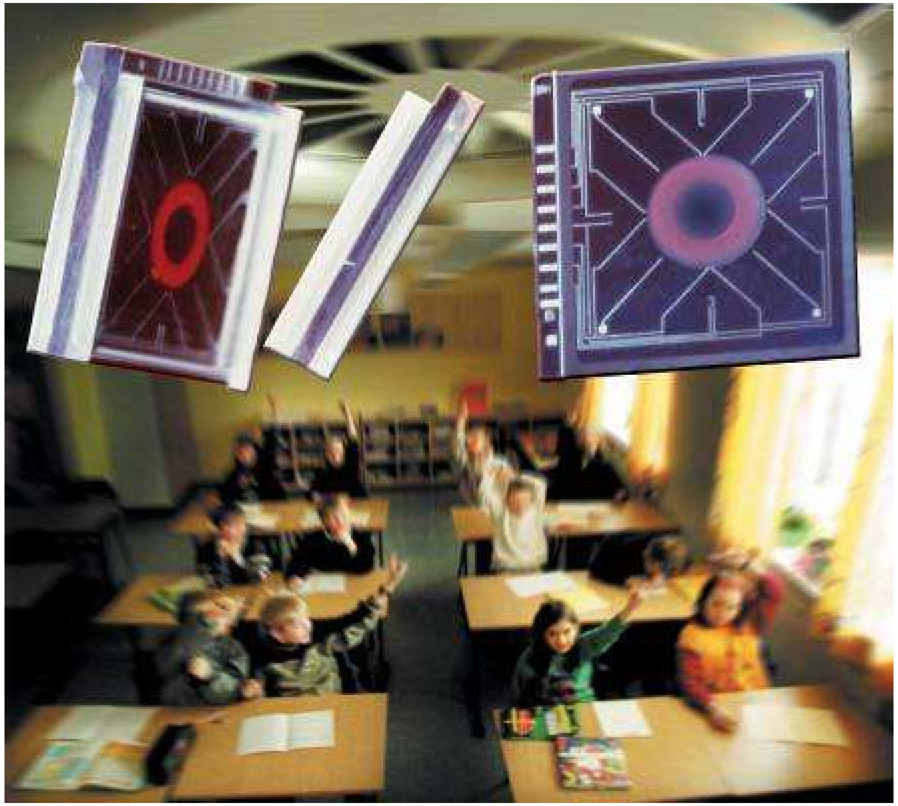
MONTIE Satellite Workshop to EUROSENSORS XX, Göteborg, September 17, 2006

IAQ (indoor air quality) sensorics today and tomorrow



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Multisensors and Other New Technology for Improved indoor Environment in buildings

Outline

- Why, when, where, what, and how to 'make sense' for IAQ
- Industrial state of the art
- Current trends
- R&D challenge

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Why, when, and where?

- The motives for IAQ sensing are mainly related to human health, security, comfort and economy
- Timing may be occasional, intermittent or real-time-continuous – seldom very demanding in terms of data transmission capacity
- As close to actual human habitats as possible – ”ubiquitous”

IAQ monitoring & control variables

- Temperature
- Relative humidity (RH)
- Carbon dioxide (CO_2) concentration
- Volatile Organic Compounds (VOC)
- Other gases (NO_x, CO, ozone, …)
- Particles, microorganisms (pollen…)

