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Observation of spin wave resonances in nano-scale single magnetic dots using high sensitivity ferromagnetic resonance based on microwave interferometer

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Thorough understanding of magnetization dynamics in confined geometry is crucial for the study of various high frequency magnetic devices. As the element size shrinks, detection of magnetic excitations, especially higher order spin wave resonance (SWR) modes, becomes increasingly difficult, thus requiring very sophisticated techniques [1,2]. It would be highly desirable to have a simpler measurement technique whose sensitivity is high enough to detect such higher order SWR in nano-scale magnetic elements.

We have developed a ferromagnetic resonance (FMR) measurement apparatus based on microwave interferometric detection technique [3]. Fig. 1 shows the block diagram of the interferometer based FMR. The key of this technique is to cancel the stimulus signal by destructive interference when FMR is not excited. When the FMR condition is met, only the difference between two microwave paths, which reflects the FMR response of the sample, comes out of the interferometer. This results in significant sensitivity improvement, as large as about 400, compared with the conventional vector network analyzer FMR.

Using this apparatus, we measured FMR on 5 nm thick CoFeB single magnetic circular dots with diameters of 400 and 800 nm under 6.4 GHz stimulus signal as a function of in-plane bias field. Fig. 2 shows the FMR spectra observed on these two sizes. These plots both show a clear FMR peak at around 340 Oe. Furthermore, weak variations are observed on the higher field side, which should originate from the higher order SWR modes as shown in Figs. 1 and 2 of Ref. [1]. Another peak is seen at around 150 Oe for 400 nm and 130 nm for 800 nm dot, which are not understood yet and thus still under investigation.

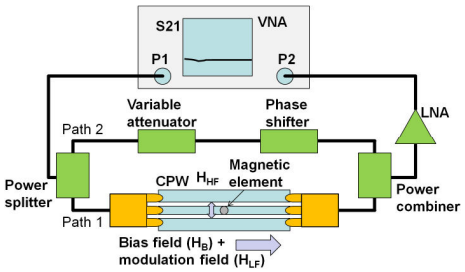

Fig. 1, Block diagram of interferometer based FMR

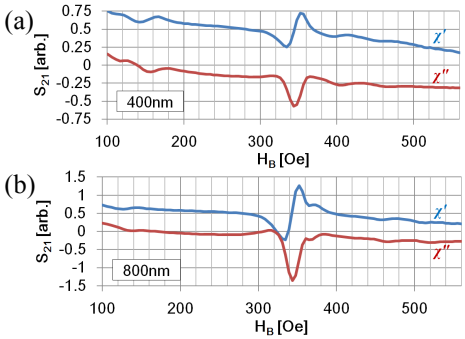

Fig. 2 FMR signal from CoFeB single dots with a diameter of (a) 400nm and (b) 800nm, respectively. Red and blue lines show the real and imaginary parts of the FMR response.

References

[1] F. Guo et al., Phys. Rev. Lett., 110, 017601 (2013)

[2] J. Jersch et al., Appl. Phys. Lett, 97, 152502 (2010)

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