mir sense

Distributor training material

New 10 to 17 microns lasers

French manufacturer of QCL laser systems

Headquarters and chip production near Paris and Montpellier

Assembly in Grenoble
Near the Alpes mountains

Dr. Mickael Brun, COO

Dr. Mathieu Carras, CEO

cea leti

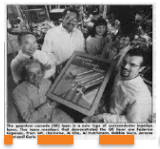
cea leti

mir sense

Founded in 2015

III-V lab

ALCATEL-THALES



THOMSON-CSF

THALES

AT&T Bell Laboratories

Alcatel·Lucent Bell Labs Research

15+ employees, mostly PhDs

10 to 17 microns is a new playground for spectroscopy

- Measure BTEX (Benzene, Toluene, Xylene), CH3i, HCN at absorption rays that are stronger than in the other wavelength regions

- There is less cross interference from other molecules between 10 to 17 microns

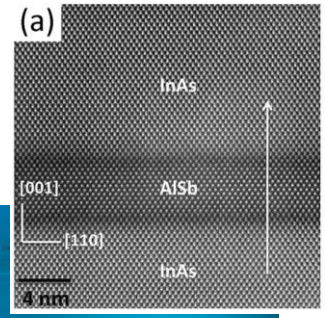
Manufacturing in Montpellier, France

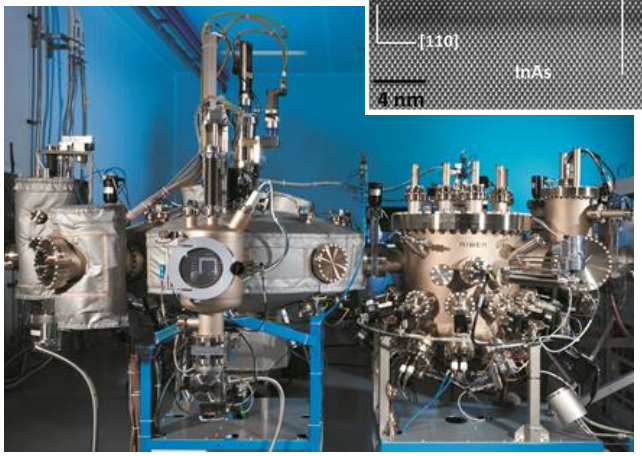
Known industrial player in QCL industry
Manufactures QCLs for defense & spectroscopy
Manufactures QCL-based spectrometers

Brings a new QCL technology
Brings production capacity
Brings 20 years of expertise on QCLs

Modern production buildings & equipment investment in 2014

Investment	Amount
350 m² Process clean-room 120 m² Epitaxy clean-room + equipment	40 million euros
Two molecular beam epitaxy tools under ultravacuum	5 million euros
TOTAL	**45 million euros**

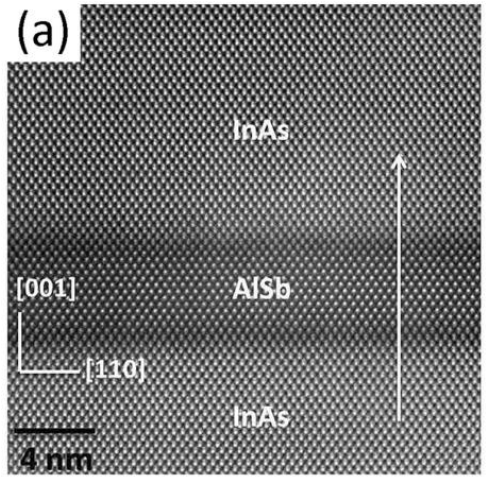


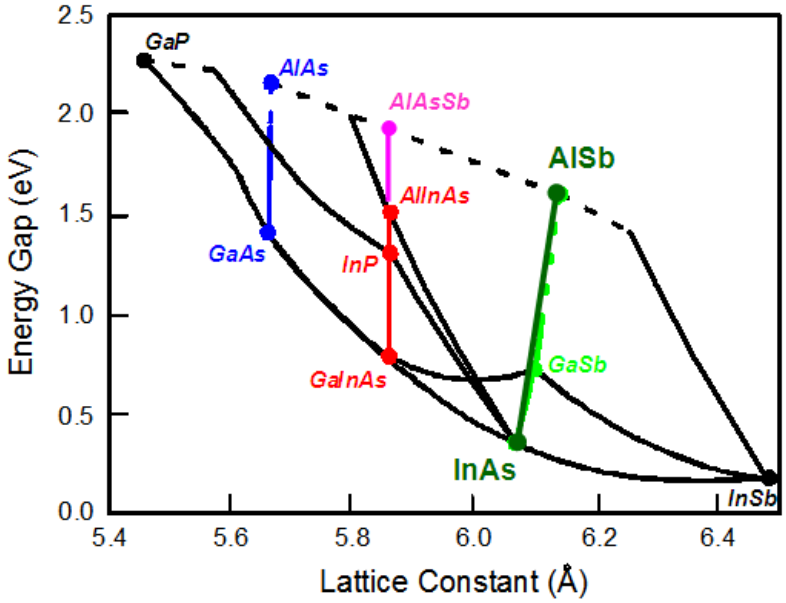


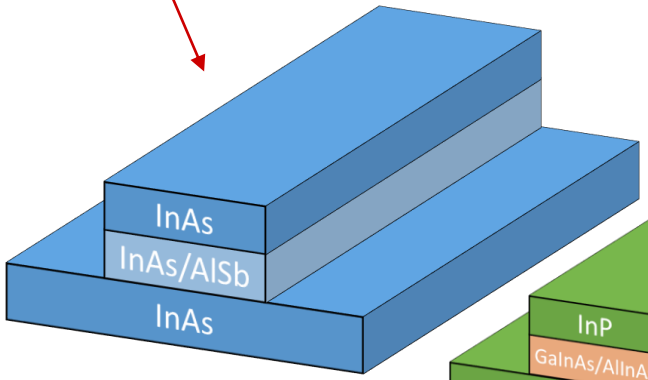
We manufacture antimonide QCLs

3 tradiational III-V compound families for optoelctronics:

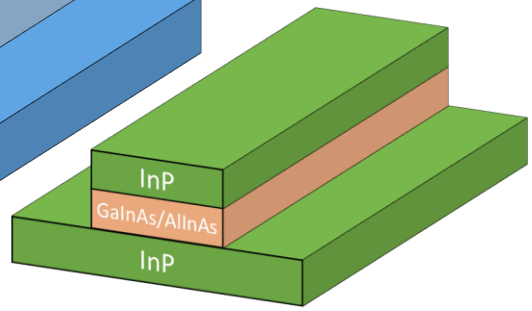
- GaAs ‘Gallium arsenide’ substrate material
- InP ‘Indium phosphide’ substrate material
- InAs ‘Indium arsenide’ substrate material (our family)





