Technological advances within the field of micro multisensors: A Nordic perspective

”IAQ Sensors – a quick Nordic overview”,
Bertil Hök, Hök Instrument AB (www.hokinstrument.se)

”MASCOT: Micro-acoustic sensors for CO2 tracking”,
Per G. Gløersen, SensoNor AS (www.sensonor.com)

”Future Nordic Sensors”
Niels Peter Østbø, SINTEF (www.sintef.no)

IAQ (indoor air quality) sensors
- a quick Nordic overview

Bertil Hök

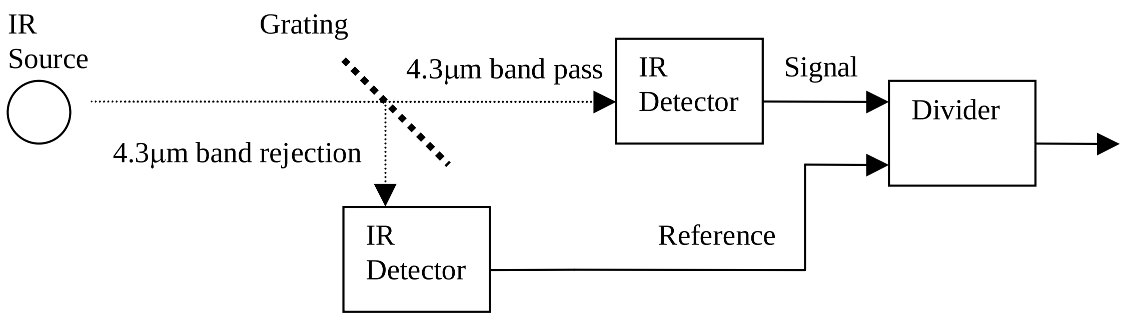
HÖK INSTRUMENT AB

IAQ monitoring & control variables

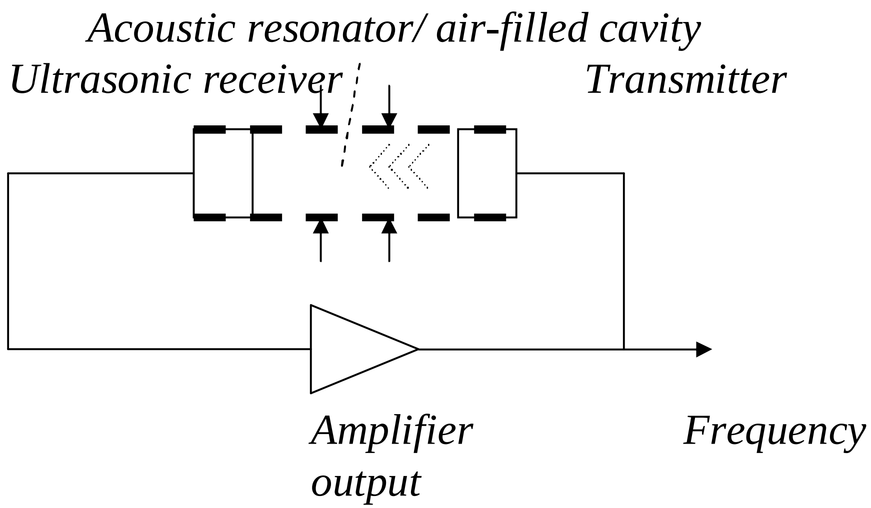
- Temperature
- Relative humidity
- Carbon dioxide concentration
- Particles, microorganisms (pollen…)
- Volatile Organic Compounds (VOC)
- Other gases (NO_x, ozone, …)

CO_2 sensor principles

Nondispersive
Infrared spectroscopy



Electro-acoustic
resonating sensor



instrument ab

SenseAir infrared IAQ sensors

Housing for industrial environments

CO_2 sensor for embedded solutions

Hök instrument ab

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**

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

MASCOT:
Micro-Acoustic Sensors for CO_2 Tracking

Per Gerhard Gløersen, SensoNor AS
Bertil Hök, Hök Instrument AB
Niels Peter Østbø, SINTEF

The MASCOT project was co-financed by the IST programme of the European Commission under grant number IST-2001-32411

