CHAPTER 7

SUMMARY AND SUGGESTIONS FOR FUTURE WORK

7.1 SUMMARY AND CONCLUSION

The field of Dilute Magnetic Semiconductors (DMS) have been widely distinguished as one of the most promising and rapidly emerging research areas. The novel properties of DMS materials are dominated by two major facts such as spin injection by foreign atoms within the host lattice and size of the particle. Hence, the present work focussed on synthesis and characterization of pure and Cr doped perovskites ($SrTiO_3$& $SrSnO_3$) and scheelite ($SrMoO_4$ and $SrWO_4$) structured compounds to import ferromagnetic behaviour at room temperature.

Polycrystalline pure and Cr doped $SrTiO_3$ compounds were synthesized by glycol assisted sol-gel method. Powder XRD patterns of prepared samples reveals the formation of cubic perovskite structure. The availability of metal oxide vibrations (Sr, Ti, O and Cr) and functional groups was identified by FTIR analysis. The local order and disorder parameters and presence of active roman modes in strontium titanate compounds were investigated by Raman spectroscopy. The existence of oxygen vacancy, variation in oxidation states and shift in their binding energy of each element in compounds was analyzed by XPS. By SEM and TEM analysis, it is evident that the high degree of agglomerated spherical particles was found in pure $SrTiO_3$ compounds, whereas all the Cr doped compounds exhibits the spherical particles along with rod like shape. EDX spectra confirm the presence of Sr, Ti,

O and Cr elements. Further, the morphology of compounds was confirmed by TEM analysis. SAED pattern reveals the poly crystalline nature of all the prepared compounds. Optical absorption analysis of pure and Cr doped $SrTiO_3$ shows the intense absorption at 320 nm and the addition of dopant leads to shift towards higher wavelength which enumerates the decrease in optical band gap. Defective states and multi colour emission was observed in all the prepared compounds by photoluminescence studies, which confirms the excellent optical behavior of all the Cr doped compounds. EPR spectra confirm the ferromagnetic transition of Cr doped $SrTiO_3$ compounds was due to the carrier induced by dopants. Magnetization behaviour of Cr doped $SrTiO_3$ compounds reveals the occurrence diamagnetic to ferromagnetic phase transition. From the characterization studies, it was found that the room temperature ferromagnetic behaviour was not only attributed by oxygen vacancy whereas supported by the carrier induced by the dopants.

The effect of Cr doping on surface morphology, optical and magnetic characteristics of orthorhombic $SrSnO_3$ perovskite compounds was studied. The pure and Cr doped $SrSnO_3$ compounds was prepared by chemical precipitation technique. From the XRD pattern it was confirmed that the Cr^{3+} ion was incorporated into $SrSnO_3$ lattice. Metal oxide vibrations (Sr, Sn O and Cr) and the presence of Raman modes in the pure and Cr doped $SrSnO_3$ compounds were found and interpreted by FTIR and Raman spectroscopy. This confirms the chemical and structural purity of the prepared compounds. The high resolution scanning electron microscopy (HRSEM) reveals the agglomerated polydispersed particles of pure $SrSnO_3$ compound. All the other Cr doped compounds exhibits the rod like shape, further it was evident from TEM images. It was found that the increasing level of Cr^{3+} doping reduces the particle size and enhances “blue-shift” in the optical absorption spectra. The Calculated optical energy bandgap are found to be in the range of 4 eV. The shift in absorption band edge may be due to the incorporation of larger size Cr

ion and influences the luminescence efficiency significantly. The systematic investigation of optical studies reveals that interesting optical behaviour of Cr doped $SrSnO_3$.The trapped electrons in the oxygen vacancies induce the resonance EPR signal in pure $SrSnO_3$ compound. In Cr doped compounds the EPR signal arise due to the presence of paramagnetic centres. The magnetic study demonstrates that pure $SrSnO_3$ compound does not show the signature of ferromagnetic ordering, where as all the Cr doped samples possess oxygen vacancy in association with charge carrier leads to the transformation of dia to ferromagnetism. In addition, the surface morphology also influences the magnetic property of the prepared compounds.

