

## Attosecond dynamics in solids

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In the 1980s, rapid progress in picosecond and femtosecond ultrafast lasers has enabled to start to bridge the gap between electronics and optics with the optical generation of terahertz frequencies for the investigation of ever faster physical processes and device performance. More recently with full electric field control within few-cycle pulses [1] we have continued to fully bridge this gap approaching the petahertz regime. A number of pioneering publications demonstrated that attosecond carrier transport can be resolved with attosecond transient absorption spectroscopy (ATAS) [2-5] and an attosecond interferometry technique at solid surfaces [6,7]. After a general introduction with this plenary talk I will discuss in more details some recent results from our group in diamond [5], GaAs [8,9] and Ti-metal [10]. In addition I will discuss the effective mass approximation in the attosecond regime [11].

- [1] H. R. Telle et al., "Carrier-envelope offset phase control: A novel concept for absolute optical frequency measurement and ultrashort pulse generation," *Appl. Phys. B* 69, 327 (1999)
- [2] M. Schultze et al., "Attosecond band-gap dynamics in silicon " *Science* 346, 1348 (2014)
- [3] H. Mashiko, et al., "Petahertz optical drive with wide-bandgap semiconductor," *Nature Physics* 12, 741 (2016)
- [4] M. Schultze et al., "Controlling dielectrics with the electric field of light," *Nature* 493, 75 (2013)
- [5] M. Lucchini et al., "Attosecond dynamical Franz-Keldysh effect in polycrystalline diamond," *Science* 353, 916 (2016)
- [6] R. Locher et al., "Energy-dependent photoemission delays from noble metal surfaces by attosecond interferometry" *Optica* 2, 405 (2015)
- [7] M. Lucchini et al., "Light-matter interaction at surfaces in the spatiotemporal limit of macroscopic models", *Phys. Rev. Lett.* 115, 137401 (2015)
- [8] F. Schlaepfer et al., "Attosecond optical-field-enhanced carrier injection into the GaAs conduction band", *Nature Physics* 14, 560 (2018)
- [9] S. A. Sato et al., "Role of intraband transitions in photocarrier generation", *Phys. Rev. B* 98, 035202 (2018)
- [10] M. Volkov, S. A. Sato, F. Schlaepfer, L. Kasmi, N. Hartmann, M. Lucchini, L. Gallmann, A. Rubio, U. Keller, submitted
- [11] L. Kasmi et al., "Effective mass effect in attosecond electron transport", *Optica* 4, 1492 (2017)