CHAPTER 7

Summary and outlook
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Abstract

This chapter summarises the results obtained in the entire work followed by the scope for the future work.
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7.1 Conclusion

From the present work we can conclude that single phase indium selenide can be prepared using SHI irradiation at relatively lower annealing temperature of 100°C, whereas a temperature of 400°C is required without irradiation. Interestingly $\gamma$-In$_2$Se$_3$ thin film prepared using this method (annealing only) exhibited negative photoconductivity even at room temperature. This behaviour showed by $\gamma$-In$_2$Se$_3$ is due to the trapping of photogenerated carriers at trap levels, 1.46 and 1.32 eV and destruction of conduction band electrons at recombination centre at 290 meV above valance band on illumination. SHI irradiation annihilated the trap levels in the sample and converted negative photoconductivity to positive photoconductivity. Structural analysis proved that the growth of $\gamma$-In$_2$Se$_3$ along c-axis depends on In concentration and annealing temperature. However Se rich indium selenide film never grew along c-axis whatever may be the annealing temperature. Irradiation using 40 MeV Si ions resulted in the variation of the band gap of $\gamma$-In$_2$Se$_3$ from 2 eV to 2.8 eV. In fact this is due to the reduction of Urbach energy induced by SHI irradiation. On-line RBS study using 40 MeV Si ions proved that swift heavy ions can be used for online interface mixing study. Irradiation study at different electronic energy regime explored the threshold fluence for mixing to take place between In/Se bilayer system is $6 \times 10^{12}$, $1 \times 10^{13}$ and $1 \times 10^{14}$ ions/cm$^2$ for 100 MeV Ag, 80 MeV Ni and 90 MeV Si ions respectively. Irradiation study in In/Sb system, deposited on Si substrate, proved that InSb can be prepared on Si substrate using SHI irradiation at room temperature. This work also proved that InSb can be integrated with Si matrix using 100 MeV Au ion irradiation without any post annealing treatment. To the best of our knowledge there is no report on integration of InSb with Si using IBM technique.
7.2 Scope for future work

The present study proved that the structural, electrical and optical properties of $\gamma$-In$_2$Se$_3$ can be improved using SHI irradiation. Hence we can adapt this technique to increase the band gap of indium selenide and could fabricate CuInS$_2$/In$_2$Se$_3$ solar cells. As we are using SHI irradiation, there is no need to decrease the thickness of the window layer, and we can get better solar cell characteristics than that obtained earlier in CuInSe$_2$/In$_2$Se$_3$ based solar cells. Since single phase films without traps are forming induced by SHI irradiation we can expect more reliable and better reproducibility. Lots of work has been done on CuInSe$_2$/In$_2$Se$_3$, and CdS/In$_2$Se$_3$ p-n junctions. But with CuInS$_2$/In$_2$Se$_3$ junctions, little work was reported. Because both CuInS$_2$ and $\gamma$-In$_2$Se$_3$ have tetragonal structure with lattice parameter $a = 5.52Å$, $c = 11.13Å$ and $a = 7.11Å$, $c = 19.34Å$ respectively, lattice mismatch will be very much less. This opens a new scope for future work.

The fact that InSb could be integrated with Si using SHI irradiation even at room temperature will really benefit semiconductor industry, since they are using discrete circuits which are physically separated from the InSb sensor array for signal processing and amplification. By Integrating InSb with highly advanced Si circuitry, one could get significant gain in terms of reliability and speed. Moreover, high density of integration will allow considerable cost savings in the manufacturing process.
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