III-V group (InSb) dilute magnetic semiconductor

Naveen Agrawal

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Semiconductors are extremely sensitive to impurity atoms (doping), defects and charge carriers. If the charge carriers are introduced by doping magnetic impurity atoms into the host lattice of semiconductors, the material would possess magneto-optical properties. The realization of materials that combine semiconducting behaviour with magnetism has long been a dream of material physicists. Adopted a strategy for creating systems that are simultaneously semiconducting and magnetic is initiated in the 1980's by introducing local moments into well-understood semiconductors.

The DMS materials are conventional semiconductors, in which appropriate fraction of the original atoms is substituted by elements which are capable to introduce the localized magnetic moment. These materials are commonly known as dilute magnetic semiconductors (DMSs). Due to this substitution, these materials not only retain the semiconducting properties, but can also possess magnetic properties. In order to develop multifunctional devices, it is essential to combine both the properties of electron; charge and spin. In this the spin of electrons that carries the information can be used as an extra feature in novel electronic devices. The charge and spin property of electron is combinely known as spintronic or spin transport electronics [1].

The binary intermetallic compound InSb was synthesized in 1929 with a zinc blende structure [2]. But the In-Sb phase diagram was fully explained in 1952 [3]. Indium Antimonide (InSb) is an III-V group low gap semiconductor, low effective mass (0.014 me), and high electron mobility at RT [4,5]. Due to it being low band gap semiconductor, it has been particularly attractive as a potential material for high performance devices, low temperature diodes, infrared detectors, IR laser devices, X-ray monochromation detector, optical-immersion lenses as well as magnetic sensors [6-9].

InSb has the highest RT mobility (7–8 × 104 $cm^2V^{-1}s^{-1}$) amongst semiconductor, due to this mobility range InSb thin films are widely used in magnetic sensors.

Pramila Mohan et al. [10] reported the growth of the InSb bulk system, which is used for infrared device application. Maske et al. [11] reported the Bi doped InSb bulk crystals prepared using Vertical Directional Solidification (VDS) technique and characterized for various studies. Gadkari et al. [12] reported the characterization of p-type and n-type InSb bulk using VDS technique. Grober et al. [13] reported the time resolved photoluminescence studies of bulk InSb. Ebnalwaled AA [14] reported the growth of InSb crystal using the vertical Bridgeman technique and results is compared with previous studies. While in one of the study by Ebnalwaled [15] reported the hopping conduction and dielectric properties of InSb bulk crystals. Recently Hnida et al. [16] reported the electrochemically deposited nanocrystalline InSb with its electrical properties. There are many reports which show the various properties of pure InSb bulk. Apart from the studies of pure InSb there are many reports available with the inclusion of the various elements [17-19] in InSb bulk. Gadkari et al. [17] reported the high mobility of InSb bulk with the doping of Tellurium. Shigeo et al. [18] reported the thermo-electric properties and figure of merit of the Te doped InSb bulk. Deshpande et al. [19] reported the optical characteristics of dilute Nitride doped InSb bulk.

These results based on the studies of InSb in form of bulk and thin film may lead to realization of various applications such as IR detectors, magnetic sensors, and temperature sensors with an additional application of spintronics.

REFERENCES

1. Agrawal N. Bulk and thin film study of some dilute alloys and compounds. Maharaja Sayajirao University of Baroda, Gujarat, India. 2016;166.
2. Goldschmidt VM. Crystal structure and chemical constitution. Trans Faraday Soc. 1929;25:253-83.
3. Liu TS, Peretti EA. Transactions of the American Society of Metals. 1952;44:539-45.
4. Rao BV, Gruznev D, Tambo T, et al. Heteroepitaxial growth of high quality InSb films on Si(111) substrates using a two-step growth method. Semicon Sci Technol. 2001;16:216.
5. Stradling RA. The electronic properties and applications of quantum wells and superlattices of III-V narrow gap semiconductors. Braz J Phys. 1996;26 :7-20.
6. Kanisawa K, Yamaguchi H, Hirayama Y. Two-dimensional growth of InSb thin films on GaAs(111)A substrates Appl Phys Lett. 2000;76:589.
7. Finger G, Dorn R, Meyer M, et al. Performance evaluation and calibration issues of large format infrared hybrid active pixel sensors used for ground and space based astronomy. Nucl Instr Meth Phys Res A. 2005;549:79.
8. Okamoto A, Yoshida T, Muramatsn S, et al. Magneto resistance effect in InSb thin film grown using molecular beam epitaxy. J Cryst Growth. 1999;201:765.
9. Ozer S, Besikci C. Assessment of InSb photodetectors on Si substrates. J Phys D: Appl Phys. 2003;36:5-59.
10. Mohan P, Senguttuvan N, Babu SM, et al. Bulk growth of InSb crystals for infrared device applications. J Cryst Growth. 1999; 96-100.
11. Maske DS, More PS, Deshpande MD, et al. Characterization of InSbBi bulk crystals grown at various growth-rates by vertical directional solidification (VDS). Arch Phys Res. 2012;3:15-20.
12. Gadkari DB, Lal KB, Arora BM. Characterization of p and n-type bulk InSb crystals grown by vertical directional solidification techniqueInd. J Pure Appl Phys. 2000;38:237-242.
13. Grober RD, Harris DT, Trautman JK, et al. Optical spectroscopy of a GaAs/AlGaAs quantum wire structure using near-field scanning optical microscopy. Appl Phys Lett. 1994;64:1421-3.
14. Ebnalwaled AA. Evolution of growth and enhancement in power factor of Insb bulk crystal. J Cryst Growth. 2009;311: 4385-90.
15. Ebnalwaled AA. Hopping conduction and dielectric properties of InSb bulk crystal. IJBAS. 2011;11:194-207.

Department of Physical Sciences, Natubhai V Patel College of Pure and Applied Sciences (N.V.P.A.S.), Vallabh Vidyanagar, Anand, Gujarat, India

Correspondence: Dr. Naveen Agrawal, Department of Physical Sciences, Natubhai V Patel College of Pure and Applied Sciences (N.V.P.A.S.), Vallabh Vidyanagar, Anand, Gujarat, 388120, India, Tel: +919879194771; Email ID: nvnagrl@gmail.com

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16. Hnida KE, Babler S, Mech J, al. Electrochemically deposited nanocrystalline InSb thin films and their electrical properties. J Mater Chem C. 2016;4:1345.
17. Gadkari DB, Lal KB, Shah AP, et al. Growth of high mobility InSb crystals. J Cryst Growth. 1997;173:585-588.
18. Yamaguchi S, Matsumoto T, Yamazaki J, et al. Thermoelectric properties and figure of merit of a Te-doped InSb bulk single crystal. Appl Phys Lett. 2005;87: 201902-201902-3.
19. Deshpande MJ, Maske D, Arora BM, et al. Optical Characteristics of Dilute Nitride of InSb Bulk Crystal. IJSRP. 2014;4:251-3.