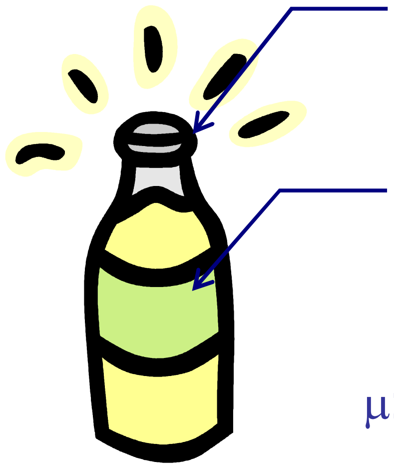
Device modelling basics

Relationship between velocity of sound c and molecular mass M of a gas:

$$c = \sqrt{\frac{RT\gamma}{M}}$$

R: universal gas constant (=8.314 J/mol K),
T: absolute temperature (K)
γ: Ratio of specific heat at constant pressure and volume

Resonant frequency and Q of a Helmholtz resonator:



Neck effective length l and area A (radius a)

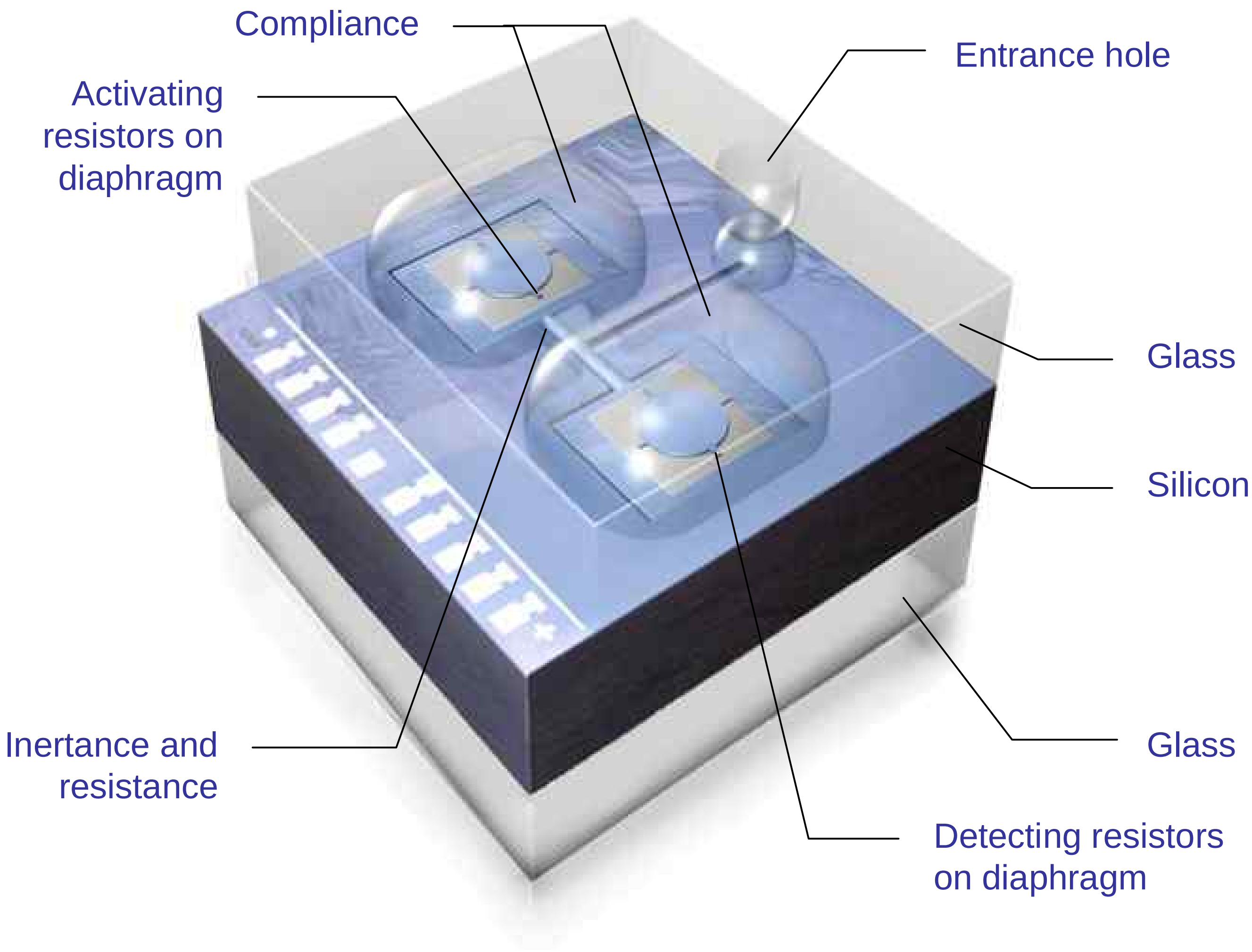
Compliant gas volume V

$$f_r = \frac{c}{2\pi}\sqrt{\frac{A}{\ell \cdot V}}$$

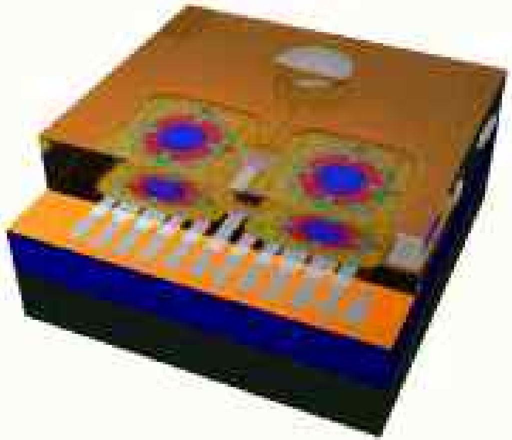
$$Q \approx a \cdot \sqrt{\frac{\omega_r}{2\mu}}$$

μ: kinematic viscosity of gas

Schematic drawing of sensor chip

