Imaging of caustic-like spin wave beams radiated from different waveguide widths using heterodyne detection

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Spin wave-based logic devices are widely investigated due to their promising technology with extended functionality and improved performance [1]. Imaging the propagating spin waves in real-space is fascinating approach to characterize their properties. In this study, we investigated the caustic-like spin wave beams [2-4] radiated from different waveguide widths. For this purpose, we developed a spatially-resolved optical heterodyne detection of propagating spin waves by using the polar Kerr effect.

Figure 1(a) shows a device used in the experiment. 20-nm-thick Py films were patterned into 20-µm-wide structure with a narrow waveguide (w = 2 – 8 µm). An antenna to excite the spin waves was fabricated by a lift-off process out of Ti(5 nm)/Au(100 nm). An external magnetic field of 20 mT was applied to the direction shown in Fig. 1(a). Spin waves were excited by applying microwave current to the antenna from the port 1 of a vector network analyzer (VNA). A linearly-polarized CW laser beam with the wavelength of 660 nm was focused on a sample surface by an objective lens, and reflected light intensity was detected by a high-speed photodetector through the polarizer rotated by 45° from the polarization axis of the input light. The heterodyne signal was then sent to the port 2 of VNA. Figures 1(b) and 1(c) show the real-space images of the intensity and the phase of the heterodyne signal (S_{21} of VNA) at the excitation frequency of 5.4 GHz. The radiation of caustic-like spin wave beams is clearly observed. The 2D fast Fourier transformation for the region of 20-µm-wide structure revealed a 2D spin wave dispersion which agrees with the calculated one. In the presentation, we will discuss the difference of caustic-like spin wave beams radiated from the different waveguide widths.

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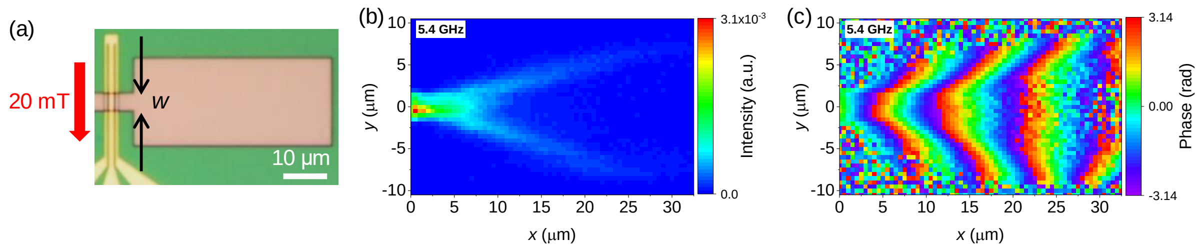

Fig. 1 (a) Optical image of the patterned structure. (b)(c) Two-dimensional real-space images of (b) the intensity and (c) the phase of the heterodyne signal at the excitation frequency of 5.4 GHz.