In the 1980s, rapid progress in picosecond and femtosecond ultrafast lasers has enabled to start to bridge the gap between electronics and optics. The resulting synergy has since given rise to a wealth of new technologies and scientific insights as for example demonstrated with the optical generation of terahertz frequencies for the investigation of ever faster physical processes and device performance. Meanwhile we have fully bridged the gap based on more recent progress in ultrafast laser sources to few-cycle femtosecond and attosecond pulses with full electric field control up to the petahertz frequency regime [1]. A number of pioneering publications demonstrated that attosecond transient absorption spectroscopy (ATAS) is a suitable tool for resolving the fastest carrier processes in wide-bandgap semiconductors [2, 3] and dielectrics [4, 5].

After a general introduction in this plenary talk I will discuss in more details some recent results from our group in diamond [5], GaAs and Ti-metal. For the latter two cases we had initially unexpected observations in the sub-cycle regime of the near infrared (NIR) laser field driven dynamics. With regards to GaAs we have investigated for the first time the sub-femtosecond dynamics in a direct narrow-bandgap semiconductor pumped in the resonant regime (Fig. 1). With regards to Ti-metal we observed an unexpected sub-cycle absorption modulation that only takes place in a highly correlated process. In addition we can follow the dynamics within a broad probe spectrum of more than 10 eV from around 200 attoseconds to a millisecond.

![Diagram](image)

**Fig. 1.** (a) The resonant near infrared (NIR) pump pulse excites either electrons from the valence (VB) into the conduction band (CB) via the absorption of photons (inter-band transition) or moves carriers within a band (intra-band transition). The XUV probe excites the carrier population around the bandgap via carrier injection from the As core level. (b) Measured change of the XUV absorption of GaAs as a function of pump-probe delay. During the overlap, oscillations with twice the NIR frequency appear. (c) The first-principles simulation reproduces nicely the main measured features. (d) Simulated conduction band population \( n_{CB} \) induced by the NIR-pulse. The green curve shows the population in the absence of intra-band motion (inter only). Including both transitions results in a three-fold enhancement of the final conduction band population.


