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Real Time Imaging of Topological Magnetic Defects in Lorentz TEM

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Abstract :
Skyrmion, which is vortex-shaped spin structure, is quasi-particle with topological property. This topological property is due to the topological charge Q, also called the skyrmion number, and the skyrmion satisfies Q = 1 (for the core magnetization of -nz). Thanks to the topology, the skyrmion has a stable structure and can move with the electric current a million times lower (10^{-6}) than that of a magnetic domain wall. This property give skyrmion a remarkable potential for application such as next-generation semiconductors and spintronics devices.
Here, we report new types of skyrmion and skyrmionic bubble in centrosymmetric permanent magnet $Nd_2Fe_{14}B$ by field cooling (FC) and investigate their properties using LTEM. Since it is known that uniaxial anisotropy suppresses the formation of skyrmions, it is astonishing that skyrmions appear in $Nd_2Fe_{14}B$, a hard magnet with large uniaxial anisotropy. Skyrmions are typically generated by raising the magnetic field in the stripe domain, but skyrmions in $Nd_2Fe_{14}B$ do not appear in this way. The only way to generate skyrmion is the FC at the specific range of magnetic field. Unlike the conventional skyrmions, the skyrmions in Nd2Fe14B are surrounded by a shell and coexist in opposite helicities. A helicity reversal is also observed, in which the skyrmions in opposite helicities are reversed without any manipulation. Detail magnetic sturcuture of the skyrmion and skyrmion bubbles will be discussed by LTEM and TIE analysis.

Keyword :
Lorentz TEM, skyrmion, magnet, topological property

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