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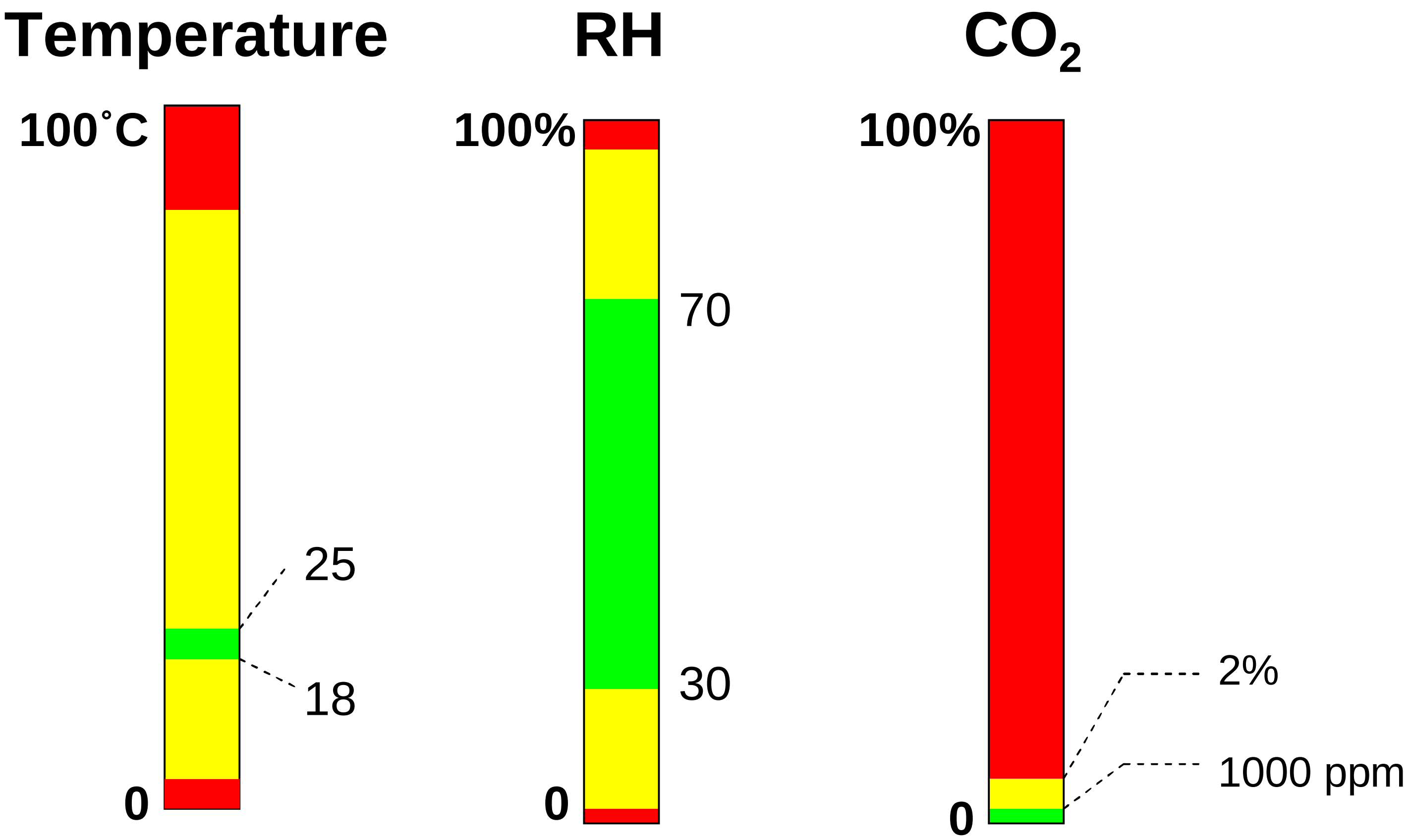
Health and comfort intervals



IAQ sensing principles

- Catalytic
- Infrared (IR) spectroscopy
  - -Transmission
  - -Photoacoustic
- Electroacoustic

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Catalytic sensors

$$X + A \xrightarrow{\text{catalysis}} B \pm \text{energy}$$

Features:

- Size
- Cost
- Sensitivity

Issues:

