



European Sensor Systems Cluster – ESSC

“Renaissance of chemical and biological sensors”

Indoor Air Quality

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WG 2: Indoor Air Quality – why?

Indoor:

- mainly buildings (private homes, offices, schools, kindergarten, public)
- also transportation (cars, buses, trains, airplanes)

“Furthermore, it is worth noting that most health-related pollution policies are targeted to the outdoor environment. **A somewhat neglected area in this regard is the indoor environment** – considering that European citizens spend up to 90% of their time indoors. ... The quality of indoor environment is affected by ambient air quality; building materials and **ventilation**; consumer products, including furnishings and electrical appliances, cleaning and household products; occupants’ behaviour, including smoking; and **building maintenance (for example, energy saving measures)**. Exposure to particulate matter and chemicals, combustion products, and to dampness, moulds and other biological agents has been linked to asthma and allergic symptoms, lung cancer, and other respiratory and cardiovascular diseases.”

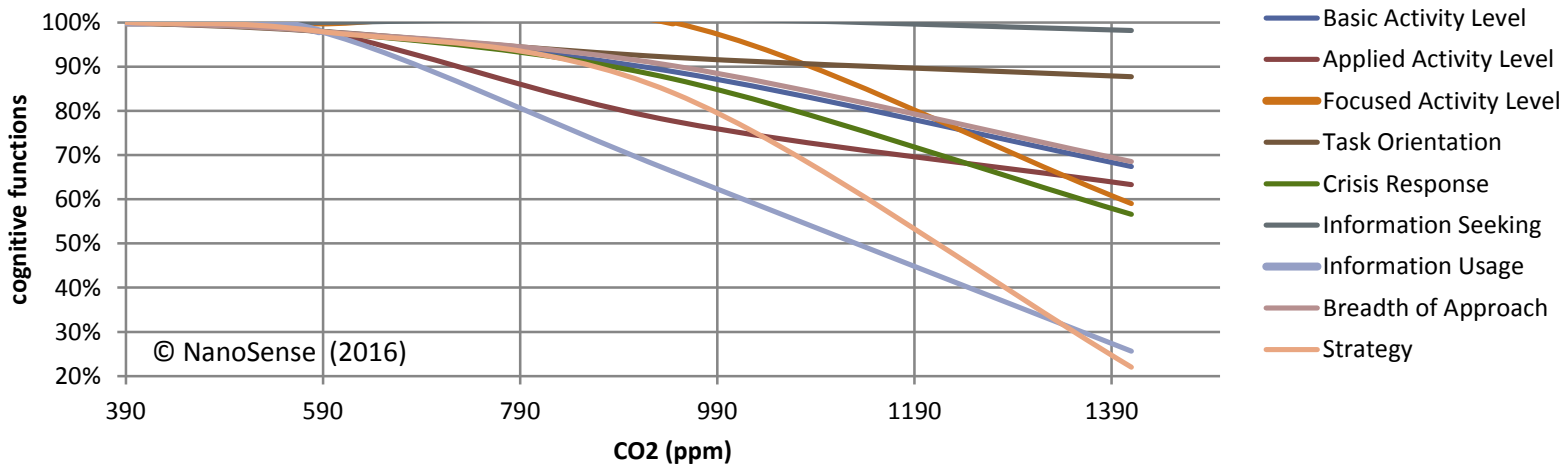
European Environmental Agency: The European environment | State and outlook 2010

WG 2: Indoor Air Quality – why?

