Transient grating time-resolved PEEM to study charge-carrier transport

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Background

Understanding the transport of charge carriers on surfaces enables us to get insights into a material's fundamental properties, which is also important from an application point of view. Time-resolved photoemission electron microscopy (TR-PEEM) has gained popularity in the study of ultrafast photocarrier dynamics in different materials. Since it is technically difficult to create a diffraction-limited excitation beam on the sample, we have used a novel approach for measuring the transport of photoexcited electrons at surfaces - transient grating TR-PEEM. Here we present the preliminary results obtained.

Method

- The sample is simultaneously excited by two pump pulses (650 nm) whose interference leads to a periodic spatial modulation of the excited electrons.
- These electrons are then photoemitted by the probe pulse (260 nm) with a variable delay and are imaged in the PEEM.
- The gradual decay of the spatial modulation due to transport processes can be observed over short length and time scales.
- We were able to create a spatial modulation with a spacing of around 700 nm between the maxima.

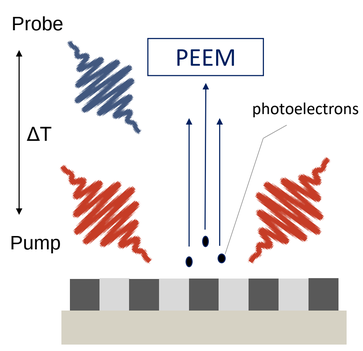

Fig.1: Schematic with the principle of transient grating PEEM.

Results

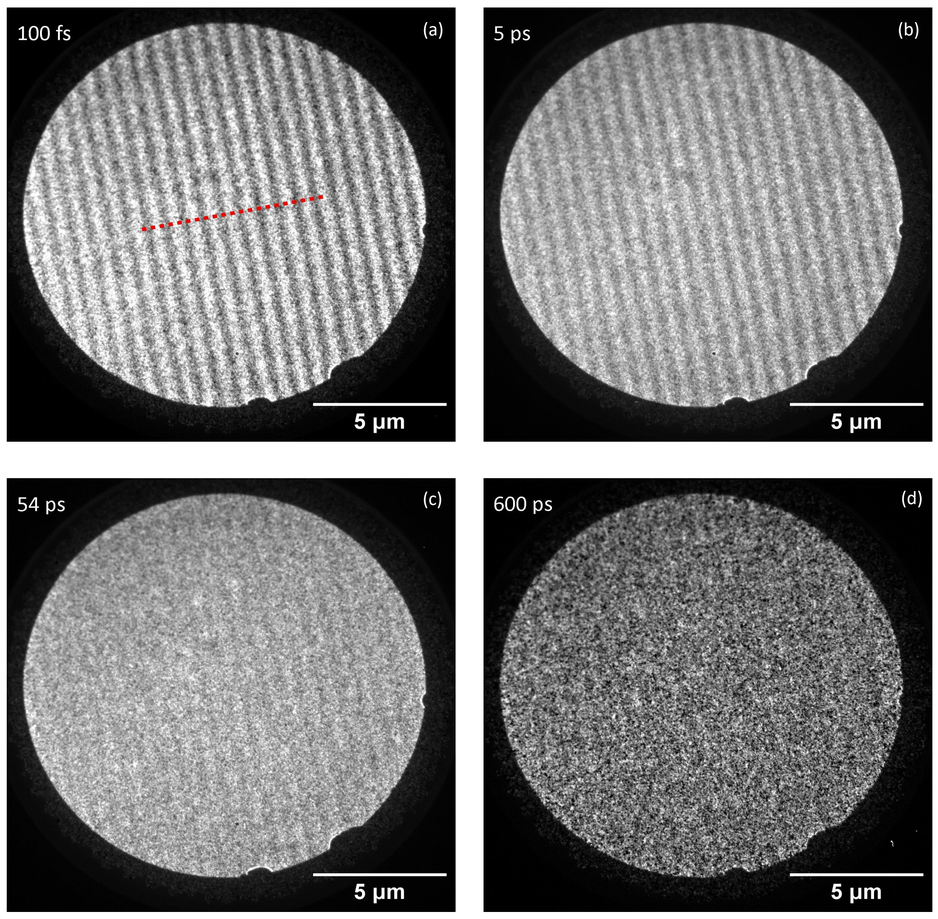

Fig.2: (a), (b), (c) and (d) shows the time-resolved PEEM images of a GaAs substrate at different time delays, after excitation by two pump pulses.