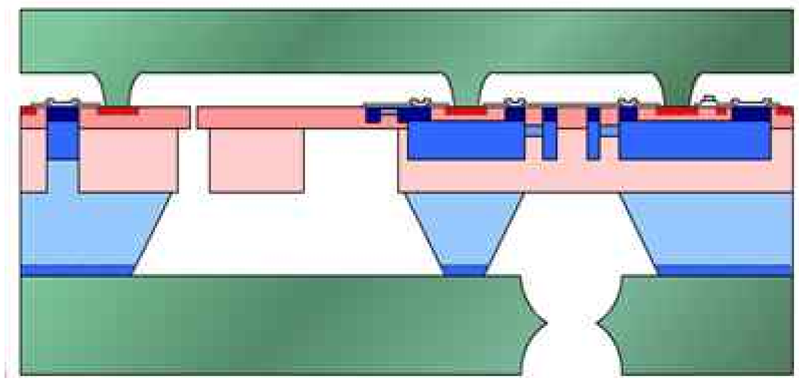


MASCOT in operation



Features of MEMS process

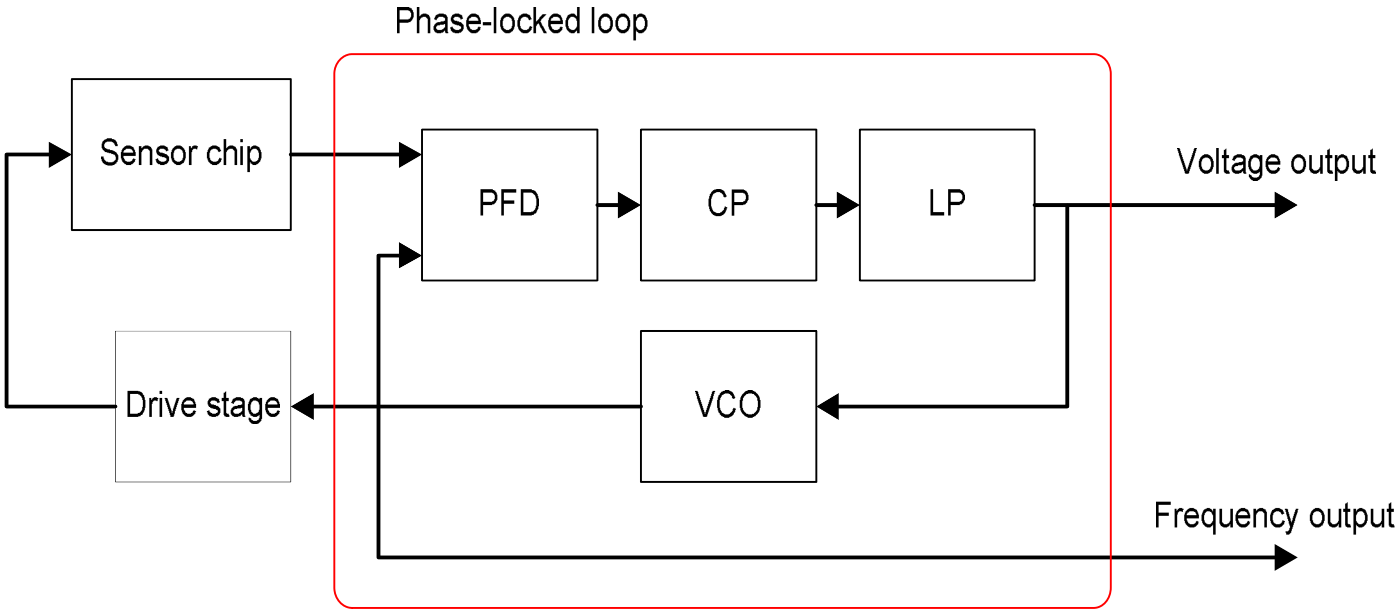
- Buried piezoresistors for precise and stable transduction of stress signals
- Sealed cavities for reference pressures
- Microchannels for gas / liquid flow
- Controlled 3D features for micromachined MEMS elements such as masses, beams, channels, springs and diaphragms
- Materials compatible with a large range of media / environments
- Wafer-level package provides stable enclosure and environmental protection for the sensor chip
- SensoNor's process platform is QS 9000 certified for automotive high-volume sensor production.



