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Mid-infrared semiconductor laser based trace gas sensor technologies: Recent advances and applications

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Abstract

This talk will focus on recent advances in the development of sensors based on infrared semiconductor lasers for the detection, quantification and monitoring of trace gas species and their applications in atmospheric chemistry and industrial process control.

The architecture and performance of four sensitive, selective and real-time gas sensor systems based on mid-infrared semiconductor lasers will be described. High detection sensitivity at ppbv and sub-ppbv concentration levels requires sensitivity enhancement schemes such as tunable laser diode absorption spectroscopy (TDLAS) and wavelength modulation spectroscopy (WMS), photo-acoustic absorption spectroscopy (PAS) or quartz-enhanced-PAS (QEPAS). These spectroscopic methods can achieve minimum detectable absorption losses in the range from 10^{-8} to 10^{-11} $cm^{-1}/\sqrt{Hz}$.

A 3.36 µm CW TEC DFB GaSb based laser diode was used as the excitation source for C2H6 detection with a detection sensitivity of 130 pptv with a 1 s. acquisition time. A QEPAS based sensor capable of ppbv level detection of CO was developed. A noise-equivalent sensitivity (NES, 1σ) of 2 ppbv was achieved at atmospheric pressure with a 1 s. acquisition time at 2169.2 cm^{-1}. Furthermore, high performance 5.26 µm and 7.24 µm CW TEC DFB-QCL (mounted in a high heat load (HHL) package) based QEPAS sensors for atmospheric NO and SO_2 detection will be reported. A 1σ minimum detection limit of 3 ppb and 100 ppb was achieved for a sampling time of 1 s. using interference free NO and SO_2 absorption lines located at 1900.08 cm^{-1} and 1380.94 cm^{-1} respectively.

Biography

Frank K. Tittel is the Josephine S. Abercrombie Professor of Electrical Computer Engineering at Rice University, where he also holds a joint faculty appointment in the Department of Bioengineering. He obtained his bachelor, master, and doctorate degrees in physics from the University of Oxford in 1955 and 1959, respectively. From 1959 to 1967 he was a Research Physicist with General Electric Research and Development Center, Schenectady, New York. Since 1967 he has been on the faculty at Rice University in Houston, Texas. Current research interests include various aspects of quantum electronics, in particular laser spectroscopy, nonlinear optics, and laser applications in environmental monitoring, industrial process control, and medicine. Dr. Tittel is a Fellow of the IEEE, the Optical Society of America and the American Physical Society.