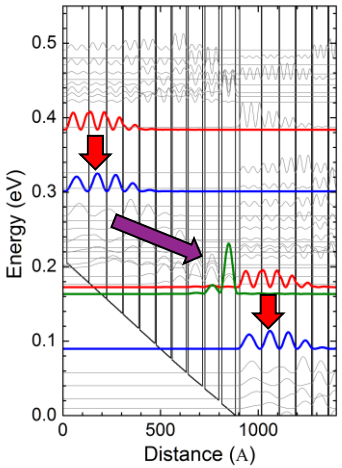


InAs/AlSb or « antimonide » QCL

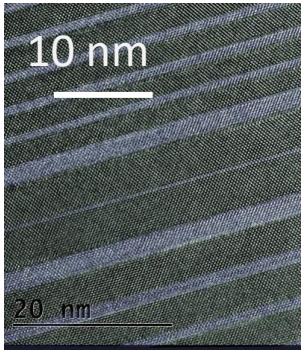


Standard InP QCL

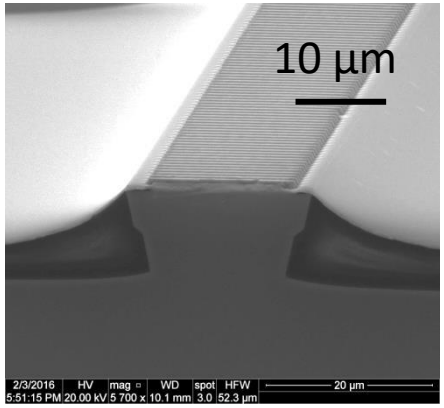
We have a total control of the technology



