# デュアルビーム FIB/SEM を用いたフェライト・カンチレバーの作製

## Fabrication of Ferrite Cantilevers using a Dual Beam FIB/SEM

ERATO-SQR project [1]，東北大 AIMR [2]，原研 [3]，東北大金研 [4]，東北大院工 [5]，
○徐 溶晙 [1,2]，針井一哉 [1,3]，高橋 遼 [1,3]，中堂 博之 [1,3]，大柳洸一 [4]，邱 志勇 [2]，小野 崇人 [5]，
塩見雄毅 [1,4]，齊藤英治 [1,2,3,4]

°(P)Yong-Jun Seo[1,2], Kazuya Harii[1,3], (P)Ryo Takahashi[1,3], Hiroyuki Chudo[1,3], (M2)Koichi Oyanagi[4],
Zhiyong Qiu[2], Takahito Ono[5], Yuki Shiomi[1,4], and Eiji Saitoh[1,2,3,4]

E-mail: seo@imr.tohoku.ac.jp

Cantilevers can be used as powerful sensors for a variety of measurements such as electron spin resonance detection [1], force microscopy, and cantilever based magnetometry [2]. Focused ion beam (FIB) milling is a popular technique for rapid and maskless nanofabrication. In this study, we have fabricated an yttrium iron garnet (YIG) cantilever with a Pt mirror deposited by using the FIB mehod and demonstrated efficient control of resonant frequencies by external magnetic fields. Figure 1 shows the fabrication process of the YIG cantilever. The starting material is a YIG film with 3 μm thickness grown on a gadolinium gallium garnet (GGG) substrate. The cantilever structure was patterned by the FIB milling (Fig. 1). The base of the cantilever was made by milling at the 52 degree angle to the wafer. The fabricated cantilever was then lifted out of the YIG film and welded on a Si wafer using an *in situ* lift-out technique of the FIB system. A SEM image of a successfully fabricated YIG cantilever (width: 800 nm, thickness: 600 nm, and length: 80 μm) on a Si wafer is shown in Fig. 2. The resonant frequency of the YIG cantilever was measured with a laser Doppler vibrometer in vacuum. In zero magnetic field, the measured resonant frequencies of the YIG cantilever are 54.960 kHz and 68.531 kHz with the quality factor value of 1200, as shown in Fig. 3. Two frequencies were identified as the horizontal and vertical vibrational modes, respectively. As the external magnetic field increases from 0 to 1100 G, the resonant frequencies are shifted. The maximal magnitude of the shift is 3.61 kHz, which is as large as several percent of the resonant frequency. The efficient control of the resonant frequencies with external magnetic fields indicates that ferrite cantilevers provide new functionality in cantilever technology.

[1] D. Rugar, R. Budakian, H. J. Mamin, and B. W. Chui, Nature (London) 430, (2004) 329.
[2] B. C. Stipe, H. J. Mamin, T. D. Stowe, T. W. Kenny, and D. Rugar, Phys. Rev. Lett. 86, (2001) 2874.

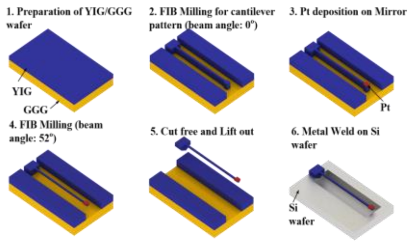


Fig. 1. Process chart for the YIG cantilever on Si substrate

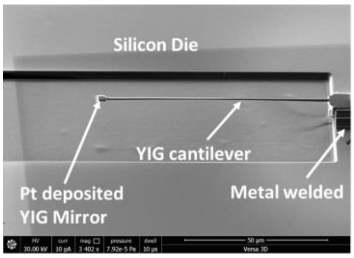


Fig. 2. SEM image of the YIG cantilever on a Si substrate.

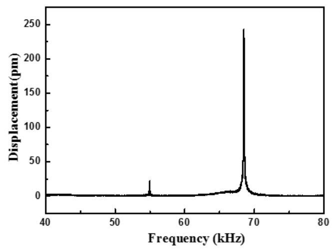


Fig. 3. Mechanical resonant spectrum of the YIG cantilever.