University of Victoria | Graduate Studies

Notice of the Final Oral Examination for the Degree of Doctor of Philosophy

of

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"Plasmonic-Enhanced THz Generation and Detection Using Photoconductive Antennas"

Department of Electrical and Computer Engineering

Thursday, September 15, 2016
9:00 A.M.
Engineering Lab Wing
Room A126

Supervisory Committee:
Dr. Thomas Edward Darcie, Department of Electrical and Computer Engineering, University of Victoria (Co-Supervisor)
Dr. Reuven Gordon, Department of Electrical and Computer Engineering, UVic (Co-Supervisor)
Dr. Dennis Hore, Department of Chemistry, UVic (Outside Member)

External Examiner:
Dr. Jonathan Holzman, School of Engineering, University of British Columbia

Chair of Oral Examination:
Dr. Kara Shaw, School of Environmental Studies, UVic

Dr. David Capson, Dean, Faculty of Graduate Studies

Abstract

Terahertz technology is rapidly growing for applications in various fields such as medical sciences, remote sensing, material characterization, and security. This accelerated growth has motivated engineers to develop compact, portable, and cost-effective terahertz sources and detectors. Terahertz generation and detection can be achieved using photoconductive antennas (PCAs), which have unique advantages. Notably, they do not require a vacuum or cryogenic cooling to function. PCAs operate on the principle of photoconductivity, which allows for compact integration with a fiber optic laser. It is also possible to launch THz radiation to a waveguide, which can be used for making a robust THz spectroscopy system.

Ultra-short laser pulses are available in both 800 nm and 1550 nm wavelengths. However, the 1550 nm window has distinctive advantages such as availability of fiber amplifiers and fiber based electro-optical components at a relatively lower cost. The goal of this research is to introduce cost-effective and state-of-the-art solutions to develop THz transceivers for use in terahertz time-domain spectroscopy (THz-TDS) at 1550 nm wavelength.

In this thesis we explore three approaches for enhancing THz emission and reception using PCAs. First, an array of hexagonal shape plasmonic nano-structures was used to increase the optical field coupling to the minimum depth of the substrate. Next, nano-structures also helped with enhancing the local electric field inside a low-cost semi-insulating GaAs substrate. This technique resulted in a 60% enhancement of the THz emission compared to a commercial LT-GaAs based PCA with antireflection coating. Moreover, the plasmonic nano-structures efficiently remove heat from the gap area allowing for operation at higher bias voltages. Plasmonic structures on LT-GaAs were investigated, which use a mid-gap Arsenic defect state to absorb 1550 nm light. The plasmonic devices were found to outperform existing InGaAs substrate based THz devices by factor of two. Finally, optimization of the LT-GaAs growth and annealing conditions was investigated to maximize the THz signal at 1550 nm. Outcomes of this research pave the way for designing cost-effective THz transceivers for time domain Terahertz spectroscopy systems at 1550 nm wavelength.