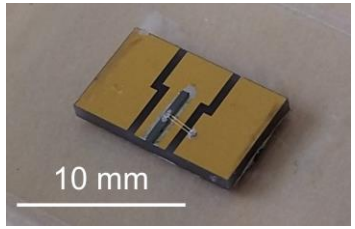
Design



Create multilayers

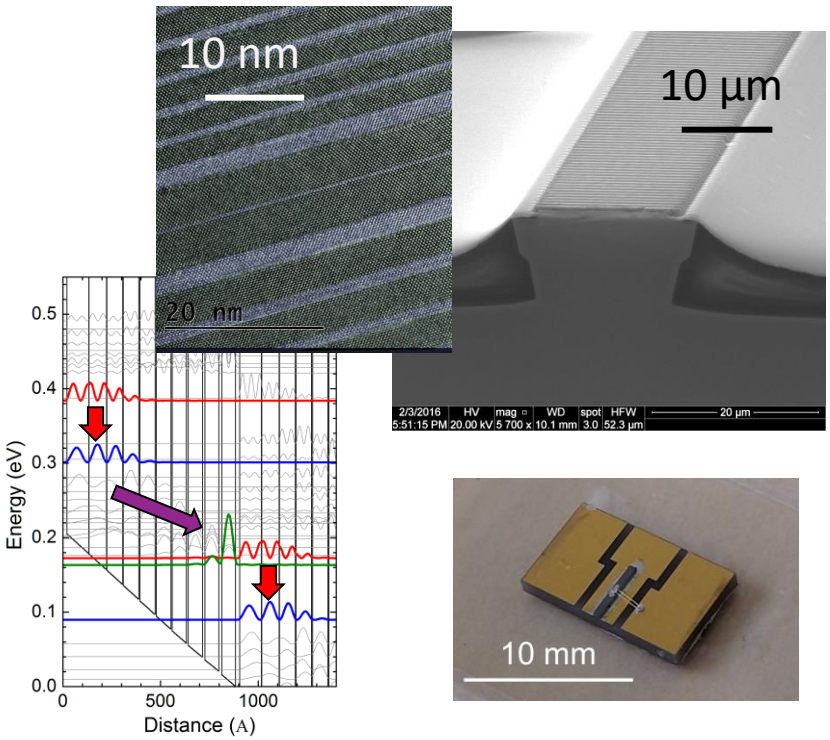


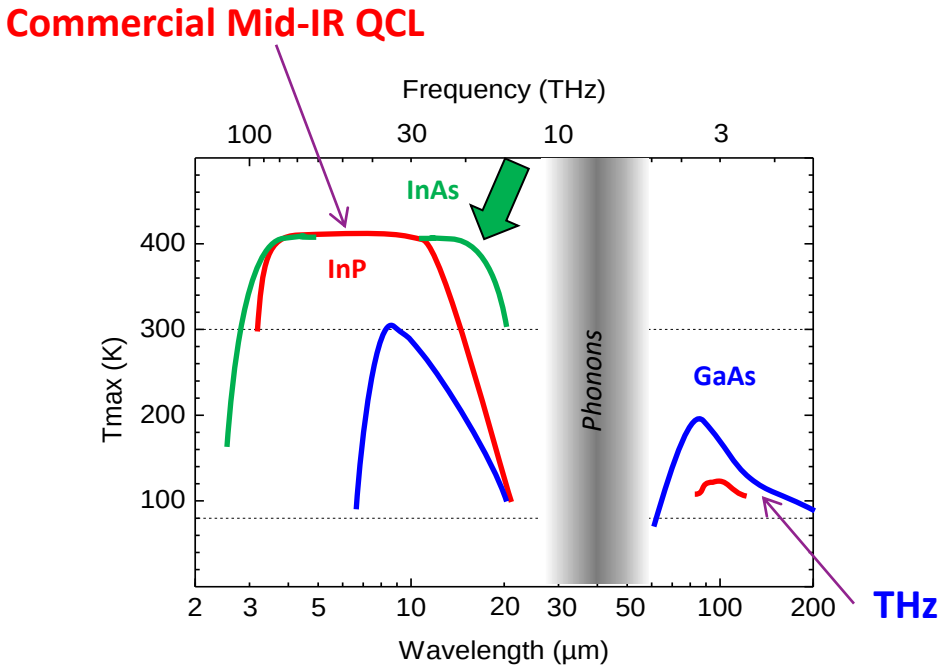
Structure the laser



Final assembly

Our antimonide QCL performance is state of the art for wavelengths >10µm

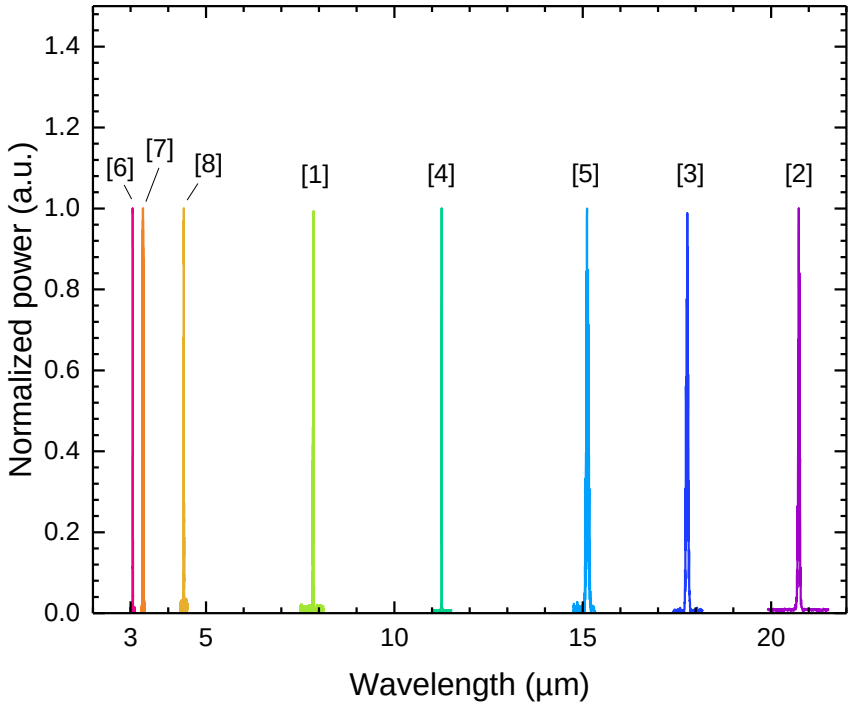




- This alternative QCL technology is efficient and yields state of the art results
- It opens up access to new wavelengths: 10 - 20 µm et 3 - 4 µm

Pulsed operation results: λ from 3 to 20 µm

High temperature: T_{max} > 100 ºC
Power > 100 mW



[1] **APL Photonics 5**, no. 4, p. 041302, (2020).

[2] **Appl. Phys. Lett. 115**, no. 15, p. 151101, (2019).

[3] **Photonics 6**, no. 1, p. 31, (2019).

[4] **Electron. Lett. 54**, no. 17, pp. 1045–1046, (2018).

[5] **Opt. Express 24**, no. 16, pp. 18799–18806, (2016).

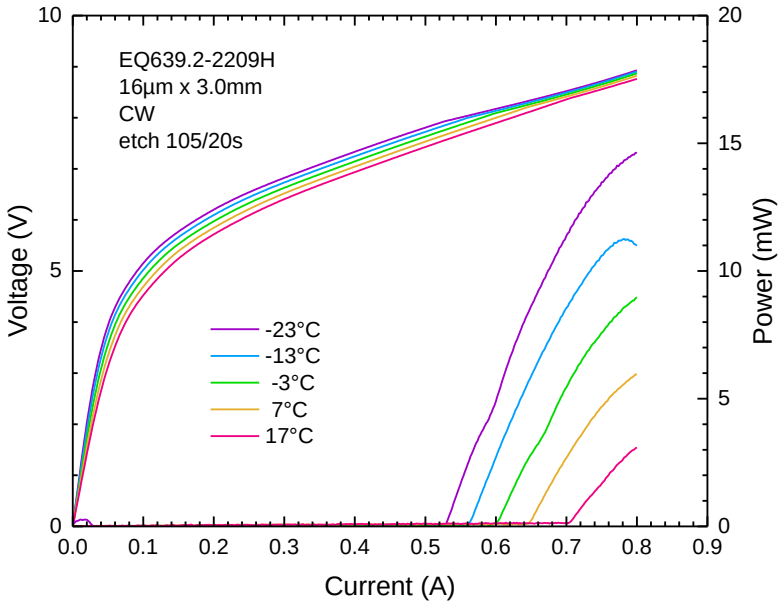
[6] **AIP Adv. 2**, no. 2, p. 022119, (2012).

[7] **Appl. Phys. Lett. 91**, no. 14, p. 141106, (2007).

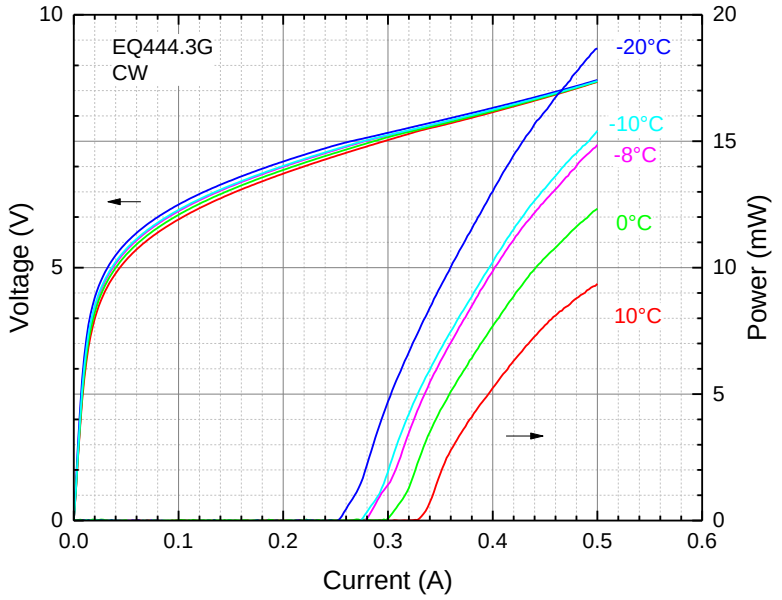
[8] **Appl. Phys. Lett. 85**, no. 2, pp. 167–169, (2004).

CW operation results

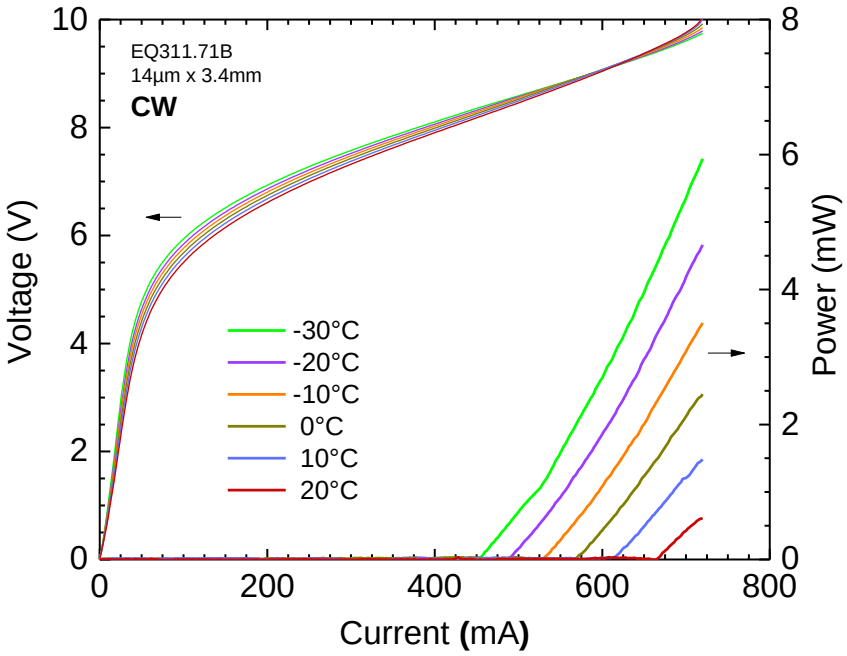
QCL DFB @ 14.9µm (Benzene spectroscopy)



