Ferromagnetic Semiconductors: Ilmenite-Hematite (FeTiO$_3$-Fe$_2$O$_3$) Solid Solutions

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What is (1-x)FeTiO$_3$.xFe$_2$O$_3$ (IH) solid solution system?

- Growth of Single Crystal Films of IH members
- Determination of as many physical properties as possible
- Study spin transport properties
- Study the effect of radiation on materials properties and device performance
- Fabrication and evaluation of p-n and tunnel junction devices

Objectives

Magnetic moment and transition temperature for different compositions of Ilmenite-Hematite

- Ferrimagnetic or antiferromagnetic properties depending on x:
  - Tc or TN > room temperature
  - Semiconducting properties (p or n type): x dependent
  - High degree of radiation resistance to proton and neutron

Magnetic moment before and after neutron and proton irradiation

- Ferrimagnetic Phases
  - Magnetic moments unaffected after neutron irradiation
  - Magnetic moments enhanced after proton irradiation
  - Magnetic moment of Ilmenite increases with increase in Mn concentration
  - Good single crystals grown by high temperature solution route
  - Highly textured films on MgO and Sapphire substrate

X-ray diffraction of single crystal of IH with x=0.33

- TEM : Diffraction Pattern and Bright Field Image of x=0.33

X-ray diffraction of IH with x=0.33 on Sapphire (c-axis) and MgO Substrate

Seebeck coefficient as a function of composition

- Wide band gap, 2.0<E$_g$<2.58 eV
- Semiconducting properties (p or n type): x dependent
- Ferrimagnetic or antiferromagnetic properties depending on x:
  - Tc or TN > room temperature
- Ferroelectricity with T$_c$ ≈ 600 K for x = 0

Conclusions and Future Work

- Nature and mechanism of transport – spin and electronic
- Models for coupled behaviors – dielectric+magnetic+semiconductor
- Fabricate tunnel junction devices