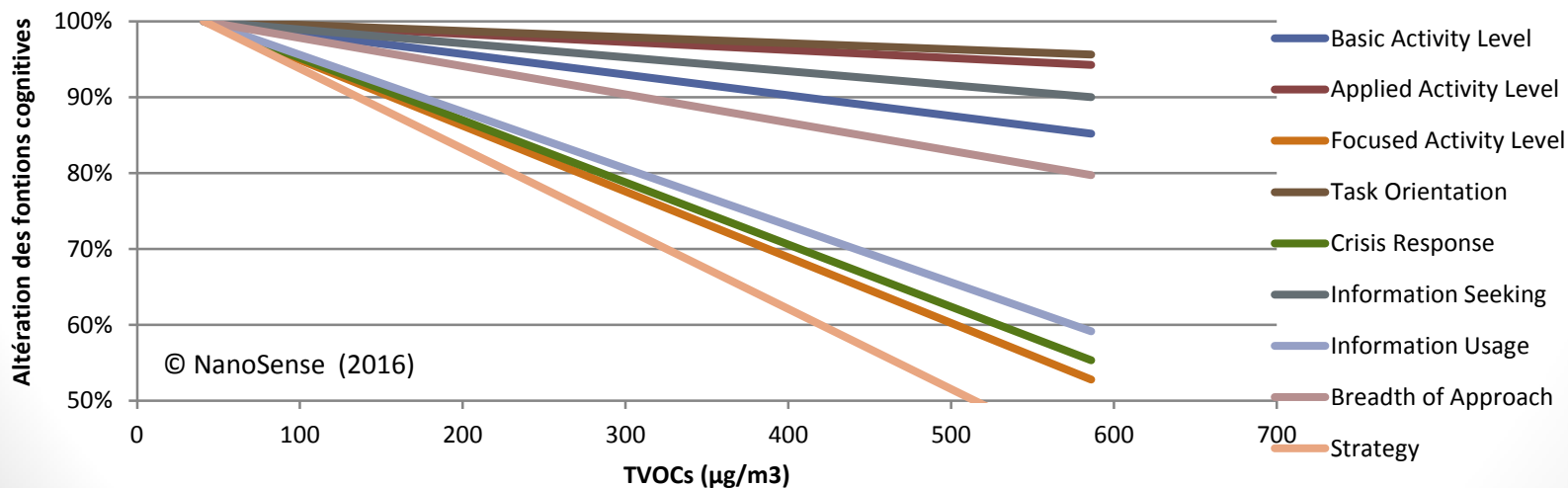
- **Health:**
 - high concentrations of hazardous or even toxic gases for brief periods
 - extended or continuous exposure to very low concentrations, especially for carcinogenic compounds
 - particulate matter (PM) and pollen are increasing concern
- **Comfort:**
 - odours like isovaleric acid are not hazardous but influence comfort, both awake and during our sleep
 - complex aspect involving humidity, CO₂, VOCs and “smell”, but also physical parameters, i.e. temperature, light and air flow/draft.
- **Productivity:**
 - increased CO₂ & VOC concentrations greatly reduce productivity.
 - productivity losses in workers and students w high economic impact
- **Building integrity and value:**
 - Humidity can generate mould growth and deteriorate building structure and decoration

WG 2: Indoor Air Quality – why?

CO₂ effects on various cognitive functions



Total VOC effects on various cognitive functions



WG 2: Indoor Air Quality – what?

- **Sensor systems measuring IAQ can have several purposes:**
 - Purely informative, i.e. indoor weather station
 - Prove compliance with regulations (typically long term average exposure, data logging)
 - Give active feedback and advise to people (“open the window to ventilate”)
 - Actively control IAQ as part of a complex system to control dilution with outdoor air and possibly also active air treatment (by recirculation or treatment of incoming air: filtering, catalytic decomposition, air ionization, ...)