- Long term stability
- ”Poisoning”
- Reliability

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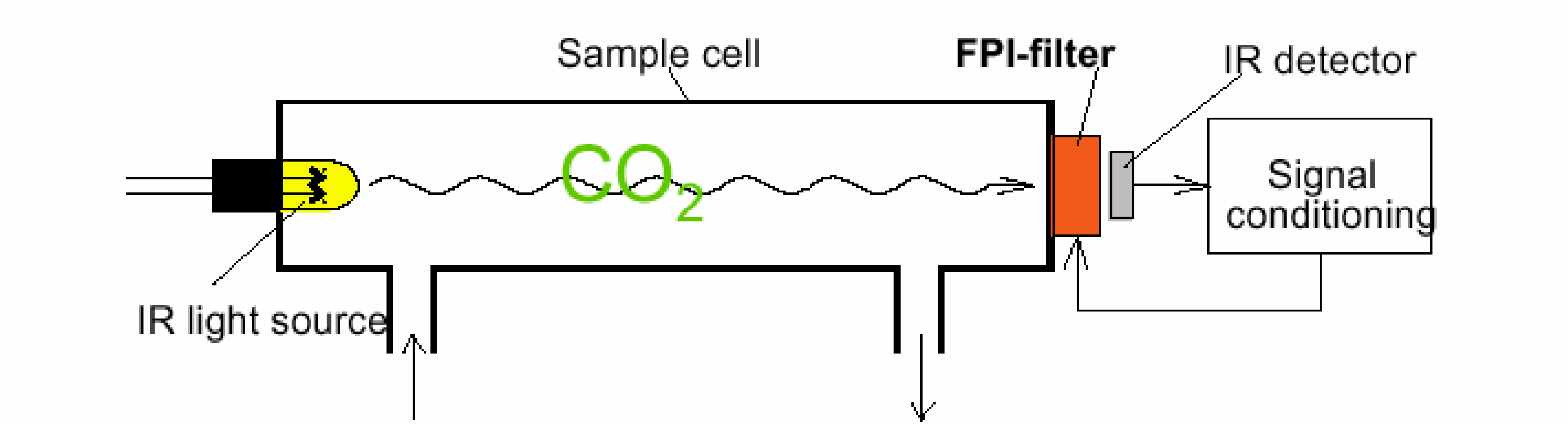
IR Transmission

Features:

- Selectivity
- Reliability

Issues:

- Cost
- Power consumption



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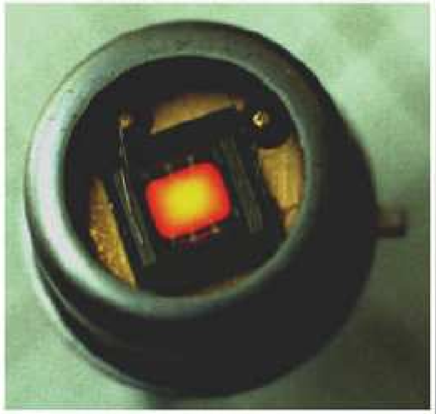
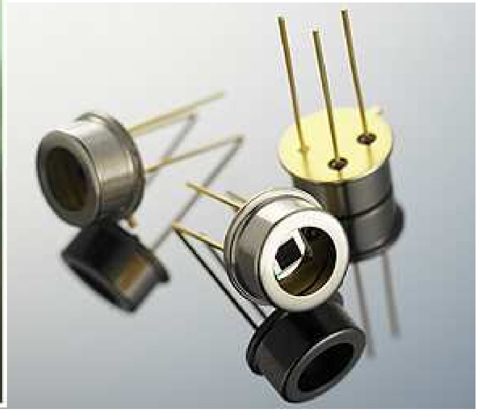
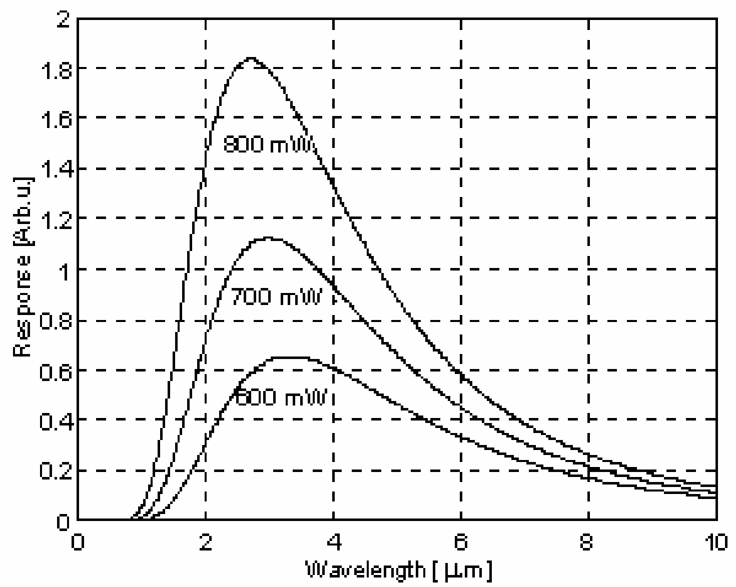
IR sources





