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TRACE GAS DETECTION WITH DISTRIBUTED FEEDBACK QUANTUM CASCADE LASERS

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Quantum cascade lasers with distributed feedback (QC-DFB) are single-frequency semiconductor mid-IR light sources capable of delivering >100 mW of continuous wave power with an intrinsic linewidth of ~ 1 MHz. In pulsed mode, QC lasers can be operated at a near room temperature. These unique features make QC-DFB lasers convenient new sources for spectroscopic trace gas detection in the 4 to 19 micron region. Gas sensors based on cw (cryogenic temperature) and pulsed (near room temperature) operated QC-DFB lasers will be described [1-3]. Recent advances in photonic technologies and spectroscopic detection schemes have been employed in various sensor platforms to achieve minimum detectable absorption coefficients of 10^{-9} cm^{-1} in real world applications.

For sensitivity enhancement different techniques have been investigated that include a multipass cell, balanced detection, cavity enhanced spectroscopy (CES), and cw cavity ringdown spectroscopy (CRS). The gas sensor architecture depends on the concentration levels of a desired trace gas species. A number of gases such as CH_4, N_2O, NO, CO, NH_3, C_2H_5OH, and H_2O have been detected and quantified to date in ambient air and other gas mixtures with sensitivity of several parts per billion by volume. Detection of biomedically produced nitric oxide (NO) is of particular importance because of its critical role in human physiology. NO in human breath samples was detected by its fundamental absorption at 5.2 μm (1921.6 cm^{-1}) with a CES technique. Application of CRS yielded a single ringdown event sensitivity to absorption of $2\cdot10^{-8}$ cm^{-1}. Recently also ammonia detection at 10.04 μm (997 cm^{-1}) was carried out at the NASA Johnson Space Center, Houston, on a bioreactor being developed for water reprocessing in future spacecraft habitats.

References:

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