Emission dynamic of ions by monocycle THz pulse

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We recently proved that high amplitude THz monocycle (20MV/m) is enhanced at the vicinity of the apex of nanometric needle to <1GV/m [1]. The field is in the magnitude range of internal field of solid materials (10-100GV/m). It is able to trigger field emission of atoms from the surface of the nanometric needle [2] and positively ionizes them.

This property is used in a home-made Atom Probe Tomography (APT [3]) setup where Time of Flight Mass Spectrometry (ToF-MS) is performed on each emitted ions to chemically identify them keeping high 3d resolution of the instrument (<1nm).

However, from now we only presented results on pure metallic materials and the extend of the technic to insulating materials is still a challenge. A better understanding of interaction between THz monocycle is required.

In this paper, we will present experiments where we study the dynamic of emission of ions playing with the parameters of the high amplitude THz monocycle (amplitude, or the sign +/- of the high amplitude part of the THz monocycle regarding the tip orientation written THz+ or THz-). We will show that, even with a negative THz pulse, ions can be emitted as shown in **Fig a**. In this case, light ions like Boron from a LaB_6 sample present a double emission peak, it can be attributed to either a delay emission (1ns after the THz pulse) or an energy loss of 42 eV, the two hypotheses will be discussed.

An original pump probe experiment setup on APT (**Fig b.**), using infrared 35 femtoseconds pulse as a pump and a negative or positive THz monocycle as a probe, shows an ultrafast response of the sample (400fs). It can be attributed to charge transfer across the small band gap of LaB_6 by the IR laser follows by its relaxation.

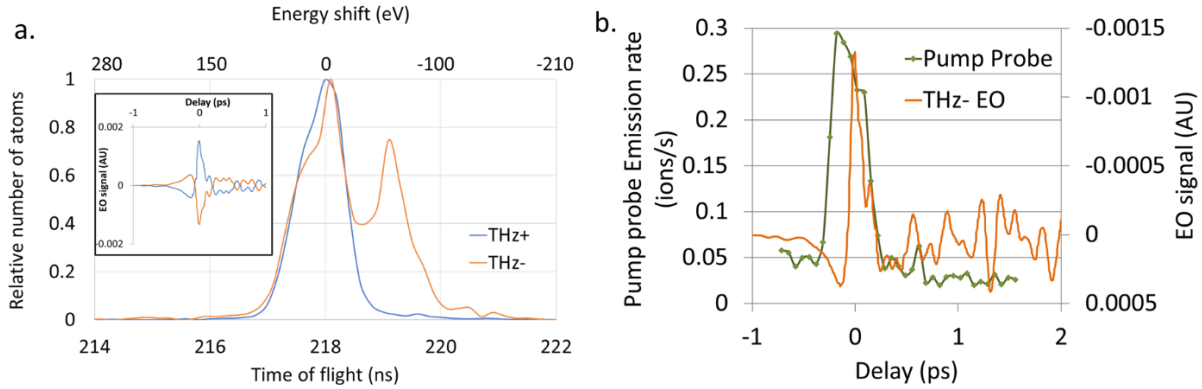

Fig. a. Time of flight spectrum of $_{11}B^{2+}$ from a LaB_6 sample field evaporated by a positive (THz+) or a negative (THz-) THz monocycle. Insert shows Electro-Optic trace (EO) measured on a 100µm GaP crystal of the two THz monocycles. **b.** Pump probe experiment in APT setup (see [2] for details) showing as a fast behaviour in advance on the THz pulse.

References

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