

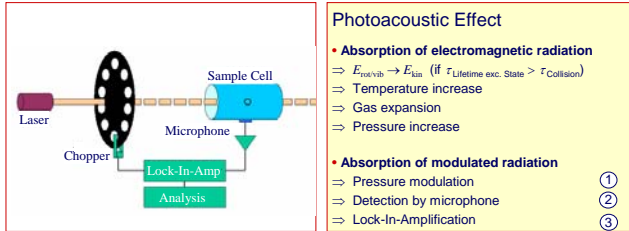
Marcus Wolff ^a, Johannes Koeth ^b, Lars Hildebrandt ^b, Peter Fuchs ^b

^a Hamburg University of Appl. Sciences, Institute for Physical Sensors, Berliner Tor 21, 20099 Hamburg/Germany

^b nanoplus Nanosystems and Technologies GmbH, Oberer Kirschberg 4, 97218 Gerbrunn/Germany

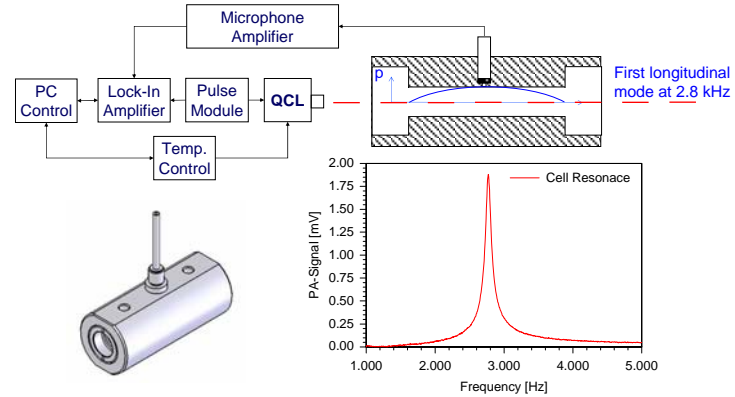
Photoacoustic Sensor

Photoacoustic Spectroscopy



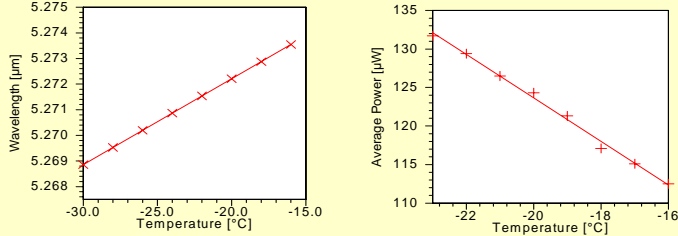
- ① $p(t) = p_0 + p_1 \cdot \sin(\omega t)$
- ② $U_{Mic}(t) = U_0 \cdot \sin(\omega t + \phi) + U_1$
- ③ $U_{LA}(t) = \sigma_{Gas} \cdot P_{Gas} \cdot I_0 \cdot C_{Cell}$

