Photoacoustic spectroscopy in Gases with High-Finesse Solid-State Resonators

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OUTLINE

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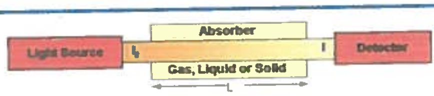
- Motivation and Technology Issues
- NIR Diode Laser-based PAS Gas Sensor
- Performance of PAS based Methane Sensor
- Summary and Outlook

Wide Range of Gas Sensor Applications

- Urban and Industrial Emission Measurements
  - Industrial Plants – Fence-line perimeter monitoring
  - Combustion Diagnostics
  - Automobile
- Rural Emission Measurements
  - Agriculture
- Environmental Monitoring
  - Atmospheric Chemistry
  - Volcanic Emissions
- Spacecraft and Planetary Surface Monitoring
  - Crew Health Maintenance & Life Support
- Diagnostic and Industrial Process Control
  - Petrochemical and Semiconductor Industry
- Medical Diagnostics
- Fundamental Science-Kinetics and Photochemistry

Absorption Spectroscopy



Beer's Law

$$I(\nu)=I_0\cdot e^{-\alpha(\nu)\cdot P_a\cdot L}$$

$\alpha(\nu)$ - absorption coefficient [cm^{-1} atm^{-1}]; L – path length [cm]
ν - frequency [cm^{-1}]; P_a - partial pressure [atm]

Molecular Absorption Coefficient

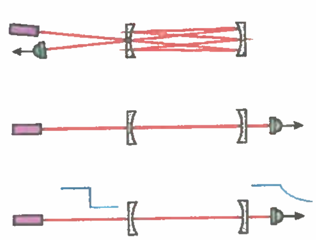
$$\alpha(\nu)=C\cdot S\cdot g(\nu-\nu_0)$$

C - total number of molecules of absorbing gas/atm/cm³ [molecule·cm^{-3}·atm^{-1}]
S - molecular line intensity [cm·$molecule^{-1}$]
$g(\nu-\nu_0)$ - normalized lineshape function [cm],(Gaussian, Lorentzian, Voigt)

Sensitivity Enhancement Techniques

- Optimum Absorbing Transition
  - Overtone/ Combination
  - Fundamental Band
- Long Pathlength
  - Multipass Cell
  - Cavity Enhanced, Cavity Ringdown
  - Open Path [with retro-reflector]
- Detection Schemes
  - Frequency Modulation, Wavelength Modulation, Two-tone frequency modulation
  - Balanced Detection
  - Zero-air Subtraction

Ultrasensitive absorption spectroscopy techniques



1. Multipass cell spectroscopy
2. Cavity enhanced spectroscopy
3. Cavity ringdown spectroscopy

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Principle of Photoacoustic Spectroscopy