Packaged prototype and system solution

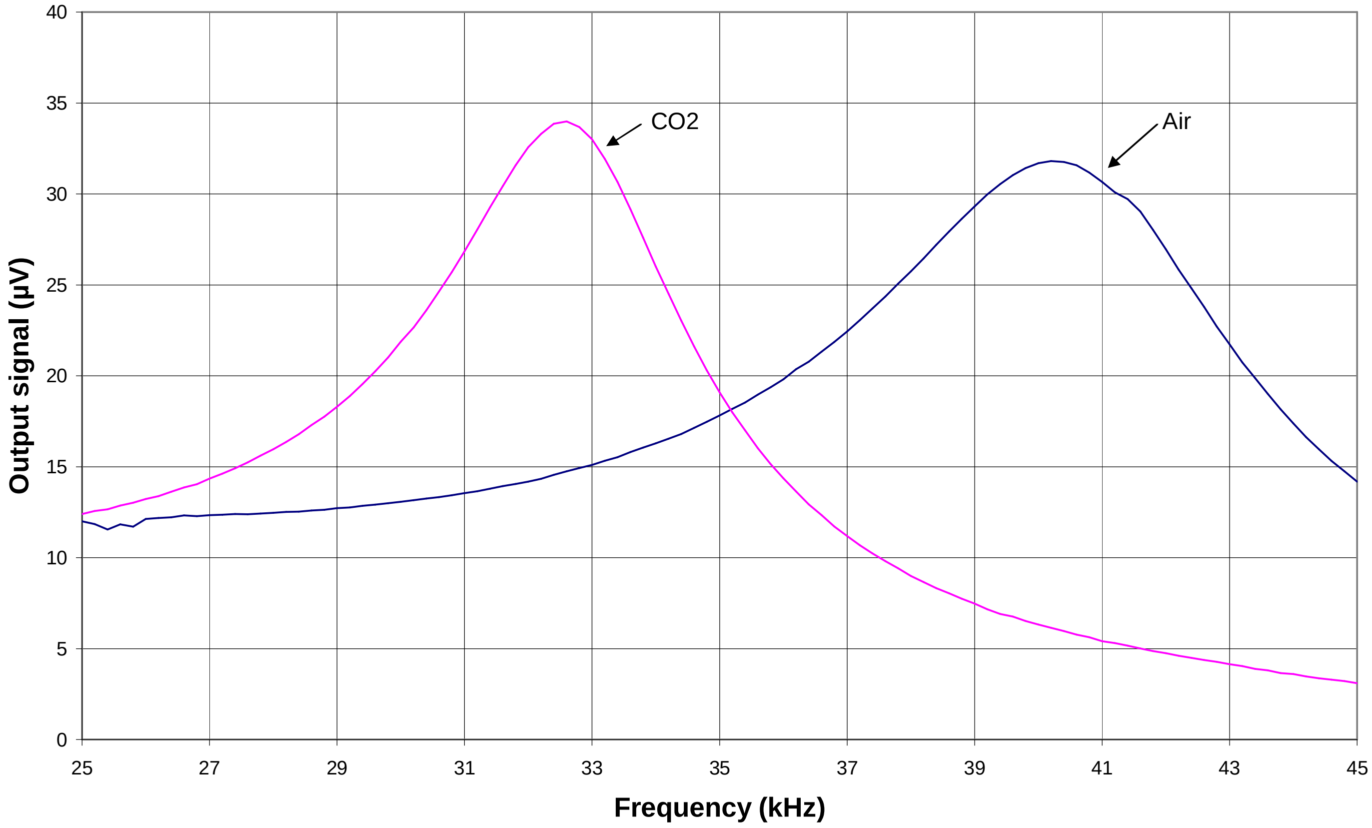
A large variety of sensors were produced with a range of characteristic dimensions

