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Ammonia Detection in Exhaled Human Breath with a Quantum Cascade Laser Based QEPAS Sensor

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A quantum cascade laser (QCL) based breath sensor platform for medical applications employing a quartz-enhanced photoacoustic spectroscopy technique is reported. The detection sensitivity for exhaled ammonia is at a <10 ppbv concentration level with 0.5 s time resolution. This work demonstrates the implementation of a sensitive QCL based sensor platform for quantitative measurements of ammonia concentrations in exhaled breath. Exhaled human breath contains ~ 400 different trace gas species, mostly at ultra low concentration levels. Many of these gases can serve as biomarkers for the identification and monitoring of various types of human diseases or wellness states. Typical concentrations of ammonia in healthy human breath may vary from tens to few hundreds ppbv, whereas elevated levels (e.g. ≥1 ppmv) may indicate significant pathology. Monitoring of ammonia concentration in exhaled breath using laser spectroscopy techniques provides a fast, non-invasive diagnostic method for patients with a variety of medical conditions, including liver and kidney disorders, and helicobacter pylori infections. Therefore laser spectroscopy in combination with a mid-infrared, cw, high performance QCL is a promising analytical approach for real time breath analysis and the quantification of breath metabolites [1].

Our study of ammonia in human breath was performed with either a CW DFB QCL or a tunable EC-QCL based QEPAS sensor and using a wavelength modulation technique [2,3]. The DFB QCL operated at 5°C and provided a maximum power of ~30 mW. A tuning range of ~ 4.5 cm^{-1} by varying the injection current enabled the monitoring of an ammonia line at 1046.4 cm^{-1}. The EC-QCL was tuned to the 930.8 cm^{-1} NH_3 line, which is free from potential spectrally interfering species such as CO_2, H_2O, and CH_3OH. Breath ammonia measurements were performed on a healthy volunteer over a three week period with DFB QCL. Performance characteristics for both the DFB-QCL and the EC-QCL sensor platforms operating with 2f and 1f wavelength modulation respectively will be reported.

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