

**European Network on New Sensing Technologies for Air Pollution
Control and Environmental Sustainability - *EuNetAir*
COST Action TD1105**

INTERNATIONAL WG1-WG4 MEETING on

New Sensing Technologies and Methods for Air-Pollution Monitoring

European Environment Agency - EEA

Copenhagen, Denmark, 3 - 4 October 2013

Action Start date: 01/07/2012 - Action End date: 30/06/2016 - Year 2: 2013-2014 (*Ongoing Action*)

**SYSTEM TO CONTROL INDOOR AIR QUALITY IN
ENERGY EFFICIENT BUILDINGS**



IK4 Research Alliance

Gemma García Mandayo (ggmandayo@ceit.es)

Invited Expert

**Ceit and Tecnun (Universidad de Navarra), P.Mikeletegi 48,
20009 San Sebastián, Spain**



IK4 Research Alliance



- Non-profit research centre in San Sebastian, Spain
- 270 researchers (120 doctoral students)
- 6 main research areas in two buildings:
Materials, Mechanics, Electronics & Communications, Environmental Eng., **Microelectronics & Micro Systems**, Biomedical Engineering

www.ceit.es



EUROPEAN COOPERATION IN SCIENCE AND TECHNOLOGY

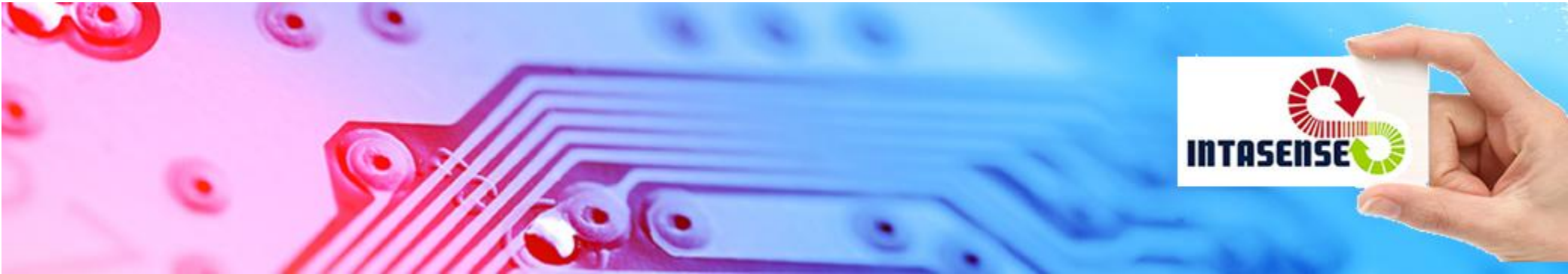


MIRAMÓN



IBAETA

The INTASENSE project

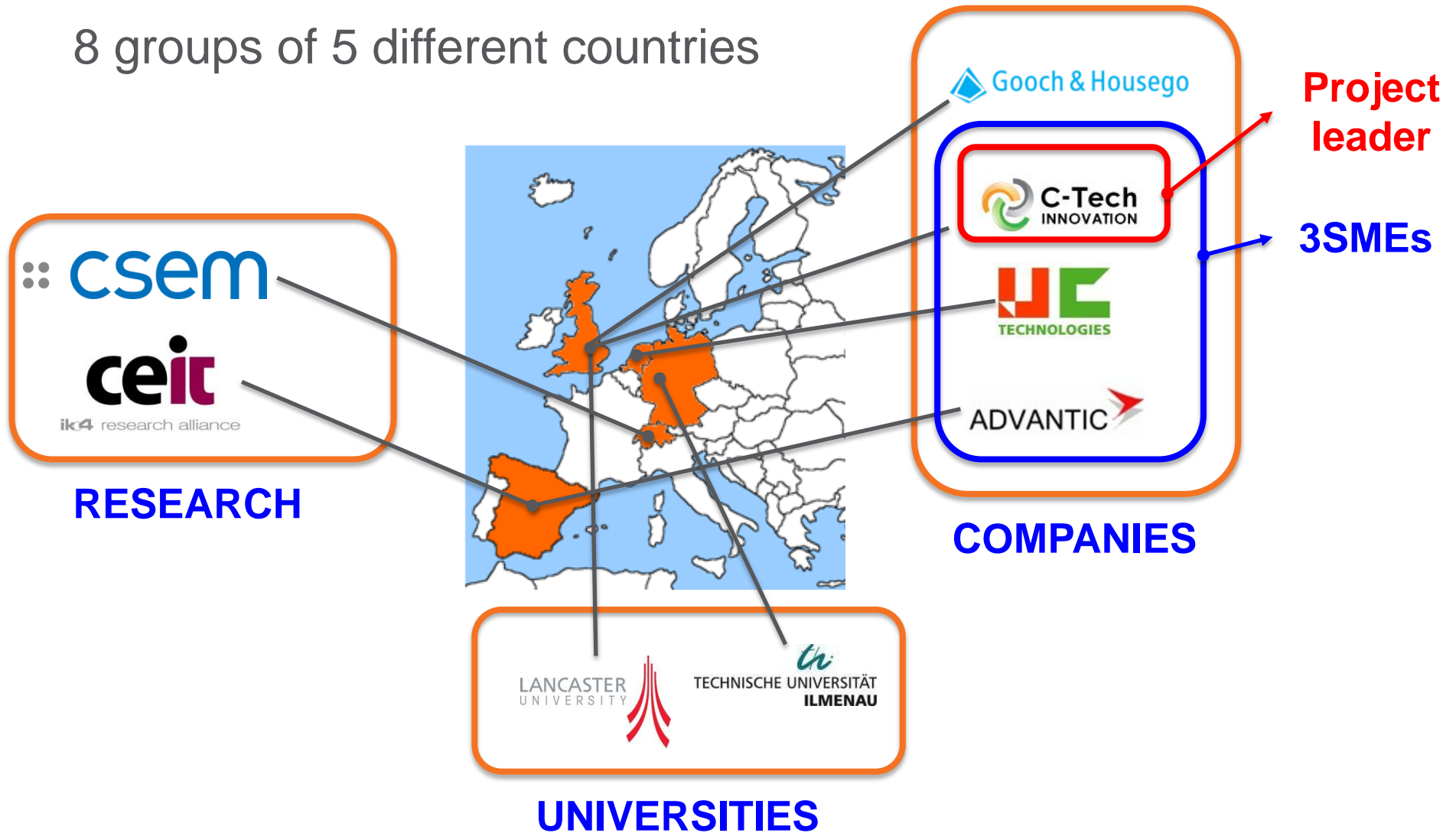


- European Commission's Energy Efficient Buildings PPP (Public Private Partnership).
- EeB.ENV.2011.3.1.5-1: Technologies for ensuring monitoring and/or controlling a high quality indoor environment, particularly in relation to energy efficient buildings






