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SEMICONDUCTOR LASER BASED CHEMICAL SENSOR TECHNOLOGY: RECENT ADVANCES AND APPLICATIONS

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Abstract:

This talk will focus on recent advances for the development of sensors based on infrared semiconductor lasers for the detection of trace gas species. Several recent examples of real world applications in environmental and industrial process monitoring as well as in medical diagnostics will be reported.

Summary:

The detection, quantification and monitoring of trace chemical species in the gas phase find applications in such diverse fields as in environmental monitoring, industrial process control, and medical diagnostics. Ultrasensitive chemical analysis of gases based on molecular absorption laser spectroscopy is a well-established approach [1]. This talk will focus on recent advances for the development of compact trace gas sensors based on the use of pulsed and continuous-wave distributed feedback (DFB) quantum cascade (QC) [2] and interband cascade (IC) [3] lasers permits targeting strong fundamental rotational-vibrational transitions in the mid-infrared, which are one to two orders of magnitude more intense than overtone transitions in the near infrared.

The architecture and performance of several sensitive, selective and real-time gas sensors based on mid-infrared cw and pulsed DFB QC-DFB and cw DFB IC 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) including isotopic signatures of carbon and oxygen at the ppm to ppt level [4-7]. This requires different sensitivity enhancement schemes such as multipass gas absorption cells, cavity ringdown or photo-acoustic absorption spectroscopy which can realize minimum detectable absorbances in the range from 10^{-4} to 10^{-5}. Several recent examples of real world applications in atmospheric chemistry (Fig.1&2), medical diagnostics (Fig. 3&4) and monitoring the air quality of spacecraft habitats will be reported.

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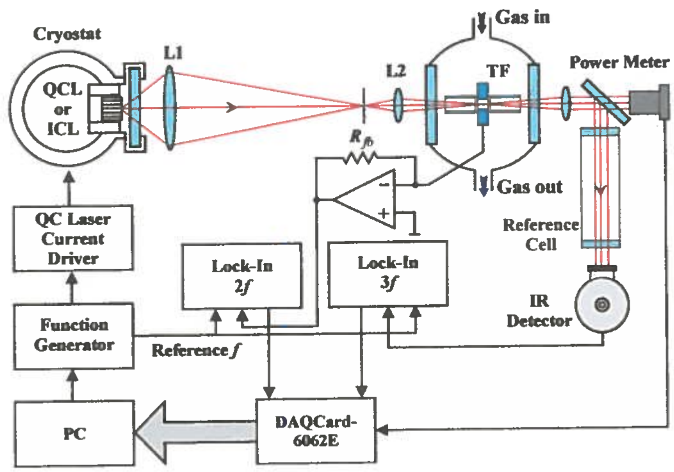

Fig. 1 QCL based QEPAS trace gas sensor

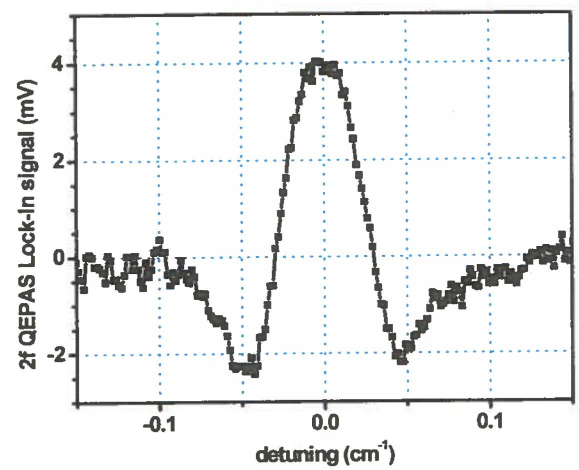

Fig. 2 2f QEPAS based H2CO signal at 5.53 μm

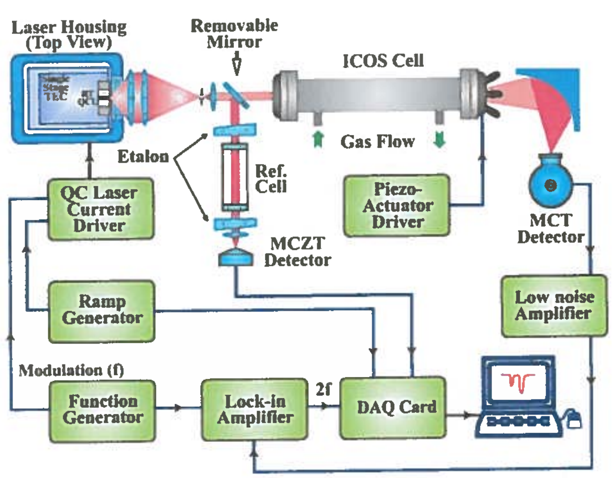

Fig. 3 TEC–CW-DFB QCL based OA-ICOS sensor

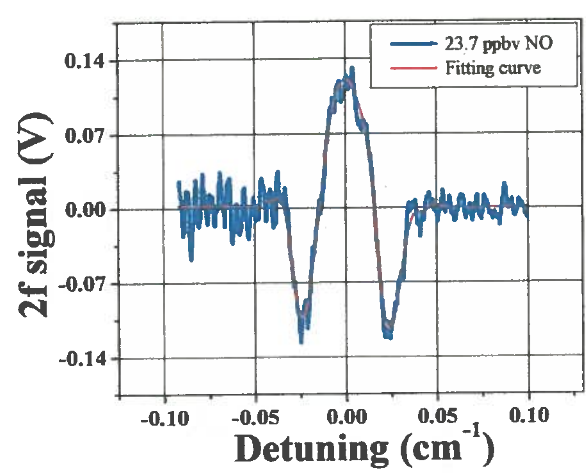

Fig. 4 2f NO absorption signal at 1835.57 cm^{-1}