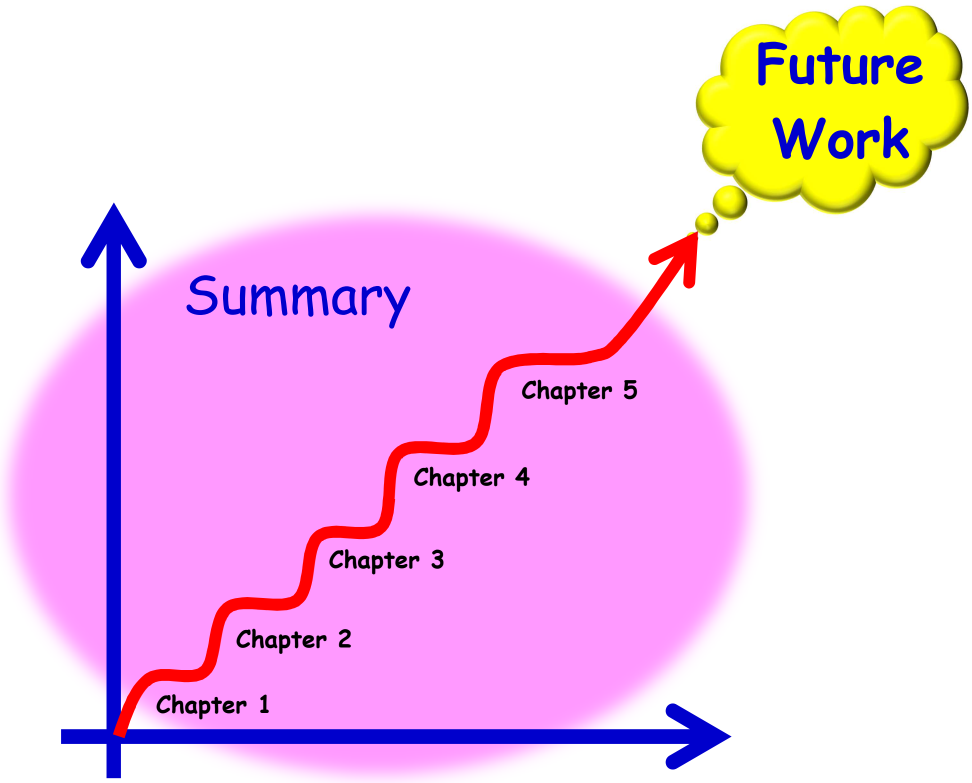
Summary and Future Work



This chapter contains the salient features of the work done in this thesis and the scope for future work in the field of semiconductor nanocomposites.

6.1 Summary

To summarize, the work presented in this thesis mainly focuses on the synthesis of transition metal sulphide semiconductor nanoparticles using environmentally benign solid-solid reaction in thermally stable and chemically resistant polyphenylene sulphide polymer matrix. The scope of the thesis has been limited to synthesis of zinc sulphide, cobalt sulphide and manganese sulphide nanocomposites and their characterization.

The first chapter deals with general introduction and the literature survey conducted during the course of this work. It also covers, in brief, the significance of different characterization techniques employed for analysis of as prepared nanocomposites.

In the second chapter, work pertaining to synthesis of zinc sulphide (ZnS) quantum dots in polyphylene sulphide matrix has been demonstrated. Two different reactions schemes were followed. In the first scheme, metal precursors were directly heated along with polymer by varying the molar ratio of polymer to ascertain whether the sulphur from polymer reacts with zinc from metal precursor to obtain the resultant zinc sulphide in the polymer matrix. In the other scheme, zinc acetate was used as metal precursor and thiourea was used as an external chalcogen source along with polymer. From the results, it was evident that under the given reaction conditions sulphur from polymer did not react with the metal precursor and the product obtained was zinc oxide embedded in the polymer matrix, whereas, with the chalcogen enriched reaction, we were able to obtain zinc sulphide quantum dots (QDs). XRD and HRTEM studies revealed that the synthesized ZnS Q-dots embedded into the polymer matrix possess cubic structure.

The third chapter summarizes the experimental work pertaining to synthesis of mixed phase of cobalt sulphide-oxide nanoparticles within the polymer matrix. Cobalt nitrate and PPS were reacted in varying molar ratios viz.1:1, 1:5, 1:10 and 1:15 at the melting temperature of the polymer (285ºC) for six hours. From the results, it was inferred that with 1:1 and 1:5 ratios, the material formed was cobalt oxide having mainly Co_3O_4 phase, whereas, for the 1:10 and 1:15 ratio, mixed phases of cobalt oxide (Co_3O_4) and cobalt sulphide (Co_3S_4) were obtained. DSC analysis indicated a characteristic lowering in the melting temperature of the resultant nanocomposites. For the 1:10 and 1:15 ratios, sulphur from the polymer partially reacted with metal precursor and as a result corresponding metal sulphide was formed along with the metal oxide in the polymer matrix.

In chapter four, cobalt sulphide has been synthesized using cobalt acetate as a precursor, thiourea as an external chalcogen source and PPS as the polymer. The reactions have been carried out by changing the molar ratio of the chalcogen source. In these reactions, single phase CoS was obtained. Cobalt sulphides being magnetic materials, the resultant nanocomposites were subjected to magnetic studies using Vibrating Sample Magnetometer (VSM) at room temperature. The neat polymer as such showed diamagnetic behaviour whereas magnetic nature was observed for the all the resultant nanocomposites. The materials displayed paramagnetic and ferromagnetic behavior, depending on the metal precursor:thiourea:PPS molar ratio. DSC analysis revealed changes in the melting behavior of PPS. A characteristic lowering of about 10 to 15°C was observed in the melting temperature (Tc) of PPS for the synthesized materials as compared to the virgin PPS.

The fifth chapter covers the synthesis and characterization of manganese sulphide based nanocomposites. The physico-chemical characterisation revealed formation of mixed phases of manganese sulphide viz.α- MnS and γ- MnS. FESEM and HRTEM images showed the formation of cubic as well as spherical nanoscale morphology depending upon the reaction conditions.

To conclude, successful synthesis of zinc sulphide, cobalt suphide and manganese sulphide in PPS polymer matrix has been accomplished by environmentally benign solid-solid route.

6.2 Future work

Polymer nanocomposites are currently being used in device fabrication and are being looked upon as potential materials for future generation smart devices. The incorporation of semiconductor nanoparticles in the polymer matrix leads to entirely different set of properties as compared to the virgin polymer. Throughout this study, we have intentionally chosen PPS as the polymer as it possesses inherent characteristics that can be used for smart device fabrication. PPS is thermoplastic in nature and can be moulded in any desired shape, it is thermally stable, chemically resistant and not soluble in any of the solvents at room temperature. These inherent characteristics when coupled with embedded semiconductor nanoparticles can be potentially used for device fabrication which can withstand very harsh and demanding environmental conditions.

The solid-solid reaction methodology being relatively simple can be explored in future using other thermoplastic polymers such as phenoxy resin, polyetheyene, polyvinylformal (PVF), polyvinylalcohol (PVA) etc. as a polymer matrix. These nanocomposites containing semiconductor nanoparticles viz. ZnS can then be explored for application in solar cells, CoS in supercapacitor applications and magnetic devices etc. This solid-solid reaction method containing CoS nanoparticles, if synthesized, in a nontoxic polymer domain can be suitably exploited for biological labeling application.