Recent advances in mid-infrared quantum and interband cascade laser-based trace gas detection (invited)

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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 in atmospheric chemistry, medical diagnostics, life sciences, industrial process control and national security. Specifically, the development of compact trace gas sensors, in particular based on quantum cascade (QC) and interband cascade (IC) lasers that permit the targeting of strong fundamental rotational-vibrational transitions in the mid-infrared and that are one to two orders of magnitude more intense than overtone transitions in the near infrared, will be considered.

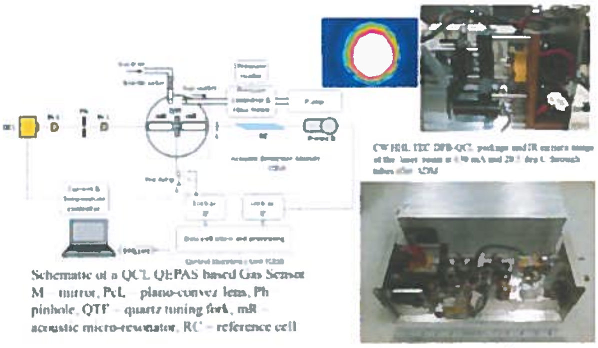

Fig.1. CW TEC DFB QCL based QEPAS NO Gas Sensor

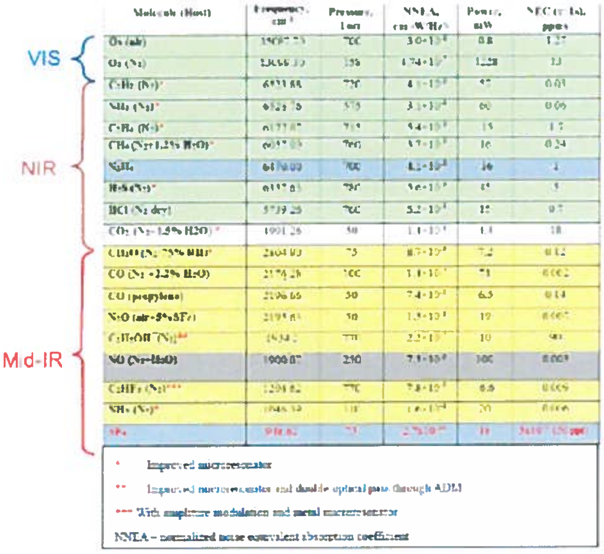

Fig 2. QEPAS Performance for Trace Gas Species (October 2014)

The spectroscopic detection and monitoring of seven molecular species (ammonia (NH_3), nitric oxide (NO) (see Fig. 1), carbon monoxide (CO), sulfur dioxide (SO_2), methane (CH_4), nitrous oxide (N_2O) and hydrogen peroxide (H_2O_2)) will be described explicitly. These molecules were detected using QCL and ICL based conventional photoacoustic (CPAS) and quartz-enhanced photoacoustic spectroscopy (QEPAS). CPAS and QEPAS can achieve minimum detectable absorption losses in the range from 10^{-8} to 10-11 $cm^{-1}/\sqrt{Hz}$ (see Fig. 2). Several recent examples of real-world applications of field deployable gas sensors will be described [1-4]. Future work will include the development of intracavity QEPAS (I-QEPAS) in order to obtain significantly lower minimum detectable gas concentration levels of < 10 pptv. Furthermore we envision a continuous THz QEPAS sensor using a THz source operating at room temperature based on intracavity difference frequency generation from mid-IR QCLs [5].

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