UNIVERSITY OF SOUTH FLORIDA
DEPARTMENT OF PHYSICS

COLLOQUIUM

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Dr. Michael McHenry
Department of Materials Science:
Carnegie Mellon University

The Role of Surface Crystallography in the Magnetic Response of NiZn Ferrite Nanoparticles.

ABSTRACT

The study of magnetic nanostructures is rich because many important magnetic length scales are on the order of 10 - 100 nm [1]. Ferrite nanomaterials have been investigated in recent years for potential applications in high-density magnetic recording, ferrofluid technology, magnetocaloric refrigeration, magnetic resonance imaging enhancement, and magnetically guided drug delivery. NiZn ferrites are the most important materials for high frequency (100 MHz - 1 GHz range) power applications because of their large resistivities, low conductive losses and high permeabilities.

In ferrite nanoparticles, the crystallography of terminating faces determines the symmetry of atomic environments at the surface. Oxygen mediated JAB and JBB superexchange bonds determine the temperature dependence of the magnetization and whether the alignment of cation magnetic dipole moments is collinear or non-collinear. The symmetry of surface polyhedra also determines surface magnetic anisotropy. Two important observations pertinent to the faceted nanoparticles are (1) the ratio of the number A-B to B-B exchange bonds at the (111) surfaces is smaller than in the bulk, and (2) the 4-fold screw axis symmetry of the bulk crystal is broken to yield linear chains of octahedra at (100) terminated faces of nanoparticles The former coupled with a higher concentration of non-magnetic Zn atoms on surface A-sites of the (111) terminated surfaces gives rise to non-collinear triangular spin configurations and the latter yield a uniaxial surface magnetic anisotropy in the large nanoparticles.

I will review TEM and HRTEM observation polyhedral surface structure of polydisperse NiZn ferrite nanoparticles synthesized using an RF plasma torch. The nanoparticles exhibit truncated cuboctahedral morphologies with more (111) surface area than (100). The critical nucleus shape is a perfect octahedron, while growth forms assume Wulff shapes. The relationship between morphology and the atomic structure of the faceted nanoparticles has been studied using Mössbauer spectroscopy and Extended X-ray Absorption Fine Structure (EXAFS) analysis. The contribution of the faceting to the surface magnetic anisotropy of the (100) and the (111) surfaces will be used to interpret the dynamic transverse susceptibility and low temperature static magnetic measurements in these systems. A surface structural model is proposed to explain surface spin canting and magnetic anisotropy for the observed (100) and (111) nanoparticle surfaces in the polydisperse and size-selected monodisperse nanoparticles.

1. M. E. McHenry and D. E. Laughlin, "Nano-scale materials development for future magnetic applications" Acta Materiala (Millenium Issue) 48 (2000) 223.