- Blackbody radiators
- Lasers
- LEDs



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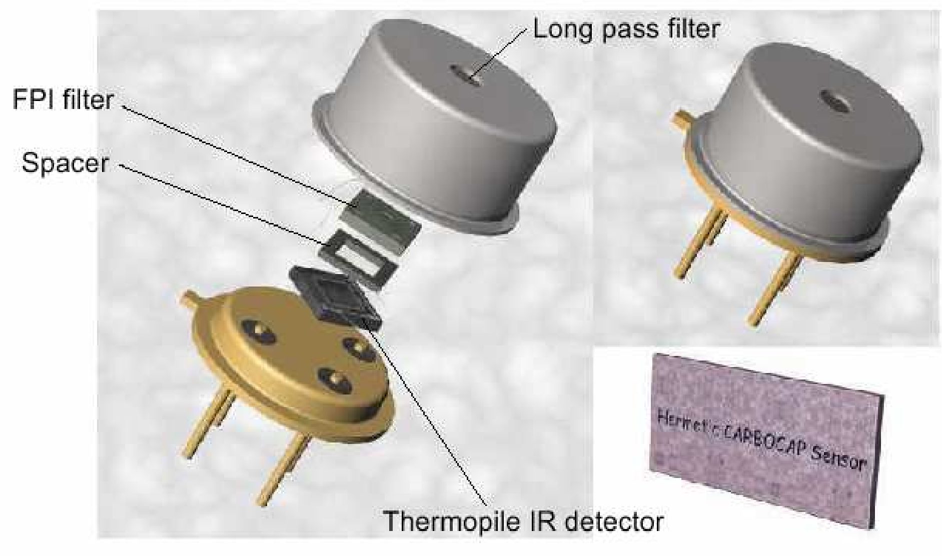
IR filters and detectors

- Interference filters
- Diffractive elements
- Thermopiles
- Pyroelectric devics



