EPITAXIAL MULTIFERROIC THIN FILM HETEROSTRUCTURE OF (SrTiO3/NiO)n/MgO FOR USE AS A FUTURE NEGATIVE INDEX MATERIAL

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ABSTRACT

Multiferroic materials are those that exhibit both magnetic polarization and electrical polarization in the same phase. A multiferroic thin film heterostructure consisting of antiferromagnetic NiO and dielectric $SrTiO_3$ is interesting due to the possibility of achieving a negative index of refraction in the far infrared. If the ionic resonance frequency of $SrTiO_3$ (~100cm^{-1}) and the antiferromagnetic resonance of NiO (~36 cm^{-1}) can be shifted to match at some frequency, the composite material should exhibit a negative index of refraction at that frequency. It should be possible to shift the $SrTiO_3$ resonance to lower frequency by lowering the temperature or by doping with Ba and therefore raising the ferroelectric Curie temperature. The NiO antiferromagnetic resonance should shift to higher temperature by applying an external magnetic field or by doping with ions with higher anisotropy, such as Fe or Co. Pressed powder bulk composite samples of NiO/$SrTiO_3$ have been fabricated and used to verify that NiO and $SrTiO_3$ are compatible and non-reacting up to a temperature of 1550°C. FTIR measurements on these bulk samples verify the existence of the ionic and antiferromagnetic resonances of interest. An epitaxial multiferroic composite of $(SrTiO_3/NiO)_n$/MgO has also been fabricated using reactive off-axis rf sputtering with n = 1 or 2. Crystal quality has been verified using x-ray diffraction and ion channeling with Rutherford backscattering. The full width at half max for the $SrTiO_3$ (100) diffraction rocking curve is only 1.3° for the composite with n = 2. Off-axis sputtering is a useful technique because it can be used to achieve a concentration gradient between constituents. This allows for a method of quickly determining the effects of Ba doping in $SrTiO_3$ or Co, Fe doping in NiO. It should be possible to measure the frequency response of these films in the future with FTIR techniques with polarized radiation and/or a synchrotron high intensity source.

BIOGRAPHICAL SKETCH

Steven Kirby, originally from Moatsville, WV graduated from Rochester Institute of Technology with honors in a B.S. degree in Microelectronic Engineering in May 2003. While there he also completed internships at Dominion Semiconductor in Manassas, VA and Micron Technology in Boise, ID. He began studying Materials Science & Engineering at Cornell University in the fall of 2003.

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