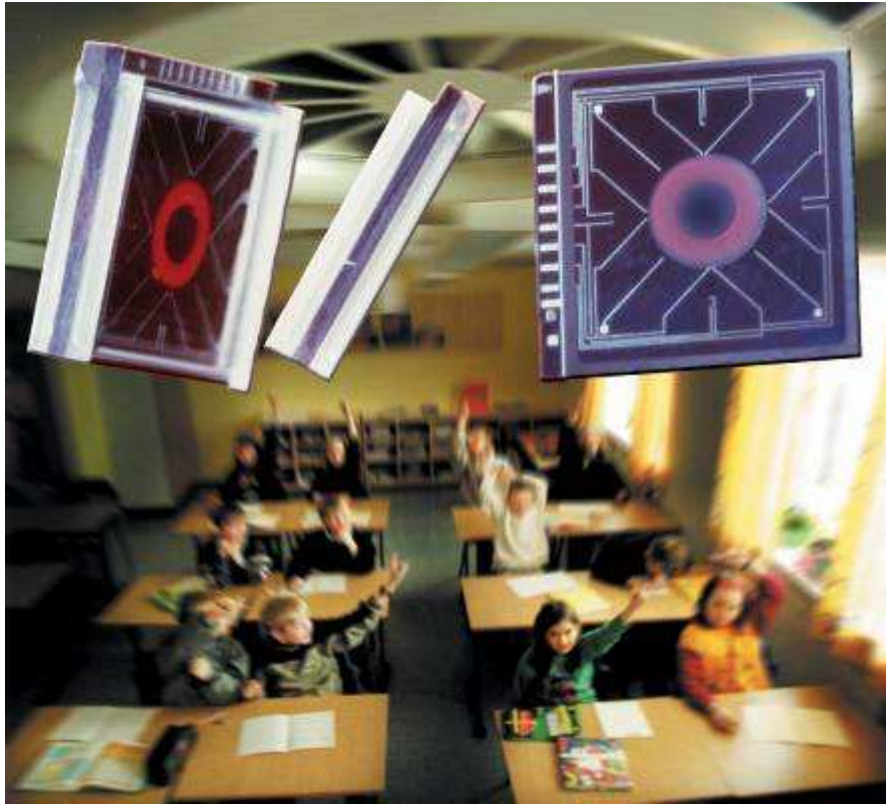


MONTIE Workshop, Espoo, Finland, November 7, 2006

IAQ (indoor air quality) sensors today and tomorrow

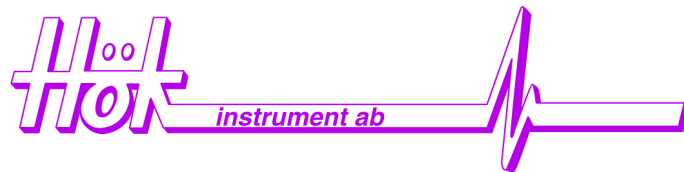


Bertil Hök
HÖK INSTRUMENT AB



Outline

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



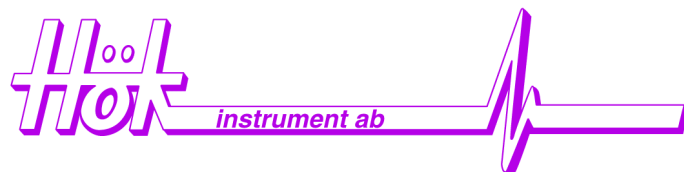
Why, when, and where?

- 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”



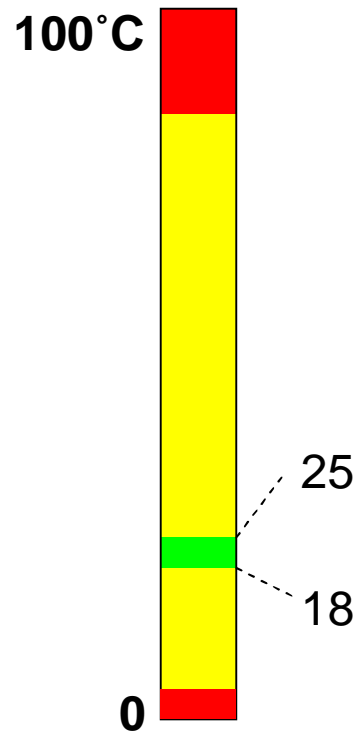
IAQ monitoring & control variables

- Temperature
- Relative humidity (RH)
- Carbon dioxide (CO₂) concentration
- Volatile Organic Compounds (VOC)
- Other gases (NO_x, CO, ozone, ...)
- Particles, microorganisms (pollen...)

