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Magneto-electric control of emission in spintronic terahertz emitters

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Polarization control of THz light is of paramount interest for the numerous applications offered in this frequency range. Recent developments in THz spintronic emitters allow for a very efficient broadband emission, and especially unique is their ability of THz polarization switching through magnetization control of the ferromagnetic layer[1]. So far, such a control has only been achieved using an external magnetic field. We present here a scheme to achieve a voltage controlled coherent polarization rotation using a **strain mediated magnetoelectric** effect in spintronic emitters.

The considered emitter is a W(2nm)/ CoFe(0.5nm)/ $TbCo_2$(0.8nm)/ CoFe(0.5nm)/ Pt(2nm) stack deposited by RF sputtering on a 300 μm thick <011> cut PMN-PT ferroelectric relaxor. During the growth, a magnetic field was applied in the plane of the substrate in order to induce a well-defined uni-axial anisotropy that allows for a stoner-wohlfarth coherent rotation of the magnetization in the ferromagnetic layer. The CoFe/$TbCo_2$/CoFe tri-layer acts as an exchange-coupled multilayer and the 5d metals Pt and W provide the ISHE with opposite signs for their spin-Hall angles. The THz emission was characterized on a customized existing terahertz time-domain spectroscopy (TDS) setup. The ISHE-mediated terahertz emission is generated by pumping the sample with femtosecond pulses and the E-field of the emitted terahertz pulse is measured by sampling the response of a photo-conductive Auston switch that is probed by a split-off fraction of the femtosecond infrared pulse by a delay line. In order to measure the horizontal and vertical components of the E-field and deduce the polarization angle, two wire-grid polarizers were inserted in the THz path, as seen on figure 1. Setting the delay line to obtain the maximum signal amplitude, E-field components were measured while cycling the applied voltage on the PMN-PT substrate. A static magnetic bias is also applied to the emitter. The deducted polarization angle is shown on figure 1, which clearly shows its controlled rotation over a span of nearly 40 degrees. Thanks to the magnetostrictive properties of the ferromagnetic tri-layer, and upon voltage application, the substrate generated stress induces a large change in magnetic anisotropy [2] which causes a coherent rotation of magnetization and thus of the emitted polarization.

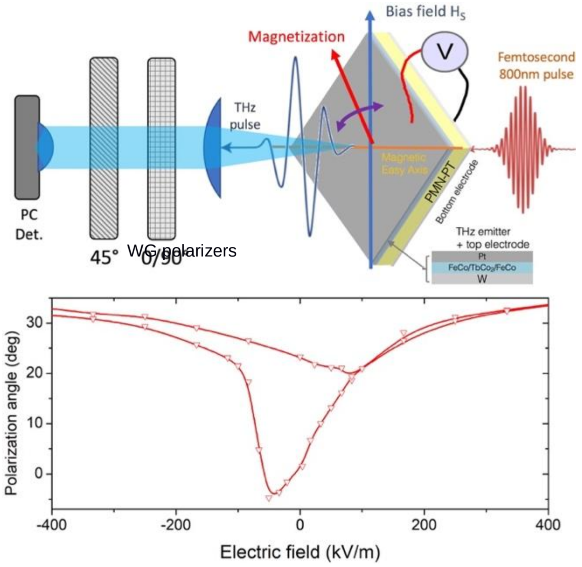

Figure 1 : Top : schematic representation of the magnetoelectric spintronic emitter and character-rization setup. Bottom: measured E-polarization angle with respect to the horizontal plane, as a function of the applied voltage on PMN-PT.

[1] Seifert, T. et al. Nat. Photonics, 10(7), 483–488 (2016)

[2] N. Tiercelin et al. Appl. Phys. Lett., 99, 192507 (2011)