THz-INDUCED STRONG-FIELD ELECTRON EMISSION FROM A GOLD SURFACE

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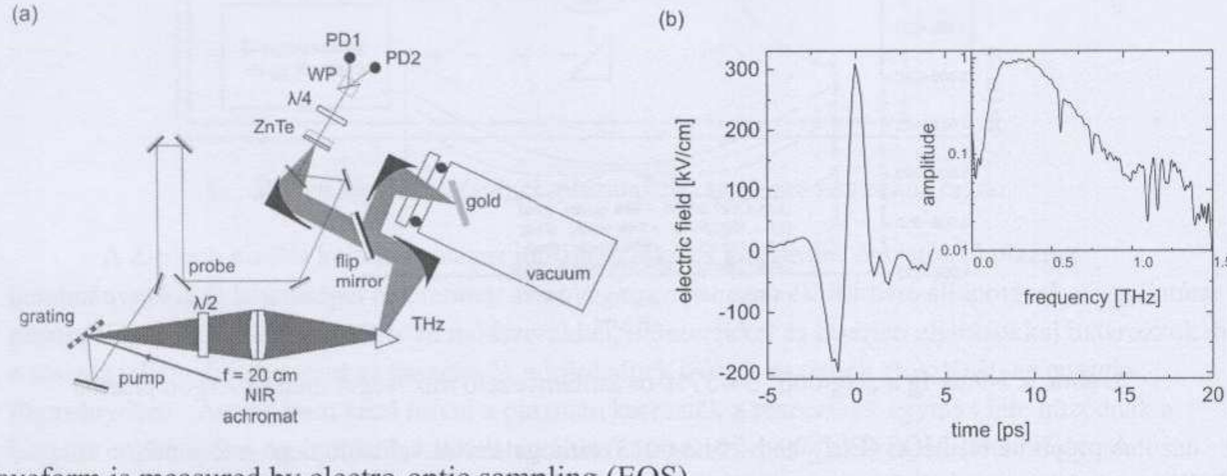
Photoemission of electrons from atoms or metal surfaces is a fundamental process in radiation-matter interaction and has been studied extensively using optical excitation (see for example [1]). Electron emission driven by high-intensity light fields is accompanied by high-harmonic generation (HHG), a process forming the basis for attosecond technology. Enabled by recent development of high-intensity THz sources, HHG driven by intense multi-THz transients was also demonstrated [2]. The photoelectric effect shows a characteristic nonlinear behavior at moderate intensities, where the Keldysh parameter is $\gamma \gg 1$. At very high intensities ($\gamma \ll 1$), (optical) field emission plays a dominant role.

In our ongoing experiments we study the scaling behavior of electron emission from a gold surface irradiated by intense THz pulses. The experimental setup is shown in Fig. 1a. Near single-cycle THz pulses are generated by optical rectification (OR) of 200-fs laser pulses in $LiNbO_3$ by the tilted-pulse-front pumping technique [3]. Up to 6 mJ pump pulse energy is used. The THz pulses are focused onto a gold surface at ~45° angle of incidence, which is placed inside vacuum together with a subsequent electron multiplier (EM) chain to amplify the photocurrent. Energy, focal spot, and waveform measurements give about 300 kV/cm maximum peak electric field strength and 0.35 THz mean frequency for the THz pulses (Fig. 1b). The



waveform is measured by electro-optic sampling (EOS).

Fig. 1. (a) Experimental setup. (b) Measured THz waveform and spectrum.

One unique feature of THz irradiation is the extremely low photon energy compared to the work function, and consequently, the extremely high order of nonlinearity $n{\sim}10^3$ for $\gamma \gg 1$. This leads to a threshold-like behavior in the scaling of the photocurrent with THz energy. The other unique feature of THz radiation is that the transition region to field emission, i.e. $\gamma{\sim}1$, can be accessed with orders of magnitude smaller pulse energies (μJ) than in case of optical pulses, owing to the ~10^3 times lower frequency. We will present details and results of our experiments in this region (Fig. 2).

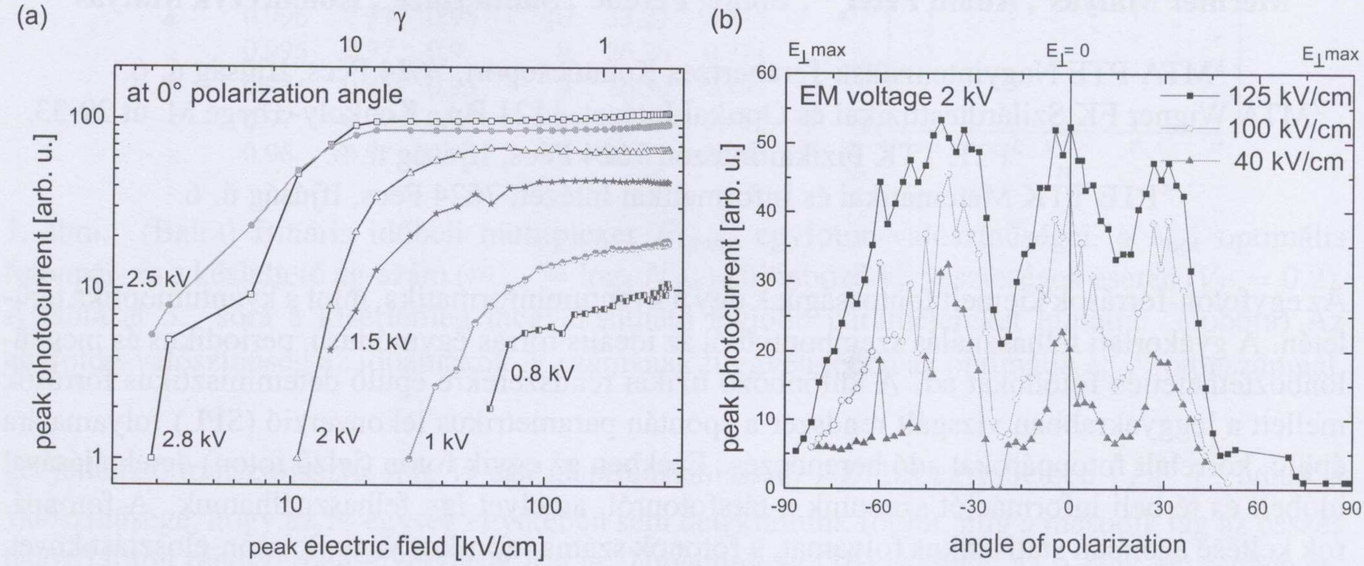


Fig. 2. (a) Measured photocurrent vs. THz peak electric field for different EM bias voltages, and (b) photocurrent vs. polarization angle.

References

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