THz Emission Amplitude Enhancement of Fe/Pt Diabolo-shaped Spintronic Antennas Fabricated on MgO Substrates

(D)Miezel Talara*[1], Dmitry Bulgarevich[2], Valynn Katrine Mag-usara[1,3], Chiyaka Tachioka[1], Joselito Muldera[1], Hideaki Kitahara[1,3], Mary Clare Escaño[1], Makoto Nakajima[3], Makoto Watanabe[2] and Masahiko Tani[1]

[1]Research Center for Development of Far-Infrared Region, University of Fukui, Japan
[2]Research Center for Structural Materials, National Institute for Materials Science (NIMS), Japan
[3]Institute of Laser Engineering, Osaka University, Japan
***Email: miezel@fir.u-fukui.ac.jp**

Terahertz (THz) generation of spintronic heterostructures has become a popular and interesting subject of research due to its unique and superior qualities over other conventional THz sources. Spintronic heterostructures, which are thin film layers of ferromagnetic (FM) and nonmagnetic (NM) metals, do not require any contacts for spin-to-charge conversion and the emitted THz wave polarization can be controlled by the applied external magnetic field. In an FM-NM spintronic system, THz wave generation is by spin current to charge current conversion via the inverse spin-Hall effect [1]. Several studies were performed to further improve the performance of the spintronic heterostructures. However, improved outcoupling and enhanced directive gain offered by antennas were only applied to semiconductor-based THz emitters and detectors. It was only just recently [2] that antennas were incorporated to spintronic heterostructures to improve THz emission performance. In this regard, we report here THz emission performance of diabolo-shaped spintronic antennas compared with a spintronic bilayer. The diabolo-shaped spintronic antenna and the spintronic bilayer which are thin film metal layers of Fe and Pt with optimized thicknesses [3] of 2 nm and 3 nm, respectively, were grown on MgO substrates, see Fig. 1(a). Another diabolo-shaped spintronic antenna with Pt thickness of 100 nm at both ends of antenna flares was studied for its THz emission performance, see Fig 1(b). Results showed that the diabolo-shaped antenna with the same metal thicknesses with that of the spintronic bilayer showed ~51% improvement which may have been caused by the enhanced outcoupling [4] of THz radiation brought by the diabolo-shaped structure. Moreover, the diabolo-shaped antenna with thicker Pt showed ~88% improvement. This improvement can be attributed to the enhanced coupling of THz wave to free space and improved radiation directivity [4]. Also worth noting is the symmetrical time-domain waveform, as shown in Figure 1, of the diabolo-shaped antenna with thicker Pt. For THz detection, we used an LTG-GaAs dipole-type photoconductive antenna (PCA). The spintronic emitters were powered by a 2.6 mW pump beam while the detector received a 4.7 mW probe power.

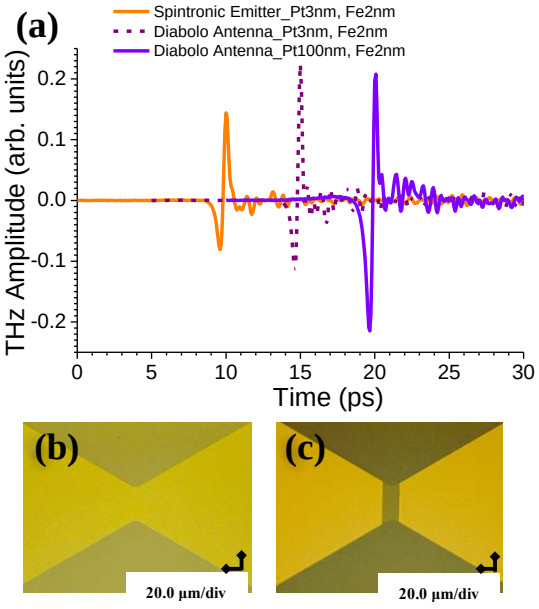

Figure 1. THz time-domain waveform comparison (a) of the diabolo-shaped spintronic antennas with the spintronic bilayer. Also shown are optical images (b and c) of the central part of the fabricated diabolo-shaped spintronic antennas.

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