Wavelength Modulation Off-Axis Integrated Cavity Output Spectroscopy for Biogenic NO detection in Human Breath

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Abstract: A compact gas sensor based on a CW mid-infrared tunable quantum cascade laser and wavelength modulation off-axis integrated cavity output spectroscopy has been developed to measure biogenic NO concentrations in human breath.

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Nitric Oxide (NO) detection from exhaled human breath is of particular interest for the early detection of a number of diseases [1]. Tunable laser absorption spectroscopy in the mid infrared spectral region is a sensitive analytical technique for trace gas monitoring. Distributed feedback quantum cascade lasers (DFB QCLs) are new single frequency tunable sources, which are particularly suited for mid-infrared gas sensing [2,3].

A gas analyzer based on a CW DFB QCL operating at ~ 5.2 μm and off-axis integrated cavity output spectroscopy (OA-ICOS) [4] has been developed to measure NO concentrations in human breath. A compact sample cell, 5.3 cm in length with a volume of 80 cm^3, suitable for on-line and off-line measurements during a single breath cycle has been designed and tested. Feasibility experiments using OA-ICOS and wavelength modulation spectroscopy (WMS) [5] were performed in order to determine biogenic NO concentrations from nasal exhaled air. The second harmonic (2f) signal of the OA-ICOS compact cavity output was sampled with a lock-in amplifier and averaged using a data acquisition card and LabView software. The amplitude of 2f spectra is directly proportional to the gas concentration [5], which can be retrieved from calibration measurements. Figure 1 depicts 2f spectra of the R(10.5) NO line at 1912.07 cm^{-1} for the 95 ppbv NO:N_2 calibration mixture as well as for nasal NO (nNO), collected offline in a Tedlar bag. The nNO concentration was deduced to be 53 ppbv.

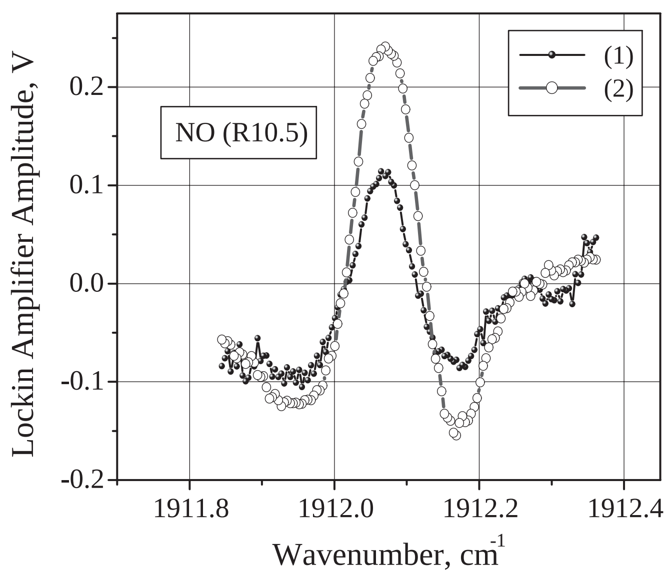

Fig.1. NO concentration of 53 ppbv from nasal breath (1) and NO: N_2 calibration mixture with 95 ppbv of NO (2), measured using an OA-ICOS wavelength modulation technique.

A detection limit ~ 2ppbv, based on a SNR of 1 was obtained. Our approach for further improvement of the SNR and detection limit will be discussed. The feasibility and merit of NO detection in expired human breath as a non-invasive medical diagnostic tool using the described OA-ICOS wavelength modulation technique will also be reported.

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