CoFeB/$Y_3Fe_5O_{12}$ bilayer resonator for magnonic control and magnetic sensor application

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Magnonics, an emerging research field that uses the quanta of spin waves as data carriers, has a potential to dominate the post-CMOS era owing to its intrinsic property of ultra-low power operation. Spin waves can be manipulated by a wide range of parameters; thus they are suitable for sensing applications in a wide range of physical fields. In this study we have reported an ingenious method to control the spin wave propagation by forming a magnonic resonator using CoFeB/$Y_3Fe_5O_{12}$ bilayer. In the subsequent step this resonator structure has been used to design a highly sensitive, simple structure, and ultra-low power magnetic sensor.

We grew a 70 nm-thick YIG thin film on a [001]-oriented single-crystalline $Gd_3Ga_5O_{12}$ (GGG) substrate using a pulsed laser deposition (PLD) technique. A ferromagnetic metal stripe of CoFeB with a thickness of 60 nm was patterned onto the YIG films by photolithography and room-temperature DC magnetron sputtering. A few atomic layers of TiOx were used as the spacer layer between the YIG and CoFeB stripes. Subsequently, a system of two CPWs composed of 90 nm-thick Au was integrated into the YIG film using photolithography and DC magnetron sputtering. The reference and bilayer device has bees shown in Fig. 1(a) and (b), respectfully.

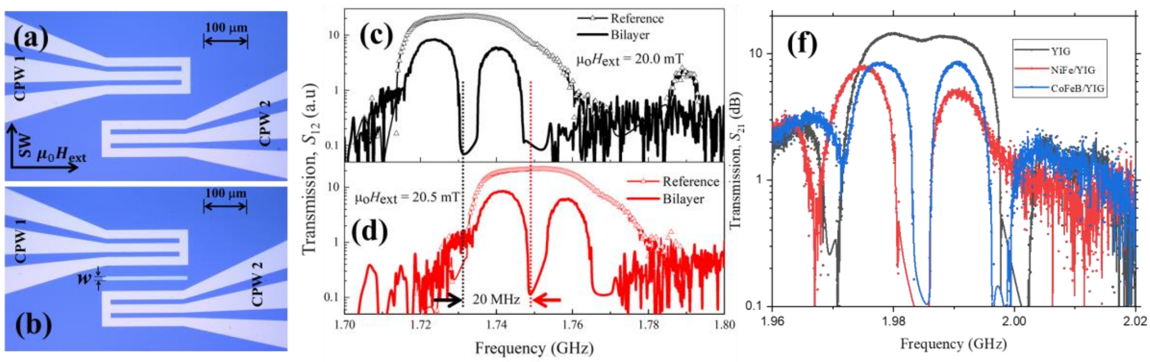

Figure 1. Schematic diagram of (a) reference and (b) bilayer resonator device. S_{21} spectra of reference and bilayer device with (c) 20 mT and (d) 20.5 mT magnetic fields (f) Resonator formation with different magnetic bilayers.

The transmission spectra, S_{12} of the reference (black line with black triangle and red line with red triangles), and bilayer (black and red line) are shown in Fig. 1(c) and (d), respectfully. The reference device shows an almost flat S_{12} band starting from 1.71 to 1.76 GHz. However, a sharp dip in the S_{12} spectra at the frequency of 1.73 GHz was observed in the case of the bilayer device compared to the reference device [1]. The lowest point of this strong rejection band allows detection of a small frequency shift owing to the external magnetic field variation. Experimental observations revealed that such a bilayer magnetic sensor exhibits 20 MHz frequency shifts upon the application of an external magnetic field of 5 Oe. Assuming a high-spec spectrum analyzer, we predicted that our sensor can detect magnetic fields as low as 10^{-9} T range at room temperature. Similar sharp rejection band has also been observed for NiFe/YIG bilayer (Fig. 1(f)) confiimg the generalization of this behavior in metallic FM/YIG bilayer.

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References.

[1] H. Qin et al., Nature Communication, vol. 12, 2293 (2021)