Fabrication of Thin-Film Materials

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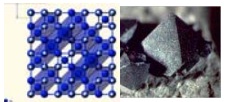
Motivation


http://webmineral.com/data/Magnetite.shtml

Multiferroic composite material consisting of both ferro-/ferrimagnetic and ferroelectric phases offer applications in multifunctional micro-devices:

1. These materials can display magnetoelectric (ME) effect, a dielectric polarization variation in response to an applied magnetic field.
2. These materials can display an induced magnetization by an external electric field.

ENHANCED POTENTIAL TUNEABILITY + MINIATURIZATION

Methods for Preparing Ferrite Thin-film

Spin-spray
Physical Vapor Deposition
Sol-Gel
Alternating Target Laser Deposition
Pulsed Laser Deposition
Molecular Beam Epitaxy-Chemical Vapor Deposition
others

Advantage of the Spin Spray Technique

-direct plating of thin-film from an aqueous solution at a low temperature (≤ 90°C) compared to conventional film preparation methods (>600°C)
--no vacuum
-Ease of screening multiferroic composites for optimizing magnetic and electrical properties
-Low cost

•Research Experience for Teachers at Northeastern University
Claire Duggan, Program Director

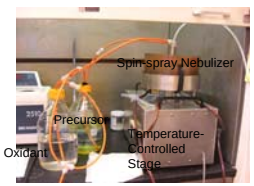
Preparation of Multiferroic Ferrites

An aqueous solution with various stoichiometric combinations of Ni(II), Co(II), Zn(II) and Fe(II), and a pH of 4.7-5.5 was used as a precursor solution.

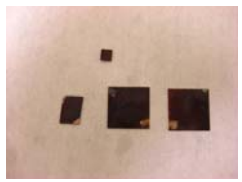
An aqueous solution of sodium nitrite and sodium acetate, and a pH of 8.2-9.2 was used as oxidizing solution.

Through separate nozzles, these two solutions were simultaneously sprayed at a flow rate of 70 mL/min onto a spinning hot substrate at 90°C, with a rotation speed of 150 rpm, under N_2(g) atmosphere.

After 30 minutes of plating, a uniform thickness (1 μm) of the ferrite film on the substrate was obtained.



Spin-Spray Set-up


Ferrite Thin-films

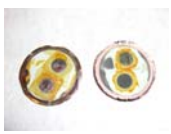
Preparation of Nanowires


Physical Vapor Deposition (PVD) Instrument

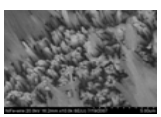

Copper deposited on Whatman Anodisc 47


EG&G Princeton Applied Research Potentiostat 273A

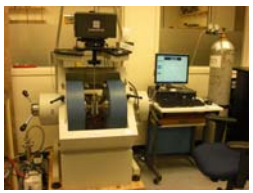

Flat cell K0235 with Nickel(II) solution

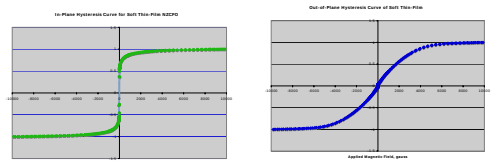

Nickel nanowires after 30 min electrodeposition

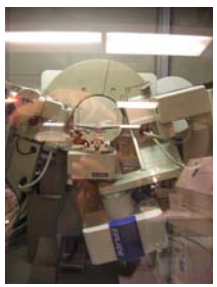

Nickel nanowires isolated from alumina membrane

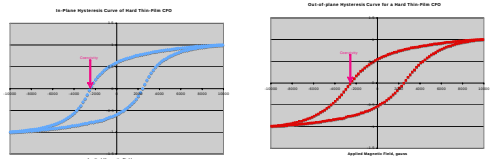

Nickel nanowires viewed using SEM

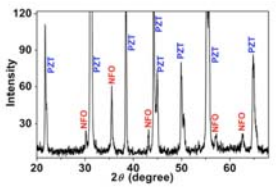
Characterization of Thin-FIlms


Lakeshore Vibrating Sample Magnetometer for magnetic property measurements



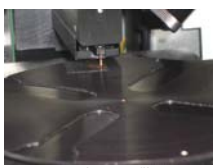

Rigaku Xray Diffractometer for crystalline phase measurements

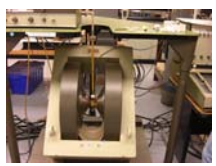


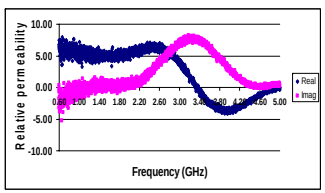


XRD of a Nickel Ferrite on a PZT substrate


http://www.crystalmaker.com/crystaldiffract/


Veeco Stylus Profilometer for film thickness measurements.


Varian Ferromagnetic Resonance Spectrometer



Permeability measurement showing the resonance frequency of a ferrite sample

Extension in a High School Classroom

Fabrication of nanomagnetic thin-films and nanowires will be discussed in a unit on nanomaterials, employing the chemical principles of precipitation, crystal structure and oxidation-reduction reaction using electrochemistry.

Dry lab using CrystalDiffract software to understand how XRD can be used to fingerprint and determine the number of polycrystaline phases present in the thin film.

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