Flush mounted integration

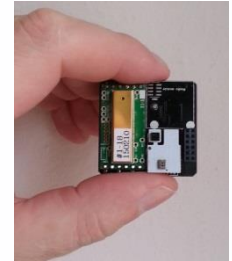
- IAQ probes
 - CO2, VOC, T°, RH



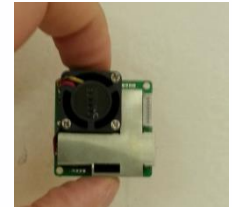
Today's probe



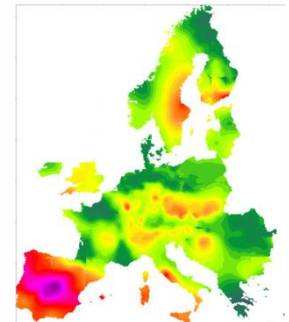
On going project



- Particles
 - PM1, PM2.5, PM10



- Radon



Metal Oxide Semiconductor sensors trend



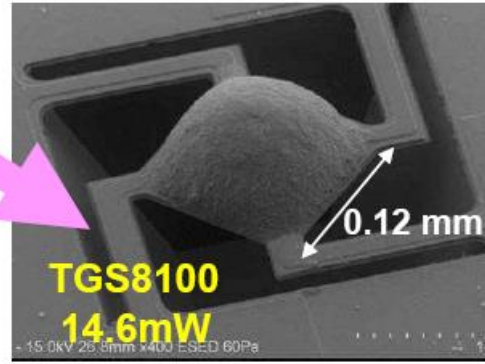
TGS8 series
835-660mW



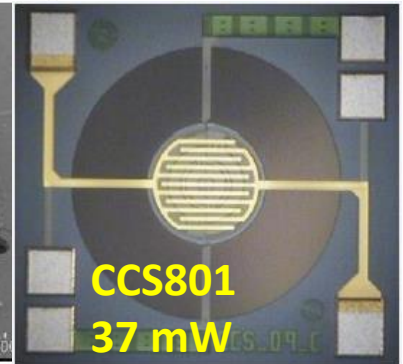
TGS2100
760mW



TGS2600
210mW

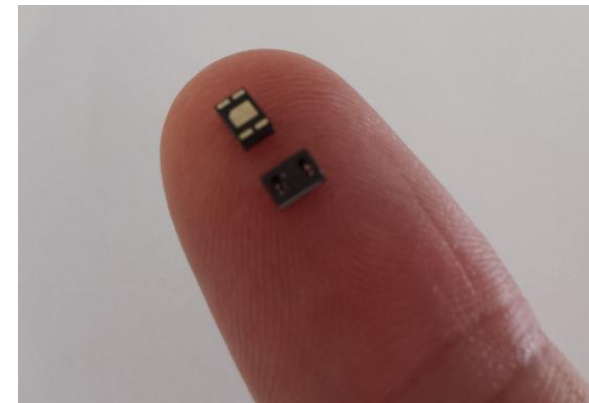


TGS8100
14.6mW



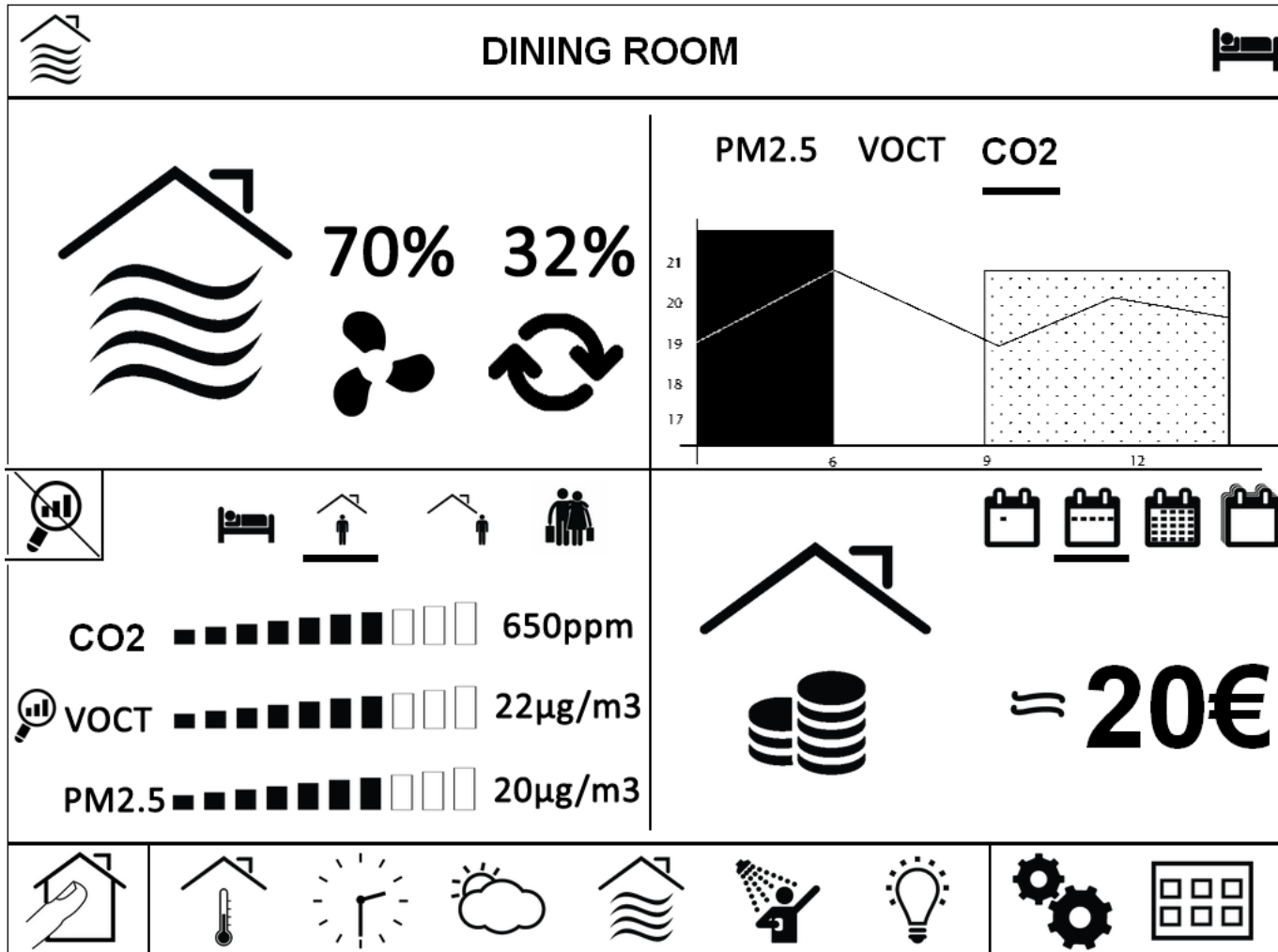
CCS801
37 mW

- MEMS
 - Lower cost
 - Low consumption
 - Life span > 10 years when pulsed



Topic: Comprehensive IAQ User Interface for demand controlled ventilation

(Source: NanoSense Sarl, project Displ'Ever)



Topic: **Comprehensive IAQ User Interface for demand controlled ventilation**

Call timing: 2018-2019

Instrument: RIA

Challenge description: To make full use of sensor systems for IAQ:

- Develop a comprehensive Air Quality Index including odour nuisance monitoring
- Connect Outdoor and Indoor AQ for optimal remediation strategy based on AQ index
- Dedicated IAQ UI to raise awareness, allow easy understanding, individual tailoring

Possible solutions: Close collaboration between specialists in sensor systems, building technologies, health experts and user interfaces is required ; specific solutions might be based on existing building control interfaces for HVAC systems or make use of smart home solutions with smart phones and tablets as omnipresent user interface