Sensor chip area: 3 x 3 mm. Packaged in a standard ceramic package



An Infineon Technologies Company

Sensor output signal in air and CO_2



The resonance frequency shifts from 40 to 32 kHz and the Q factor increases from 6.5 to 8.1

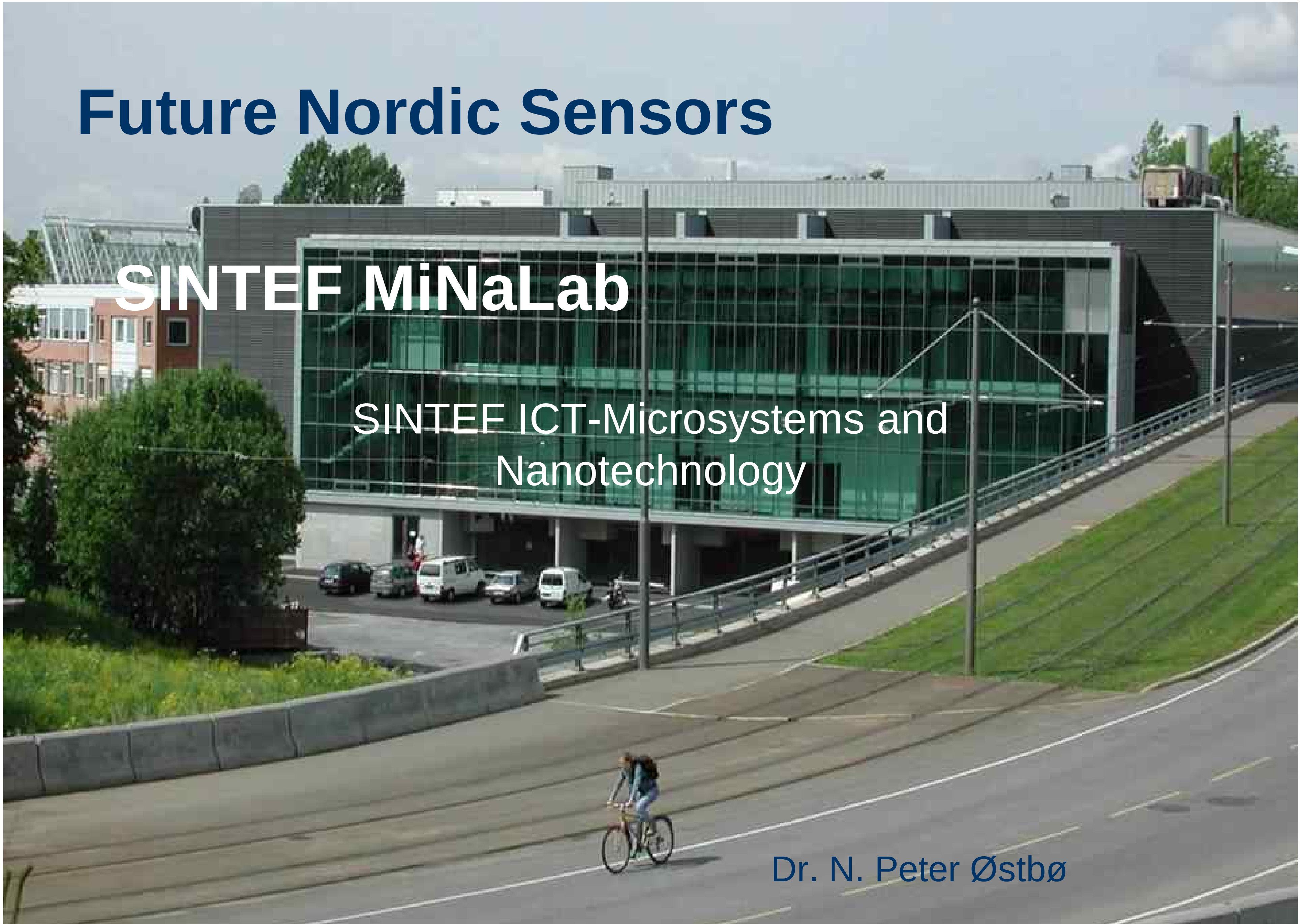
Sensor characteristics

	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

Conclusions

- A new class of MEMS-implemented CO_2 sensors has been demonstrated:
  - Simple and uncritical geometry
  - Strong potential for mass-production at low cost
- A PLL-based electronic interface ASIC has been implemented in a separate study (A. E. Edvardsen et al., Norchip 2004)
- The MASCOT project results on modelling, implementation and characterisation has established a platform for further development and performance optimisation
- The application area may be extended to other gas species
- Advantages of the MASCOT concept:
  - Performance / cost
  - Elimination of aging effects (improved lifetime and reliability)
- Industrial alliance partners are sought for the next step in the innovation process