QCL DFB @ 11.3 µm (CH_3I spectroscopy)

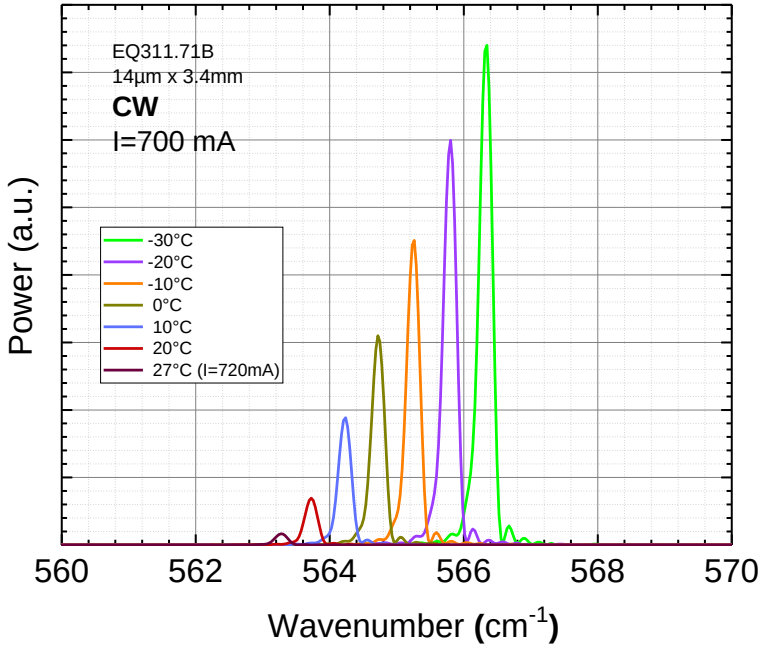


17.8 µm is our record long wavelength CW DFB at ambient temperature



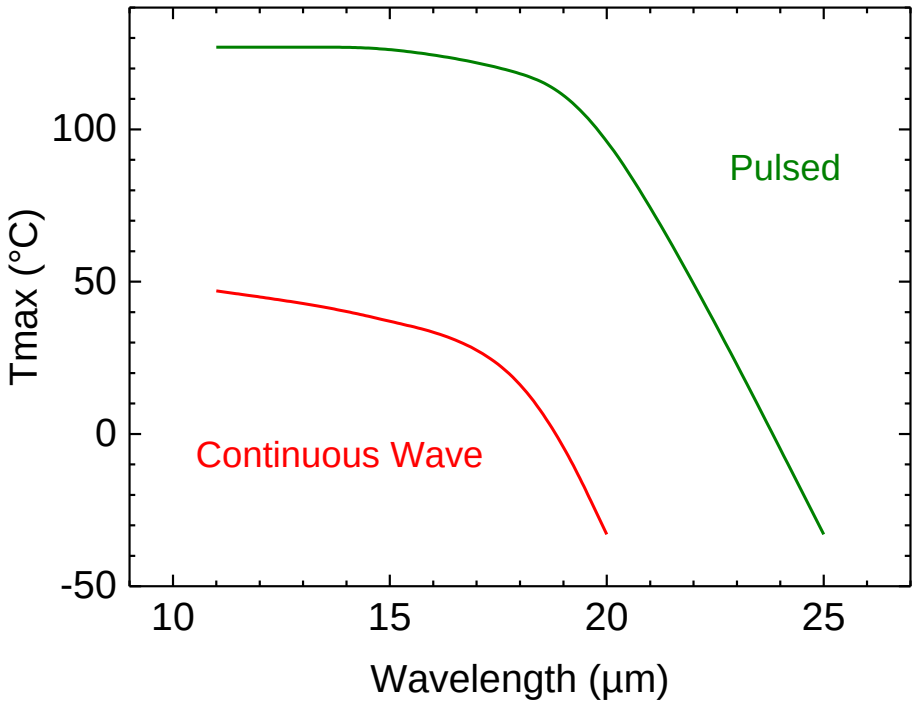
Nguyen Van et al., *Photonics*, vol. 6, no. 1, p. 31, 2019

Very good single-mode operation



Nguyen Van et al., *Photonics*, vol. 6, no. 1, p. 31, 2019

State of the art « research »



Products available today for spectroscopy

Spec code: UN0674C005HNA. Revised version: 202009

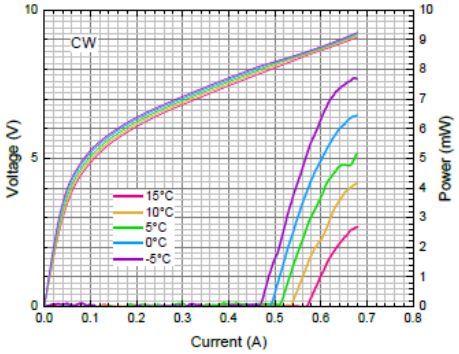
UniMir DFB CW QCLs

Perfect for **Benzene** environmental monitoring

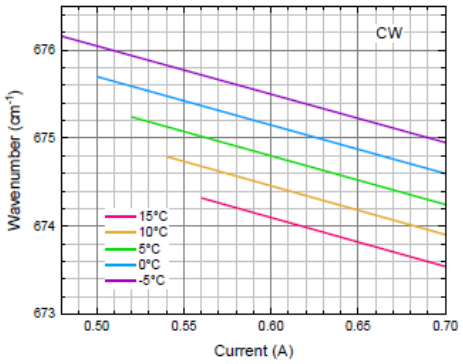
Wavelength: **~14.9 µm ~ 674 cm-1**

The UniMir products are Distributed Feedback (DFB) Quantum Cascade lasers (QCL) that emit CW (continuous wavelength) infrared light at room temperature. The laser is mounted on a thermoelectric cooler inside a sealed High Heat Load (HHL) package integrating a collimation lens and a thermistor to readout the laser chip temperature.
By controlling the chip's operating temperature through the Peltier element inside the laser's package, customers tune the emission wavelength without mode hopping while keeping a longitudinal single-mode operation.

