Tentative Outline

Special Issue for RECENT PATENTS ON MATERIALS SCIENCE

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MULTIFERROIC AND MAGNETO-ELECTRIC MATERIALS

Aims & Scope:

Multiferroics can be primarily defined as single phasic materials which simultaneously possess two or more primary ferroic viz. ferroelectric, ferromagnetic, ferroelastic and ferrotoroidic properties. Today the term multiferroic has been expanded to include materials which exhibit any type of long range magnetic ordering, spontaneous electric polarization, and/or ferroelasticity. Ferrotoroidicity is almost excluded from the fundamental definition. Both single phasic and composite/multilayers that show simultaneous multiferroic orders are now included in this definition. Extensive research is being carried out in unraveling different single phasic/composite materials which possess multiferroic ordering. Considering the new expanded definition of multiferroism, the history of magnetoelectric materials and multiferroics can be traced long back to the 1960s. Hence, the field of multiferroics can be thought of originated primarily from the studies of magnetoelectric systems. In 2003, a large ferroelectric polarization was reported in epitaxial $BiFeO_3$ thin films which triggered a prominent jump towards the multiferroics for device applications. Strong magneto-electric coupling in orthorhombic $TbMnO_3$ and $TbMn_2O_5$ was reported following to the discovery of multiferroic $BiFeO_3$ thin films, which stimulated the recent research activities in the field of multiferroics. Composite multiferroics can have bulk (3-0 Dimensional, with the ferroelectric/piezoelectric particles in the bulk form with the magnetic counterparts in the nanoparticulate form), multilayer (2-2 Dimensional), and the 2-1 type (one of the constituent as nanowires, rods or tubes) structures.

Multiferroic materials possess extensive application potential. Multiferroic composite structures in bulk form are explored for high-sensitivity ac magnetic field sensors and electrically tunable microwave devices such as filters, oscillators and phase shifters (in which the ferri-, ferro- or antiferro-magnetic resonance is tuned electrically instead of magnetically.

In multiferroic thin films, the coupled magnetic and ferroelectric parameters are often exploited for the fabrication of magnetoelectric devices. One of the most important applications comes in novel spintronic devices like tunnel magnetoresistance (TMR) sensors. A typical TMR device has two layers of ferromagnetic materials separated by a thin tunnel barrier (~2 nm) made of a multiferroic thin film and hence spin transport across the barrier can be electrically tuned.

Another application which is closely related is the spin valves with electric field tunable functions. In this configuration, a layer of multiferroic material is used as the exchange bias pinning layer. This allows the electric field tunability of the magnetoresistance of the device if the antiferromagnetic spin orientations in the multiferroic pinning layer can be electrically tuned. Another important application of multiferroic materials is in the multiple state memory elements where data are stored both in the electric and the magnetic polarizations.

Magneto-electrics are closely related to multiferroics. Their dielectric polarization can be controlled in presence of an applied magnetic field and there can be induced magnetization in applied electric field. It requires simultaneous presence of long-range ordering of magnetic moments and electric dipoles. They have applications in spintronics, different types of sensors actuators and switching devices.

Key words: Multiferroic magnetoelectric materials, nanocomposite thin films, electrophoretic deposition, tunable microwave devices, micromechanics, doped manganites.

Subtopics:

Multiferroic magnetoelectric nanocomposite thin films

Multiferroic thin films-synthesis to device applications

Thick and thin films of multiferroic materials by Electrophoretic Deposition for microelectronics applications.

Multiferroic materials for Tunable microwave devices

Multiferroics and magnetoelectric materials for spintronics applications

Multiferroics for microelectronics and micromechanics

Giant Room Temperature Magnetoimpedance in doped manganites

Schedule:

Manuscript submission deadline: December 2012