Future Nordic Sensors



SINTEF MiNaLab

SINTEF ICT-Microsystems and Nanotechnology

Dr. N. Peter Østbø

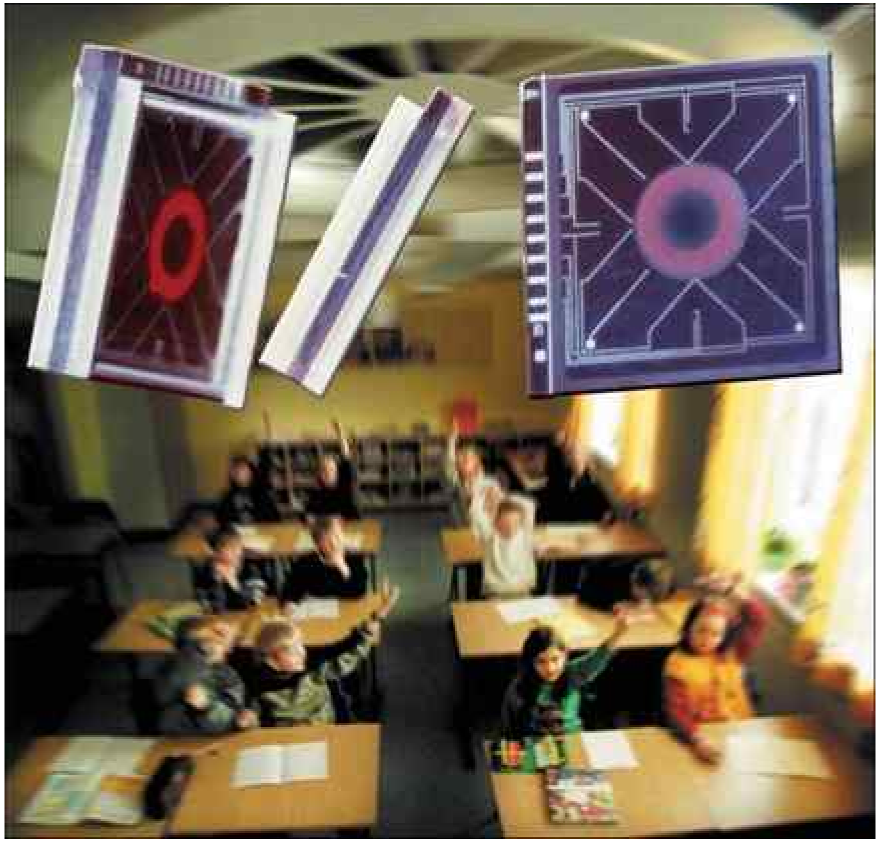
Future Nordic Sensors
Outline: A few examples from SINTEF...

- Microsystems and Nanotechnology
- SINTEF + NBI merger January 2006
  - NBI=Norwegian Building Research Institute

- MASCOT... (Presented by Per)
- **R&D on Other new technologies**

- MEMS possibilities
- IP Proposal “Multi-CEPOC”