www.intasense.eu

The INTASENSE consortium






8 groups of 5 different countries



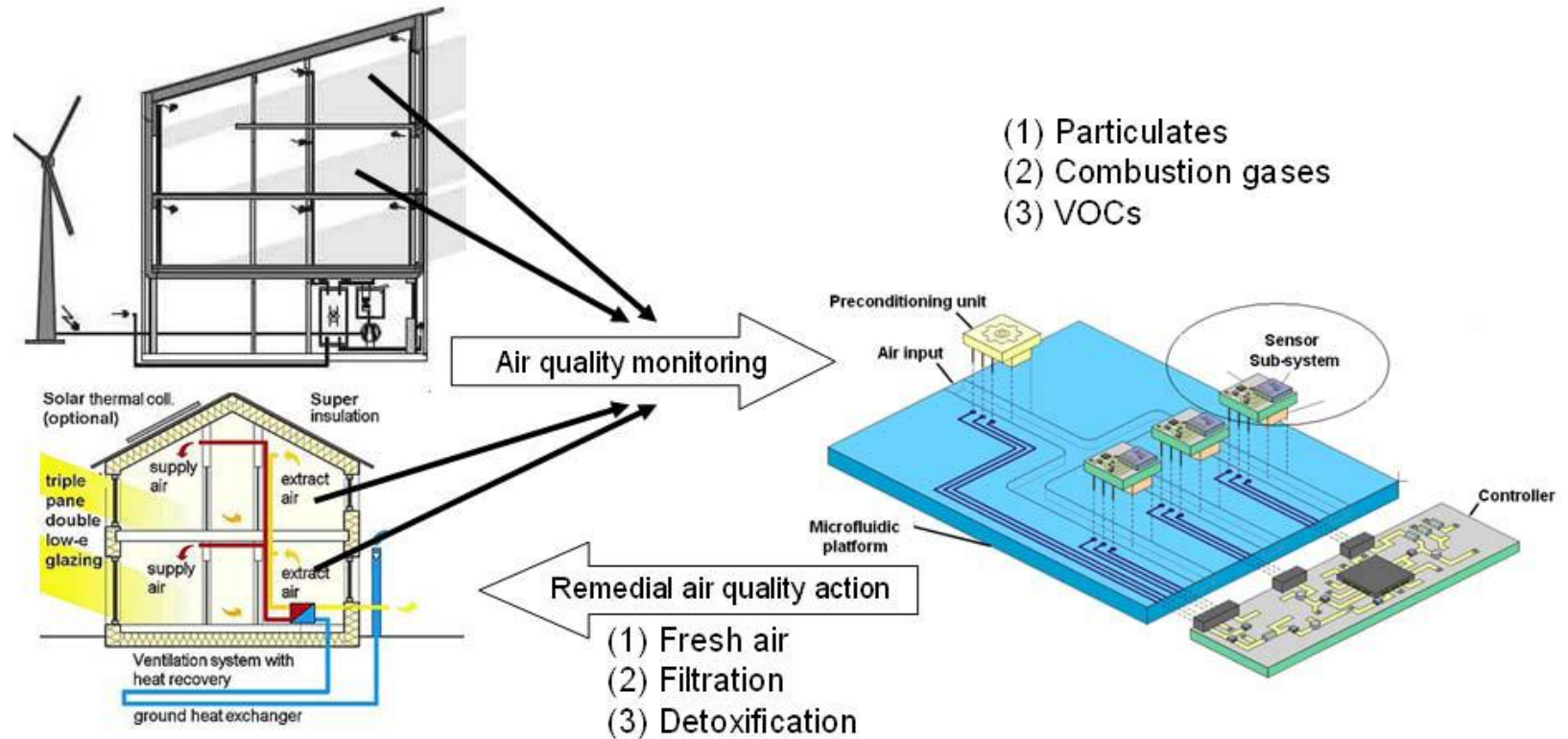
Outline of the presentation

- Introduction: the INTASENSE concept
- System specifications
- Main technological approach:
 - Fluidic platform for air preconditioning :: 
 - Particle detector  TECHNISCHE UNIVERSITÄT
ILMENAU
 - Toxic gas/ vapour detection
 - Conductometric sensors 
 - Impedimetric sensors+UV  
- Conclusions and future work

Outline of the presentation





- Introduction: the INTASENSE concept
- System specifications
- Main technological approach:
 - Fluidic platform for air preconditioning :: 
 - Particle detector  TECHNISCHE UNIVERSITÄT
ILMENAU
 - Toxic gas/ vapour detection
 - Conductometric sensors 
 - Impedimetric sensors+UV  
- Conclusions and future work

Introduction: the INTASENSE concept



Indoor air quality monitoring tool to support the efficient use of HVAC systems in buildings while maintaining a healthy working environment.

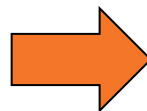
Outline of the presentation

- Introduction: the INTASENSE concept
- System specifications
- Main technological approach:
 - Fluidic platform for air preconditioning :: 
 - Particle detector  TECHNISCHE UNIVERSITÄT
ILMENAU
 - Toxic gas/ vapour detection
 - Conductometric sensors  **ceit**
ik4 research alliance
 - Impedimetric sensors+UV  **C-Tech**
INNOVATION
- Conclusions and future work

System specifications

- Which gases/vapours? INDEX EU project
- What type/size of particles?
- References for detection limits: OSHA, WHO, EPA, etc
- Lack of EU common standards

OSHA* limits	STEL	Action level
Formaldehyde	2ppm	500ppb
Benzene	5ppm	500ppb
Nitrogen dioxide	1ppm	300ppb
Carbon monoxide	125ppm	20ppm



Detection ranges:
formaldehyde: 50ppb-1ppm
benzene: 10ppb-1ppm
NO₂: 100ppb-1ppm
CO: 10ppm-100ppm

EPA* limits	Concentration (time)
PM ₁₀	0.05 mg/m ³ (annual)
PM _{2.5}	0.15 mg/m ³ (24 h) 0.015 mg/m ³ (annual)

Outline of the presentation

- Introduction: the INTASENSE concept
- System specifications

- Main technological approach:

- Fluidic platform for air preconditioning :: **csem**

- Particle detector



- Toxic gas/ vapour detection

- Conductometric sensors



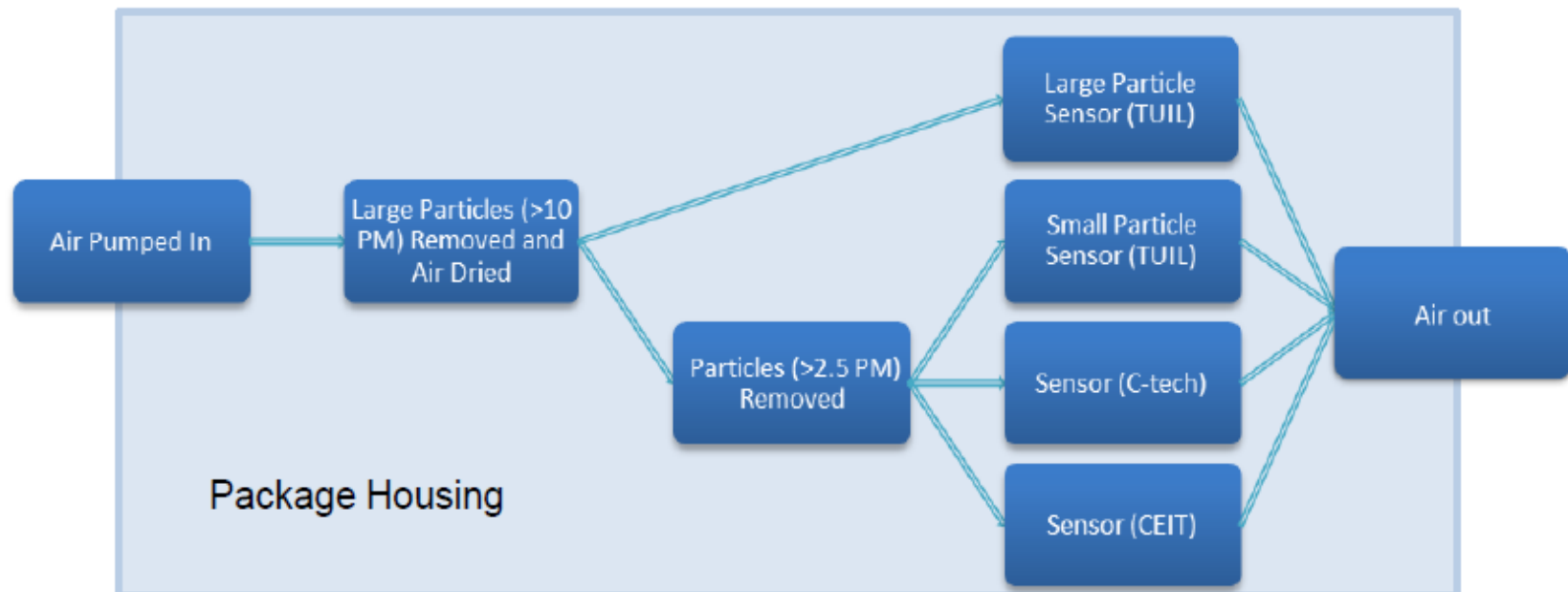
- Impedimetric sensors+UV



- Conclusions and future work

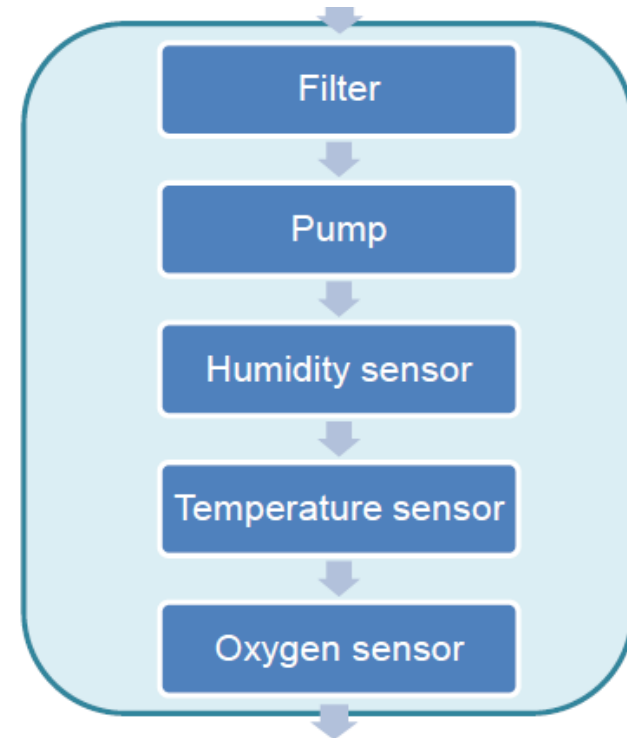
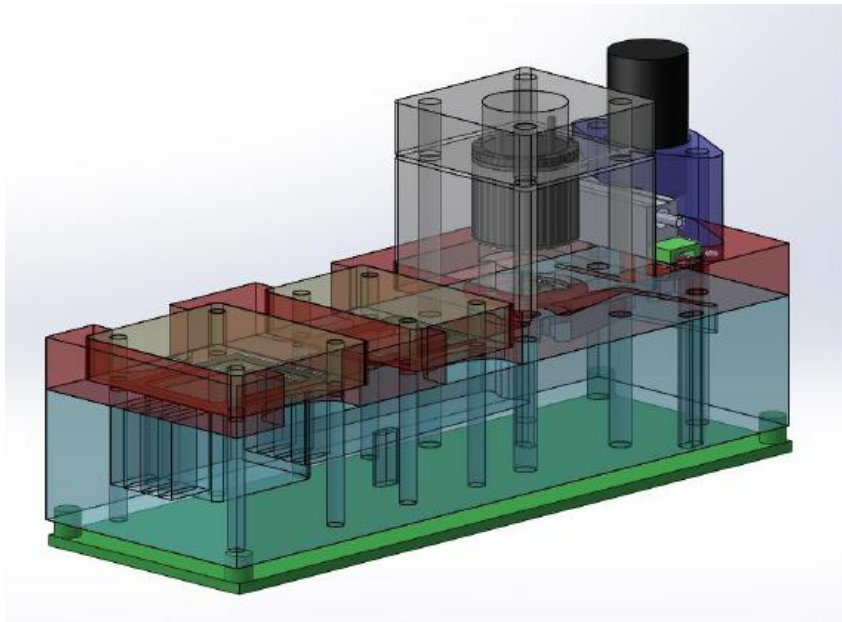
Fluidic platform for air preconditioning :: csem