Experimental Set-Up



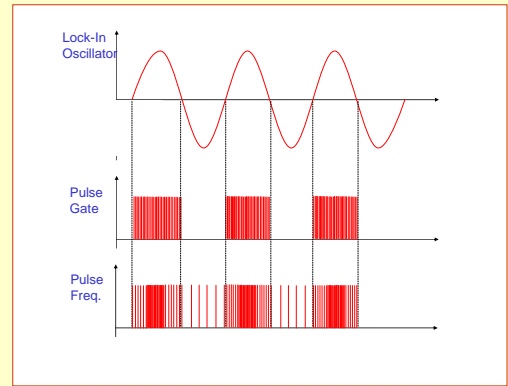
Quantum Cascade Lasers

DFB-QCL Specifications



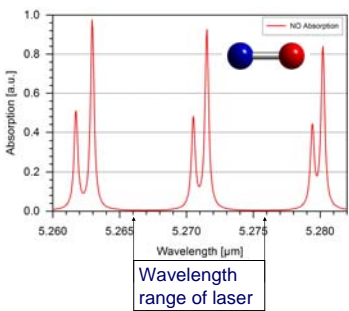
- DFB Single-Mode
 - Spectral Tuning
 - Pulse-Length
 - Wavelength
 - Output Power (peak)
 - Temperature
- SMSR > 30 db
0.4 nm/°C (Range: 5 nm)
< 100 ns (duty cycle: 2% max.)
- | | |
|----------------------|---------------------|
| L1: 5.274 μm @ -15°C | L2: 5.235 μm @ 30°C |
| L1: 10 mW @ -10°C | L2: 15 mW @ 30°C |
| L1: -30°C to -10°C | L2: 15°C to 35°C |

Modulation Techniques

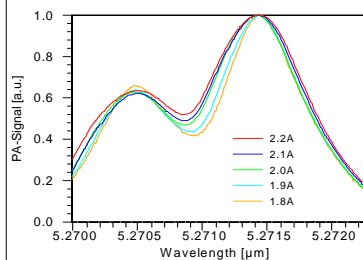


Detection Selectivity (L1)

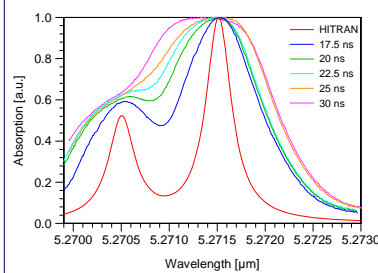
Nitric Oxide Absorption



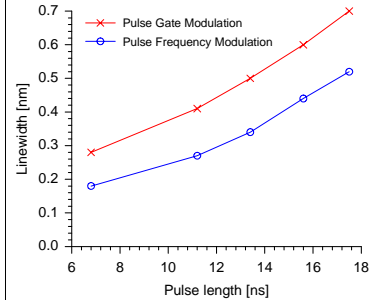
Spectral Selectivity as Fct. of Pulse-Current



Spectral Selectivity as Fct. of Pulse-Length

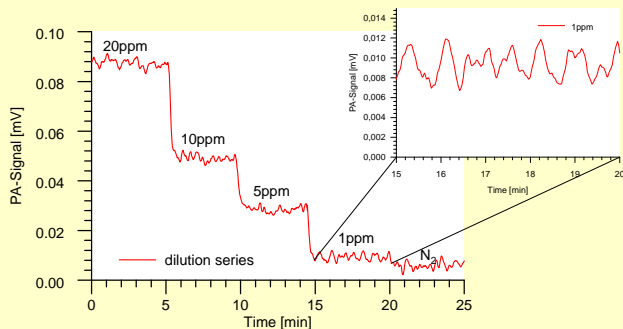


Spectral Laser Linewidth as Fct. of Mod. Technique



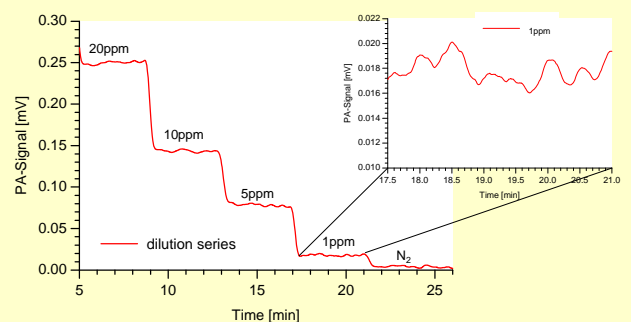
Detection Sensitivity

Pulse Frequency Modulation (Laser 2)



- Detection Sensitivity (S/N=1): 105 ppb (Laser 1)
- 360 ppb (Laser 2)

Pulse Gate Modulation (Laser 1)



- Detection Sensitivity (S/N=1): 70 ppb (Laser 1)
- 240 ppb (Laser 2)