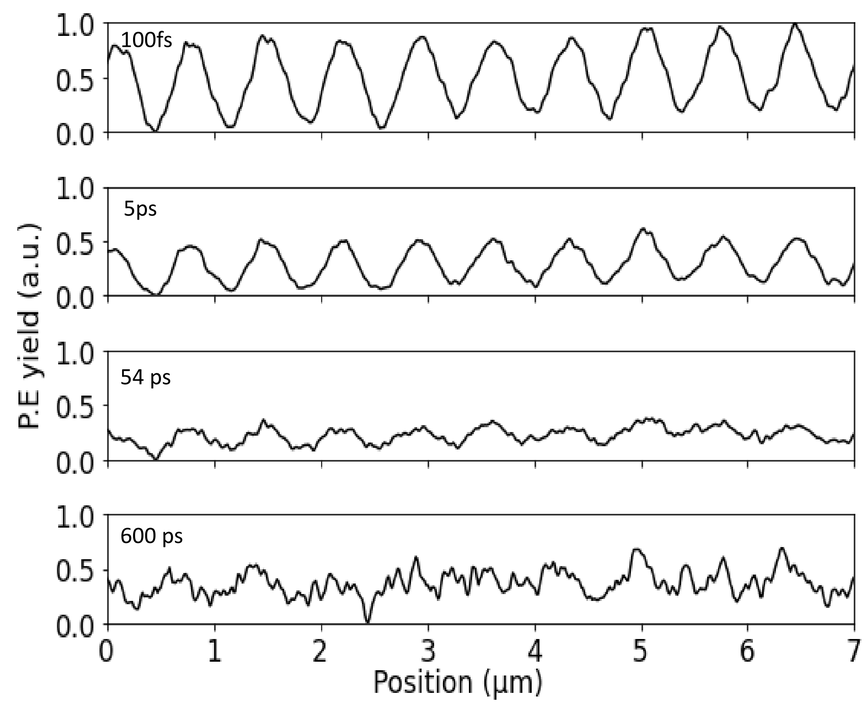

Fig.3: The intensity profile of the spatial modulation, evaluated along the red dashed line in Fig.2.

- We can see clear signs of the spatial modulation fading out on the GaAs surface, indicative of charge carrier transport.

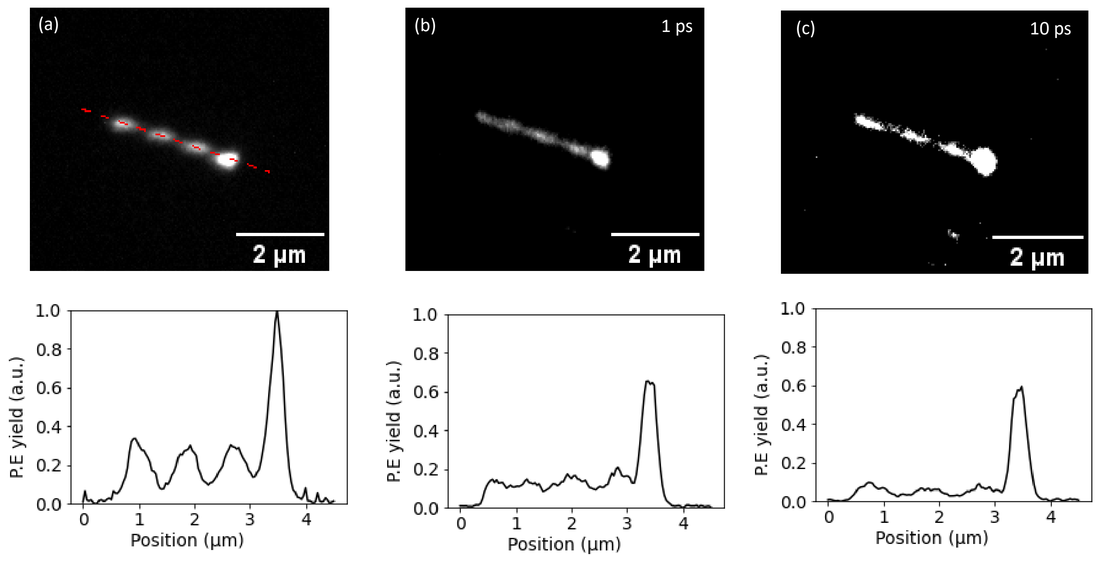

Fig.4: The PEEM images of an InAs nanowire upon excitation with just the pump pulses (a), with the pump and probe pulses at a delay of 1 ps (b), and with the pump and probe pulses at a delay of 10 ps (c). The intensity profile of the spatial modulation, evaluated along the red dashed line is shown in the lower panel.

- We were able to see the spatial modulation along the length of a single InAs nanowire.

Conclusions

- Transient grating time-resolved photoemission electron microscopy can be used to study charge-carrier transport on surfaces and across individual nanostructures.

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