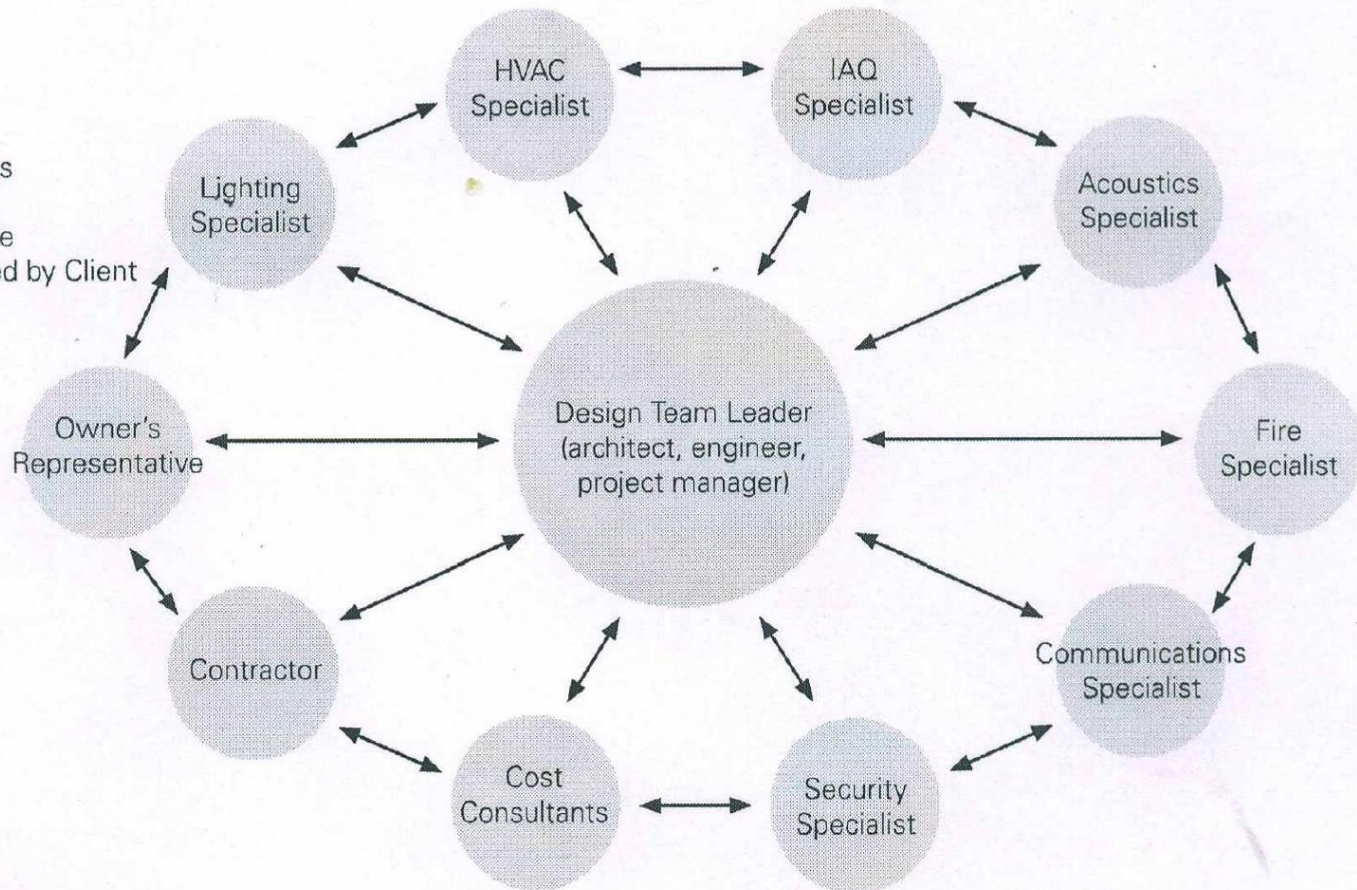
EU positioning: strong commercial position in sensor systems & building technologies; specific for Europe is refurbishment of existing buildings (far more numerous than new); awareness of indoor AQ on health has already triggered standards but emphasis on increased energy efficiency threatens to counteract measures to improve air quality

Companies interested: Building and construction: **Siemens BT, CIAT, Systemair, ALDES** Aéraulique, Acciona Infraestructuras, **Delos**, Energy Efficient Buildings (E2B EI),
Sensor systems: **ams, Samsung, Analog Devices, Infineon**, Bosch Sensortec, **NanoSense, 3S, SGX, UST, SenSiC, Environmental Monitoring Systems**

Topic: Comprehensive IAQ User Interface for demand controlled ventilation

Integrated

Holistic Thinking
Team Based
Organic design Process
Larger Inclusive Team
Users, Operators, Code
Innovations Encouraged by Client



(Source: American Society of Heating, Refrigerating and Air Conditioning Engineers)

Topic: Integration of mobile sensor systems (primarily smartphones, wearables and IoT) into IAQ networks

Call timing: 2018-2019

Instrument: IA

Challenge description: gas sensors integrated in smartphones will appear in III/2016

- localized monitoring, e.g. for indoor air quality (total VOC) and breath alcohol levels
- new paradigm could be achieved for AQ networks due to ubiquitous sensor systems
- environmental monitoring, but also safety and security applications
- requires standardized data interfaces, regulatory framework, novel data evaluation and interpretation technologies, i.e. network-based cross-validation and calibration

Possible solutions:

