



Nonlinear Terahertz Spectroscopy of III-V Semiconductor Quantum Wires and Quantum Wells Using a Free-electron Laser

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This talk reviews some recent experiments using intense narrow-band terahertz (THz) fields from a free-electron laser for exploring electronic properties in semiconductor nanostructures. In n-type III-V semiconductor nanowires (NW), intense THz excitation causes a nonlinear plasmonic response, which manifests itself by a strong red shift of the plasma resonance. This nonlinearity is investigated by scattering-type scanning near-field infrared microscopy. For the NWs under study, a spectrally sharp plasma resonance, located at a photon energy of 125 meV for weak excitation, undergoes a power-dependent redshift to about 95 meV. We attribute this nonlinearity to an increase of the effective mass caused by transient carrier heating. In another experiment, we use strong narrowband THz excitation to dress the 2–3 intersubband transition in a 40 nm wide GaAs quantum well (QW). The resulting nonlinearities are explored by THz time-domain spectroscopy using synchronous broadband THz probe pulses and electro-optic sampling. Tuning the THz pump beam into resonance with the 2–3 intersubband transition, we have investigated the induced coherent signatures in the vicinity of the 1–2 intersubband transition and found evidence for mixed light-matter states in the QW giving rise to a THz Autler-Townes effect.

The presented work was conducted in collaboration with D. Lang and J. Schmidt (HZDR) who did most experiments, L. Balaghi, E. Dimakis, M. Helm, R. Hübner, D. Lang, A. Pashkin, S. Winnerl (HZDR), and S.C. Kehr, L.M. Eng (TU Dresden, Germany).

SHORT BIO:

Harald Schneider is the head of the Spectroscopy Department at the Institute of Ion Beam Physics and Materials Research, Helmholtz-Zentrum Dresden-Rossendorf (HZDR), Germany, since 2005, and faculty member at the University of Freiburg, Germany, since 2003. From 1989 to 2005 he was with the Fraunhofer-Institute for Solid State Physics, Freiburg, Germany. He completed his Ph. D. degree in physics at the Max-Planck Institute for Solid-State Research, Stuttgart, Germany, in 1988 and his Habilitation at the University of Freiburg, Germany, in 2003. His research interests include optoelectronic properties of semiconductor nanostructures and 2D materials, ultrafast and terahertz spectroscopy, and infrared detectors and lasers. His department is also the main user of the free-electron laser FELBE at HZDR.