

Fabrication and magnetic control of $\text{Y}_3\text{Fe}_5\text{O}_{12}$ cantilevers

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Spin mechanics, in which interplay between magnetism and mechanical motion is explored, is a new research field emerging along with the advance in spintronics [1]. To detect mechanical effects induced by spins, a cantilever structure provides one of the most suitable tools [2]. We have fabricated ferrite cantilevers in which their vibrational properties can be controlled by external magnetic fields. Submicron-scale cantilevers were made from $\text{Y}_3\text{Fe}_5\text{O}_{12}$ (YIG) films by physical etching combined with use of a focused ion beam (FIB) milling technique. FIB milling is a popular technique for rapid and maskless nanofabrication via the sputtering of target materials. A fabricated YIG cantilever with a Pt deposited mirror is shown in Fig. 1. Figure 2 shows that the cantilever exhibits two resonance modes which correspond to horizontal and vertical vibrations. Under external magnetic fields, the resonance frequency of the horizontal mode increases, while that of the vertical mode decreases, quantitatively consistent with our numerical simulation for magnetic forces. The frequency shifts with magnetic fields are plotted as a function of external magnetic fields for the YIG and a gadolinium gallium garnet (GGG) cantilevers (shown in Fig. 3). The changes in resonance frequencies with magnetic fields reach a few percent, showing that the efficient magnetic control of resonance frequencies was achieved. The efficient magnetic control is well explained by a magnetic force gradient created from the surrounding YIG. We believe that the YIG cantilever will provide great application for mechanical detection of spin currents.

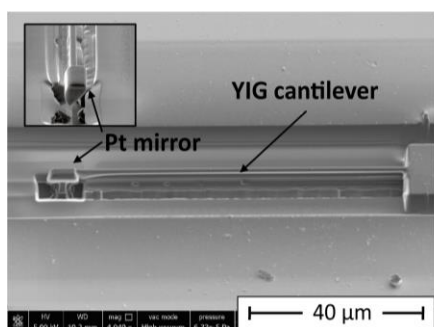


Fig.1. SEM image of YIG cantilever with Pt mirror

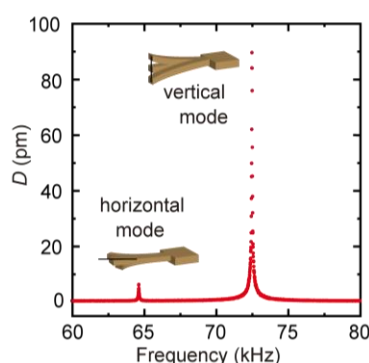


Fig.2. Mechanical resonant spectrum of YIG cantilever

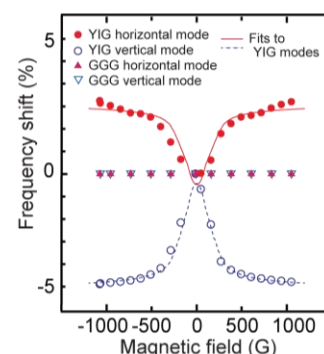


Fig. 3. Frequency shifts with magnetic field

[1] S. Maekawa, S. O. Valenzuela, E. Saitoh, and T. Kimura, *Spin Current* (Oxford University Press, 2012).

[2] T. M. Wallis, J. Moreland, and P. Kabos, *Appl. Phys. Lett.* 89, 122502 (2006).