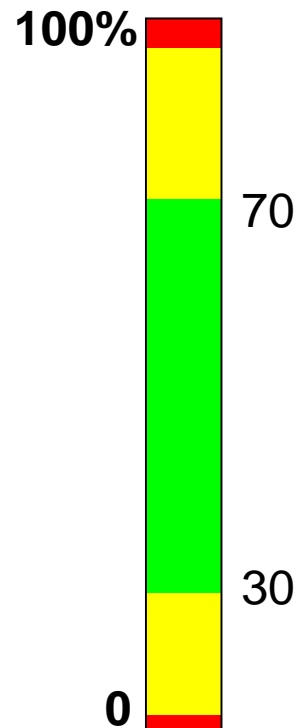


Health and comfort intervals

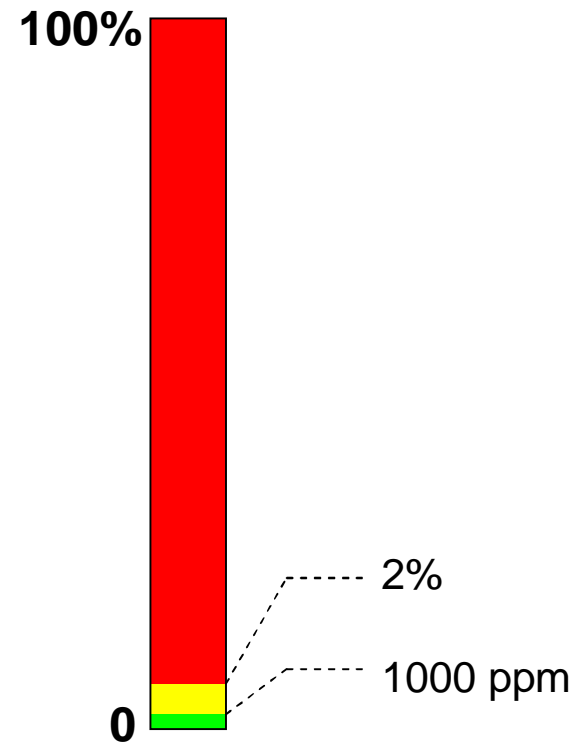
Temperature



RH



CO₂

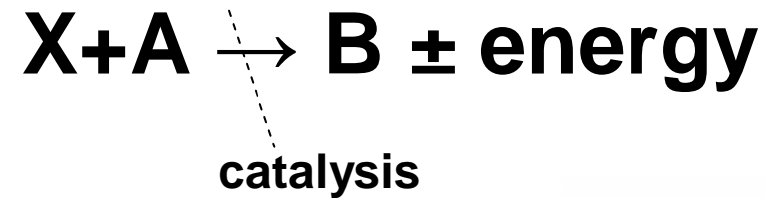


IAQ sensing principles

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



Catalytic sensors

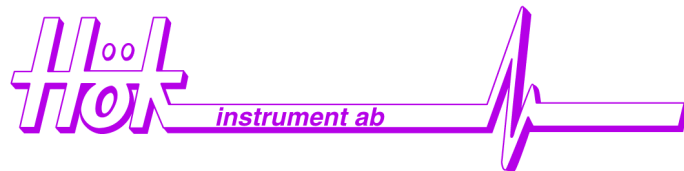


Features:

- Size
- Cost
- Sensitivity

Issues:

- Long term stability
- "Poisoning"
- Reliability



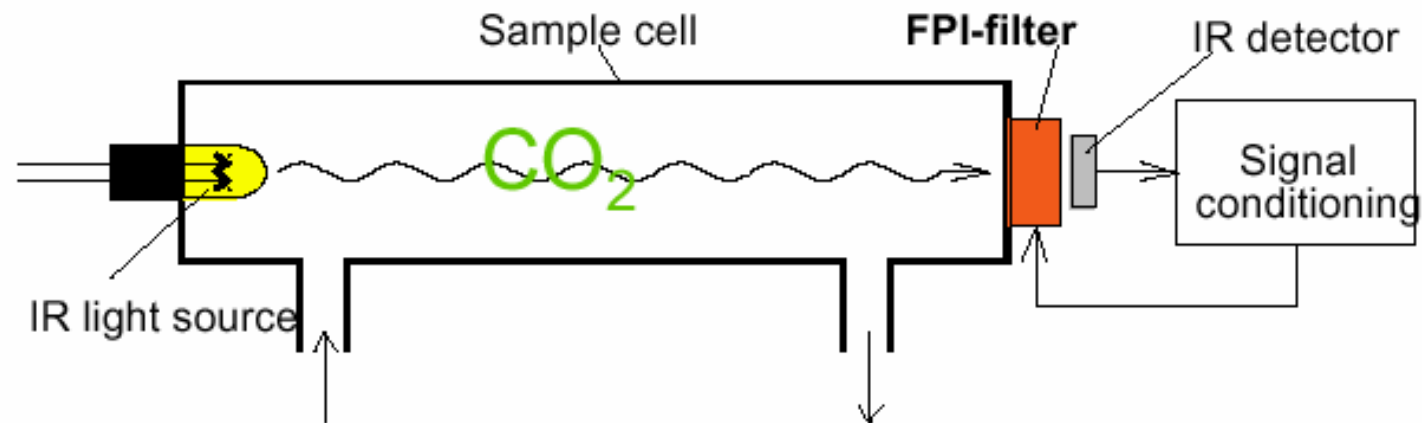
IR Transmission

Features:

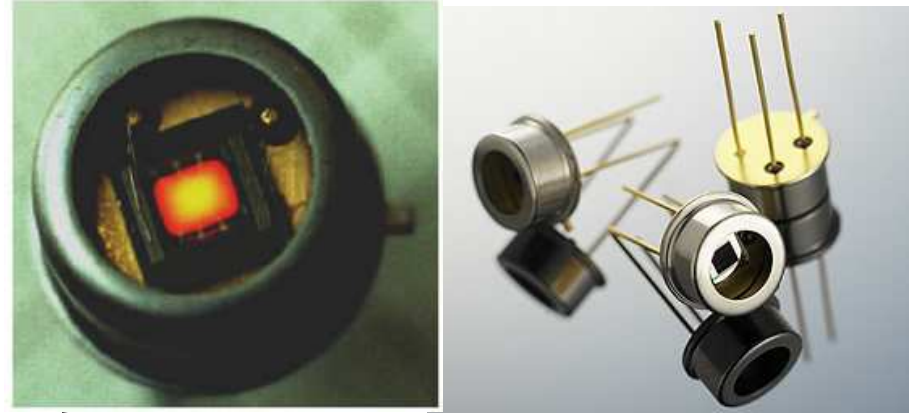
- Selectivity
- Reliability

Issues:

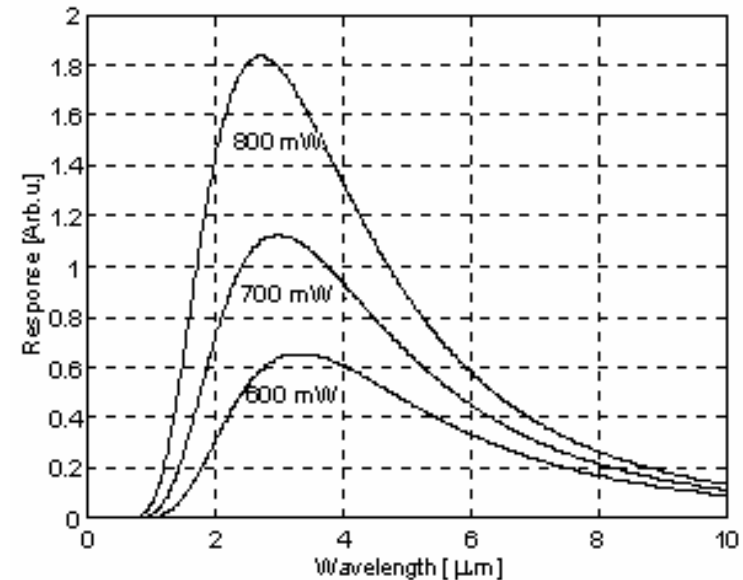
- Cost
- Power consumption



IR sources

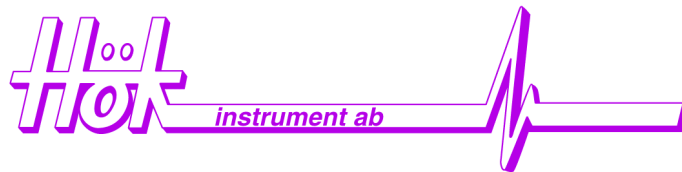
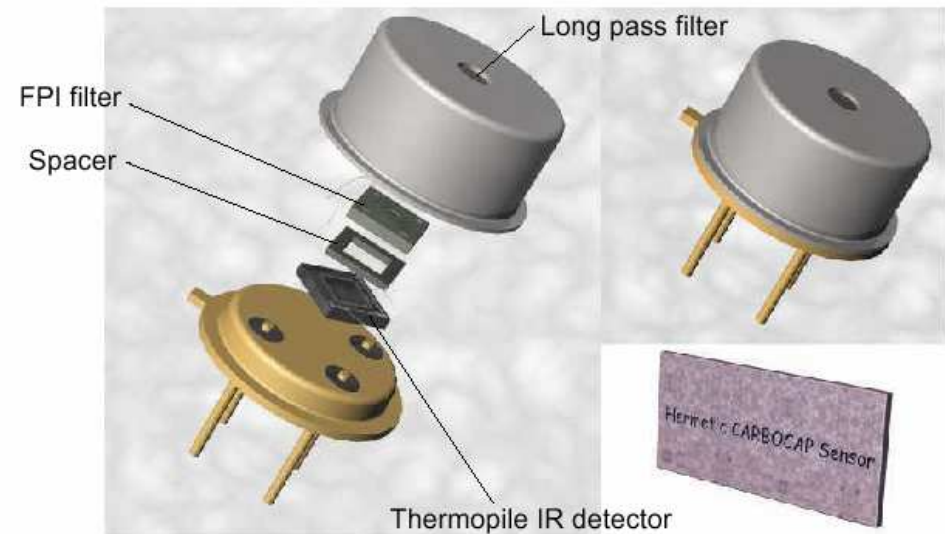


- Blackbody radiators
- Lasers
- LEDs

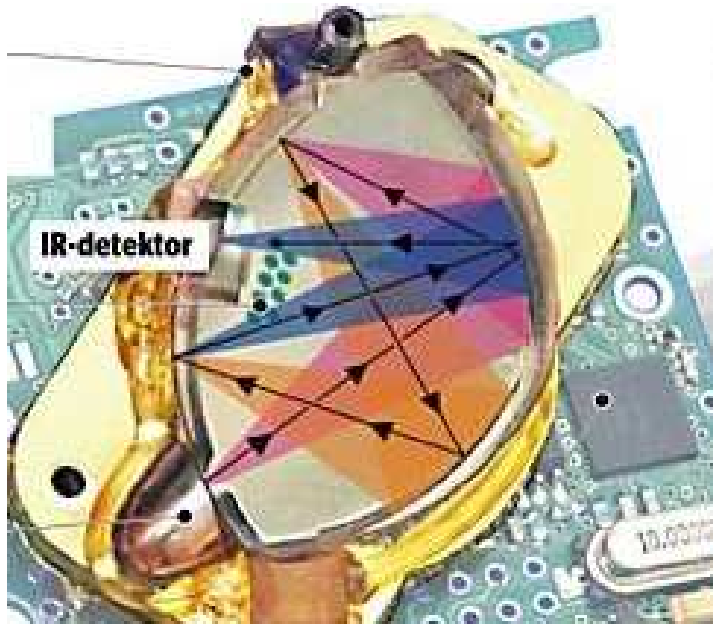


IR filters and detectors

- Interference filters
- Diffractive elements
- Thermopiles
- Pyroelectric devices