- Create packaging for air quality sensors
- Support platform with microfluidic sample handling and preconditioning
- Single common interface (microfluidics/electronics/optics) for all sensor modules

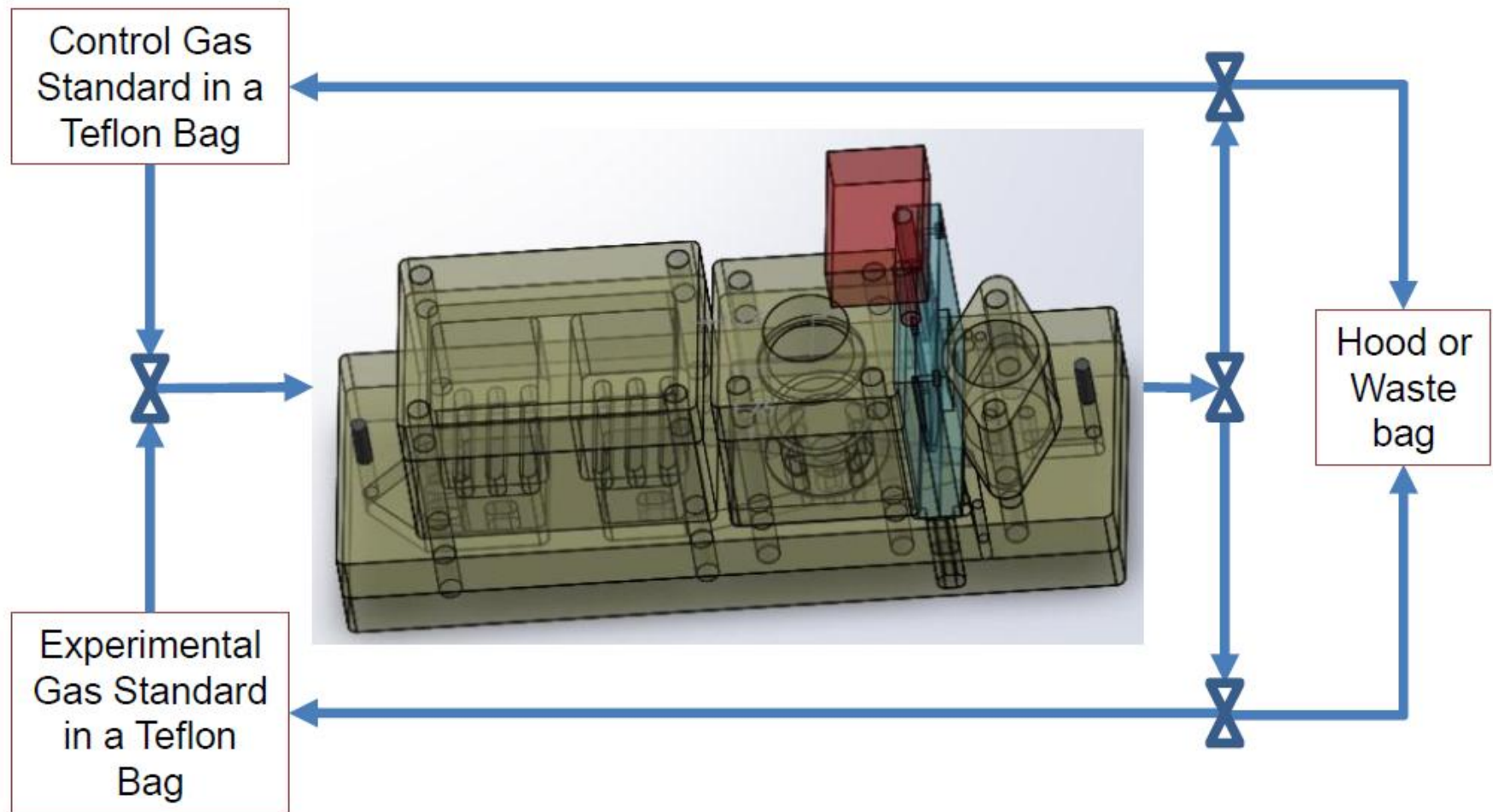


Fluidic platform for air preconditioning :: csem

- Previous schematic translated to the flow scheme in the figure.
- Test platform for sensors

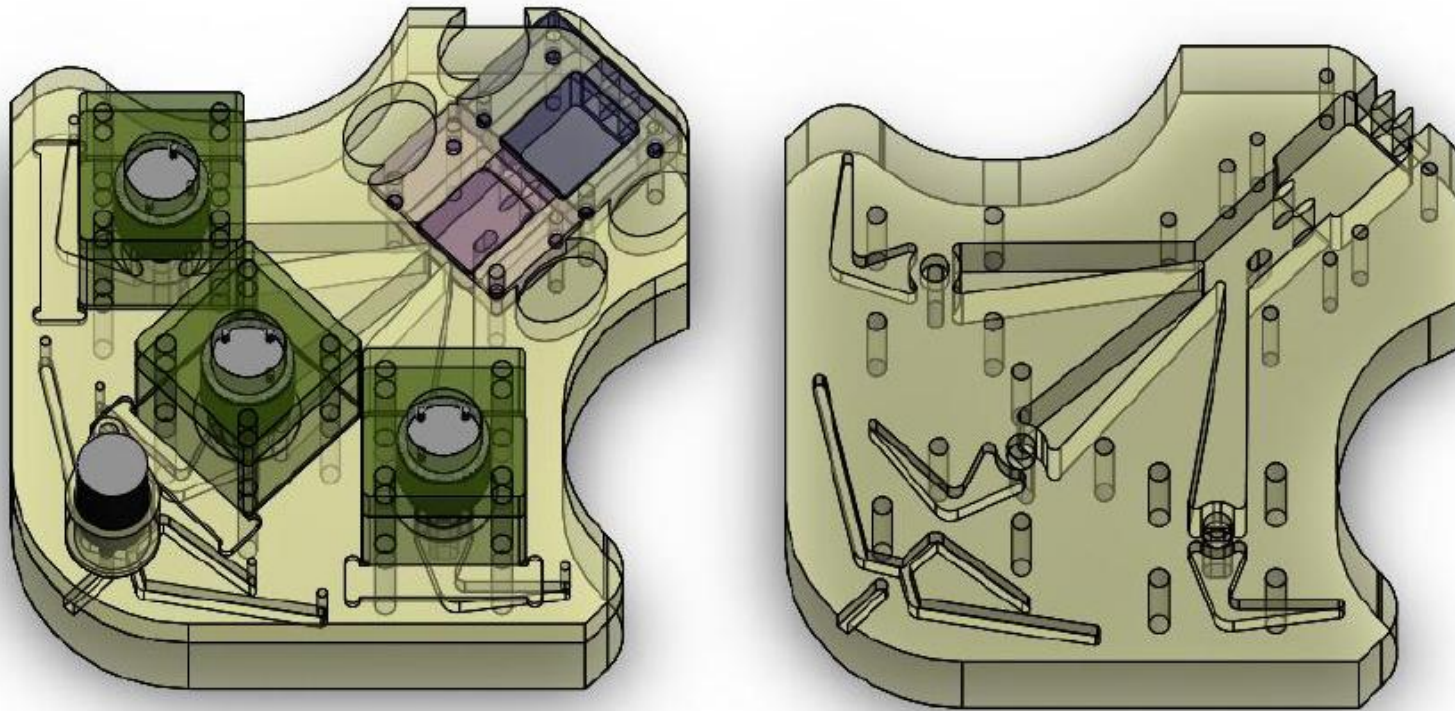


Fluidic platform for air preconditioning :: csem



Fluidic platform for air preconditioning :: csem

- Goal: 3 sensors receive air flow simultaneously



Outline of the presentation

- Introduction: the INTASENSE concept
- System specifications

- Main technological approach:

- Fluidic platform for air preconditioning :: 

