Mid-infrared trace gas detection in exhaled breath for disease diagnostics and monitoring

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This talk will focus on recent advances in the development of trace gas sensor technologies, based on infrared semiconductor lasers for the ultra-sensitive detection, quantification and monitoring of trace gas species and their application in medical diagnostics, life sciences, public health and atmospheric chemistry [1-3]. Identification and quantification of potential disease biomarkers for asthma, renal failures, diabetes and caner has been the driving force for the development of analytical instruments based on laser spectroscopy for the past two decades. Exhaled breath analysis is a method for obtaining non-invasive, accurate, and rapid information on the clinical state of an individual by monitoring volatile organic compounds instead of performing blood tests. The development of novel, compact trace gas sensors based on interband cascade and quantum cascade lasers permits the targeting of 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 spectral region. Specifically, the spectroscopic detection and monitoring of six molecular gas species of interest in medical diagnostics, such as ammonia (NH_3), nitric oxide (NO), carbon monoxide (CO), sulfur dioxide (SO_2), methane (CH_4), nitrous oxide (N_2O) and hydrogen peroxide (H_2O_2) will be described [16]. These molecules were detected using conventional photoacoustic spectroscopy (PAS), quartz-enhanced photoacoustic spectroscopy (QEPAS) and laser absorption spectroscopy with a novel, compact multipass absorption cell [1,5]. PAS and QEPAS can achieve minimum detectable absorption coefficient in the range from 10^{-8} to 10^{-11} $cm^{-1}/\sqrt{Hz}$. 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].

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