SenseAir infrared IAQ sensors



Multi-reflective optical cell



"Embedded sensor"



Housing for industrial environments



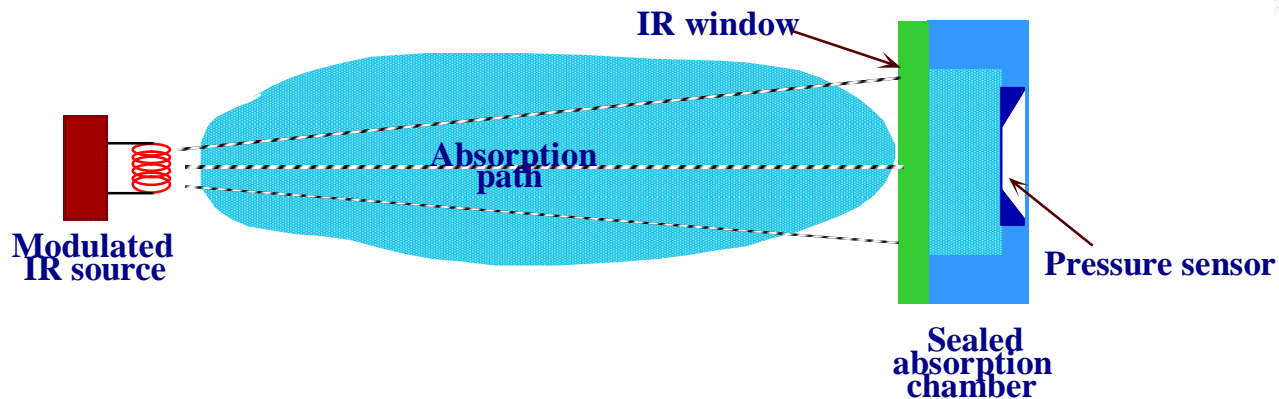
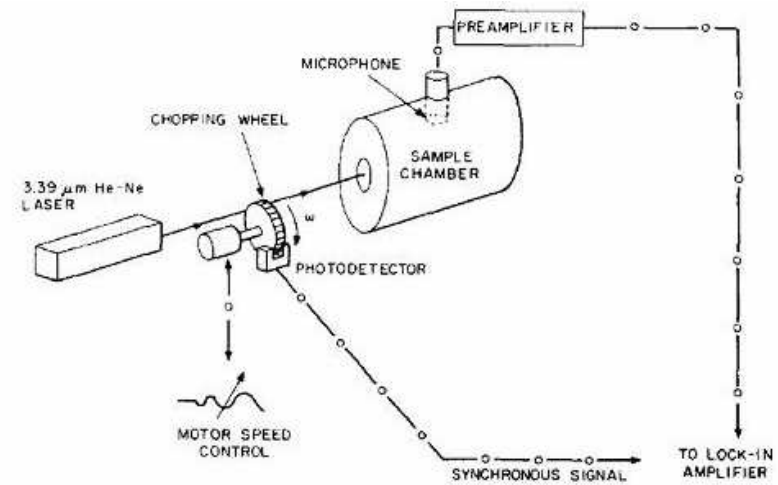
Photoacoustic IAQ sensors

Features:

- Sensitivity
- Selectivity

Issues:

- Complexity
- Cost



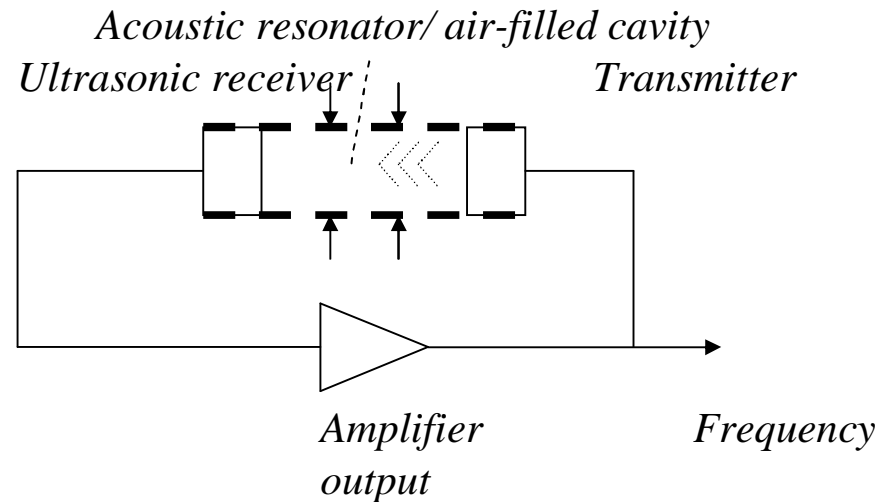
Electroacoustic sensors

Features:

- Size
- Reliability
- Power consumption

Issues:

- Selectivity
- Cross sensitivities



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

c: velocity of sound

k: Boltzmann's constant ($1.38 \cdot 10^{-23}$ J/ K)

T: absolute temperature (K)

γ : Ratio of specific heat (const press/vol)

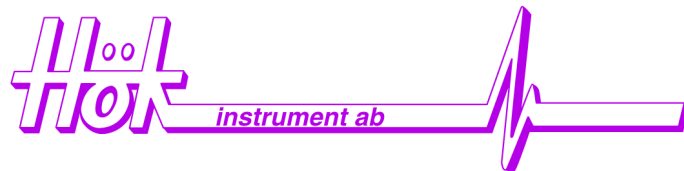
m: Molecular mass



Electro-acoustic IAQ sensor



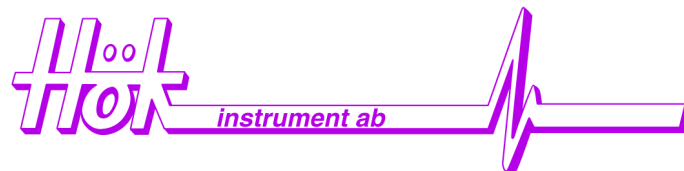
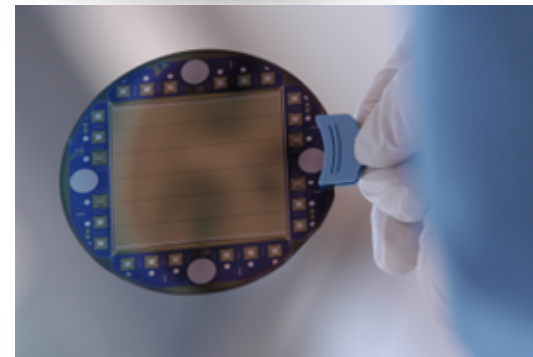
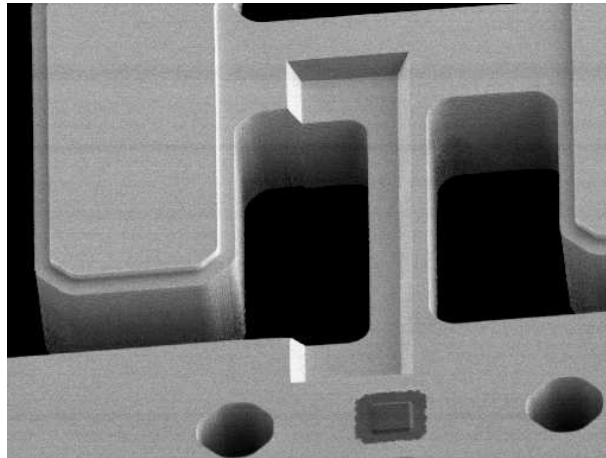
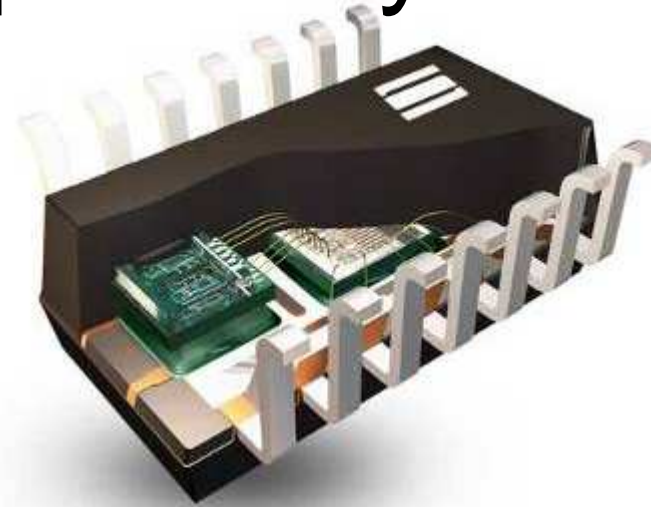
- Q-AIR322BG
- Wall-mountable Sensor for Indoor Air Quality Control
- Features: CO2, temp, RH
- Built-in controller
- Easy-to-read display



