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My current research interests are terahertz (THz) frequency science and technology and the applications of femtosecond lasers in biology and medicine.

**Experimental methods:** Time-domain THz-emission measurements, time-domain THz transmission and reflection spectroscopy, phase-sensitive backward wave oscillator based THz-spectroscopy, femtosecond optical transient reflectivity and transmittivity measurements, femtosecond optical four-wave mixing, femtosecond laser nanoprocessing of living cells and fluorescence microscopy.

The current focus of my research are (i) the study of narrow band gap semiconductors as THz-radiation source, (ii) the investigation of dielectric properties of biological tissue in the THz-frequency range and (iii) the creation of nanopores in the membranes of living cells by focused femtosecond laser beams.

**(i) Emission of THz-frequency electromagnetic radiation from narrow band gap semiconductors**

The objective of my research is the fundamental understanding of femtosecond laser excited emission of pulsed THz-radiation from narrow band gap semiconductors as a function of intrinsic semiconductor properties. Important applications of time-domain THz-wave techniques in basic and applied science are still limited by the power of the available sources. The development of bright, high bandwidth THz radiation sources is important in order to expand applications of these techniques. For this purpose it is necessary to understand the THz emission process as determined by intrinsic semiconductor properties such as dopants, majority and minority carrier concentrations, stoichiometric compositions, bulk crystal, thin film and nanostructure. The results of research enables the growth of narrow band gap semiconductor materials optimized for application as THz-emitter in time-domain THz-spectroscopy and imaging systems.

Among narrow band gap semiconductor InN thin films and nanorods are novel electronic materials. Preliminary analysis demonstrates that InN exhibits unique electronic properties for development of brighter THz-radiation sources such as low probability of intervalley scattering, strong intrinsic electric fields and low intrinsic carrier concentrations. As a novel semiconductor the optical, electronic and structural properties of InN are far from being well understood. A specific goal of my research project is the exploration of InN properties by THz-emission measurements in order to realize the great potential of this material for time-domain THz-wave techniques. This research advances applications of THz- spectroscopy and imaging in research and industries across a broad range of disciplines.

**(ii) Dielectric properties of biological tissue in the THz-frequency range**

Time-domain THz-spectroscopy and imaging are envisioned as new medical diagnostics modality. Time-domain THz-techniques spectroscopy measure and image the dielectric function of a material in the THz-frequency range. Application of THz-radiation as a diagnostic tool in medicine requires research on the correlation of disease states of tissue with the dielectric properties of tissue in the THz-frequency range. The current focus of my research in this area is feasibility studies in order to identify in-vitro experimental models which are interesting from physics point of view and of relevance to the biomedical community.

**(iii) Femtosecond near-infrared optoinjection**

Laser microbeams are powerful tools for the manipulation of single living cells and cell organelles. Tightly focused laser beams allow the alteration of single cells or cell organelles non-invasively with high precision. Femtosecond (fs) near-infrared (NIR) laser beams are a rapid and reproducible novel method for delivery of membrane impermeable molecules into single living cells. The advent of femtosecond (fs) NIR laser beams allow for an unprecedented precision of optoporation and cellular laser nanosurgery, greatly improved cell viability and the possibility analyzing *in-situ* the created immediate and long-term effects. My goals are to understand in-depth the physics of the laser interactions with the cell, to understand the limits of this approach regarding cell damage and to apply this technique to cells which are resistant to established microinjection techniques.