PhotoAcoustic Gas Sensor
I

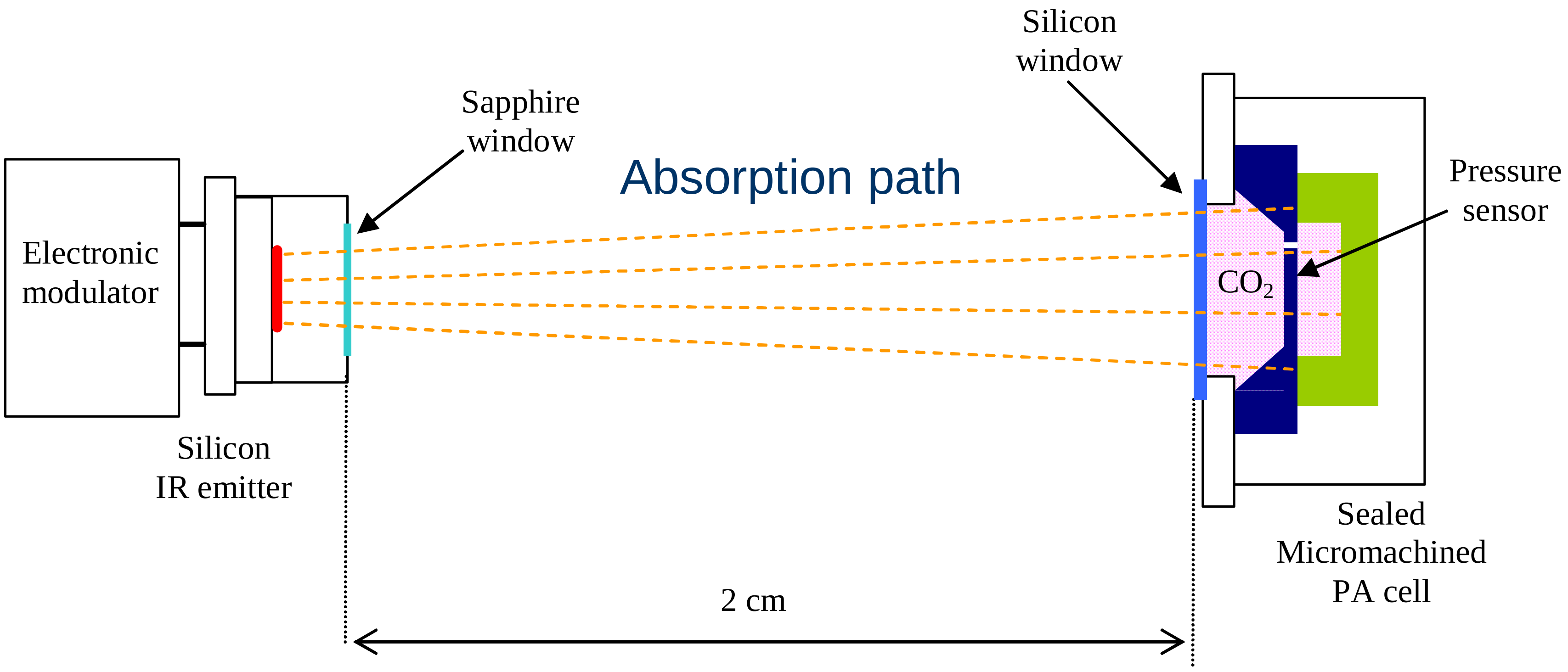


- MEMS Pressure sensor
- IR-source chip
- Reference Gas

- Goal: SINGLE Chip
- Wafer-level packaging

PhotoAcoustic Gas Sensor II

- A photo acoustic signal is generated in the micromachined PA cell
- The signal is measured by the pressure sensor (microphone)
- The pressure signal is reduced when target gas is present in the absorption path, due to the loss of IR transmission



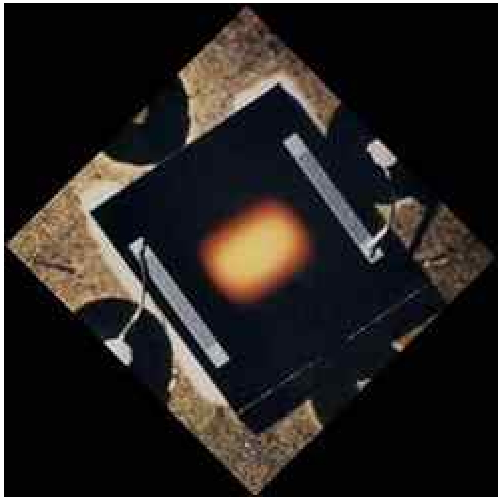
Advanced NDIR- SIMRAD Gas sensors I

- "Silicon chip inside"
- IR-source

- SIMRAD Optronics
  - Offshore Gas-sensors
  - 20 years life-time...

Advanced NDIR- (IR-source) II

- “Silicon chip inside”
- IR-source



- SIMRAD Optronics
  - Offshore Gas-sensors
  - 20 year life-time...
- Now “State-of-the-art” and soon low-cost...