MEMS opportunity

Micro Electro Mechanical Systems:

High precision and complexity at low cost

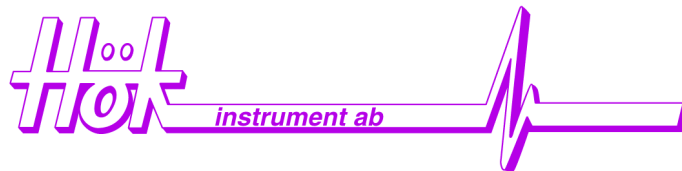
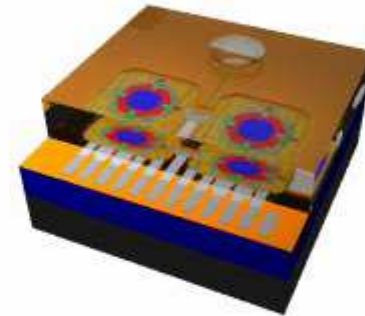


MEMS implementation: The MASCOT sensor

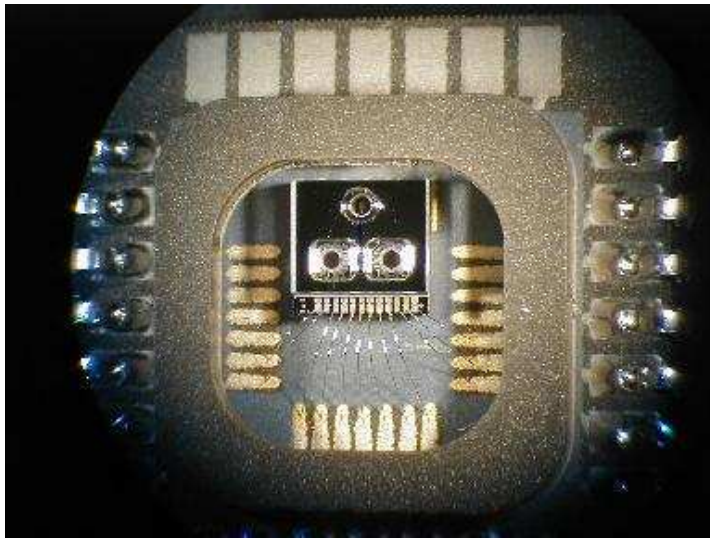


Partners:

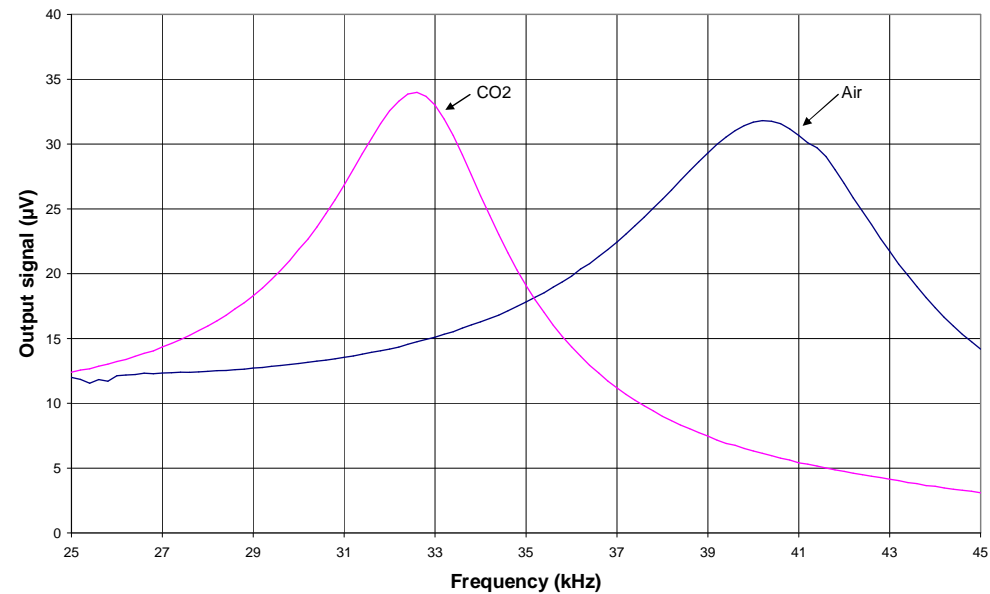
SensoNor
SINTEF
Hök Instrument



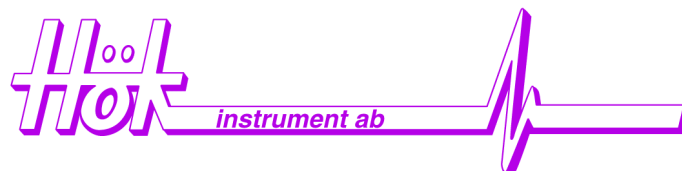
MASCOT performance



MASCOT sensor chip 3 x 3 mm

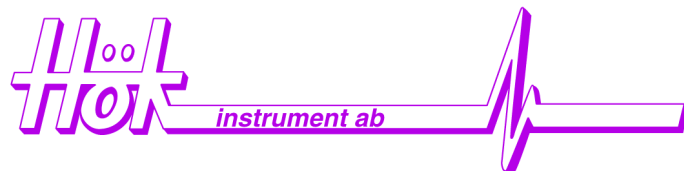


Resonance frequency decreasing from 40 kHz to 32kHz, 0 and 100% CO2. Q factor increasing from 6.6 to 8.2.



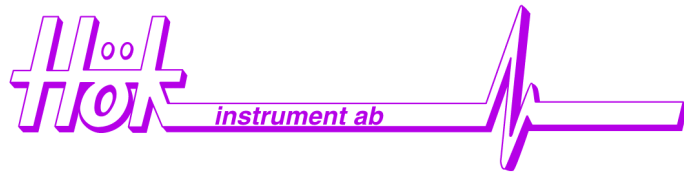
MASCOT performance cont'd

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



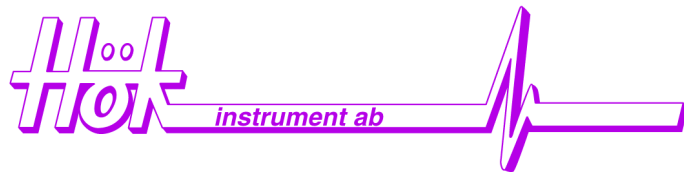
Nordic IAQ sensor suppliers

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



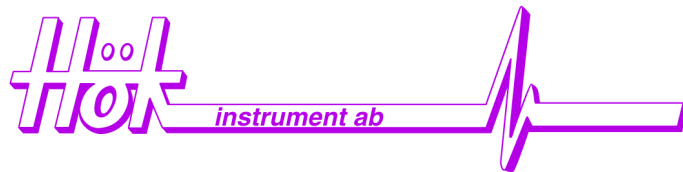
Current trends

- 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



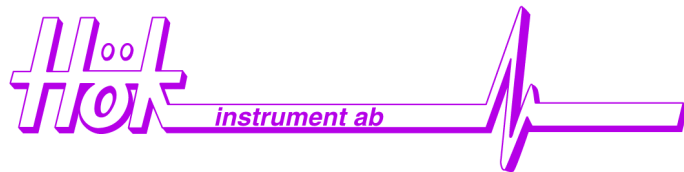
Wireless sensor networks

- 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



Thanks

Thanks to all MONTIE and MASCOT
partners for stimulating cooperation

Thanks for your attention

bertil@hokinstrument.se

