Electric field control of magnetic easy axis using phase competition in tensile strained $BiFeO_3$ thin films

Jin Hong Lee[1*], Kanghyun Chu[1], Ahmet A. Ünal[2], Sergio Valencia[2], Florian Kronast[2], Stefan Kowarik[3], Jan Seidel[4], and Chan-Ho Yang[1,5]

[1]Department of Physics, KAIST, Yuseong-gu, Daejeon 305-701, Republic of Korea

[2]Helmholtz Zentrum Berlin, Elektronenspeicherring BESSY II, Albert-Einstein-Strasse 15, Berlin 12489, Germany

[3]Institut für Physik, Humboldt-Universität zu Berlin, Newtonstrasse 15, Berlin D-12489, Germany

[4]School of Materials Science and Engineering, University of New South Wales, Sydney, New South Wales 2052, Australia

[5]KAIST Institute for the NanoCentury, KAIST, Yuseong-gu, Daejeon 305-701, Republic of Korea

Multiferroic $BiFeO_3$ (BFO) has been intensively studied since it displays both ferroelectric and antiferromagnetic order at room temperature. Recently, phase competition between tetragonal-like BFO and rhombohedral-like BFO in the regime of compressive strain has been discovered [1], and its intriguing properties have been addressed in a strain-driven morphotropic phase boundary [2-5]. Nevertheless, phase competition between rhombohedral-like BFO (R-BFO) and orthorhombic BFO (O-BFO) in the regime of tensile strain has not been reported in-depth [6-8].

In this presentation, we report on phase separation and electric field switching between R-BFO and O-BFO phases in tensile-strain-induced $BiFeO_3$ thin films. We analyze the strain state, ferroelectric domain structure, and magnetic easy axis of tensile strained R-BFO and O-BFO through x-ray reciprocal space mapping, piezoresponse force microscopy, and Fe L-edge x-ray absorption spectromicroscopy, respectively. We propose a new route toward magnetoelectric application of BFO thin films by controlling the spatial distribution of R-BFO and O-BFO with a voltage-biased conductive AFM tip [9].

[1] R. J. Zeches *et al*., Science **326**, 977 (2009).
[2] J. X. Zhang *et al*., Nature Nanotechnol. **6**, 98 (2011).
[3] A. R. Damodaran *et al*., Adv. Mater. **23**, 3170 (2011).
[4] Q. He *et al*., Nature Commun. **2**, 225 (2011).
[5] K.-E. Kim *et al*., NPG Asia Mater. **6**, e81 (2014).
[6] B. Dupé *et al*., Phys. Rev. Lett. **106**, 237601 (2011).
[7] Y. Yang *et al*., Phys. Rev. Lett. **109**, 057602 (2012).
[8] I. C. Infante *et al*., Phys. Rev. Lett. **105**, 057601 (2010).
[9] J. H. Lee *et al*., Phys. Rev. B (to be published).