University of Victoria | Graduate Studies

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

of

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BSc (University of Victoria, 2013)

"Broadband IR Stokes Polarimetry for the Electro-Optic Characterization of Cadmium Zinc Telluride"

Department of Chemistry

Monday, December 18, 2017
9:00 A.M.
Elliott Building
Room 305

Supervisory Committee:
Dr. Dennis Hore, Department of Chemistry, University of Victoria (Supervisor)
Dr. Alex Brolo, Department of Chemistry, UVic (Member)
Dr. David Harrington, Department of Chemistry, Uvic (Member)
Dr. Chris Bose, Department of Mathematics and Statistics, UVic (Outside Member)

External Examiner:
Dr. Francois Lagugne Labarthet, Department of Chemistry, Western University

Chair of Oral Examination:
Dr. Michelle Wiebe, Department of Curriculum and Instruction, UVic

Dr. David Capson, Dean, Faculty of Graduate Studies

Abstract

The infrared portion of the electro-magnetic spectrum is a challenging region in which to perform optical techniques, limited by both device efficiency and availability. In this dissertation, a new optical technique is introduced to facilitate polarization state measurement across the mid-IR. In addition, cadmium zinc telluride (CZT) is investigated as a potential new material suitable for electro-optic devices which function in the mid-IR, while also being characterized by other optical analysis methods.

Thin film interference is discussed as it relates to optical techniques and electronic devices. A Stokes polarimeter is used to study the oxide development on the surface of CZT electronic devices, and the effect of natural thin films on substrates used in optical techniques is discussed. In particular, the impact of thin film interference on sum-frequency generation spectroscopy measurements of methyl group orientation are assessed.

An FTIR source operated in step-scan mode is used to create a broadband, IR Stokes polarimeter which measures the polarization state of light from 2.5-11 μm simultaneously. Its design, involving two photo-elastic modulators and an analyzer, and theory are described in detail. This instrument is demonstrated by measuring linearly polarized light, and is applied to the measurement of the refractive index dispersion of quartz from 2.5-4 μm, which goes beyond the limits of literature values.

Electro-optic crystals of CZT with electrodes of gold and indium are characterized at each wavelength in the mid-IR in terms of their electro-optic effects and apparent depolarization using the Stokes polarimeter. The material displays high-resistivity, allowing it to be operated with up to 5 kV applied DC voltage. The linear electro-optic effect is observed, but overall properties of the samples are found to be heavily dependent on the choice of metal for the electrodes. With a high-work function electrode material in gold, a large depletion region is created when high voltage is applied, which leads to a gradient in electric field throughout the material. This causes a beam of light transmitted through it to experience a distribution of electro-optic behaviours, which leads to overall depolarization of the light. Indium's work function is lower than gold's, and is closer to that of CZT. With indium electrodes, the electric field is found to be more consistent, and behaviour is much closer to ideal.

The electro-optic effect of CZT is also characterized with AC applied voltage in order to assess its suitability to AC applied voltage applications. The power supply used for this was limited to 60 Hz, which precludes a complete characterization in this regard, but unexpected behaviour was seen. A methodology utilizing an oscilloscope and FTIR was developed in order to more completely understand the material response, and divergent behaviour with positive and negative voltage was found.