- Environmental Information (EI) services, e.g. personalized AQ information
- big data analysis (high performance, link low-cost sensors with monitoring stations)
- bottleneck is functional integration and high volume availability at low cost

Topic: Integration of mobile sensor systems (primarily smartphones, wearables and IoT) into IAQ networks

Call timing: 2018-2019

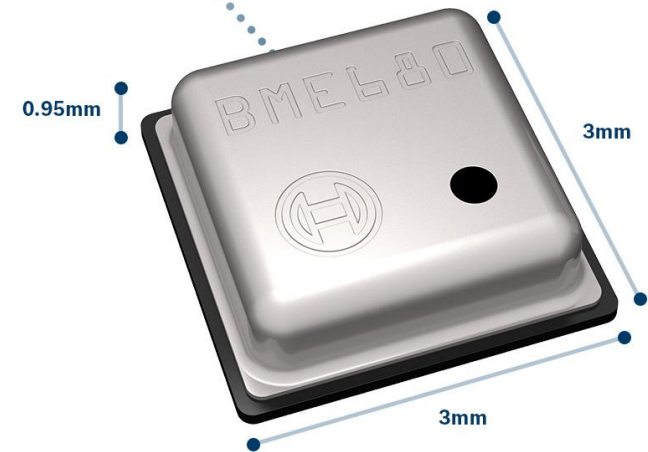
Instrument: IA

EU positioning: strong commercial position in sensor systems for mobile applications, currently weak in system integration; big data offers many opportunities; IoT can strengthen Europe's competitive situation based on systems know-how for various relevant fields from environmental monitoring, health up to safety and security.

Companies interested:

- Sensor systems: **Siemens, ams, Analog Devices, Bosch Sensortec, Infineon, Sensirion, NanoSense, 3S, SGX, CCMOSS, UST** etc.
- Wearables and IoT: **Samsung, Apple, Microsoft, Google, LG, Jawbone, Panasonic** etc.
- Networks and information services: **Worldsensing, Arianet, Siemens** etc.

(Source: Bosch Sensortec)



Main features



Environmental Unit

Measures pressure, humidity, temperature and gas



Pressure

Measures barometric pressure and altitude



Relative Humidity

Measures relative humidity with a fast response time



Temperature

Measures ambient temperature



Gas

Measures Volatile Organic Compounds (VOC)

Topic: High-performance, low-cost particle monitoring systems

Call timing: 2020-2021

Instrument: RIA

Challenge description: factors contribute to the health impact of PM:

- number of the particles (mass concentration favors larger particles over smaller)
- material composition of the particles, i.e. soot vs. inorganic
- shape of the particles (well known for asbestos)
- adsorbates attached to surface, e.g. PAH (highly carcinogenic, often found on soot, Benzo[a]pyrene primarily stemming from wood fires)
- biological (pollen) vs. inorganic

Possible solutions: multiparametric **miniaturized** sensor solutions

- optical techniques combined with fluidics to count particles
- collecting PM on surface: impedance spectroscopy, impact meas., surface ionization
- adsorbates characterized by heating and subsequent analysis of released molecules
- bottleneck is **functional integration** and high volume availability at low cost
- required building blocks are **micro & nano technologies**, use of **physical and chemical detection** principles, but also suitable **calibration schemes**.



(Source: <http://www.tsi.com>)

Topic: **High-performance, low-cost particle monitoring systems**

Call timing: 2020-2021

Instrument: RIA

EU positioning: strong commercial position in sensor systems for environmental monitoring, both in analytical equipment for scientific use and for low-cost sensors. Combining the expertise in these fields with micro- and nanotechnologies where Europe is also strong for novel multiparameter PM sensors would allow a worldwide leading position for novel PM sensors required for various applications, both indoor and outdoor

Companies interested:

- Building and construction: **Siemens Building Technologies, Camfil, CIAT Compagnie Industrielle d'Application thermique, Systemair, ALDES Aéraulique, Acciona Infraestructuras, Delos, E2B EI** etc.
- Sensor systems: **Siemens, ams, Samsung, Infineon, Panasonic, Analog Devices, NanoSense, 3S, SGX, UST, Alphasense, SenSiC** etc.

