Imaging the magnetic order in antiferromagnetic thin films using scanning NV magnetometry

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Abstract :

Antiferromagnetic (AF) thin films are currently attracting considerable excitement for low dissipative spintronic devices [1,2]. However, most of conventional real-space magnetic microscopy techniques cannot probe the AF order at the nanoscale because magnetic moments are mostly compensated, resulting in very low magnetic signals. This is a major obstacle to the fundamental understanding of nanoscale AF order and its response to external stimuli, such as spin polarized currents or electric fields. To release the full potential of AFs for next-generation spintronics, the nanoscale control and imaging capabilities that are now routine for ferromagnets must be extended to AF materials. Here we show that scanning magnetometry based on a single nitrogen–vacancy (NV) defect in diamond is ideally suited for imaging complex AF orders at the nanoscale, even under ambient conditions. As a proof of principle, we report on the first real-space visualization of a non-collinear AF order in a thin film of bismuth ferrite $BiFeO_3$(BFO), a room-temperature multiferroic material in which the AF order is intimately linked to the ferroelectric one via magnetoelectric coupling. We first image the cycloidal AF order in a BFO thin film and demonstrate that magnetoelectric coupling can be exploited to manipulate the cycloid propagation direction by an electric field [3]. We then investigate the effect of epitaxial constraint on the behaviour of the AF order in strained BFO thin-films [4]. Different substrates were used for the growth in order to tune the strain. Using scanning NV-magnetometry, we proved that tuning strain can stabilize different propagation directions of the cycloid, can change the plane in which the cycloid rotates or can collapse the cycloid into G-type antiferromagnetic domains in highly strained films. These results demonstrate how BFO can be used to design reconfigurable AF spin textures on demand.

References

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