red astronomy and gas sensing devices [1] Apart from these properties, enhancement of magnetic properties can be useful for memory storage devices and fast performing devices.

2. Materials and Methods

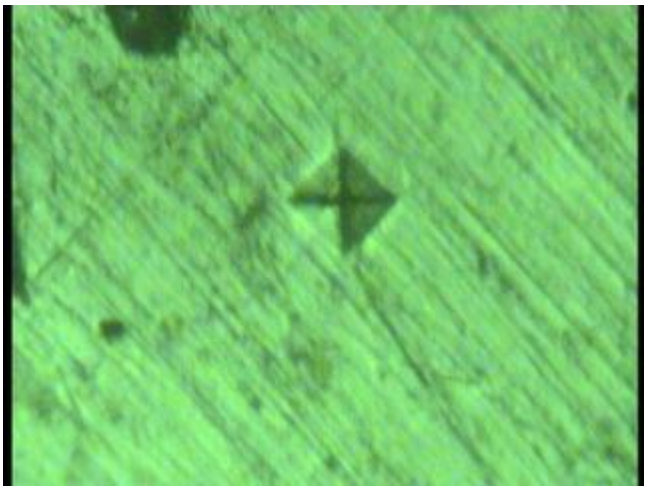
The crystals were grown using vertical directional solidification technique. The purity of Indium, antimony was 5N and magnesium was 4N. at the time of growth, magnesium of 10 atomic weight percent was added to Indium and antimony mixture. The material was filled in an ampoule and the ampoule was sealed under argon pressure. The process in depth is mentioned elsewhere. [2] The as grown ingot of length 3 cm and 1 cm diameter could easily slide inside ampoule. The ingot was cut suing diamond cutter and polished to mirror finish.

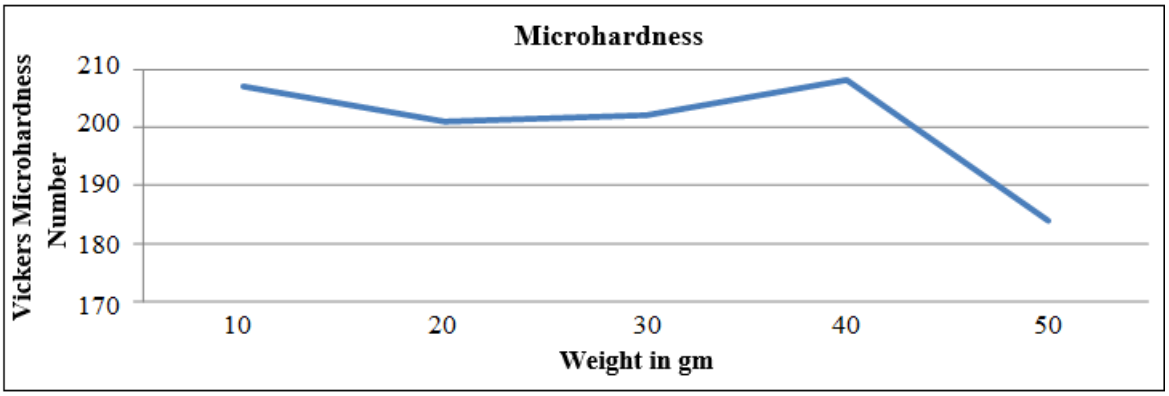
3. Results and Discussion

Optical Characteristics:
Thin wafers of 2 mm were used for optical measurements. The absorption vs energy curve was plotted as as shown in figure 1.



Microhardness measurements:
Fabrication of devices requires sturdy materials that can withstand stress and do not change material properties with time. Indium antimonide doped with magnesium has stable value of Vickers number upto 40 gms as shown in Figure 3.





4. Conclusion

In conclusion, this study presents a well - executed investigation into the growth and characterization of magnesium - doped Indium antimonide crystals via the Vertical Directional Solidification technique. The findings highlight a material with superior structural and optical qualities, poised to advance infrared detection and related technologies. In my view, the research lays a strong foundation for further exploration, particularly in optimizing doping strategies and expanding application scope. It is evident that this work not only enhances our understanding of InSb - based semiconductors but also signals promising

avenues for innovation in device fabrication and performance.

References

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