Typical laser characteristics



Spec code: UN0674C005HNA. Revised version: 202009

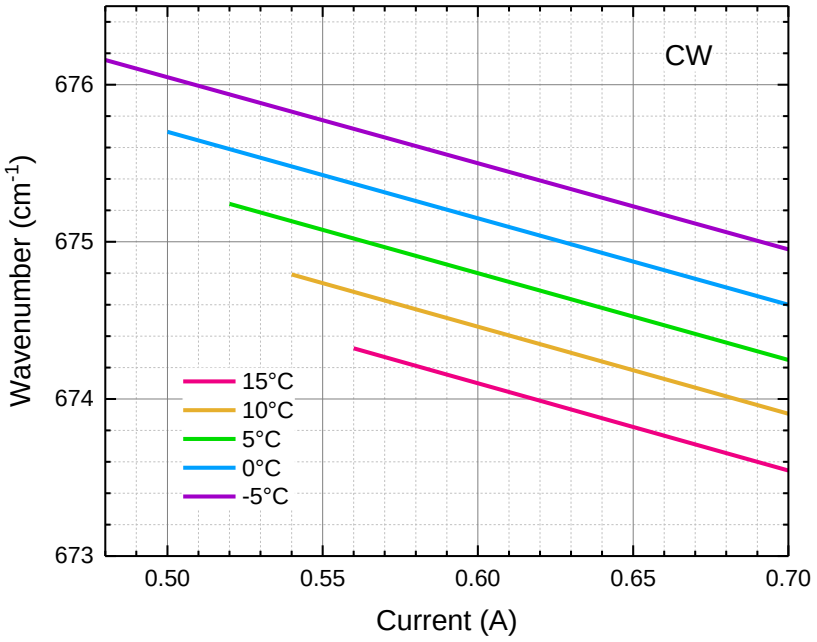


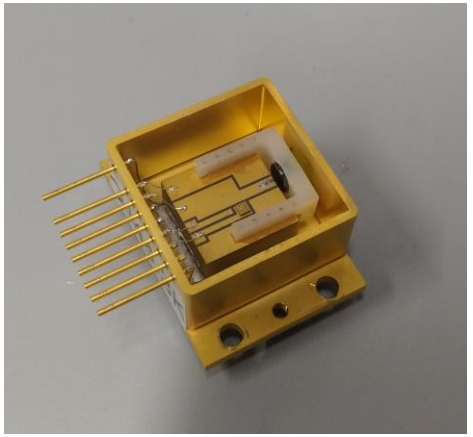
The curves indicate the laser singlemode emission wavelength as a function of the applied DC current and laser chip temperature.

Optical features

Laser type	QCL single mode DFB
Mode of operation	CW
Typical Optical Power at 674 cm-1	5mW (with the base plate of the HHL-package at +20°C)
Full accessible wavelength range	~3 cm-1
Minimum continuous tuning range	1 cm-1
Side mode suppression ratio	SMSR > 25 dB
Linewidth (FWHM)	< 100 Mhz (free-running with suitable electronics)
Divergence	< 10mrad
Beam quality	TM00
Output beam diameter (window output)	Typically 4 mm
Polarization	Linear vertically polarized

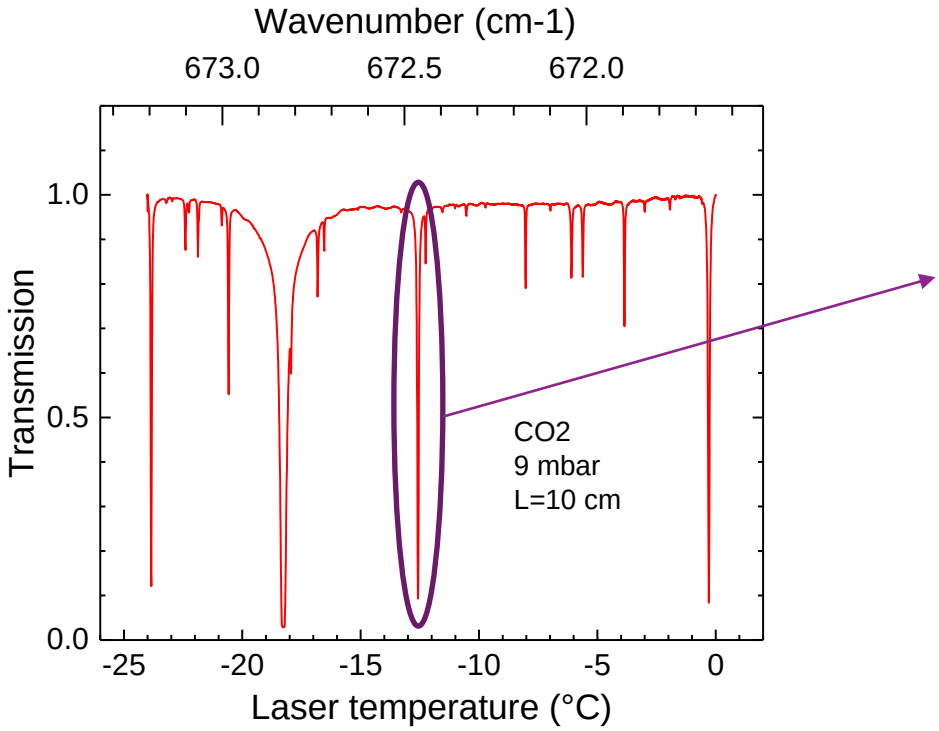
How can you use our laser for spectroscopy?

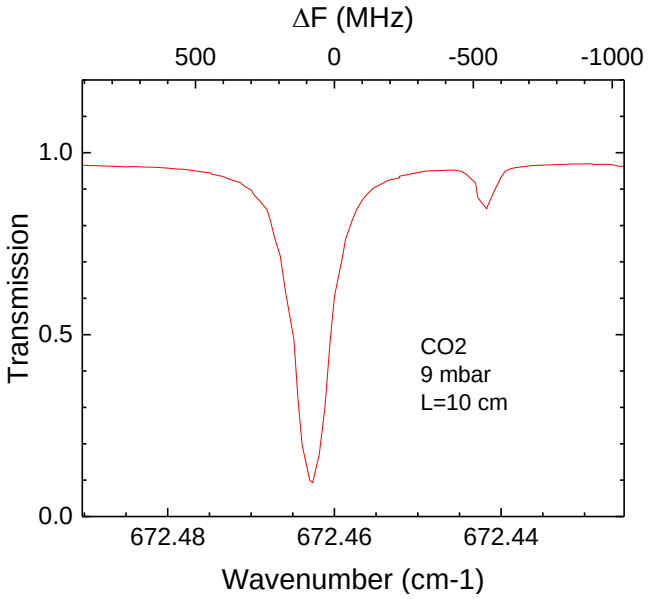




- Current and temperature control of the emission wavelength
- Collimated beam

TDLAS with temperature tuning (λ≈ 14.9 µm)