Topic: Bio-chemical sensor systems for mold detection

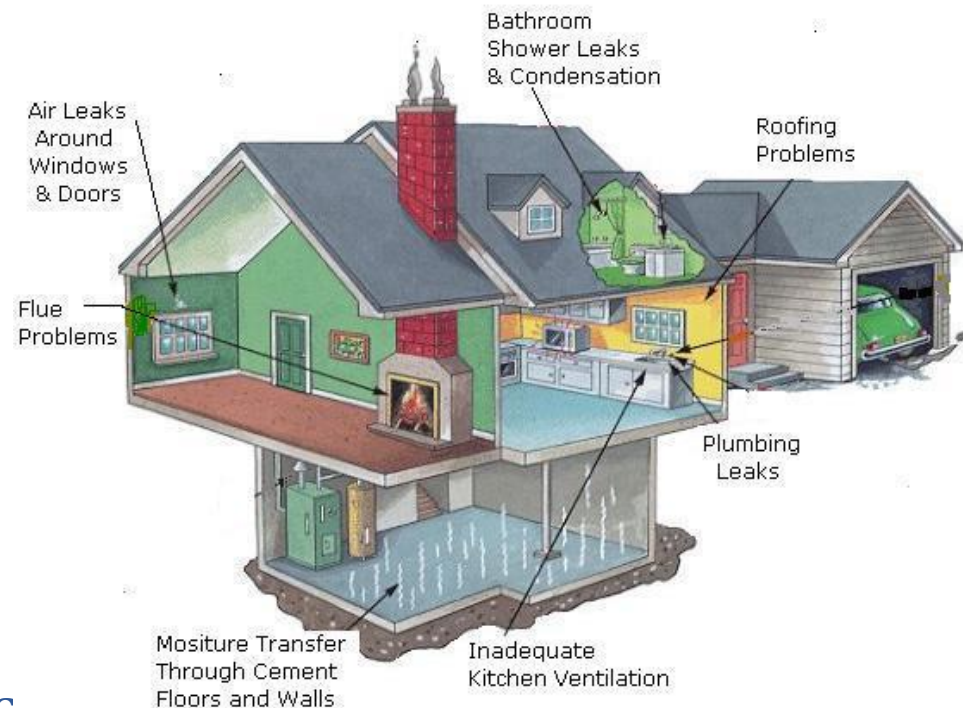
Call timing: 2020-2021

Instrument: RIA

Challenge description: Humidity can lead to (hidden) mold formation, w huge impact on health and building structure, especially highly insulated modernized buildings. Many people highly aware of the danger of molds and spores on health and building value. Current sensor solutions lack sensitivity and selectivity for detecting especially hidden mold; other technologies require lab tests and are not suitable for online use.

Symptoms of mold exposure:

- Nausea
- Headache
- Fatigue
- **Asthma**
- Memory loss
- Irritation of eyes, nose, skin, throat, lungs
- **Lung disease**
- **Kidney (renal) failure**
- Acute idiopathic pulmonary hemorrhage
- **Some forms of cancer** (lung, liver)
- Increased lower respiratory illness and/or viral infections in healthy children



Topic: **Bio-chemical sensor systems for mold detection**

Call timing: 2020-2021

Instrument: RIA

Possible solutions: Systems to detect mold at early stage or to predict mold formation based on comprehensive air quality data (temperature, humidity, ventilation, etc.).

- typ. VOC signature of molds monitored by VOC sensor systems (very low conc.)
- model-based approaches based on AQ sensor data verified with direct methods
- biosensors for on-the-spot measurement solutions

EU positioning: strong position in bio-chemical sensor systems can be combined with modelling know-how. Market demand expected to increase strongly in the near future

Companies interested:

- Building and construction: **Siemens Building Technologies, Camfil, CIAT Compagnie Industrielle d'Application thermique, Systemair, ALDES Aéraulique, Acciona Infraestructuras, Delos, Energy Efficient Buildings European Initiative (E2B EI)** etc.
- Sensor systems: Siemens, ams, **Samsung**, Panasonic, Analog Devices, Bosch Sensortec, **NanoSense, 3S, SGX, UST, CCMOSS, Environmental Monitoring Systems**, etc.