Contribution ID : **87** Type : **not specified**

Reversible electrochromism, elasto-optic and thermo-optic effects in BiFeO3 films

Friday, 5 February 2016 09:15 (15)

Chromism refers to a change in optical absorption of a material upon application of stimulus; e.g. photochromism – light; thermochromism – heat; electrochromism – electric charge; magnetochromism – magnetic field. This phenomenon has wide applications, in for example so-called 'smart glass' which can be switched from a transparent to opaque state through the application of voltage, heat, or light.
Bismuth ferrite (BiFeO3 – BFO) is the only known single-phase multiferroic material whose ordering temperatures are above ambient (ferroelectric TC = 1200 K; antiferromagnetic TN = 640 K) [1]. As a consequence, this material has attracted enormous research interest, on both a fundamental level and for its promise in room-temperature spintronics. In addition to its outstanding ferroelectric properties and rich spin physics, BFO has rather striking optical properties: a band gap in the visible range (attractive for light harvesting applications); a bulk photovoltaic effect with open-circuit voltages much higher than the band gap, very large birefringence, and a significant electro-optic response [2].
Epitaxial strain has been shown to be a powerful means of modifying the physical properties of BFO films [3]. By depositing strained thin films on substrates with different lattice parameters, the effects of both compressive and tensile strain can be explored. Important phenomena revealed using this technique are the drastic modification of the ferroelectric ordering temperature [4], and the spin order [5]. In addition, large compressive strains can stabilize a highly-distorted polymorph (T-like phase BFO) which shows distinctly modified physical properties when compared to the R (bulk-like) phase. Of particular relevance to this work is the larger optical band gap and the related modulation of optical absorption for photon energies near the band edge.
In this presentation we first describe the effect of epitaxial strain on the optical band gap and refractive index of strained BFO films. Via strain engineering techniques we uncover a large elasto-optic effect (change in refractive index with strain) that surpasses that of the best acousto-optic materials (such as quartz or TeO2). More importantly, through dynamic switching between the different phases, we demonstrate a time-stable, reversible, and intrinsic electrochromic effect. Furthermore, through temperature dependent optical measurements, we reveal a large thermo-optic effect (change in index with temperature), a phenomenon which could be attractive for optical modulators or switches. Our results constitute an important first step in the development of integrated multifunctional thin film optical devices based on complex oxides. Indeed the coupling of optical, magnetic, and piezoelectric orders possible in this class of materials suggests new device opportunities based on ferroelectric and multiferroic thin films.

References

[1] G. Catalan and J.F. Scott, Adv. Mater. 21, 2463 (2009).
[2] D. Sando et al, Phys Rev. B 89, 195106 (2014).
[3] D. Sando et al, J. Phys. Cond. Mat. 26, 473201 (2014).
[3] I.C. Infante et al, Phys. Rev. Lett. 105, 057601 (2010).
[4] D. Sando et al, Nat. Mater. 12, 641 (2013).

Primary author(s) : Dr SANDO, Daniel (School of Materials Science and Engineering, University of New South Wales)

Presenter(s) : Dr SANDO, Daniel (School of Materials Science and Engineering, University of New South Wales)

Session Classification : Contributed talk