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Magnetism of epitaxial Fe nanofilms on three-dimensionally structuralized Si{111} facet surfaces

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In nanostructured magnetic materials, such as ferromagnetic nanofilms, the magnetic behavior is widely determined by the interaction of the magnetization with its shape, by fabricating thin-film patterns with controlled boundaries between ferromagnetic regions, such as disks and squares, characteristic in-plane magnetic moment distributions such as magnetic vortices can be created [1,2]. In this case, the magnetic interaction is restricted to the flat surface. On the other hand, in ferromagnetic nanofilms on three-dimensional structures such as pyramids, the creation of various magnetically stable structures such as symmetric and asymmetric magnetic vortices depending on the three-dimensional pyramid's size and thickness of the film is predicted from Landau-Lifshitz-Gilbert (LLG) simulations have been predicted [2]. However, so far, there is no successful experimental demonstration have been obtained due to the difficulty in fabricating micro- and nano-sized 3D nanofilms with high accuracy [2].

Our group has successfully fabricated pyramidal structures with Si{111} clean faceted surfaces (edge width $\boldsymbol{W}$ 16 μm) on Si(001) substrate by combining Si substrate processing technology and ultra-high vacuum surface technology, and performed Fe deposition (film thickness $\boldsymbol{\Theta_{Fe}}$ 30 nm). The magnetization field (*M-H*) curve of the pyramid-shaped Fe nanofilm controlled with atomic precision was measured by vibrating sample magnetometer, and the characteristic of the *M-H* curve (bending point due to stable magnetic vortex formation) predicted by LLG was observed (Fig. 1) [3].

In the present study, in order to further understand the magnetic behavior of three-dimensional magnetic nanofilms, we have investigated 1) the thickness dependence of Fe film ($\boldsymbol{\Theta_{Fe}}$ = 30-150 nm) in the pyramidal structure ($\boldsymbol{W}$ 16 μm), 2) the aspect ratio dependence of the pyramidal structure with different length ($\boldsymbol{L}$) and fixed width ($\boldsymbol{W}$), that is, the facet line structure (Fig. 2, $\boldsymbol{W}$ 16 μm, $\boldsymbol{L}$ / $\boldsymbol{W}$ = 1-10, $\boldsymbol{\Theta_{Fe}}$ 150 nm) were measured. In this talk, we will report the details.

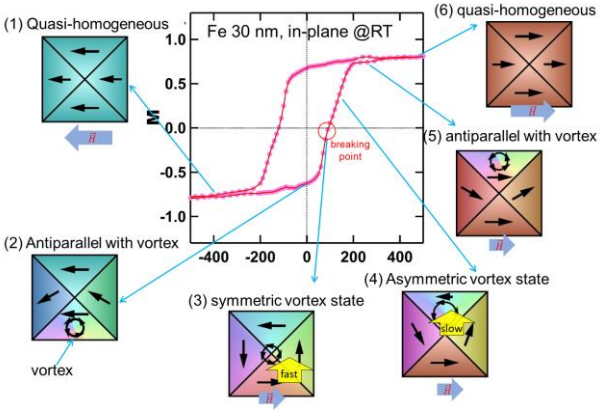

Fig. 1. *M-H* curves of pyramidal Fe nanofilms.

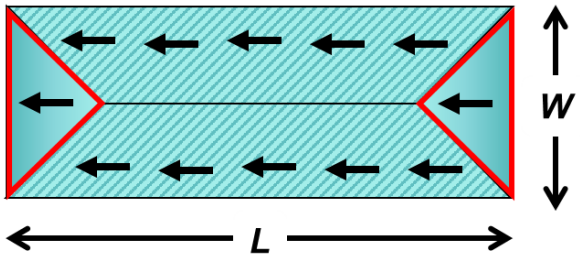

Fig. 2. Facet line structure with different aspect ratio (L/W).

References

1) A. Knittel et al., New. J. Phys. **12**, 113048 (2010).
2) R. P. Cowburn et al., Phys. Rev. Lett. **83**, 1042 (1999).
3) A. Irmikimov, L. N. Pamasi, K. Hattori, et al., ACS Cryst. Growth Des. **21**, 946 (2021).

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