Terahertz Technology for Defense and Security-Related Applications

This thesis deals with chosen aspects of terahertz (THz) technology that have potential in defense and security-related applications. A novel method for simultaneous data acquisition in time-resolved THz spectroscopy experiments is developed. This technique is demonstrated by extracting the sheet conductivity of photoexcited charge carriers in semi-insulating gallium arsenide. Comparison with results obtained using a standard data acquisition scheme shows that the new method minimizes errors originating from fluctuations in the laser system output and timing errors in the THz pulse detection. Furthermore, a new organic material, BNA, is proved to be a strong and broadband THz emitter which enables spectroscopy with a bandwidth twice as large as conventional spectroscopy in the field. To access electric fields allowing exploration of THz nonlinear phenomena, field enhancement properties of tapered parallel plate waveguides are investigated. A new method for imaging of the electric field distribution inside a parallel plate waveguide is developed and used to measure frequency-resolved field reflection coefficients. Field enhancement factors higher than 20 are demonstrated and record-high field strengths of > 1.4 MV/cm are reached. A good agreement between two independent methods of field measurement and a numerical time-domain simulation is shown. Finally, and extensive study of THz radar cross sections (RCS) of scale models of airplanes is carried out. Angle- and frequency-resolved RCS of aircraft fighters F-16 and F-35 are measured. The scaling law allows for translating THz RCS results to the microwave regime. 2D cross section images of the airplanes are reconstructed. Range resolution of 0.27 mm and cross range resolution of 0.19 mm is reached. Properties of flexible absorbing metamaterials for the THz stealth technology are investigated and significant reduction of the RCS is shown.