Tuning functional properties of $BiFeO_3$ films using strain and growth chemistry

Daniel Sando

University of New South Wales (UNSW Sydney), High St, Kensington, NSW 2052, Australia
E-mail: daniel.sando@unsw.edu.au

Multiferroics – materials with coexisting ferroic orders such as ferroelectricity and (anti)-ferromagnetism – are presently under intense study by virtue of their promise in next-generation data storage devices. Bismuth ferrite ($BiFeO_3$ – BFO) is one of the few that orders above room temperature. In the bulk, BFO is rhombohedral (R), and in thin films [1] its properties are sensitive to strain [2,3]. The discovery of the epitaxially-stabilized "super tetragonal phase" of BFO (T-BFO) [4] incited a flurry of research activity focused on understanding the phase transition and its possible functionalities [5]. T-BFO is also multiferroic, with large ferroelectric polarization and antiferromagnetic order [4], and the strain relaxation-induced T/R phase mixtures and their exceptional piezoelectric responses [6] continue to intrigue and motivate researchers. A particularly important characteristic of this phase mixture is the interconversion between the R,T phases with an applied electric field [6]. Since the oxygen configuration of the R and T polymorphs is different [5], the electronic, magnetic, and optical properties can thus be dynamically modulated. An additional rather crucial (and thus far underexplored) aspect of mixed R/T BFO is the role of *chemistry* in the formation of the metastable T-phase. Since T-BFO is typically fabricated by pulsed laser deposition, growth parameters can be used as a handle to tailor film properties and functionalities.

Here we describe the influence of *strain* and *growth conditions* on the optical, magnetic, and ferroelectric properties of BFO films. We also show that by precisely controlling the fabrication conditions, the formation of the mixed R/T phase can be completely suppressed for film thicknesses up to 100 nm. Such a result is useful for applications where thicker pure T-BFO films are needed, such as for measuring the giant polarization, or for precisely controlling the proportions of the various phases. Finally, through analysis of a large set of epitaxial films, we show that the optical band gap of BFO is rather insensitive to a host of growth and processing parameters [7]. Combined with the numerous other functionalities of this material, one can envisage multifunctional devices, for example, that harvest mechanical and solar energy, or to enhance magnetoelectric coupling at these phase boundaries.

References

[1] Sando *et al*., J. Phys: Condens. Matt. **26**, 473201 (2014).
[2] Infante *et al*., PRL **105**, 057601 (2010).
[3] Sando *et al*., Nat. Mater. **12**, 641 (2013).
[4] Bea *et al*., PRL **102**, 217603 (2009).
[5] Sando *et al*., Appl. Phys. Rev. **3**, 011106 (2016).
[6] Zeches *et al*., Science **326**, 977 (2009).

[7] Sando *et al*., Adv. Opt Mater. **6**, 1700836 (2018).