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Laser based chemical sensor technology: recent advances and applications

Frank K. Tittel*, Yury A. Bakhirkin, Anatoliy A. Kosterev, Gerard Wysocki and Robert. F. Curl
Rice Quantum Institute, MS 366, Rice University, 6100 Main St., Houston, TX 77005, USA
* corresponding author: fkt@rice.edu

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 application to environmental monitoring and medical diagnostics. Ultrasensitive chemical analysis of gases based on molecular absorption laser spectroscopy is a well-established technology [1]. The development of compact trace gas sensors based on the use of both diode lasers as well as quantum cascade (QC) [2] and interband cascade (IC) [3] lasers will be emphasized. QC and IC lasers permit the targeting strong fundamental rotational-vibrational transitions in the mid-infrared. Vibrational fundamentals are one to two orders of magnitude more intense than the overtone transitions of the near infrared.

The architecture and performance of several sensitive, selective and real-time gas sensors based on near and mid-infrared semiconductor lasers will be described. To date we have detected 13 gases (CH_4, N_2O, CO_2, CO, NO, H_2O, SO_2, NH_3, C_2H_4, OCS, C_2H_4, H_2CO and C_2H_5OH) at the ppm to ppt level [4-7]. In several cases, isotopic signatures of carbon and oxygen have also been observed. High sensitivity requires sensitivity enhancement schemes such as multipass gas absorption cells, cavity absorption enhancement, or photo-acoustic absorption spectroscopy. These methods can achieve minimum detectable absorbances in the range from 10^{-4} to 10^{-5} for field deployable gas sensors. Several recent examples of real world applications in atmospheric chemistry (Fig.1&2), medical diagnostics (Fig.3&4) and the monitoring of air quality in spacecraft habitats will be reported.

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