Application note
Laser Photoacoustic Measurement, OPO laser and PA201

Introduction

An example of low ppb level gas measurement using extremely sensitive cantilever enhanced photoacoustic detector PA201 combined with a compact tunable mid-infrared optical parametric oscillator (OPO) laser source was performed. Target molecule in the demonstration was methane whose detection limit was determined to be 4 ppb using 1 second observation time.

Measurement Setup

Measurement setup included a Gasera PA201 photoacoustic detector with an optical cantilever microphone in 95 mm long cylindrical cell and a very compact mid-infrared range tunable OPO laser source from Cobolt AB. Collimated laser beam was directed through the photoacoustic cell to a power meter. Laser power was modulated using a mechanical tuning fork chopper at 135 Hz frequency.

Table I. *Laser parameters.*

Power	100	mW
Repetition rate	10	kHz
Pulse width	4	ns
Pulse energy	10	µJ
Wavelength	3237 – 3296	nm
Laser linewidth	1.3	nm
Beam diameter	1.6	mm

Table II. *Measurement parameters.*

Cell pressure	953	mbar
Measurement frequency	135	Hz
Cell temperature	50	°C
Methane concentration	10	ppm
Observation time	0.957	s
Photoacoustic cell length	95	mm
Photoacoustic cell diameter	4	mm
Cantilever dimensions	5 x 1.2 x 0.01	mm

Gas was sampled using an internal pump inside the photoacoustic detector. The cell was sealed during the measurement and sample gas pressure was set to 953 mbar.

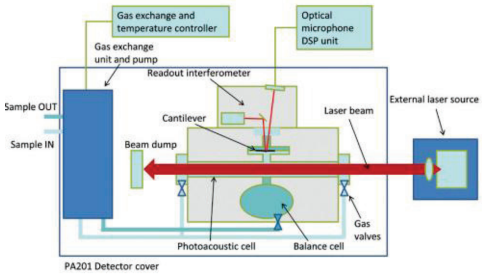

Figure 1. *Schematic drawing of the measurement setup.*

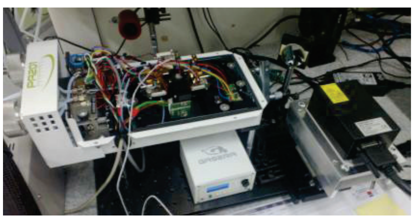

Figure 2. *Picture of the measurement setup.*

Results

Laser wavelength was scanned from 3236.45 nm to 3295.95 nm in 0.1 nm steps. Data was integrated 0.957 second time at each step. The resulting spectrum of 10 ppm of methane is shown in Figure 3.

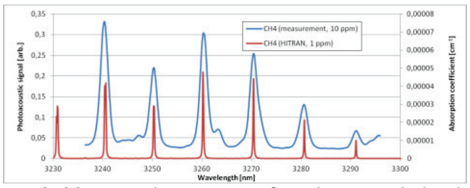

Figure 3. *Measured spectrum of methane and simulated HITRAN spectrum for a comparison.*

The background signal and the noise level at different wavelengths was measured by setting dry nitrogen inside the photacoustic cell. Due to the use of amplitude modulation, the noise followed the background signal value (Figure 14). This means that main noise source is the precision of laser power and optical microphone (0.2 %). Detection limit was calculated by dividing the concentration by the signal-to-noise ratio (2 x RMS).

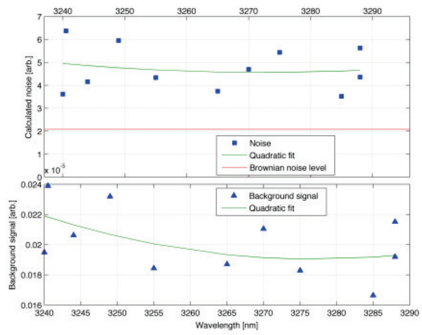

Figure 4. *Measured background signal and noise levels at different wavelengths.*

Table III. *Calculation of the detection limit.*

Methane concentration	10	ppm
Wavelength	3240.3	nm
Signal	0.331	
Background signal	0.024	
Methane signal	0.307	
Measurement time	0,951	s
Noise (1 x RMS)	5.00×10^{-5}	
SNR (1 x RMS)	6140	
Det-limit (2 x RMS)	3.3	ppb

Outlook

The combination of cantilever enhanced photoacoustics and tunable mid-infrared OPO laser source make a perfect fit for rapid and selective trace gas analysis. High sensitivity of the photoacoustic detector and relatively high laser power at fundamental vibration bands of any hydrocarbon and also large selection of other molecules guarantees the low ppb sensitivity. High selectivity is achieved by the wide tuning range of the laser source. Both the laser source and photoacoustic cell are already very compact and fit easily to a table top size analyzer, but it is also possible to implement the components to a portable size gas analyzer.

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