Diffractive Optical Elements
I

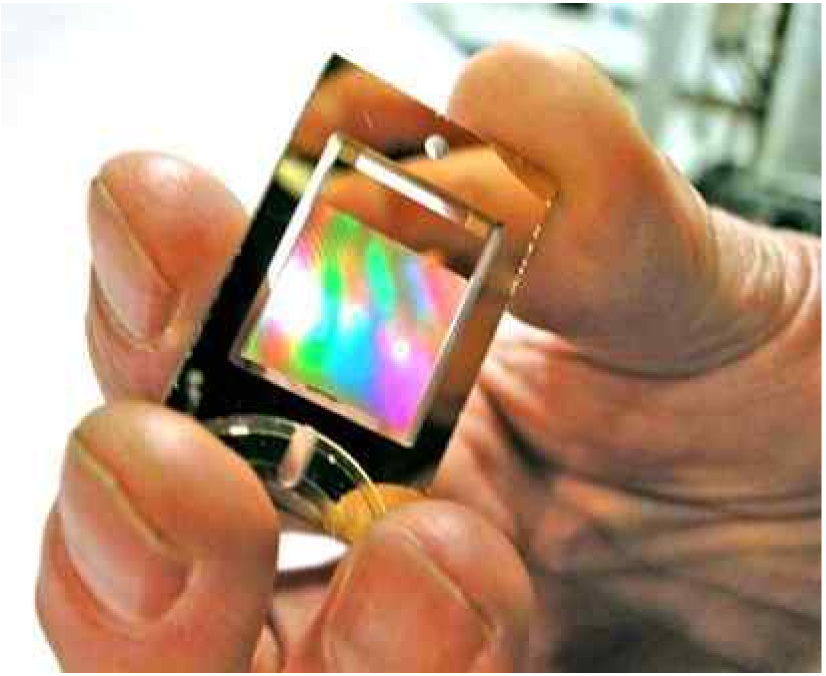
- "DOE-inside"
- Polymer replication possible
  - CD-technology...
- Optical spectrometer/ dedicated sensor for CO_2

- OptoSense AS
  - Demo
  - Folded polymer light/absorption path

Diffractive Optical Elements (DOE) II

- "DOE-inside"
- Polymer replication possible
  - CD-technology...

- OptoSense AS
  - Demo
  - Folded polymer light/absorption path
  - Polymer chip...
  - Shown: gold-plated Si-chip



IP Proposal Multi-CEPOC

- 29 partners
  - 15 countries, 10 SMEs
- 16 MEUR
- Networked Embedded Systems

- Ambient intelligence for:
  - Ambient comfort
  - Healthy, productive workers and school children
  - Energy savings
  - Cost savings...

Multi-CEPOC | Call FP6-2005-IST-5, Instrument IP

Proposal full title IP Multisensors for Controlling Indoor Environment Parameters by Optimal HVAC Control
— A case application project for a versatile embedded sensor system

Proposal acronym **Multi-CEPOC**

Call identifier FP6-2005-IST-5
Type of instrument Integrated Project
Date of submission 2005-09-21 (final version, post submission: v8)

List of participants:

Participant	Participant organisation name	Short name	Country
1	The Foundation for Scientific and Industrial Research	SINTEF	NO
2	Technical Univ. of Denmark (DTU) - International Centre for Indoor Environment & Energy	ICIEE	DK
3	Danish Technological Institute	DTI	DK
4	Senseair AB	Senseair	SE
5	Federation Of European Heating And Air-Conditioning Associations	REHVA	EU
6	Hok Instrument AB	Hok	SE
7	VTT Technical Research Centre of Finland	VTT	FI
8	IPDI SA	IPDI	CH
9	University of Neuchâtel - Institute of Microtechnology	IMT	CH
10	Fraunhofer Institute for Autonomous Intelligent Systems	F.AIS	DE
11	inAccess Networks	inAccess	GR
12	Universität Lüneburg	UniLü	DE
13	Commissariat à l'Energie Atomique - Lab of applied research on software-intensive tech.	CEA-LIST	FR
14	F.A.R. Systems s.p.a.	FAR	IT
15	AFCON Control and Automation Ltd	AFCON	IL
16	MB Air Systems Ltd	MBAS	UK
17	INTRACOM SA	INTRACOM	GR
18	Czestochowa University of Technology (Politechnika Czestochowska)	PCZ	PL
19	Spirit Information Systems a.s.	SPIRIT	SK
20	Austrian Academy of Science	AAS	AT
21	CiS Institut für Mikrosensorik gGmbH	CiS	DE
22	Aristotle University of Thessaloniki - Informatics Systems & Applications Group (ISAG)	AUTh	GR
23	Net Technologies Ltd	NetTech	GR
24	Metaphor Vision Ltd	Metaphor	IL
25	Kidde PLC - Corporate Research	Kidde	UK
26	Comtrol Systems SA	Comtrol	FR
27	Siemens AG	Siemens	CH
28	Optosense AS	Optosense	NO
29	Norwegian Building Research Institute	NBI	NO

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