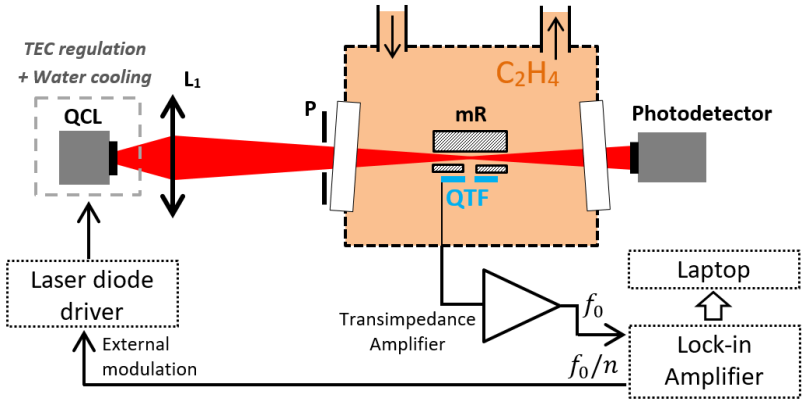


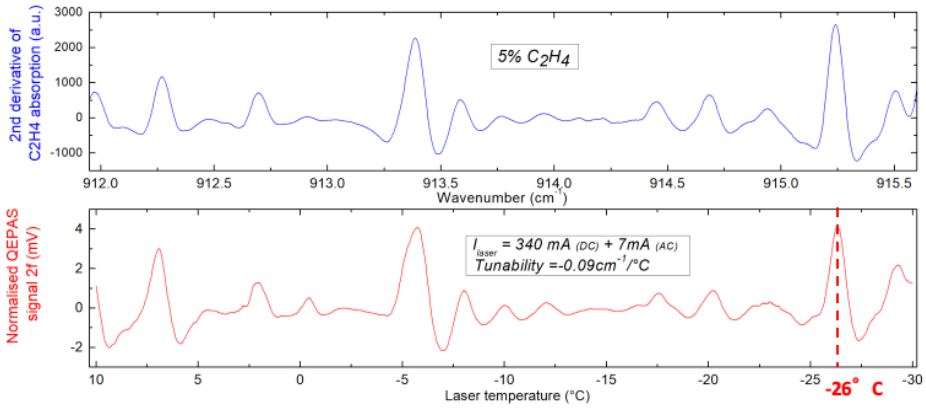


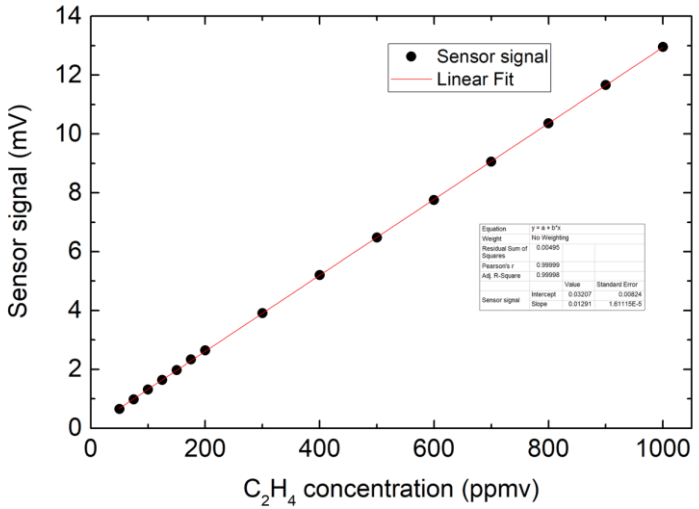
QCL for benzene spectroscopy

QEPAS measurement of Ethylene @ 11 µm

A. Vicet, R. Rousseau, Univ. Montpellier





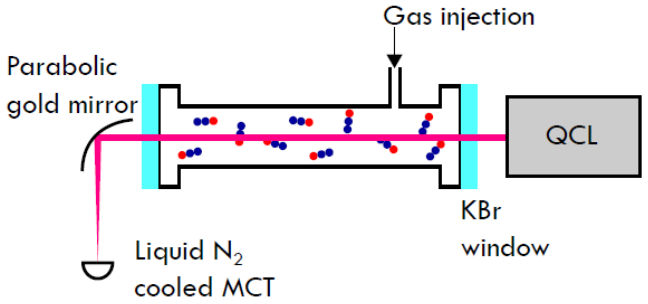


Gas	Limit of detection	Integration time
C_2H_4	60 ppbv	60 s

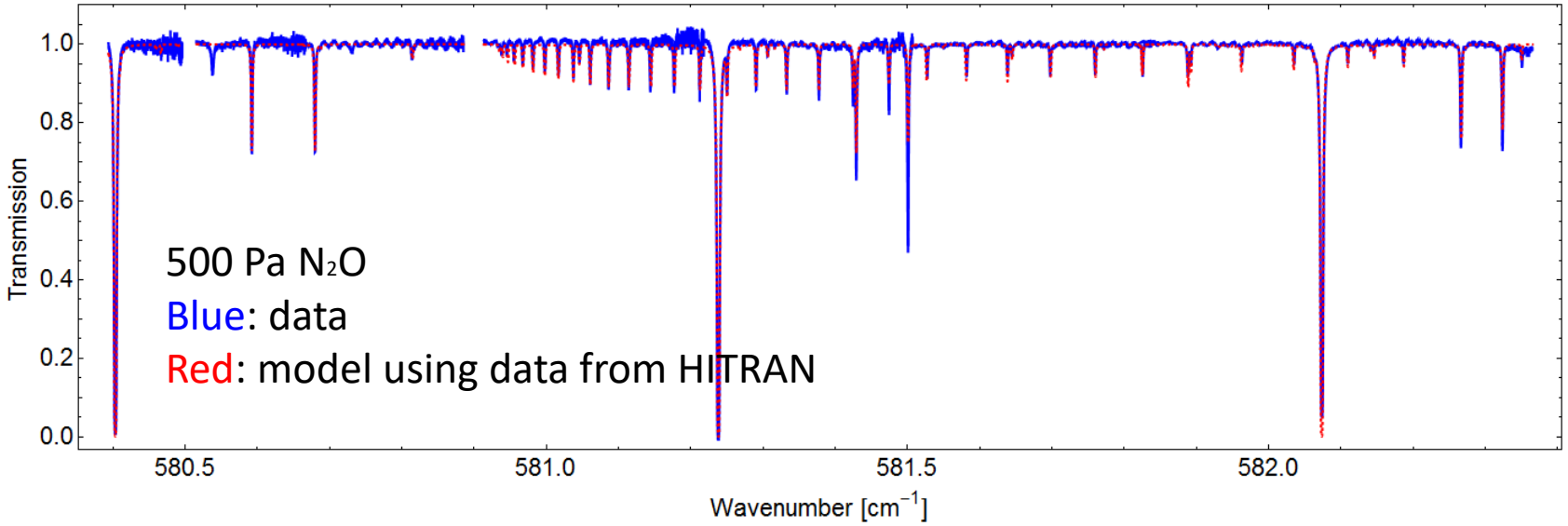
R. Rousseau et al., **Opt. Express, OE 27**, no. 5, pp. 7435–7446, (2019).

