

# Highlights of Analytical Sciences in Switzerland

Division of Analytical Sciences

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## Multi-Component Trace Gas Spectroscopy Using Dual-Wavelength Quantum Cascade Lasers

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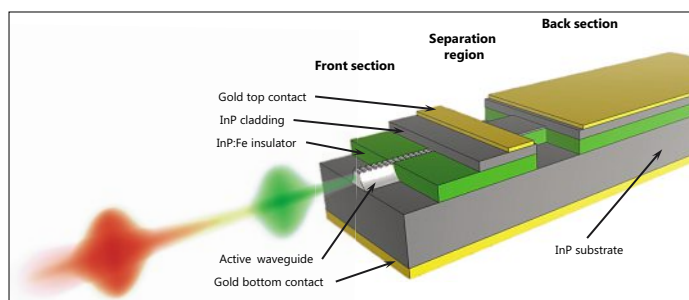
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Simultaneous detection of multiple gas species using mid-infrared laser spectroscopy is highly desired for numerous applications ranging from air quality monitoring, medical breath analysis or drug and explosive detection to industrial process control. Since it is often impossible to address the high-resolution spectra of different gases with a single laser, state-of-the-art multi-wavelength spectrometers have to rely on the use of several lasers and elaborate beam combining solutions. This makes them bulky, costly, and highly sensitive to optical alignment.

We explored a new concept for multi-component spectroscopy based on a Dual-Wavelength Quantum Cascade Laser (DW-QCL). Such a laser can emit at two spectrally well-separated wavelengths, which share a common waveguide to produce one output beam. Thereby, it is possible to detect multiple gases without the need for any beam-combining optics.

The active region of the DW-QCL consists of two different active layers stacked on top of each other, optimized for a broadband emission at 1600 cm<sup>-1</sup> and 1900 cm<sup>-1</sup>. These two spectral windows are ideally suited for the detection of nitrogen oxide (NO) and nitrogen dioxide (NO<sub>2</sub>). Single-mode emission at the desired wavelengths is ensured by a succession of two distributed-feedback (DFB) gratings with different periodicities. Electrical separation of the respective laser sections makes it possible to address each wavelength independently and integrate the laser easily in a spectroscopic setup for gas analysis.

The spectrometer reached a precision (1σ) of 0.5 ppb for NO<sub>2</sub> and 1.5 ppb for NO after 100 s of averaging. It was successfully



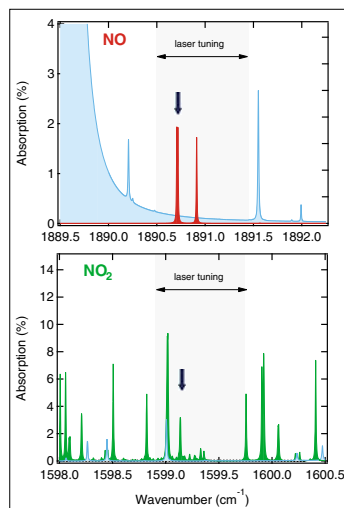
Schematic drawing of the dual-wavelength laser. The laser is approximately 200 μm wide and 5 mm long. It emits at 5.26 μm (1900 cm<sup>-1</sup>) and 6.25 μm (1600 cm<sup>-1</sup>) as indicated by the two-colored beam.

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Diesel engines are deployed in heavy-duty and passenger cars. Modern engines include both de-NO<sub>x</sub> systems and particle filters. This allows maximum efficiency (i.e. high NO<sub>x</sub> during combustion) and low tailpipe emission.



Simulated transmission spectrum of NO<sub>2</sub> (green), NO (red) and water vapor (blue), and the tuning range of the DW-QCL. The targeted absorption peaks are indicated with a blue arrow.

**developments aim to combine and optimize the concept to obtain simple and cost-effective spectrometers for the simultaneous measurement of multiple trace gas species.**

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