INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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SHORT ABSTRACT

Nanoscale transition metal (TM)-metal oxide matrix composites are indispensable materials for a wide range of potential technological applications due to their tunable physical properties. TM nanoparticles embedded/dispersed in a TM oxide matrix have been extensively applied in various areas of research, such as catalysis, gas sensors, Li-storage anodes, spintronic devices, and hard magnetic materials. For ferromagnetic TMs, changes in magnetic properties indicate the progression of *in situ* or *ex situ* reductions in TM-oxides. It forms an exciting part of the research for the creation of ferromagnetic nanoparticles embedded in an antiferromagnetic oxide matrix. Among them, NiO-based nanocomposites obtained through the in situ reduction process are a major thrust area for industrial applications. While most of the reported reductions of NiO are high temperature-based reactions, a preferable solid-solid mechanochemical (MC) reduction can lead to the fabrication of NiO-based nanocomposites with tunable structural and magnetic properties. Besides, NiO reduction processes are either limited to the evaluation of the structure or magnetic behavior of the nanocomposites. Although the microstructure and magnetic properties of a system at the nanoscale are closely connected, detailed studies involving both the features are rare in literature.

Hence, the present thesis work focuses on the detailed investigation of NiO reduction dynamics and the properties of the resulting NiO-(Al/Ti/Mg) based nanocomposites prepared by the MC processing using the high-energy planetary ball milling technique. The present study includes not only the effect of the substitutional elements on the nature and types of NiO reduction dynamics, but also the impact of reduction process on structural, microstructural, vibrational, and magnetic properties. The main objective of the research involves the understanding of the temperature and field-dependent magnetic properties of the composites and to find out the correlations between the various properties with the mechanochemical reduction dynamics and composition-dependent behaviors. The quantification of NiO reduction and the evolution of ferromagnetic Ni from antiferromagnetic NiO, the competing exchange interactions between Ni-NiO phases, finite-size effects, and enhanced magnetic anisotropy-induced ferromagnetic behavior of the nanocomposites have been studied in details.

These systematic investigations have several exciting outcomes, which contribute to the understanding of: (i) The reduction dynamics and the resulting physical properties of NiO-(Al/Ti/Mg) powders under different compositions and milling periods, (ii) The magnetic phase transitions, temperature-induced structural phase transformation, and the associated magnetic behaviors, (iii) The exchange bias effect and its magnitude depending on the relative fractions of NiO and Ni phases, (iv) The present studies have also revealed the strong correlation between structural, vibrational, and magnetic properties of NiO-(Al/Ti/Mg) based nanocomposites prepared under optimum milling conditions and (v) To the best of our knowledge, this is the first time we are reporting the mechanochemical reduction dynamics and the correlative magnetic behavior over a wide range of compositions.