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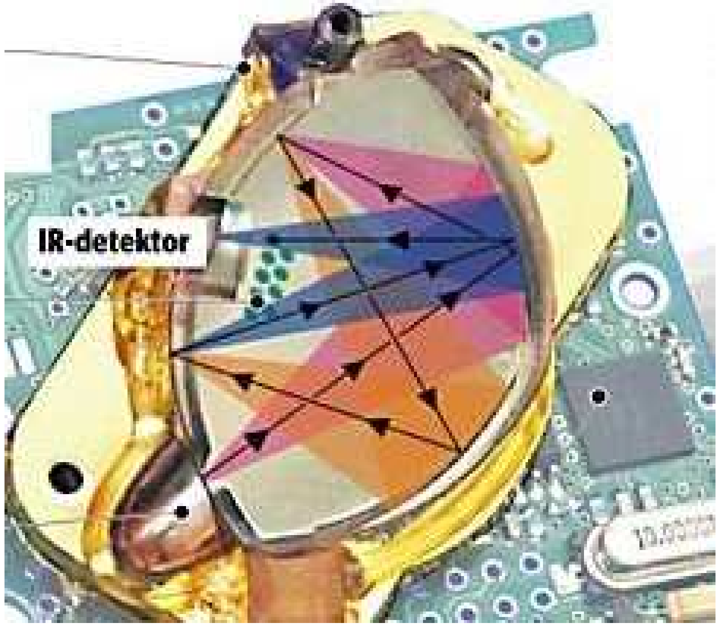
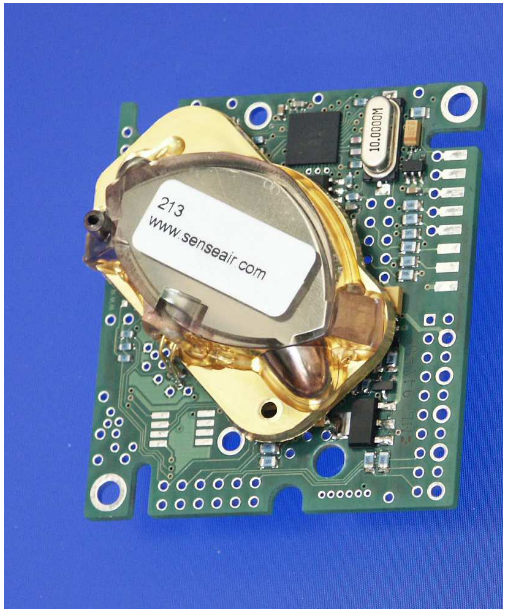
SenseAir infrared IAQ sensors



Multi-reflective optical cell



"Embedded sensor"

Housing for industrial environments

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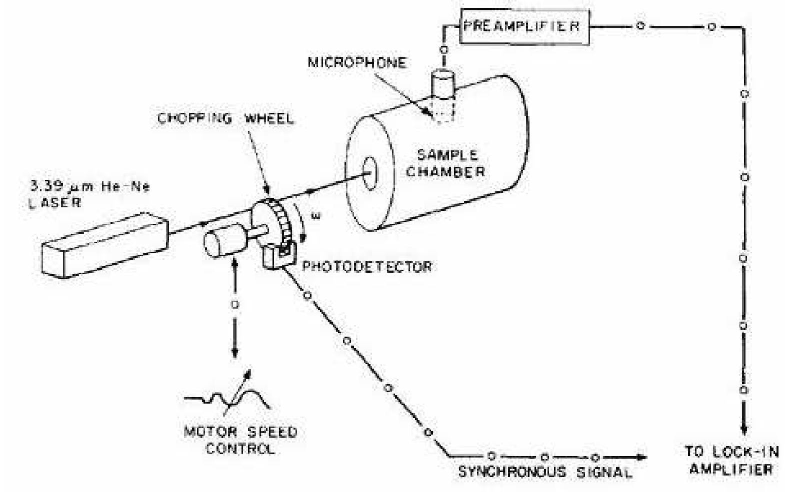
Photoacoustic IAQ sensors