- Particle detector



- Toxic gas/ vapour detection

- Conductometric sensors



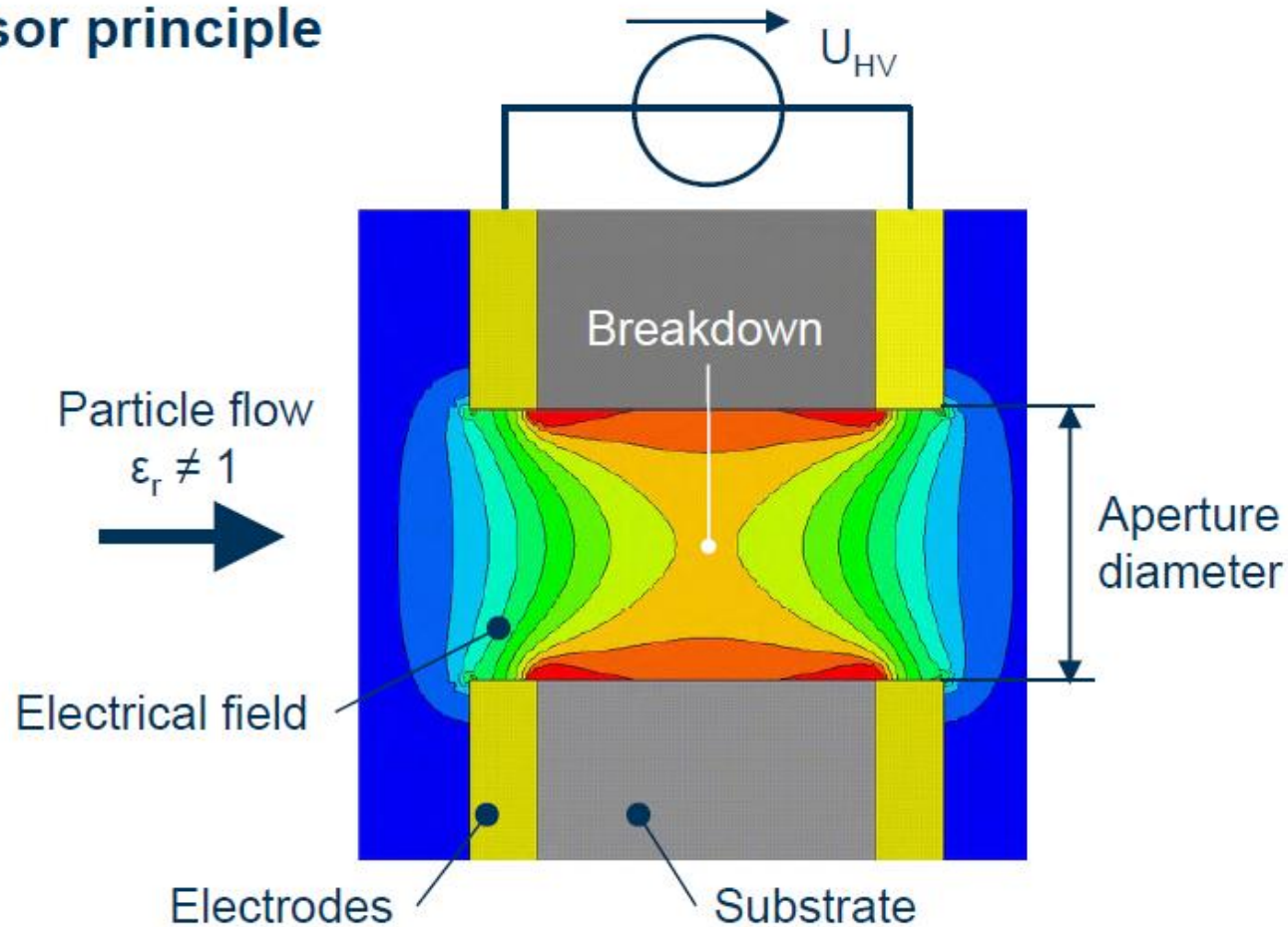
- Impedimetric sensors+UV



- Conclusions and future work

Particle detector

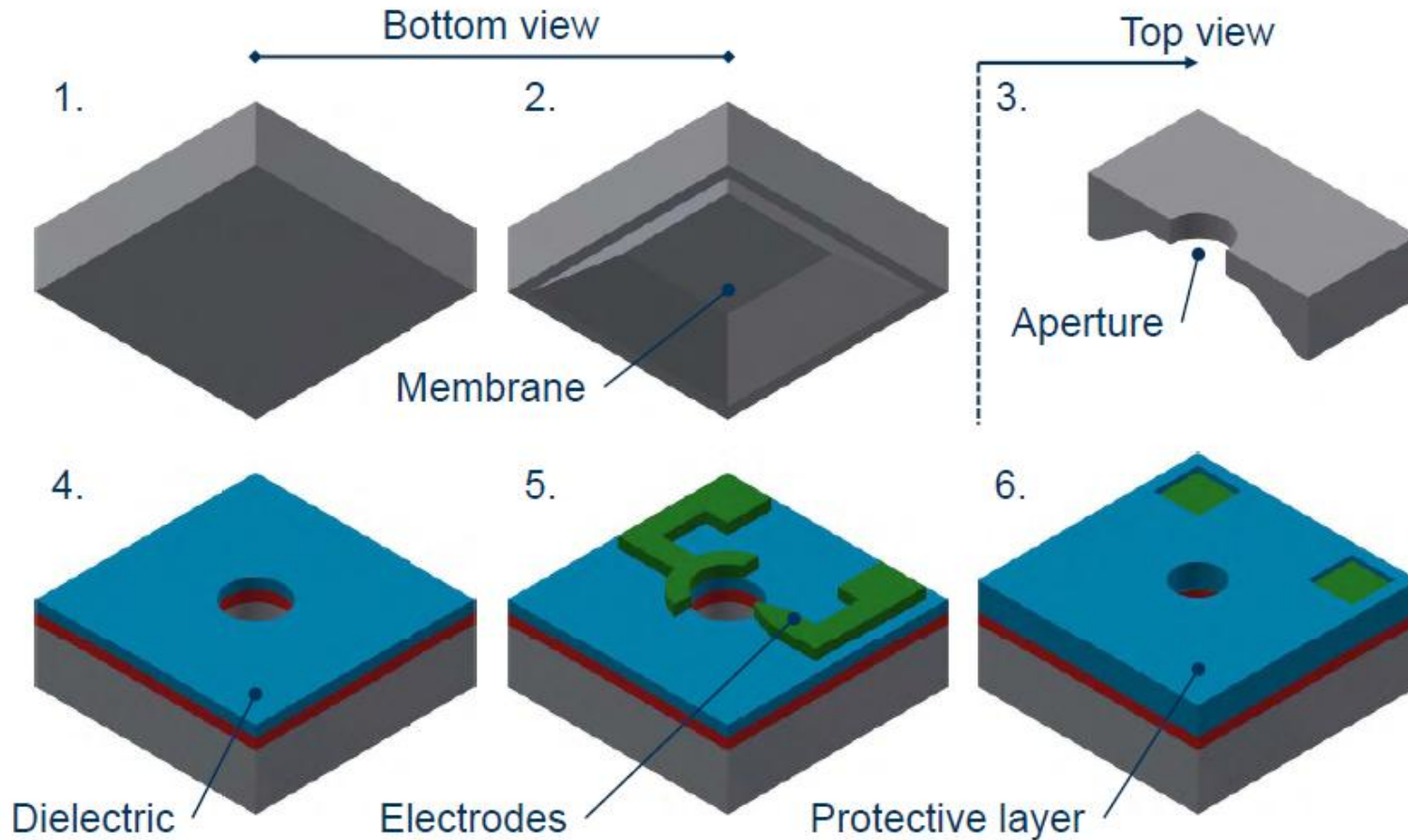
Sensor principle



PM Detection by **capacitance change** or **breakdown current**

