INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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SHORT ABSTRACT

Spintronics is a rapidly growing field of research in multidisciplinary level and intensified by a strong synergy between breakthroughs in basic science and industrial applications. Particularly, in the area of semiconductor spintronics, the realization of materials that combine semiconducting behavior with robust magnetism has long been a dream of material physics. One of the precondition for semiconductor spintronics is the use of ferromagnetic semiconductors with large Curie temperature (T_C) above room temperature. Thus, the topic of diluted magnetic semiconductors (DMS) has received extensive interest.

In this thesis work, we have made an attempt to prepare various nanocrystalline oxides such as NiO, ZnO and TiO_2 using ball mill process in high energy planetary ball mill. Systematic studies of evolution of nanocrystalline structure, vibrational, electronic, magnetic, resonance and optical properties of NiO, ZnO and TiO_2 powders were carried out to understand the effect of milling. The milled powders were subsequently heat treated at elevated temperatures under air atmosphere to understand origin of ferromagnetism in these nanocrystalline oxides. For comparative study, NiO nanoparticles were prepared by sol-gel method with different molar concentrations and annealed at different annealing temperatures, and characterized. Structural studies of milled powders revealed that the average crystal size decreases with increasing milling time. The existence of defects, size reduction, oxidization of Ni^{2+} to Ni^{3+} due to breaking of Ni^{2+}-O^{2-}-Ni^{2+} super-exchange interaction could be evidently seen through Raman and X-ray photoelectron spectroscopy (XPS) spectra. Similarly, the development of defects due to oxygen vacancies and/or Zn interstitials in ZnO milled powders has been observed from Raman and XPS spectra. Raman and XPS studies in TiO_2 powders not only confirmed the development of defects, but also supported the formation of new phases with increasing milling period. On the other hand, NiO prepared through sol-gel method (i) showed the evolution of different shaped particles with increasing molar concentration, (ii) exhibited a new Raman band associated with magnetic origin induced by strong phonon-magnon interaction and (iii) revealed blue-shifting of band edge emission peak confirming finite size effect. Pure NiO, ZnO and TiO_2 powder exhibited antiferromagnetic (AFM), paramagnetic (PM) and PM nature, respectively, in bulk form, which transformed into ferromagnetic one at room temperature after milling. The magnitude of induced ferromagnetism in milled powders not only dependent on the milling period, but also on the type of nanocrystalline oxides. Annealing of as-milled NiO and ZnO powders resulted in a large reduction in magnetization and confirmed the origin of induced ferromagnetism as intrinsic one. High temperature thermomagnetization measurements showed the presence of mixed magnetic phases and on-set of ferromagnetic behavior with a well-defined T_C at high temperature above 700 K. The obtained results suggested that the NiO powders prepared by ball milling process having cubic structure, induced ferromagnetism at room temperature, high T_C and tunable optical properties could facilitate integration of spintronic devices.

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