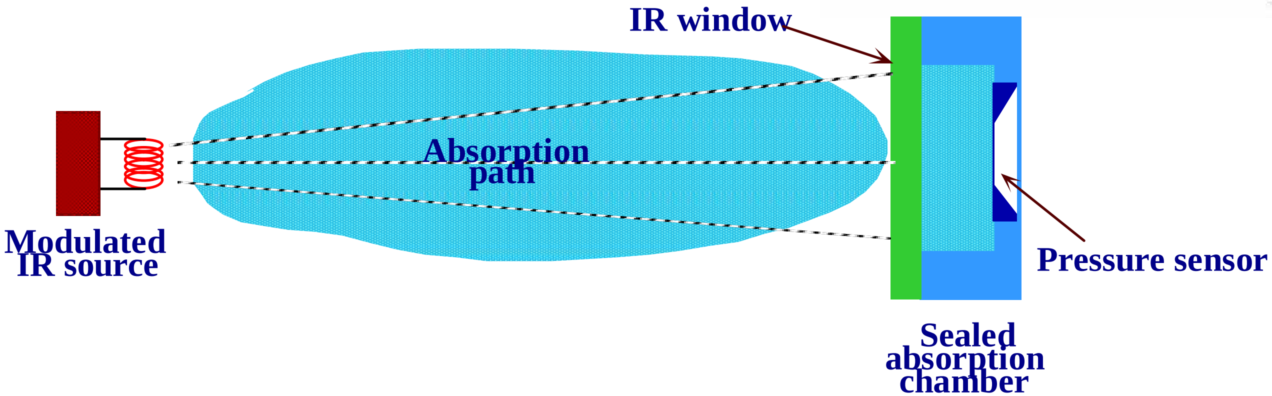
Features:

- Sensitivity
- Selectivity

Issues:

- Complexity
- Cost





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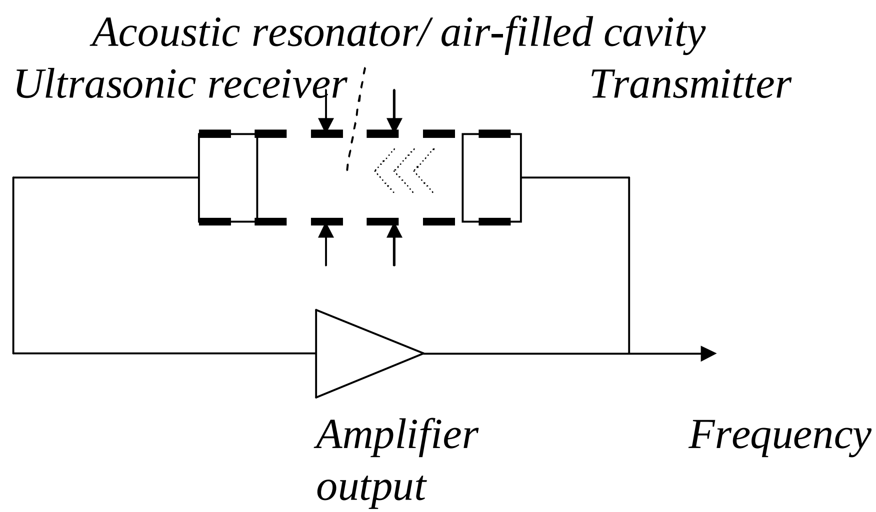
Electroacoustic sensors

Features:

- •Size
- •Reliability
- •Power consumption



Issues:

- •Selectivity
- •Cross sensitivities

$$c = \sqrt{\frac{kT\gamma}{m}}$$

c: velocity of sound
k: Boltzmann's constant ($1.38*10^{-23}$ J/ K)
T: absolute temperature (K)
γ: Ratio of specific heat (const press/vol)
m: Molecular mass

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Electro-acoustic IAQ sensor

- **Q-AIR322BG**
- **Wall-mountable Sensor for**
- **Indoor Air Quality Control**

- **Features:** **CO2, temp, RH**
- **Built-in controller**
- **Easy-to-read display**

