# Terahertz Magneto-Optic Sensing/Imaging using a Diabolo-Shaped Antenna with Thin Spintronic Layer between its Flares

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## 1. Introduction

Finding balance in the different performance metrics has been a crucial consideration in the development of new types of magneto-optic imaging (MOI)-based techniques [1, 2, 3, 4], including the MOI with Faraday effect for non-destructive testing (NDT) of material defects [5, 6].

Here, we continue to develop our recently reported original MOI with on-chip terahertz time-domain spectroscopy (THz-TDS) emission/detection scheme [6] by using a diabolo-shaped emitter with 2/3-nm Fe/Pt spintronic layer at the gap of its 100-nm thick Pt antenna flares. The advantages of such structure were recently reported and explained by the combination of the enhanced outcoupling of THz radiation to free space brought by the shaped structure and the reduced sheet resistance of the thicker metallic flares of the diabolo-shaped antenna [7].

## 2. Results and Discussion

Figure 1 shows the simplified experimental scheme with permanent magnet on XYZ-scanning stage in the proximity (~5 mm) of the MOI chip. The resulted MOI THz-TDS image contrast reflects changes in magnetization vector ($\vec{B}$) due to magnet movements above the spintronic layer at fixed fs-laser pump spot. In MOI, $\vec{B}$ determines the efficiency of the THz emissions from diabolo antenna structure at each image pixel. The THz electro-optic (EO) ZnTe sensor and the fs-laser pump/probe polarizations are adjusted for maximum and minimum sensitivity of spintronic and parasitic optical rectification emission, respectively. Note that image contrast with EO sampling is also affected by a factor of $\sqrt{1+3cos^2\alpha}$, where α is an angle between THz polarization from diabolo antenna with respect to the (110) axis of ZnTe crystal. Generally, the current image patterns agree well with our reported studies [6, 8]. As expected, we observed better signal-to-noise ratio for THz waveforms compared to previously reported ones from continuous spintronic film or uniformly thin spintronic diabolo antenna [6, 8].

## 3. Conclusion

In this study, we have shown that using diabolo antenna with thicker flares in MOI improves signal-to-noise ratio. However, for accurate image contrast comparisons, the long-time THz-TDS stability and fine tuning of the fixed delay time for image collection is needed. Obviously, image quality also crucially depends on optical alignments. These points will be discussed and examples will be given. Further improvement for possible NDT will also be outlined.

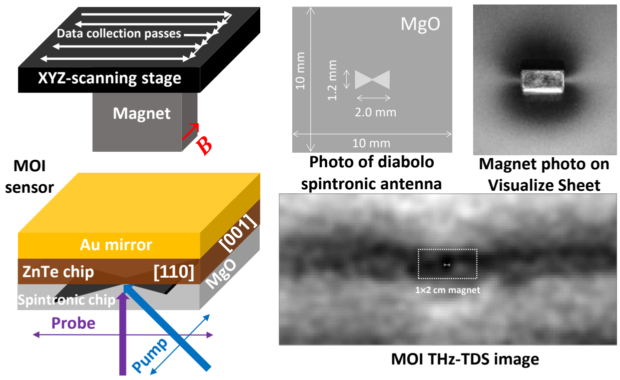


**Fig. 1.** THz-TDS-MOI of permanent magnet in proximity of the MOI sensor. The magnet/antenna drawings on THz-TDS MOI is only for size comparisons and antenna positioning with respect to image plane.

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