N_2O rovibrationnal spectroscopy (λ=17.2 µm)

The first high resolution spectroscopy of N_2O is this spectral range

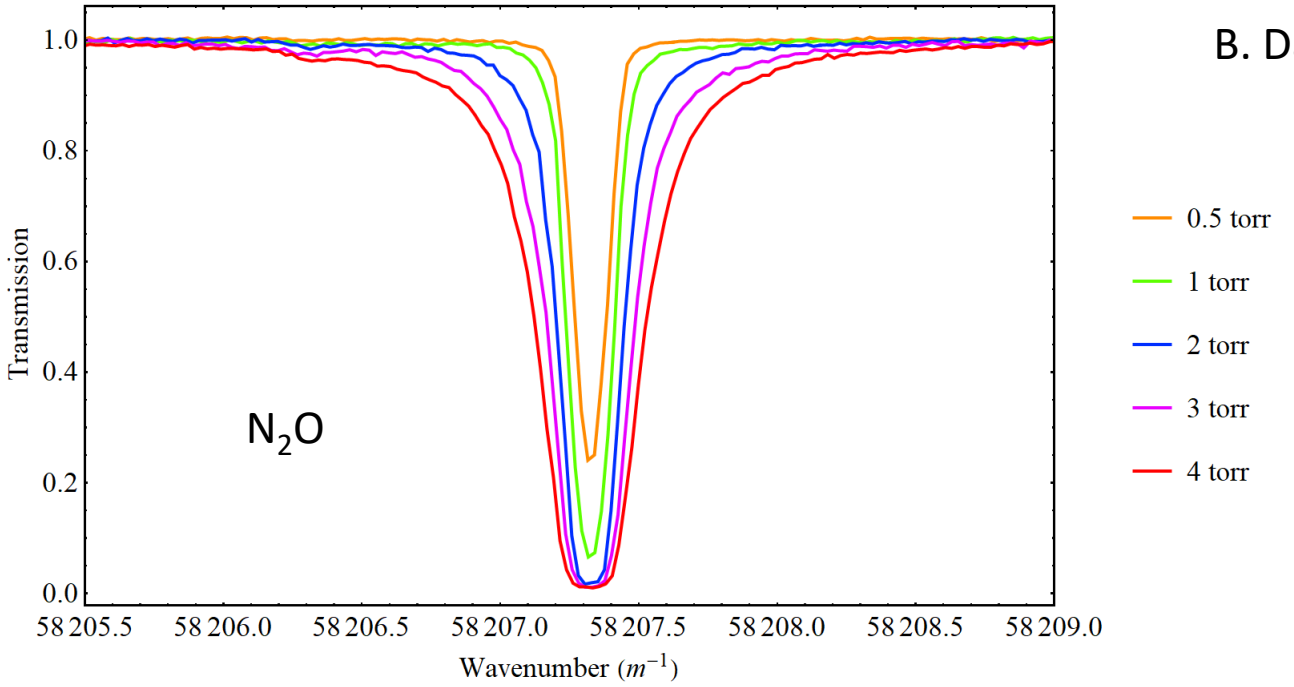


B. Darquié, T.E. Wall et al.

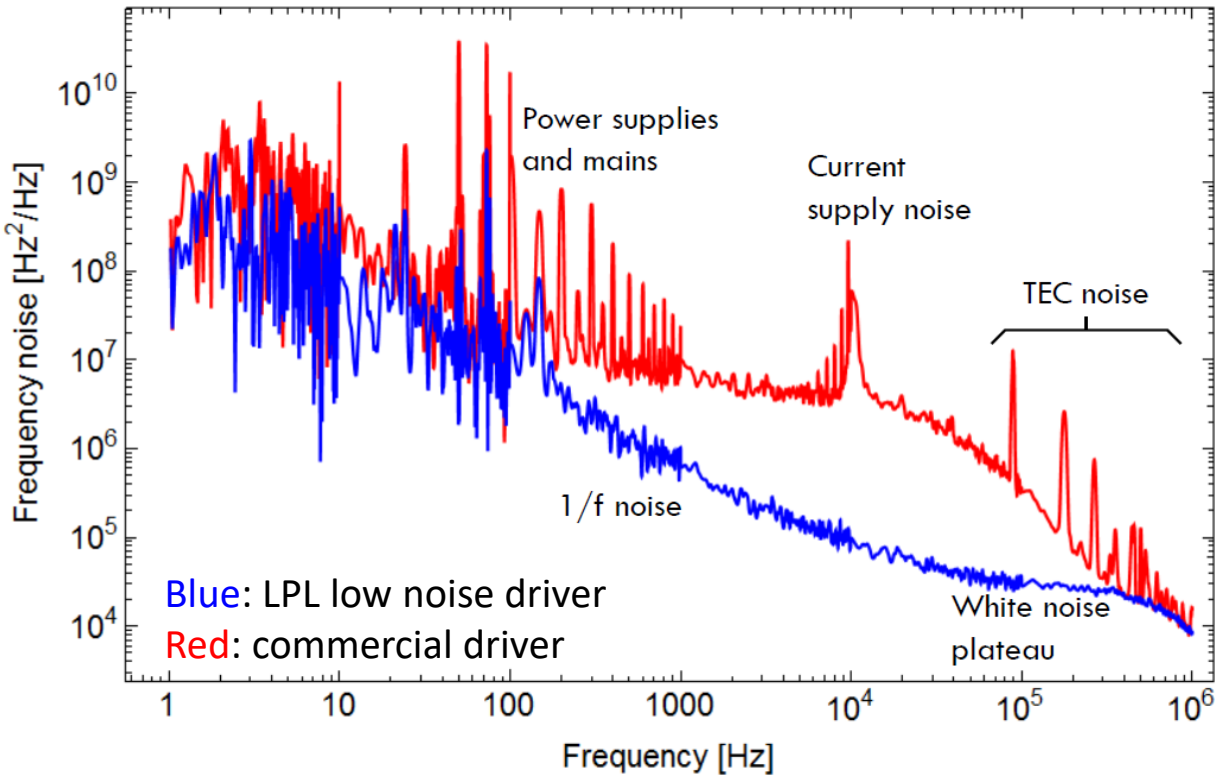


High resolution pressure broadening

B. Darquié, T.E. Wall et al.



Frequency noise (λ=17.2 µm)



B. Darquié, T.E. Wall et al.

Free running linewidth of 250 kHz for 1 s integration time

Benzene detection at 674 cm^{-1}

Sub-ppb detection of benzene using cantilever-enhanced photoacoustic spectroscopy with a long-wavelength infrared quantum cascade laser

JUHO KARHU[1,*], HADRIEN PHILIP[2], ALEXEI BARANOV[2], ROLAND TEISSIER[2], AND TUOMAS HIETA[3]