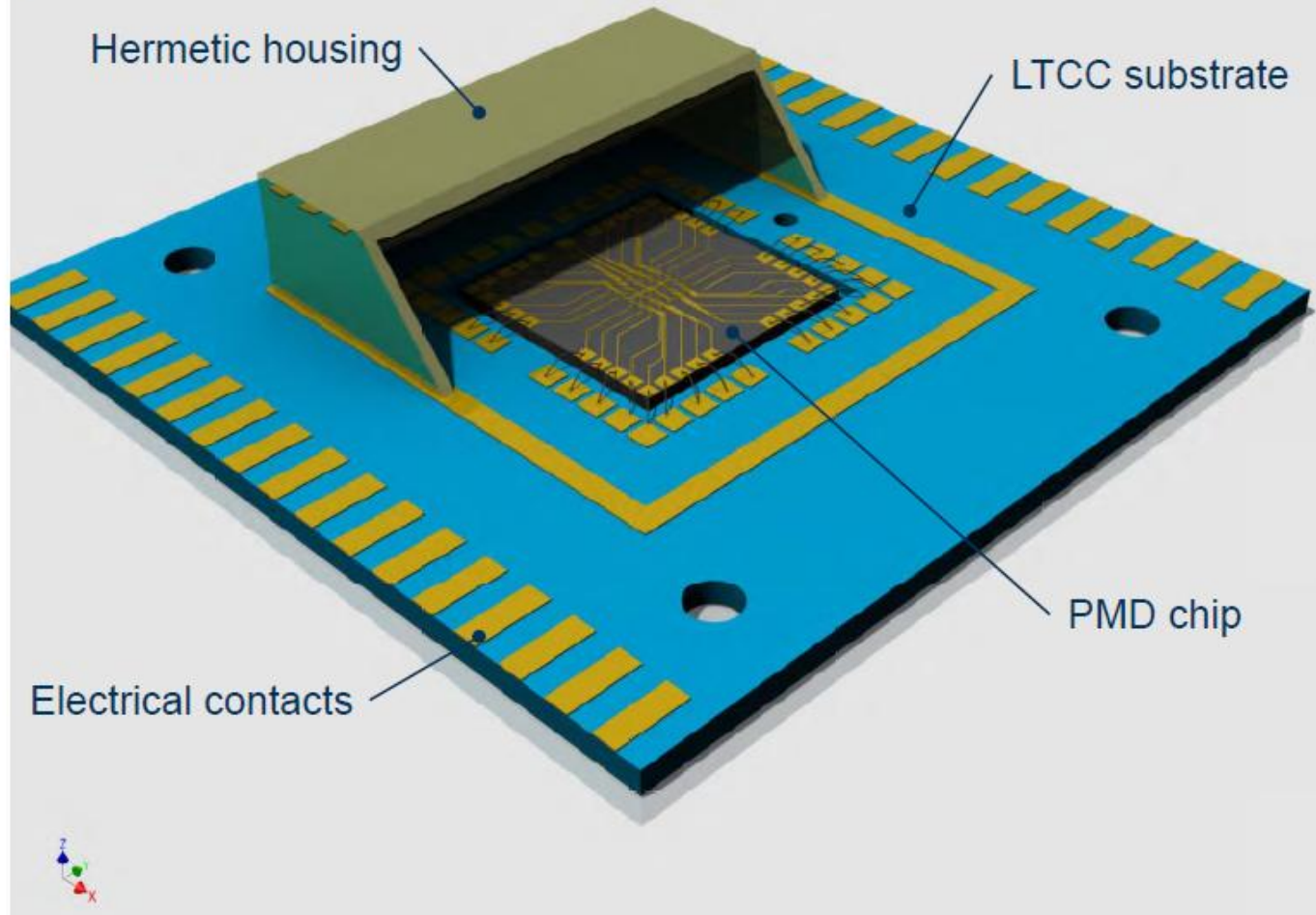
Particle detector

Sensor design



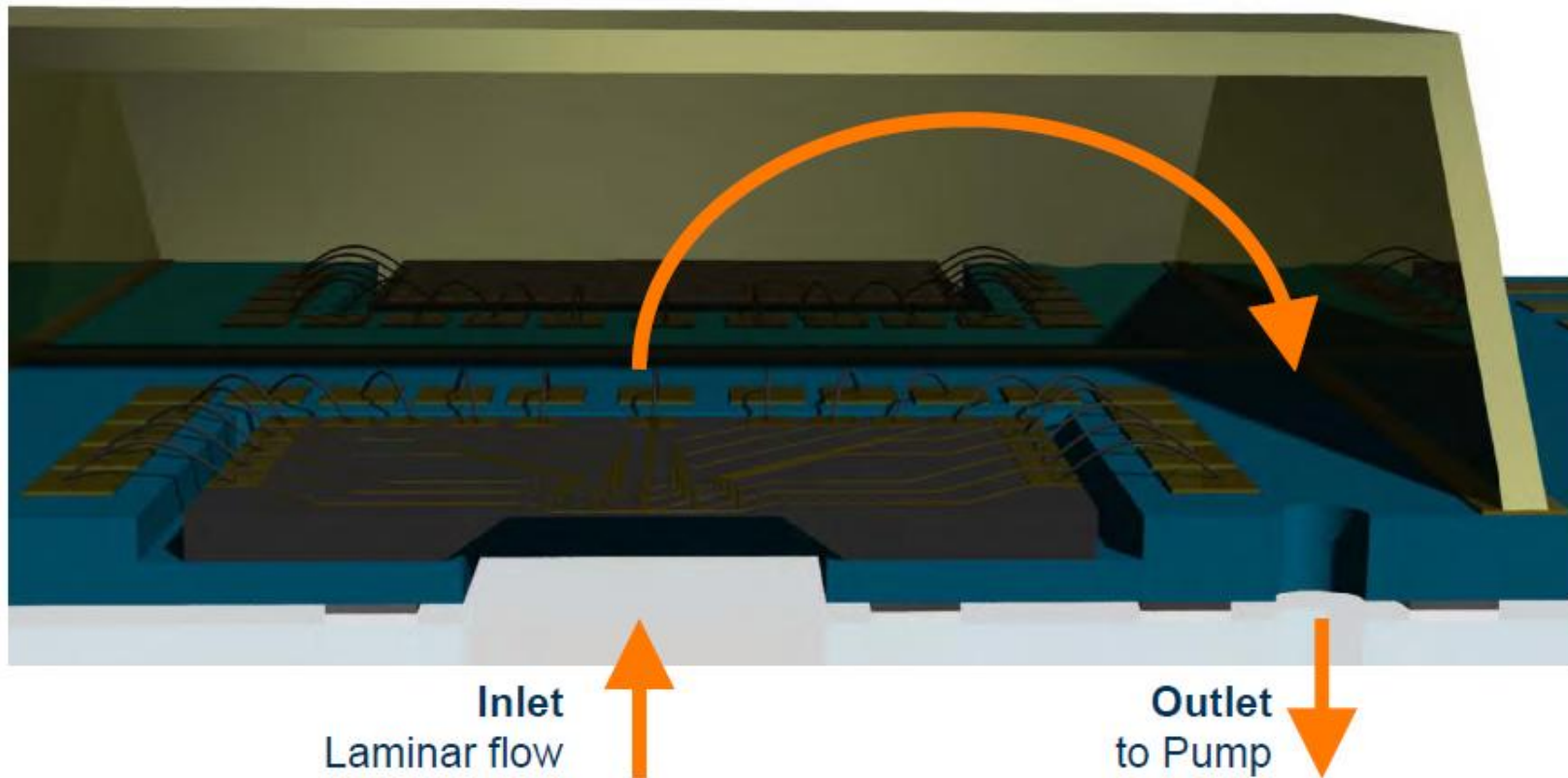
Particle detector

Hybrid module

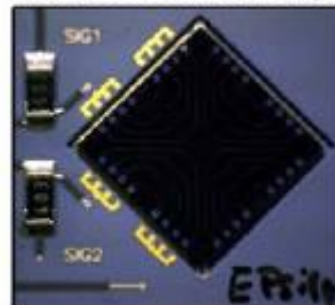
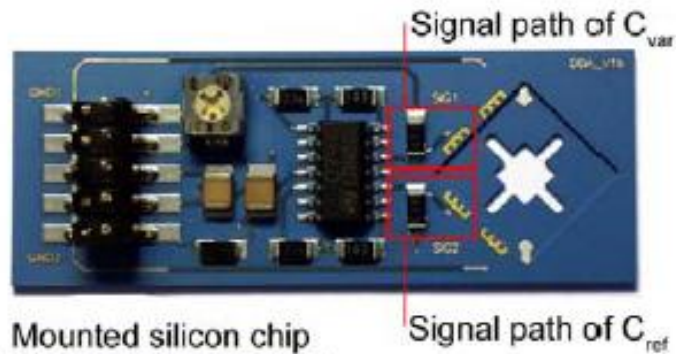
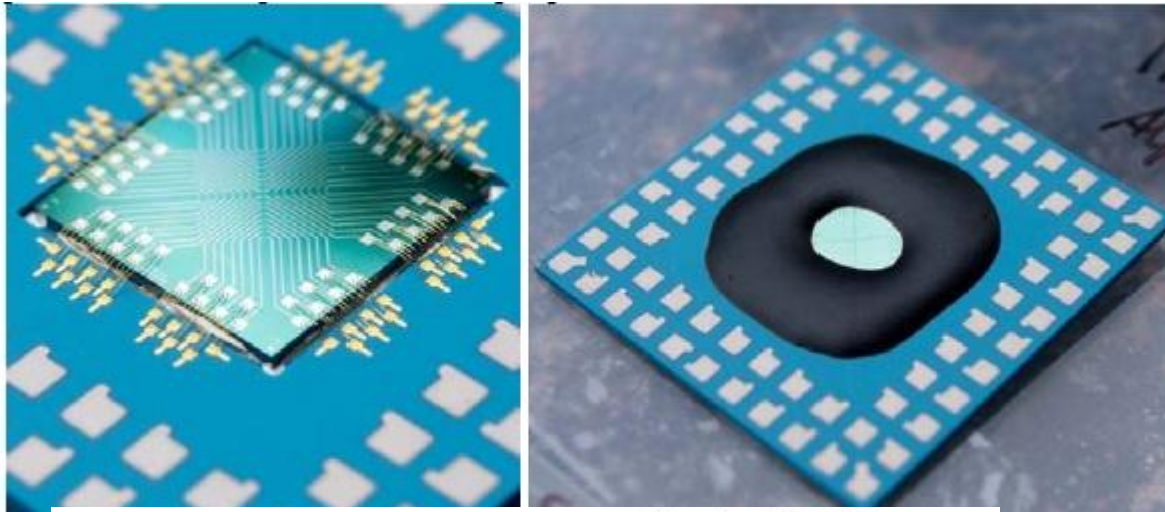


