

PhD viva voce

Metasurfaces enabled terahertz wave polarization control and manipulation

by

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Metasurfaces offer a compact platform for controlling terahertz (THz) waves, potentially overcoming the size, bandwidth, and integration limitations of conventional polarization components. This thesis investigates passive and active metasurface strategies for broadband, multifunctional, and tunable THz polarization manipulation. First, anisotropic resonant structures are designed for reflective linear-to-cross-polarization conversion. Electromagnetic simulations, parametric optimization, and surface-current analysis are used to examine resonant coupling and improve conversion performance. The resulting designs exhibit high polarization-conversion efficiency over a broad frequency range and good tolerance to oblique incidence. A planar dual-functional metasurface is then developed to combine cross-polarization conversion with quarter-wave plate (QWP) operation. Fabricated using UV photolithography, the device is assessed numerically and experimentally, demonstrating broadband circular-polarization generation with high polarization ellipticity and stable response across different incident polarization states and angles. To explore the additional design freedom offered by three-dimensional architectures, 2PP-fabricated metasurfaces are investigated for phase and polarization control. Broadband THz QWP operation is demonstrated through electromagnetic simulations and characterized using terahertz time-domain spectroscopy (THz-TDS), with experimental results agreeing well with the simulations. Finally, graphene-integrated metasurfaces are studied as a route to active polarization control. Numerical analysis of graphene conductivity and Fermi-level tuning indicates the potential for electrically reconfigurable polarization-selective responses. Collectively, these results demonstrate complementary approaches to THz polarization engineering through anisotropic resonances, multifunctional planar designs, three-dimensional fabrication, and tunable graphene integration. The proposed approaches provide a foundation for compact THz components for imaging, spectroscopy, sensing, communication, and adaptive electromagnetic systems.