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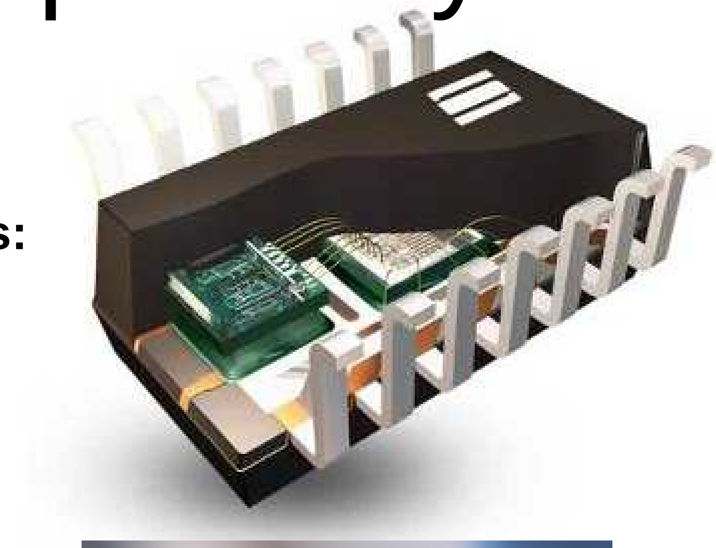
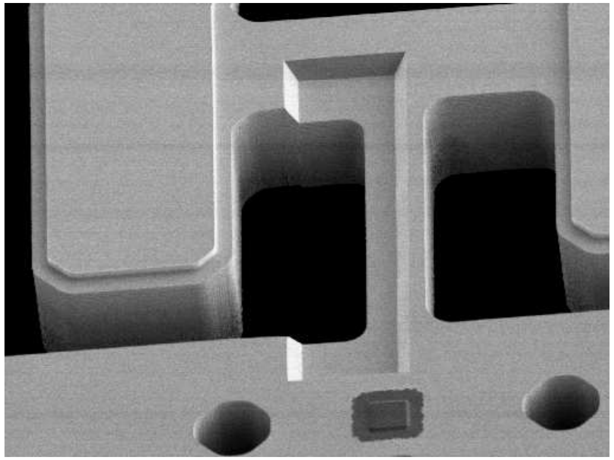
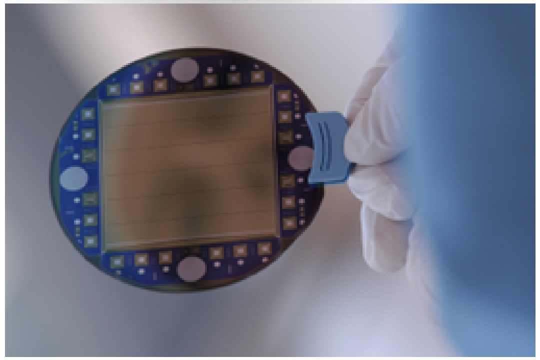
MEMS opportunity



Micro Electro Mechanical Systems:

High precision and complexity at low cost





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MEMS implementation:
The MASCOT sensor

MASCOT
Micro Acoustic Sensor System for CO_2 Tracking

Partners: SensoNor
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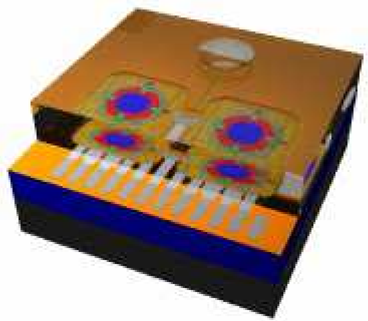