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[2] IES, University of Montpellier, CNRS, 34095 Montpellier, France
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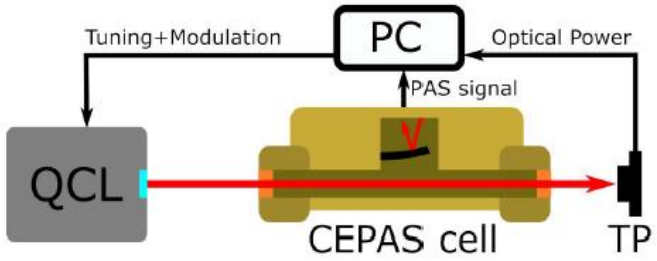
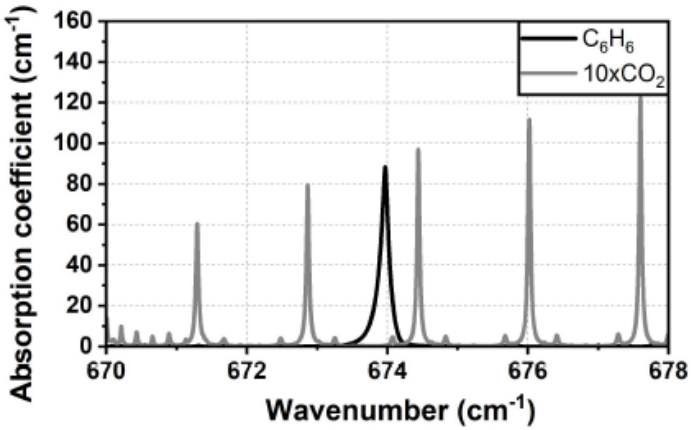
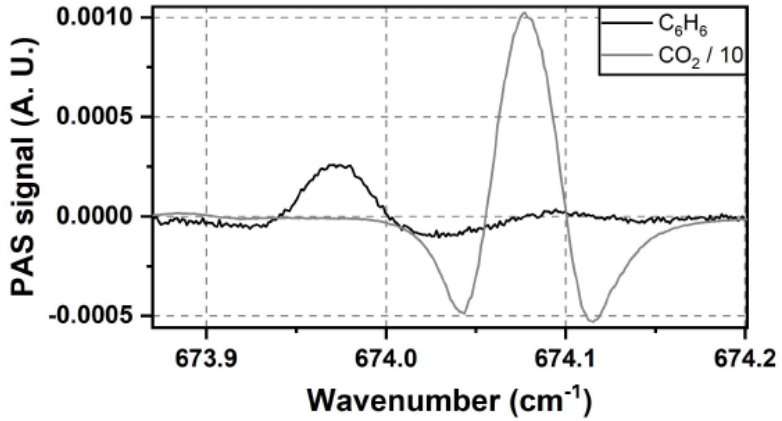
[*] Corresponding author: juho.karhu@helsinki.fi

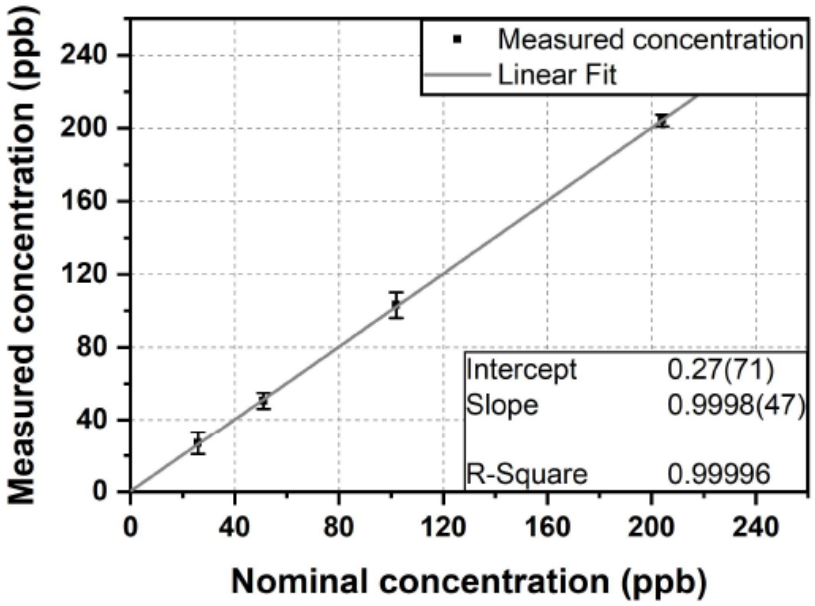
Coll. Gasera/Univ. Helsinki
Accepté pour publication dans *Optics Letters* (2020)

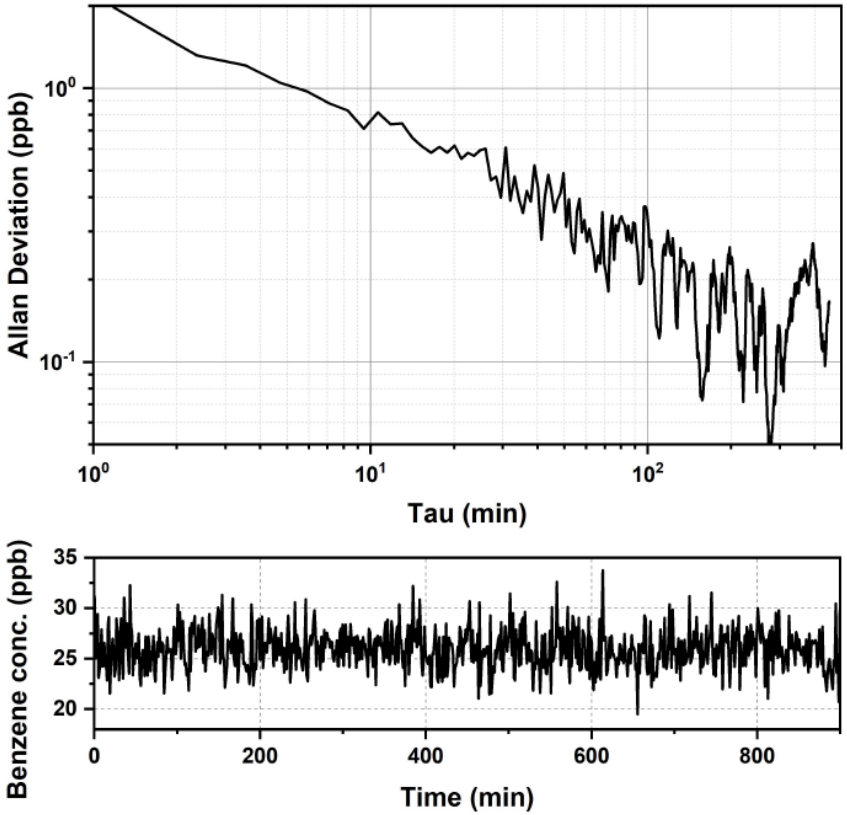






Benzene detection at 674 cm^{-1}





Our technology is unique and patented

French patent number FR 3048561
Currently being expanded to cover the rest of the world

This patent is owned by Montpellier University and CNRS research institute and mirSense has received an exclusive exploitation licence.

www.mirsense.com

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