The effect of Cr doping in structural, optical and magnetic studies of $SrMoO_4$ compounds were carried out. The samples were prepared by chemical precipitation method. Powder X-Ray diffraction pattern reveals that the pure and Cr doped compounds were crystallized in scheelite type tetragonal system. The analysis of metal oxide vibrations (Sr, Mo, O and Cr) and functional groups were identified by FTIR spectra. The Laser Raman spectra elucidate the presences of local order and disorder parameter in Cr doped $SrMoO_4$ compounds. XPS studies confirm the presence of oxidation states, chemical composition and evidence for oxygen vacancy in both pure and Cr doped compounds. Electron microscopy analysis authenticates the presence of irregular and agglomerated particles in pure $SrMoO_4$ compounds, whereas all the Cr doped compounds exhibits nuts like shape. Optical absorption spectra reveal the distinctive shift in absorption peak of pure and Cr doped compounds. The decreasing trend in optical bandgap values with increasing dopant concentration reveals the effect of Cr in $SrMoO_4$ lattice. The decreasing trend in PL intensity was observed in all the doped compounds which evident that the dopant may occupy the emission centers present in the host lattice. The presence of paramagnetic Cr^{3+} ion in the host lattice was found by EPR analysis. The magnetic study demonstrates that the pure $SrMoO_4$ compounds

exhibits the signature of paramagnetism whereas all the Cr doped compounds reveals the saturated ferromagnetic behaviour. From magnetization the characterization, it was found that the presence of excess free charge carrier leads to Cr^{3+}-Cr^{3+} interactions and results in ferromagnetic ordering till 15% doping of Cr and showing antiferromagnetic interaction in highly doped (20%) compounds.

Structural, optical and magnetic properties of pure and Cr doped $SrWO_4$ compounds synthesized by chemical precipitation method was studied. The scheelite type tetragonal structure was confirmed by Powder XRD analysis. The variation in crystallite size and shift in diffraction peaks confirms the incorporation of Cr in $SrWO_4$ lattice. The presence of metal oxide vibrations (Sr, O, W, and Cr) and functional groups were analyzed by FTIR analysis. Local order-disorder parameters of Cr doped compounds were investigated by Micro Raman analysis and found that the active Raman modes of $SrWO_4$ compounds were shifted towards lower region while increasing dopant concentrations and emphasis the tuning of inactive Raman modes into active by dopants. XPS study provides the evidence for oxygen vacancy, oxidation states of elements and shift in binding energy due to addition of Cr in $SrWO_4$ compound. The agglomerated microsphere like particulate system was investigated through HRSEM and TEM microscopy studies. Optical absorption spectral analysis of $SrWO_4$ compound exhibits intense absorption at 220 nm and a shift towards higher wavelength region addressing the interaction of Cr ion with $SrWO_4$ lattice and the possible tuning of band gap values. The enhanced luminescence intensity with distinctive blue and green emission provides the evidence of oxygen vacancies and confirms the excellent optical behavior of pure and Cr doped $SrWO_4$ compounds. EPR studies confirm the incorporation of paramagnetic Cr^{3+} ion into the $SrWO_4$ host lattice. Magnetization study demonstrates the signature of frustrated ferromagnetism in pure $SrWO_4$ compound and enhanced ferromagnetic ordering in Cr doped

$SrWO_4$ compounds due to the free charge carriers induced by dopants associated with oxygen vacancies.

From the present investigation, the effect of Cr which was doped in Strontium based perovskite ($SrTiO_3$& $SrSnO_3$) and scheelite ($SrMoO_4$& $SrWoO_4$) structured compounds was analyzed. In an overview, it was identified that the Cr ion interacts with host lattice and induces the morphological changes along with local disorder in all the compounds. Oxidation state of elements was also found affected by the dopant. From the transition metal series, doping of Cr ion strongly influences the electronic structure of the all the compounds which could be used to tune the bandgap of material by changing the electronic structure. In the case of Cr doped $SrTiO_3$ compounds, the inducement of ferromagnetic ordering leads the materials to be potential for magneto-optical applications. The Cr doped $SrSnO_3$ compounds show good optical and magnetic behaviour. Investigations on Cr doped $SrWO_4$ compounds reveals eminent optical features by showing strong photoluminescence characteristics but found to exhibit weak ferromagnetic behaviour. In Cr doped $SrMoO_4$ compounds the presence of Cr^{3+}- Cr^{3+} interaction, reflects on the magnetic property of the compounds. The enhanced ferromagnetic behaviour of all the Cr doped compounds may be explained on the basis of RKKY interaction theory of carrier mediated ferromagnetism. Hence from the present investigations, it was found that the physical nature of dopant ion, preparation technique, pH, temperature, doping level and morphological difference play important role on defining optical and magnetic properties of the prepared materials.

7.2 SUGGESTIONS FOR FUTURE WORK

- Attempts have to be made to prepare the title compound with different dopant such as transition metals, semimetals and rare-earth metals.
- Investigations on effect of doping in surface morphology of the compounds should be carried out for the analysis of optical and magnetic properties.
- Alternatively, different preparation method would be tried to synthesis uniform crystalline strontium based nanostructure compounds
- Semi metallic, Transition metal and Rare earth metals doped perovskite and scheelite nanostructures have to be evaluated with optical and magnetic properties for device fabrication.
- Attempts have to be made to prepare the title compounds in thin film form which could be useful for magneto-optical device applications.