Observation and analysis of current-driven motion of magnetic domain boundaries in a chiral-lattice helimagnet FeGe

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A magnetic skyrmion[1] is a nanometer-scale vortex-like magnetic structure stabilized in magnets without spatial inversion symmetry. The magnetic skyrmions have been actively investigated for their potential applications to the next generation magnetic memory devices owing to its particle nature and mobility. Understanding their electric-current-induced dynamics is indispensable for their practical applications. Although there are experiments and theories on current-induced dynamics of magnetic skyrmions, direct observation of their dynamics is still limited especially in chiral-lattice magnet system.

Here, we study the current-induced dynamics of the coexistence states of magnetic skyrmions and magnetic helices in a thin plate of B20-type helimagnet FeGe using Lorentz transmission electron microscopy (TEM)[2]. Current pulses with various heights and widths were applied, and Lorentz TEM images before and after each single pulse application were analysed. We mapped out distribution of magnetic domains, skyrmions and magnetic helices, using a machine-learning technique (Figure) and evaluated the shift of the domain boundaries. Our analysis has revealed that the domain boundaries tend to move in anti-parallel direction to the electric current and that the critical current density required for driving the boundary is about 1×10^9A/m^2. We also found that the driving distance tends to increase with increasing the pulse duration time, current density, and sample temperature.

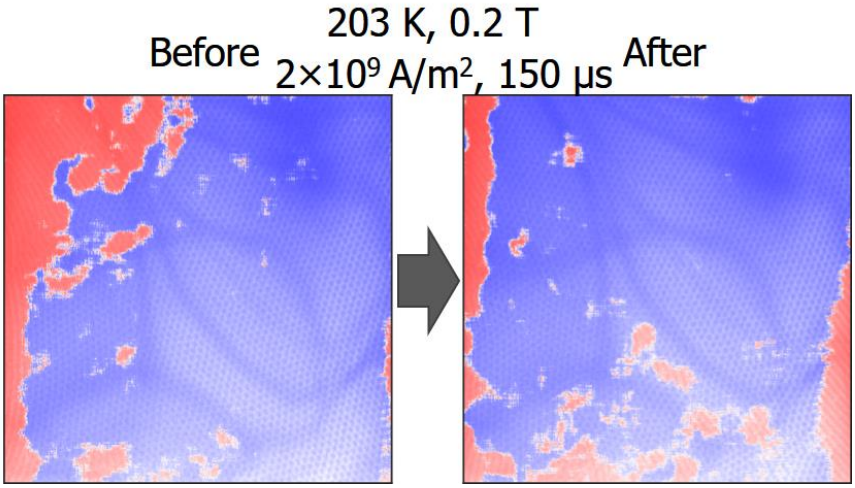

Figure:

Colored over-focused Lorentz TEM images before and after single current pulse application. Blue and red color corresponds analyzed domain type of skyrmion lattice and helix, respectively.

[1] S. Mühlbauer *et al.*, Science **323**, 915 (2009); X. Z. Yu *et al.*, Nature **465**, 901 (2010),

[2] K. Shibata *et al.,* Nano Letters **18**, 929 (2018).

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