Antisite disorder induced spin-glass and exchange bias phenomena in double perovskites

Thesis submitted in partial fulfilment for the Award of Degree
DOCTOR OF PHILOSOPHY

by
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18111009

YEAR OF SUBMISSION
2023

Chapter 6

Conclusions and future plan

6.1 Overview

In this thesis, studies of structural, morphological, compositional, and magnetic properties of double perovskite is reported. The key attraction of thesis is antisite disorder induced competiting FM/AFM interaction govering features like spin-glass, exchange-bias, memory and rejuvenation. Along with experimental, DFT analysis also conclude the presence of antisites. For collectively dynamics of spins, Cole-Cole formulism, electron spin resonance were presented. This chapter summarizes the results and conclusions with possible future extension of the work.

6.2 Results and conclusions

The La_2NiMnO_6 crystallites were synthesized using solid state routes having core-shell structure as confirmed by the transmission electron microscopy. The XPS analysis confirms the presenece of different charge valence and charge transfer. The different charge valences having different cation ordering with temperature confirmed by dc magnetization. **Chapter 3** describe the presence of multiple magnetic transition belong to different cations ordering and competiting FM/AFM interaction. This thesis highlights transitions temperatures shifted with mixing and magnetic field. The magnetization dynamics conclude by the ESR and Cole-Cole formulism.

The antisites disorder varies with site subtitution and mixing, present in thesis. **Chapter 4** conclude the *sol-gel* synthesized sample having biphase (rhombohedral+monoclinic) which transform into aphasic (monoclinic) structure with Sm doping. The Sm doping influence the antisite disorder confirmed by the spin-glass and exchange bias measuremnets.

The various protocols and charactersticis utilized to confirm spin-glass nature. The Sm-doping influenced the spin-dynamics and spin glass transition temperature. The Raman spectra also confirmed the antisites disorder decrease with Sm doping.

Chapter 5 highligts the novel findings of $La_{1.5}Sm_{0.5}NiMnO_6$. As Sm fraction increased above a threshold value spin-glass nature tranform to cluster glass nature due to faster spin dynamics. The exchange bias explored by the magnetic traning effect and different field cooled protocols. The magnetic memory effect also explored in this thesis. The DFT calculation was empliment to confirm the band structuture and antisites disorder. The antisites have antiferromagnetic interaction and its presence decreased the magnetization.

This thesis explored the presence of competiting FM/AFM interaction systems having magnetic frustration. The magnetic frustration and exchange bias was explored using various protocols and charterstictics. The Sm doping alter the spin glass state into a cluster glass phase.

6.3 Future scope of the work

The double perovkites are interesting topics due to wide range of applications and properties (such as multiferroic, laser, superconductor, LED, and X-ray imaaging etc). Especially in magnetism its show exotic magnetic features such insulating ferromagnet/antiferromagnet, metallic ferromagnet, spin-glass (geometric and spin frustration), Griffith phase, metamagnet, exchange-bias, *etc.* that these compounds interesting to investigate. There are various possible combination of double perovskites remains to explore, its open area to reserach.

We are focused on La_2NiMnO_6 due to its intersting properties, which are already discussed. This compound are the best material to explore the different magnetic properties driven by multiple charge valences and their distribution. The distribution of different charge valence intriguing different properties which also depend on crystallite size and shape. Advanced experimental tools (EXAFS, pdf, and LTEM) are needed to closely investigate the properties connection with cation distribution and valences.

This kind of materials have various other properties such as Mott materials, half-metallic, thermal, electronic and optical, which need to be investigated. The Sm have good thermal & optical properties therefore possibilty good properties which need to be investigate. The $SmNiO_3$ having Mott insulator characteristic, that devlop a possibility of this nature in this compound. In addition, it would be also interesting to fabricate the thin films on different substrates using pulsed laser deposition and sputtering technique to study their comparative effects on the structural, electronic transport and magnetic properties in

the context of film thickness, strain, surface roughness, substrate temperature, ambient gas pressure of chamber etc.