Logic gates using spin waves

Taichi Goto[1,2]
[1] Toyohashi Univ. of Tech., Toyohashi 441-8580, Japan
[2] MIT, Cambridge 02139, USA

Magnonics is an important research field that aims to realize post-CMOS devices by taking advantage of spin waves (SWs). The wave properties of SWs enable multiple input/output logic operation modes depending on the orientation of the wavevector/wavelength and the magnetization direction. A yttrium iron garnet (YIG) is suitable as a SW propagation medium because of its low damping constant. And a forward volume SW mode is preferable for construction of SW logic circuits because it enables the use of waveguides with curved and bent section. However, the logic gate using forward volume SWs propagating in YIG films were not demonstrated. Hence, we show our recent works on the development of the devices and discuss future work related to new computation using SWs.

First, we fabricated the three port SW ExNOR gate using ~20 μm thick YIG film.[1)] This gate worked as a SW phase interferometer. The device size was 1 mm × 16 mm. Edge reflection of SWs was totally canceled by abruption boundaries using gold films.

Second, four port SW AND and OR gates were demonstrated (Figure 1).[2)]

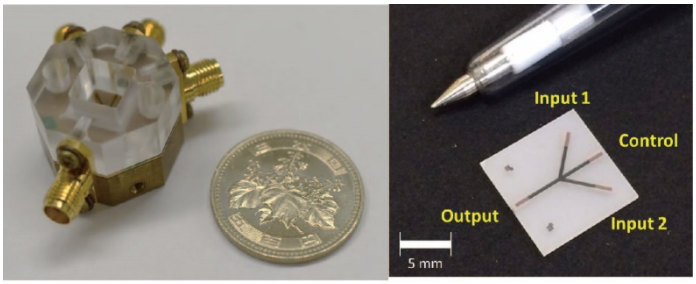

Fig. 1 Fabricated four ports spin wave logic gate using ~10 μm thick single crystalline YIG film.

This device also worked as a majority gate. The interferometer consisted of 10 μm thick monocrystalline YIG film grown a gadolinium gallium garnet substrate. The Ψ shaped waveguide was composed of three input ports. Input 1 and input 2 entered the junction area with 45° angle of incidence. The ridge waveguide was fabricated using photolithography and a micro-sandblasting technique. The film was magnetized perpendicular to the plane so that forward volume SWs were excited. Figure 2 showed the obtained results. Multilevel AND and OR gates were demonstrated. In the conference, miniaturized SW logic gates would be also shown.

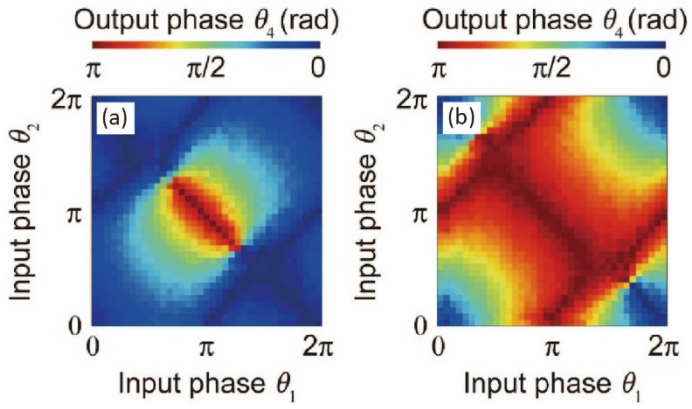

Fig. 2 AND (left) and OR (right) operation configuration obtained by experiment.

Reference

1) N. Kanazawa, T. Goto, *et al.*, Sci. Rep. **6**, 30268 (2016).
2) N. Kanazawa, T. Goto, *et al.*, Sci. Rep. **7**, 7898 (2017).