Particle detector

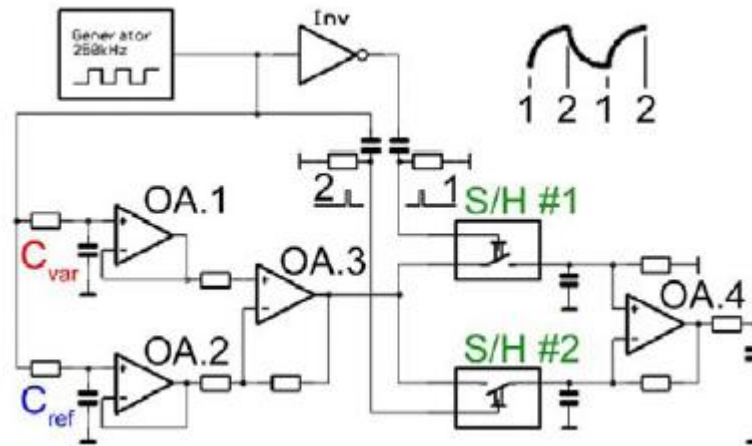
Hybrid module



Particle detector



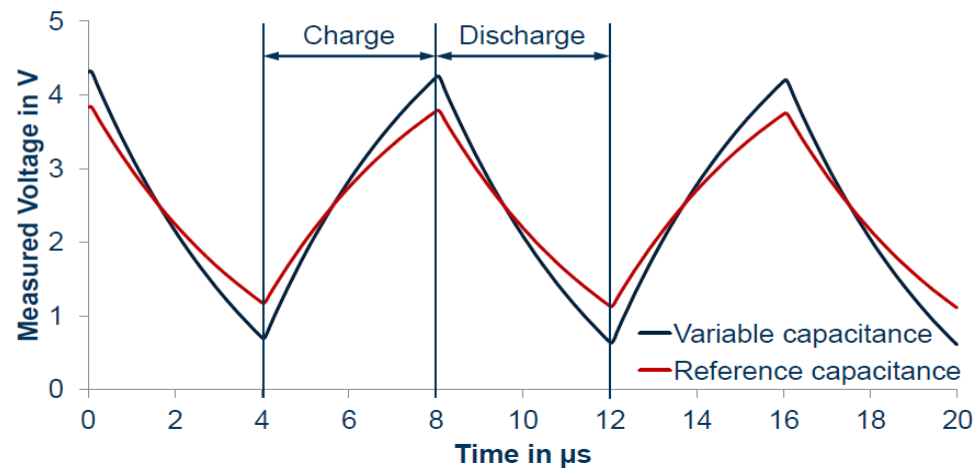
Particle detector



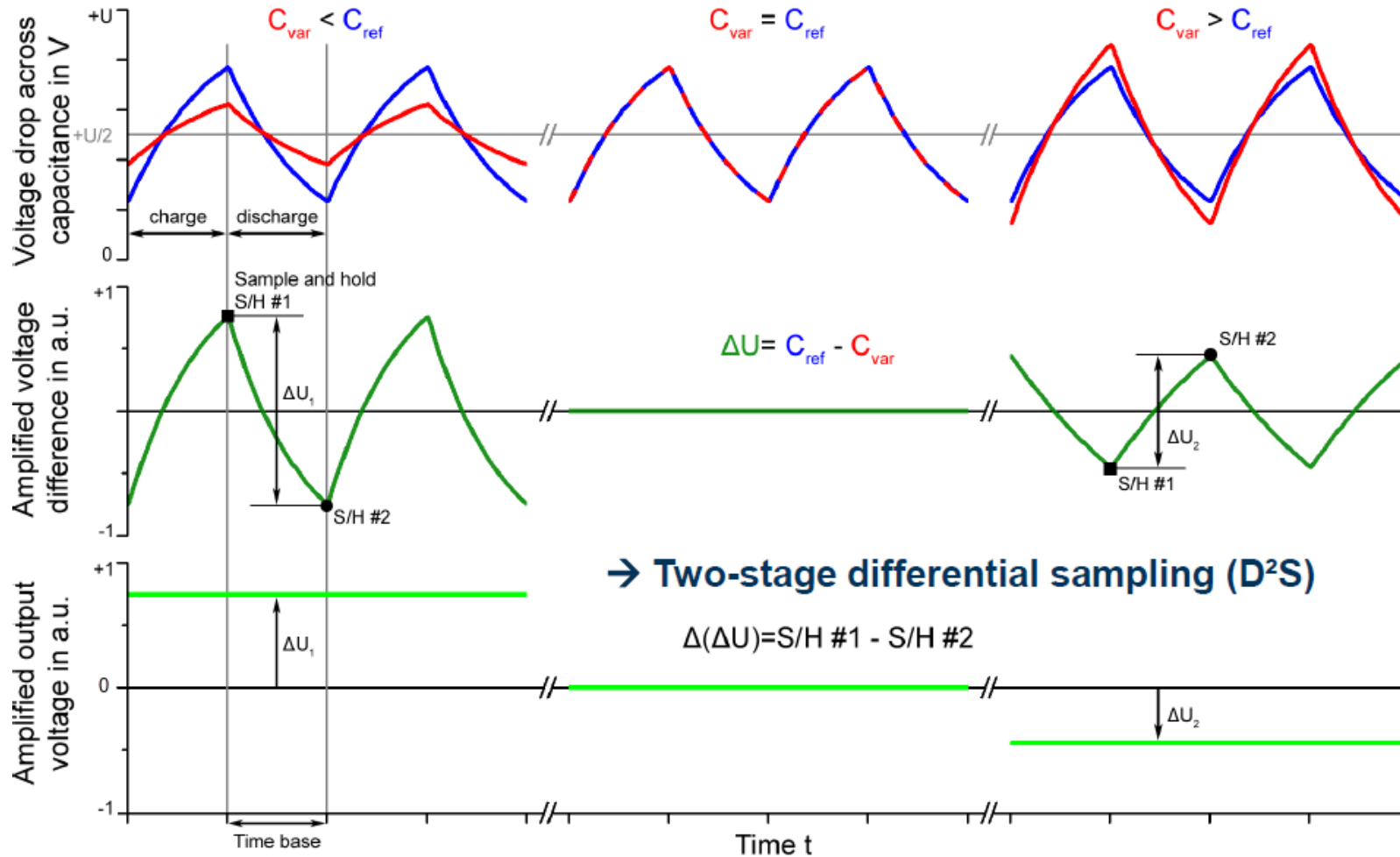
Capacitance measurement

Compare 2 capacitors

Variable capacitance
 ≠ Reference capacitance



Capacitance measurement



Outline of the presentation

- Introduction: the INTASENSE concept
- System specifications

- Main technological approach:

- Fluidic platform for air preconditioning :: 

- Particle detector 

- Toxic gas/ vapour detection

- Conductometric sensors



- Impedimetric sensors+UV

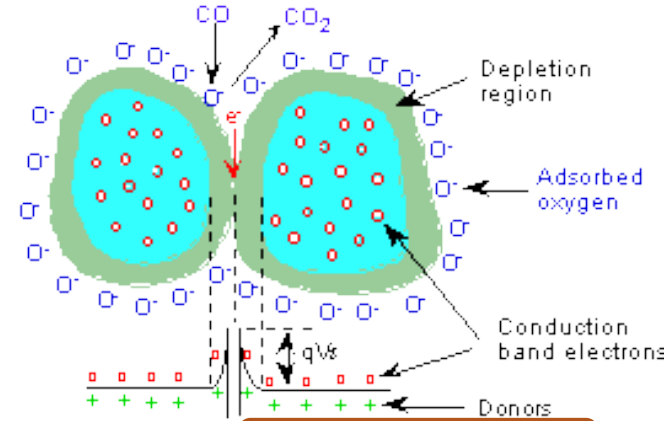
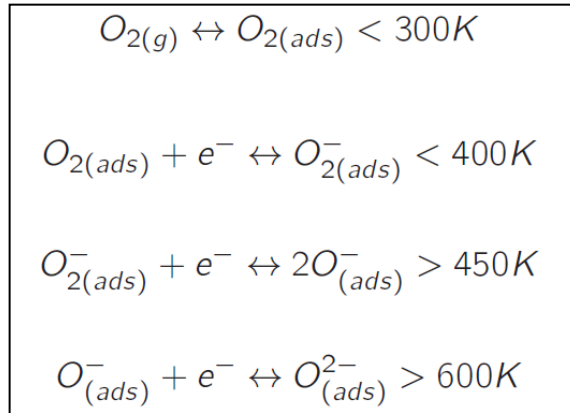


- Conclusions and future work

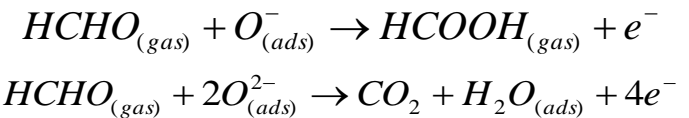
Toxic gas/vapour detection: conductometric sensors.

SENSING MECHANISM

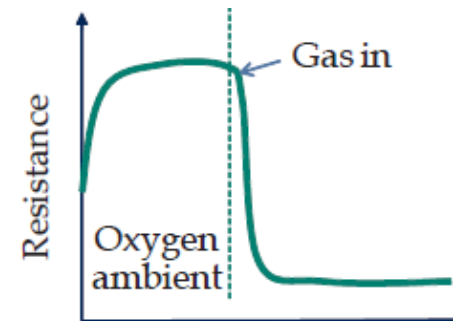
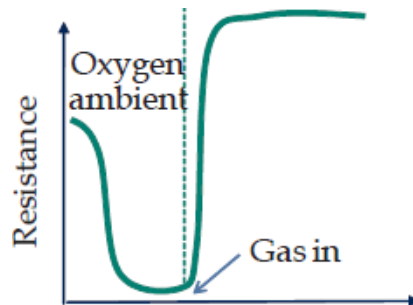
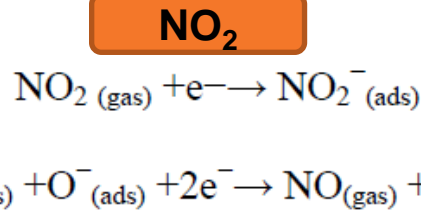
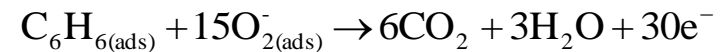
Oxygen Adsorption



