

Stony Brook University The Graduate School

Doctoral Defense Announcement

Abstract

Multifunctional Iron-Based Metal Oxide Nanostructures: Synthesis, Characterization, and Properties

By

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Metal oxides are promising materials for the design and synthesis of multifunctional materials. They are noteworthy for their unique and diverse properties including ferroelectricity, ferromagnetism, and ferroelasticity. Recent research on a multiferroic system, such as BiFeO_3 , reveals that there are unique couplings among those independent physical properties. For this reason, metal oxide nanostructures are being considered as an interesting model system to investigate fundamental physical properties and for a host of potential applications as diverse as additives, catalysts, electronic devices, magnetic recording media, information storages, spintronics, and sensors.

Monodisperse metal oxide “nanostructures” with well-defined size, shape, chemical composition, and crystallinity are fundamentally interesting due to their fascinating size-dependent properties which are distinct from their bulk counterparts. Developing approaches to prepare and scale up as well as investigating properties of new synthetic formulations of these transition metal oxide nanomaterials has been the recent focus of much of our efforts in this group. Multiferroic bismuth ferrite (BiFeO_3) nanoparticles have been synthesized employing a facile sol-gel method and their size-dependent magnetic properties have been studied and correlated with: (i) increased suppression of the known spiral spin structure (period length of ~ 62 nm) with decreasing nanoparticle size and (ii) uncompensated spins and strain anisotropies at the surface. In addition, BiFeO_3 nanotubes have been generated using a modified template methodology and extensively characterized. Single-crystalline $\text{Bi}_2\text{Fe}_4\text{O}_9$ nanocubes have been fabricated utilizing a molten salt method and the role of various experimental parameters has been examined towards predictive control of shape and size. Furthermore, solid solutions of BiFeO_3 and typical perovskites, such as BaTiO_3 and SrTiO_3 , have been prepared employing a molten salt method and the study has been extended to properties associated with their inherent compositions. Single-crystalline iron oxide ($\alpha\text{-Fe}_2\text{O}_3$) rhombohedra have been generated using environmentally friendly protocols and transformed into aggregates of magnetic nanocomposites of Fe and Fe_3O_4 .

Date: August 9, 2007

Time: 10 am

Place: Chemistry Building, Room 412

Program: Chemistry

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