University of Victoria | Graduate Studies

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

of

ROBERT LEVI SMITH

MASc (University of Victoria, 2014)
BEng (University of Victoria, 2011)

"Experimental Evaluation of Low-Loss/Non-Dispersive Terahertz Waveguides"

Department of Electrical and Computer Engineering

Tuesday, April 23, 2019
1:00 P.M.
Engineering Office Wing
Room 430

Supervisory Committee:
Dr. Thomas Darcie, Department of Electrical and Computer Engineering, University of Victoria (Supervisor)
Dr. Jens Bornemann, Department of Electrical and Computer Engineering, UVic (Member)
Dr. Stephanie Willerth, Department of Mechanical Engineering, UVic (Outside Member)

External Examiner:
Dr. J. Steven Dodge, Department of Physics, Simon Fraser University

Chair of Oral Examination:
Dr. James Nahachewsky, Department of Curriculum and Instruction, UVic

Dr. David Capson, Dean, Faculty of Graduate Studies

Abstract

Low-loss waveguides with minimal dispersion are desired throughout the electromagnetic spectrum. These properties are difficult to achieve in the Terahertz (THz) region due to material and geometric constraints. This thesis focuses on the design, fabrication, and testing of waveguide-based devices using two promising technologies: the free-space metallic-slit waveguide (MSWG) and the coplanar strip (CPS) waveguide on a thin (1 μm) silicon nitride membrane. The work presented here differs from standard THz waveguide research which commonly uses the field radiated by a photoconductive antenna (THz optics) for excitation and detection. To improve upon system integration a focus is placed on planar waveguide devices without refractive THz elements. Three main waveguide devices are investigated. First, an edge-coupled MSWG-based linear tapered slot antenna (LTSA) was used for THz-Time Domain Spectroscopy (TDS). This device functions as an alternative to a standard photoconductive switch coupled to silicon lens. Next an edge-coupled tapered MSWG was investigated. The MSWG conductor separation was increased to a low-loss configuration where the field propagated for 24 mm, after which the conductors were tapered to focus the field onto the receiving active region where a THz-bandwidth pulse was detected. Finally a CPS waveguide was fabricated on a thin silicon nitride membrane where a THz-bandwidth pulse was detected after propagating for 10 mm. The active regions for this device were fabricated using a unique method. This method results in the creation of thousands of small (40 μm × 20 μm) active regions (from a 4 mm × 4 mm host substrate) which can be placed anywhere for THz excitation and detection. The small active regions in conjunction with the CPS waveguide on the silicon nitride membrane provide an excellent platform for THz system testing. A single membrane can host many of THz circuits which can be made “active” by the placement of a few thin-film photoconductive devices.