Formaldehyde

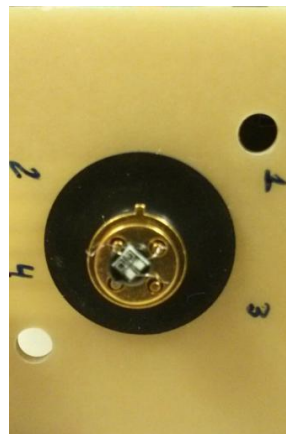
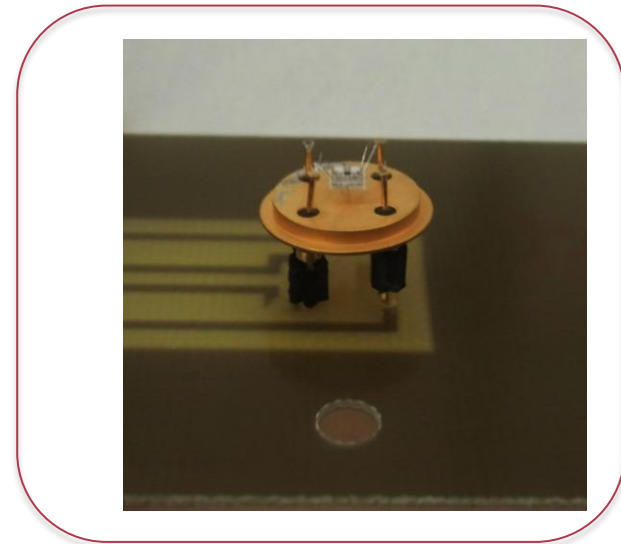
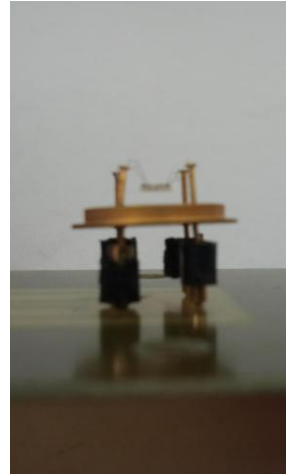
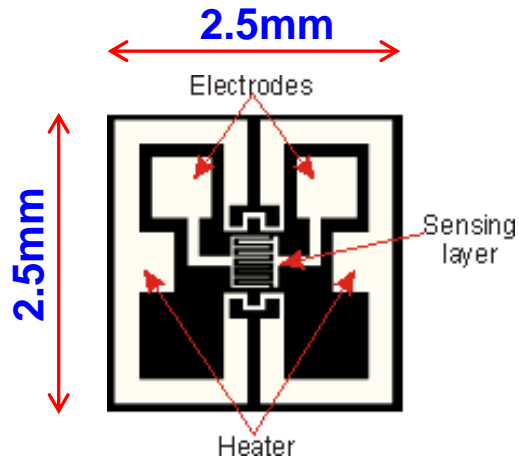


Benzene



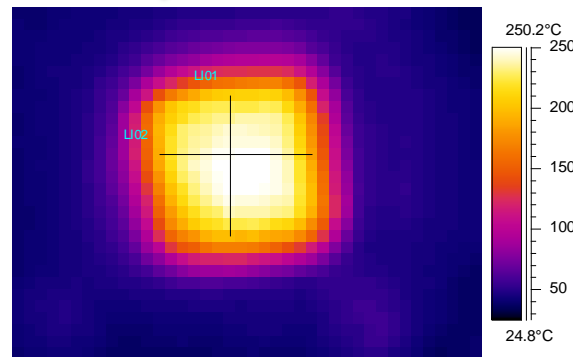
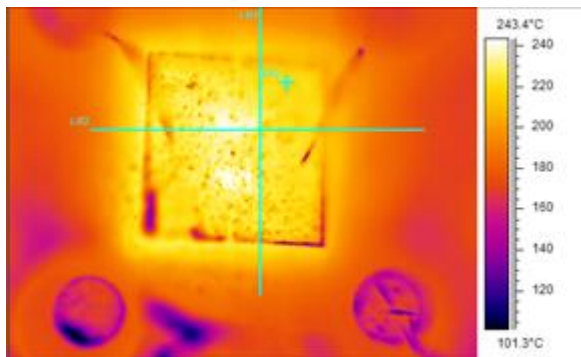
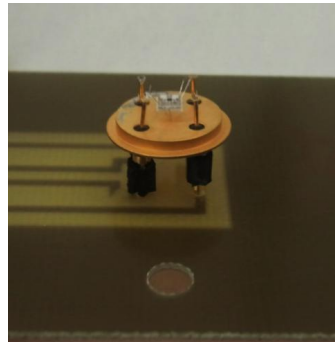
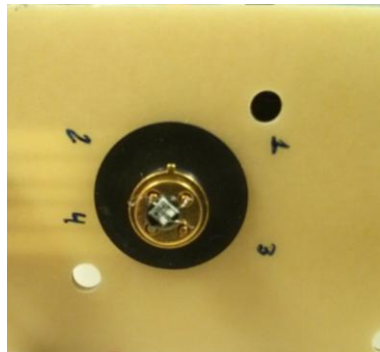
Toxic gas/vapour detection: conductometric sensors

SENSOR PROTOTYPES



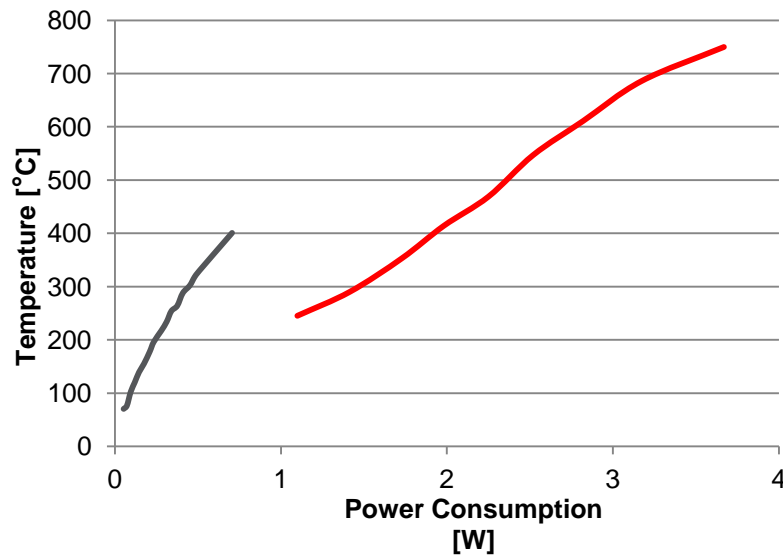
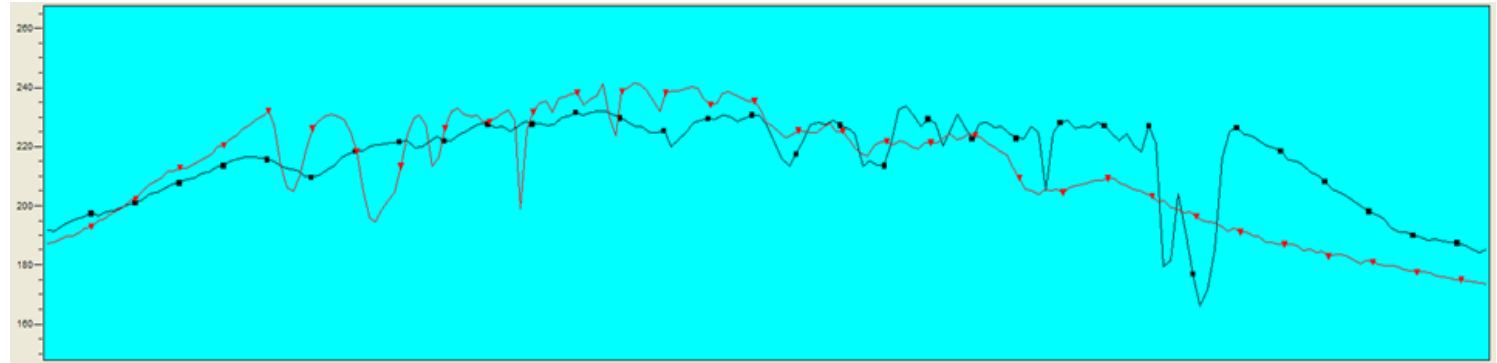
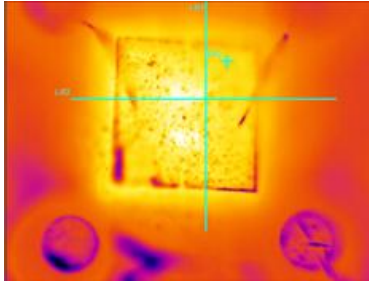
Toxic gas/vapour detection: conductometric sensors