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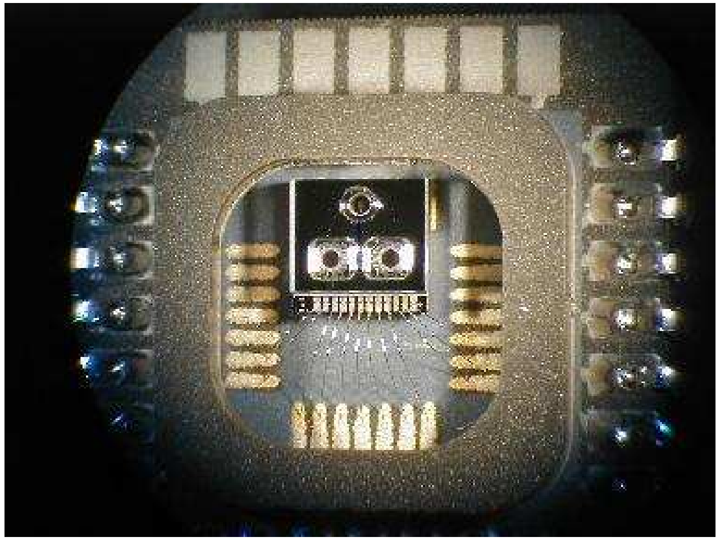
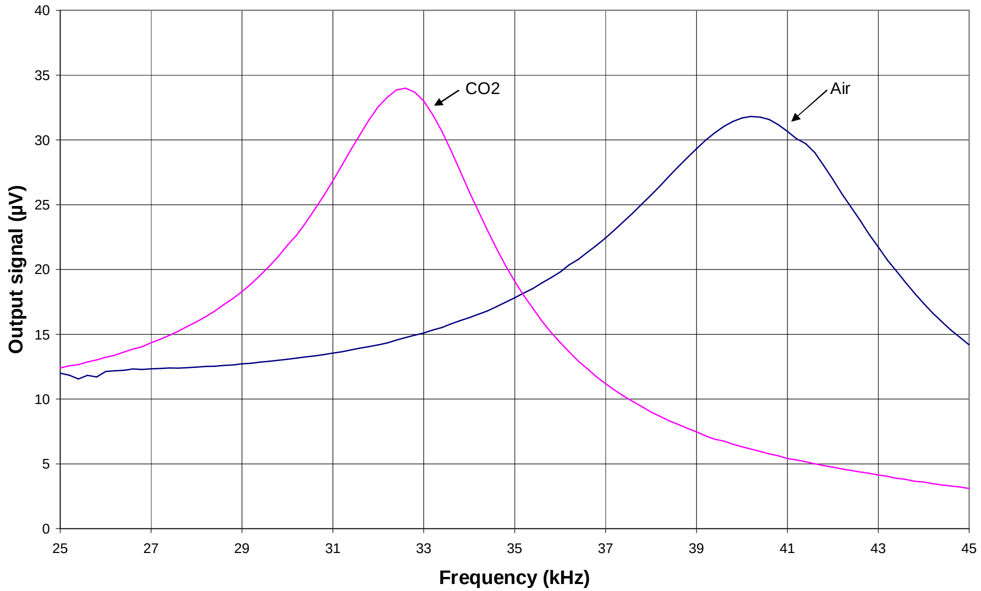
MASCOT performance





MASCOT sensor chip 3 x 3 mm

Resonance frequency decreasing from 40 kHz to 32kHz, 0 and 100% CO_2. Q factor increasing from 6.6 to 8.2.

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MASCOT performance cont'd

	f_r	**Q**
Typical value	*40250 Hz*	*6.60*
CO_2	*-11 Hz/1000ppm*	*+0.009/1000ppm*
RH	*+4 Hz/%RH*	*-0.001/%RH*
Temp	*63 Hz/°C*	*-0.015/°C*
Pressure	*0*	*+0.04/kPa*
Resolution	*±2 Hz (±200 ppm CO_2 or ±0.5% RH)*	*±0.01*

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Nordic IAQ sensor suppliers

- kT Sensors, Norway, ktsensor.no
- Optosense, Norway, optosense.com
- Vaisala, Finland, vaisala.fi
- SenseAir, Sweden, senseair.se
- Hök Instrument AB, Sweden, hokinstrument.se

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Current trends

- Steady incremental improvements in performance and cost efficiency
- Multivariable sensors available
- Integration by MEMS and other technologies
- Wireless system solutions close to industrial break-through

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Wireless sensor networks

- Cluster-tree topology is more likely in IAQ than star, ring or mesh topologies
- ZigBee offers attractive features – but there are offenders (2.4GHz being one limitation)
- Power consumption of sensor nodes is an important issue

R&D challenge:

To identify and quantify exotic gaseous substances and biological particles at low concentration levels

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Thanks

Thanks to all MONTIE and MASCOT partners for stimulating cooperation

Thanks for your attention

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