Magnetically switchable ultrafast spintronic THz emitters

M. Fix,[1] R. Schneider,[2] J. Bensmann,[2] S. Michaelis de Vasconcellos,[2] R. Bratschitsch,[2] and M. Albrecht[1]

[1] *Institute of Physics, University of Augsburg, 86159 Augsburg, Germany*

[2] *Institute of Physics and Center for Nanotechnology, University of Münster, 48149 Münster, Germany*

The recent discovery of ultrafast spintronic THz emitters has attracted a lot of attention due to their high power, broadband emission as well as easy fabrication [1,2]. They are based on nanometer-thin bilayers of a ferro-/ferrimagnetic (FM) and a non-magnetic (NM) metal layer and rely on the inverse spin Hall effect. The THz emission properties can be tuned by using different FM and NM materials, tailoring the magnetic properties [3], or building functional layer stacks [4]. Here, we present a spin valve THz emitter, which allows for switching of the THz emission amplitude by a small magnetic field of a few mT [5].

The operation of the switchable THz emitter is based on a magnetically soft free Fe layer and a pinned Fe layer, which is exchange biased by an antiferromagnetic $Ir_{23}Mn_{77}$ film. The Fe layers are magnetically decoupled from each other by thin NM spacer layers of Pt or W, which exhibit a high spin Hall angle. Excitation of the structure with ultrashort optical laser pulses leads to the creation of spin currents from the two Fe layers into the sandwiched NM film. There, the spin currents are converted into ultrafast charge currents by the inverse spin Hall effect. Depending on the relative magnetization direction of the two Fe layers, and hence the polarization of the spin currents, these charge currents add up or cancel each other out, leading to a high or vanishing THz emission. The relative alignment of the two Fe layers can be controlled by switching the free Fe layer with applied magnetic fields on the order of 10 mT, while the magnetization direction of the pinned Fe layer remains constant due to the exchange bias. Therefore, the system allows the switching from the low to the high amplitude THz emission state by small applied magnetic fields, enabling easy implementation and high switching rates.

Our study demonstrates the large potential of ultrafast spintronic THz emitters and combines the high power and broadband emission with an easy to use switching mechanism.

References:

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