Control of the magnonic band gap in magnonic crystals by barrier width modulation

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Introduction:

Magnonic crystals (MCs), which are periodically changed conduit on the order of the wavelength of the spin wave (SW), have been attracted much attention for modulating and controlling SWs. MCs can increase the degree of freedom in SW propagation, such as the emergence of band gaps and change of spin wave speed. Various proposals and experiments have been carried out for application, such as logic operation, majority circuits, and transistors [1, 2]. The characteristics of MCs, such as band gaps, are mainly determined by their structural period. In order to design novel magnonic devices, the band width and center frequency of the band gap should be controlled by other than the structural period. In this report, we investigated the correlation between the barrier width and the band structure in 1 dimensional (1D) magnonic crystals of permalloy (Py) to control the band structure under keeping the period of the MC.

Simulation method:

The 1D-MC model was shown in Fig. 1. The period of one set of wall and valley was fixed at 2.0 μm. A static magnetic field was applied to y-direction and an impulse magnetic field was applied for spin wave excitation under an excitation antenna region. SW propagations were calculated for various wall widths w by using mumax3, and the band structures were obtained by performing Fast Fourier Transform (FFT) on the spatial distribution and time evolution of dynamic magnetization in the Py conduit.

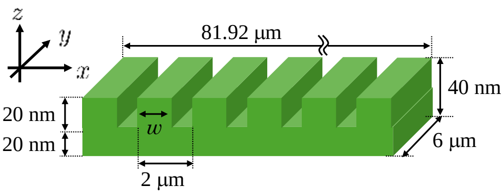

Fig. 1. Schematic image of 1D-MC

Results:

Figure 2 shows the calculated band structures for MCs with w = 0.4, 0.6, 1.2 and 1.6 μm. Since the structural period is fixed, the wavenumber at which the band gap appears does not change. As the barrier width increases, the dispersion relation curves become steep. This is due to an increase in the average film thickness of the MC. These results show that the central frequency of the band gap can be controlled by the average film thickness. It can also be seen that the band gap width changes with the change in wall width w. Figure 3 summarizes the wall width dependence of the upper and lower frequencies of the 1st band gap, and the interval between these frequencies indicates the band gap. The band gap width is maximum when the wall and groove widths are approximately equal, and becomes smaller toward both ends of the graph. Thus, it was found that the band gap can be controlled by changing the wall width.

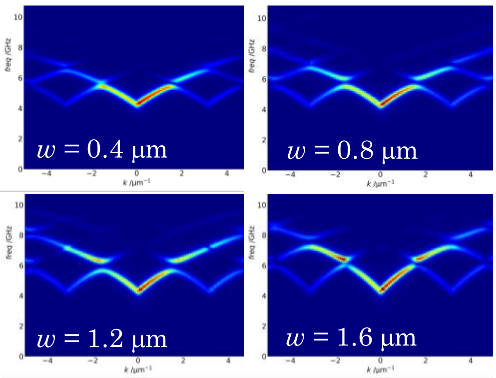

Fig. 2. Band structures of spin waves for MCs for various w.

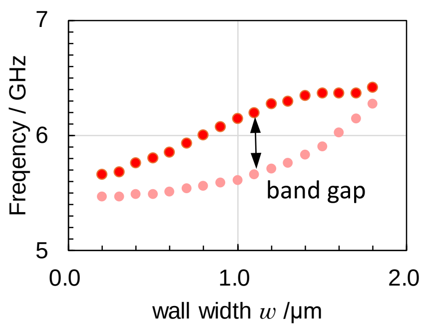

Fig. 3. Barrier width dependence of the upper and lower frequencies of the 1st band gap.

[1] A. V. Chumak *et al.*, Nat. Commun. **5**, 4700 (2014).
[2] Chumak *et al.*, J. Phys. D: Appl. Phys. **50**, 244001 (2017).