Using Cavity-Enhanced Spectroscopy to Improve Healthcare: In-Airways O_2 Consumption Sensing Based On OA-CEAS

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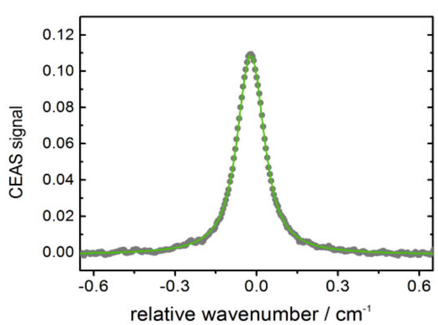
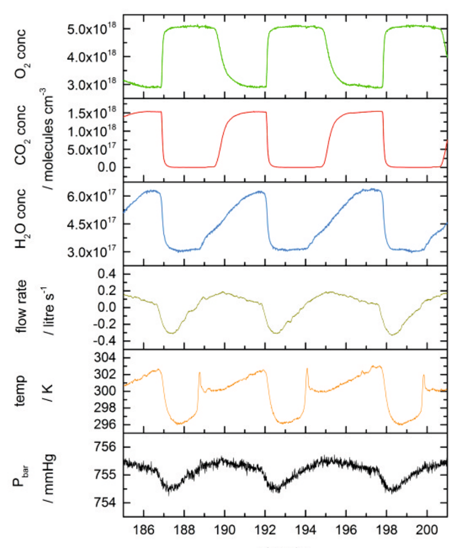
Directly interfacing cavity-enhanced spectrometers with a hot, humid, and turbulent gas mixture such as exhaled breath is a difficult task. So far, the general approach has been to opt for side-stream configurations that rely on a small portion of the respired gas mixture to be diverted via a sampling tube or bag to the measuring site, where pre-conditioning of the pressure, temperature, and relative humidity of the sample is often required. These strategies raise a number of issues when it is necessary to combine synchronous measurements of molecular concentration with those of respiratory flow for calculating the rate of gas uptake by the lungs. The impact of monitoring on-going oxygen consumption in a range of clinical settings (anaesthesia, intensive care) where current side-stream technology is not applicable, [1, 2] has prompted the development of an O_2 sensor that can offer high accuracy (< 2000 ppm at 1 atm), fast response (<50 ms), large dynamic range (0-100%), and operates directly within the airways. We present a compact, off-axis cavity-enhanced absorption spectrometer (OA-CEAS) constructed from a 764 nm VCSEL and a 27 mm optical cavity with re-entrant configuration. RF noise perturbation of the laser current was employed to improve the sensitivity by promoting the non-resonant properties of the cavity. [3] The O_2 sensor is integrated into a purpose-built CO_2 and water vapour absorption spectrometer and respiratory flow sensor, from which the O_2 consumption rate is calculated. The performance and challenges in achieving high accuracy and precision when dealing with a gas sample with time-varying physical properties (composition, temperature, humidity, flow) will be presented, alongside with data collected from patients undergoing surgical procedures.





References
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2. B. Cummings et al, J. Appl. Physiol. 111, 303-307(2011)
3. L. Ciaffoni et al, Opt. Express 22, 14, 17030-8 (2014)