Bachelor Thesis Task in the NanoEngineering Program

Topic: Investigation of mouse brain slices in the presence of terahertz RTD oscillators and detectors

Task:

The terahertz frequency range (THz), particularly between 300 GHz and 4 THz, holds great potential for numerous applications in biology and medical technology. In the terahertz.NRW project, we aim to develop miniaturized devices for detecting neural activity in mouse brains. Indium phosphide (InP)-based resonant tunneling diodes (RTDs), considered the highest-frequency solid-state electronic oscillators, are promising components for generating signals in the high-frequency range. RTD structures can also serve as highly sensitive THz detectors, owing to their small capacitance and high nonlinearity at zero bias voltage. Previously fabricated THz emitters based on RTDs at our facility (BHE) demonstrate sufficient output power, and integrated RTD detectors with acceptable noise-equivalent power can be utilized for anticipated field applications.

In this design-oriented project, we employ RTDs to detect induced electric fields and voltages in mouse brain slices, leveraging the unique properties of RTDs to develop a novel benchmark modeling and simulation approach capable of replicating neural activity in the mouse brain. By exploiting the characteristics of RTDs, we aim to gain insights into neural behavior and synaptic transmission within the brain's complex network. In the first phase of simulations, amplitude variations and signal-to-noise ratios are investigated in a transmission configuration comprising a single RTD oscillator, an RTD detector, and a mouse brain slice model (using its optical properties such as conductivity and relative permittivity). Following this initial phase, the next design iteration focuses on analyzing phase noise in a heterodyne configuration using subharmonic oscillation of RTDs. The main simulations are carried out using Keysight Advanced Design System (ADS) and SystemVue.