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Multiferroic thin films investigated by neutron diffraction

Artificially grown thin film heterostructures of transition metal oxides by far exceed the capabilities of current semiconducting technology as they offer additional functionalities such as metal-insulator transitions, magnetism, superconductivity, or multiferroicity. Bismuth ferrite (BiFeO3) is the rare case of a room temperature multiferroic material and offers as such the most promising pathway for spintronics applications. The existence of a spin cycloid, which is mandatory for magneto-electric switching, is hindered in thinnest films due to the large epitaxial strain. Our neutron diffraction experiments have demonstrated that we were able to realize a spin cycloid in thinnest films through improved electrostatic and epitaxial constraints [1] and the use of Co-doping. This cycloid, despite its out-of-plane propagation vector, can be stabilized in films as thin as 25 nm, a length smaller than the cycloid period itself. The cycloid expands significantly for thinnest films and as a function of temperature close to TN and showing a distinct systematic scaling behaviour.
A further fascinating example are SrCoO3 thin films. Theoretical calculations have predicted ferromagnetic to antiferromagnetic phase transitions induced by epitaxial strain. With the proper choice of substrate material we were able to confirm the FM-AFM transition by neutron diffraction [2]. As such, SrCoO3 would constitute a new class of multiferroic material where magnetic and electric transitions can be driven through external strain. This opens new avenues for fundamental research and technical applications in spintronic or magnonic devices.

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[1] J. Bertinshaw, et al., Nature Comm. 7, 12664 (2016).
[2] S. J. Callori, et al., Phys. Rev. B 91, 140405(R) (2015).

Topic

Advanced Materials

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