TEMPERATURE DISTRIBUTION

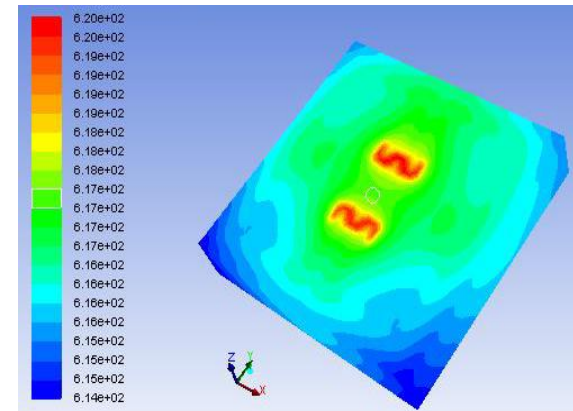


Toxic gas/vapour detection: conductometric sensors

TEMPERATURE DISTRIBUTION MODEL AND POWER CONSUMPTION

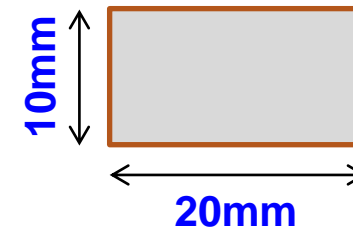
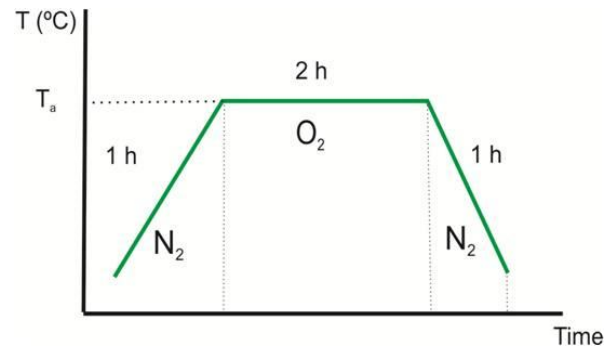
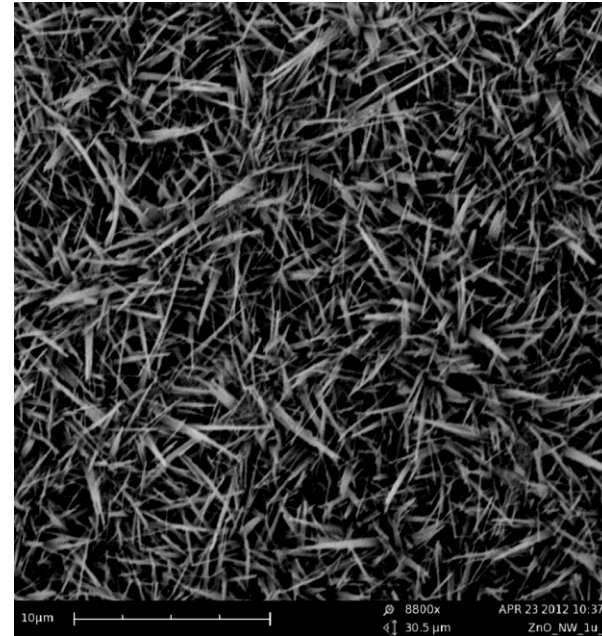
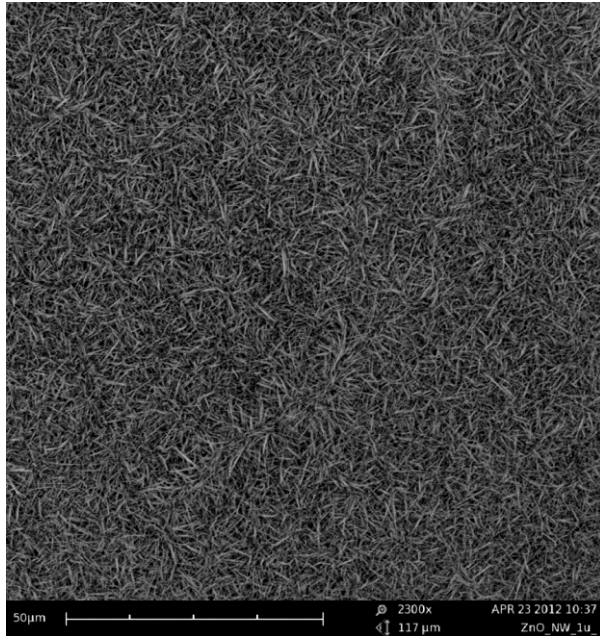


— Glued
— Suspended



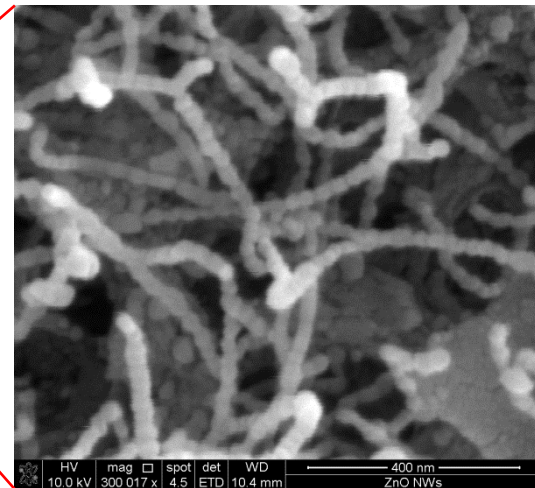
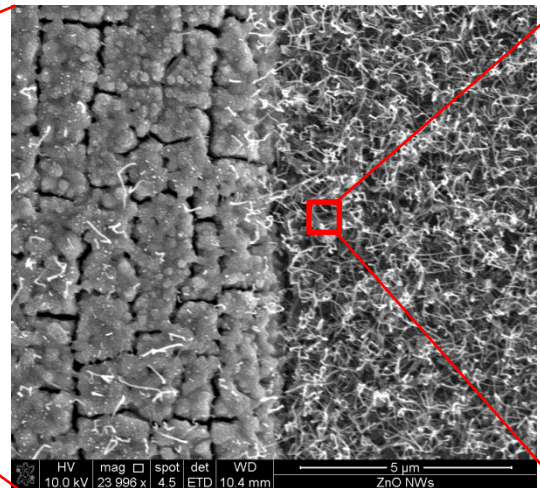
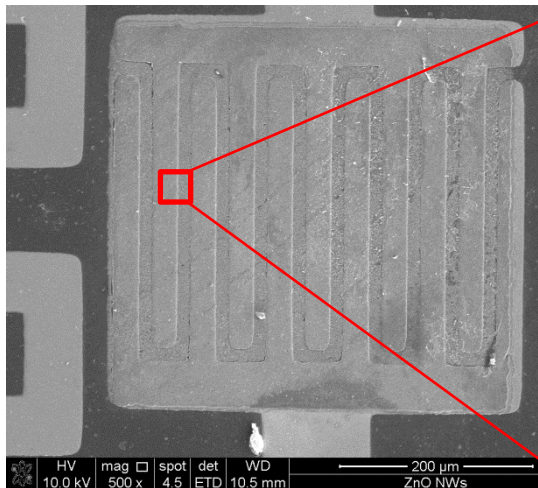
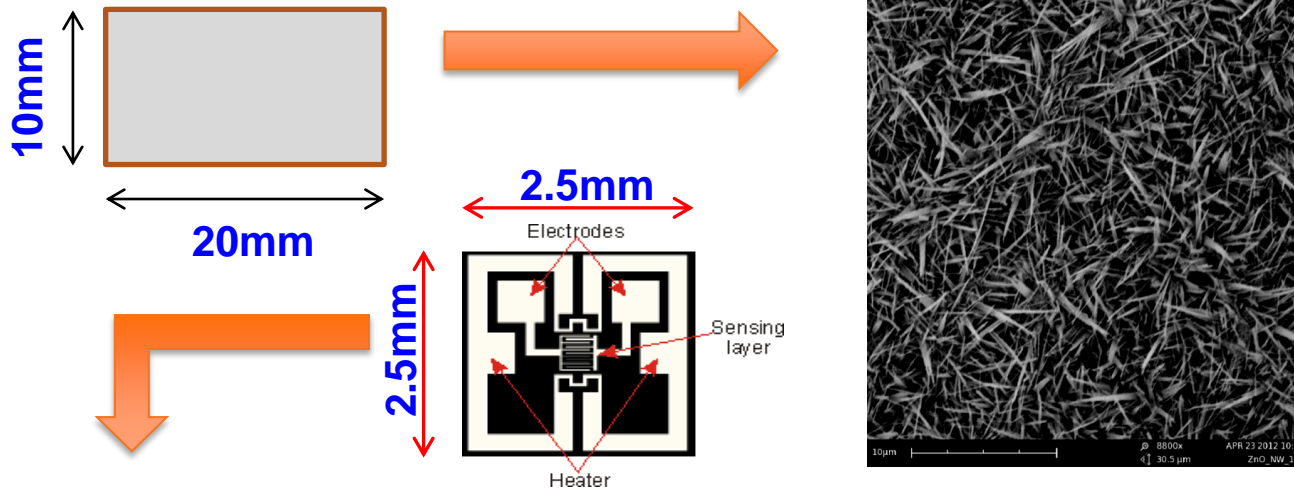
Toxic gas/vapour detection: conductometric sensors

ZnO NANOSTRUCTURES GROWTH



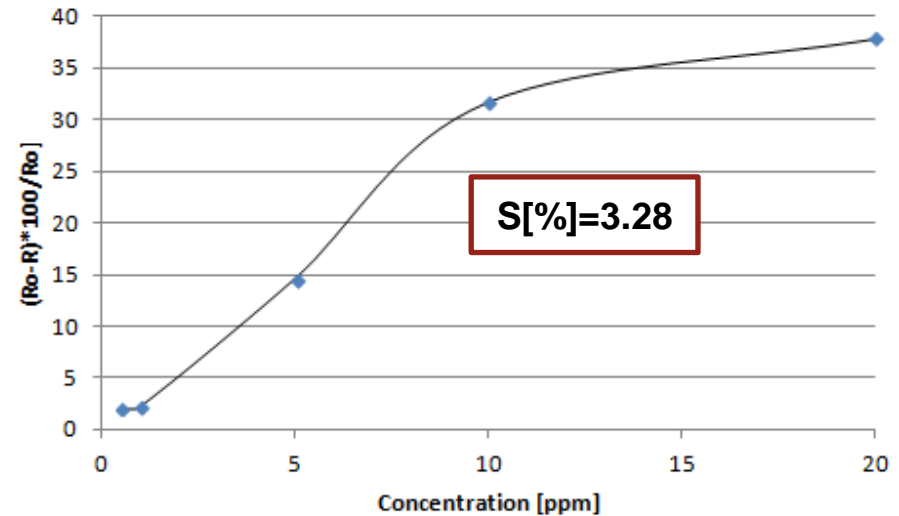
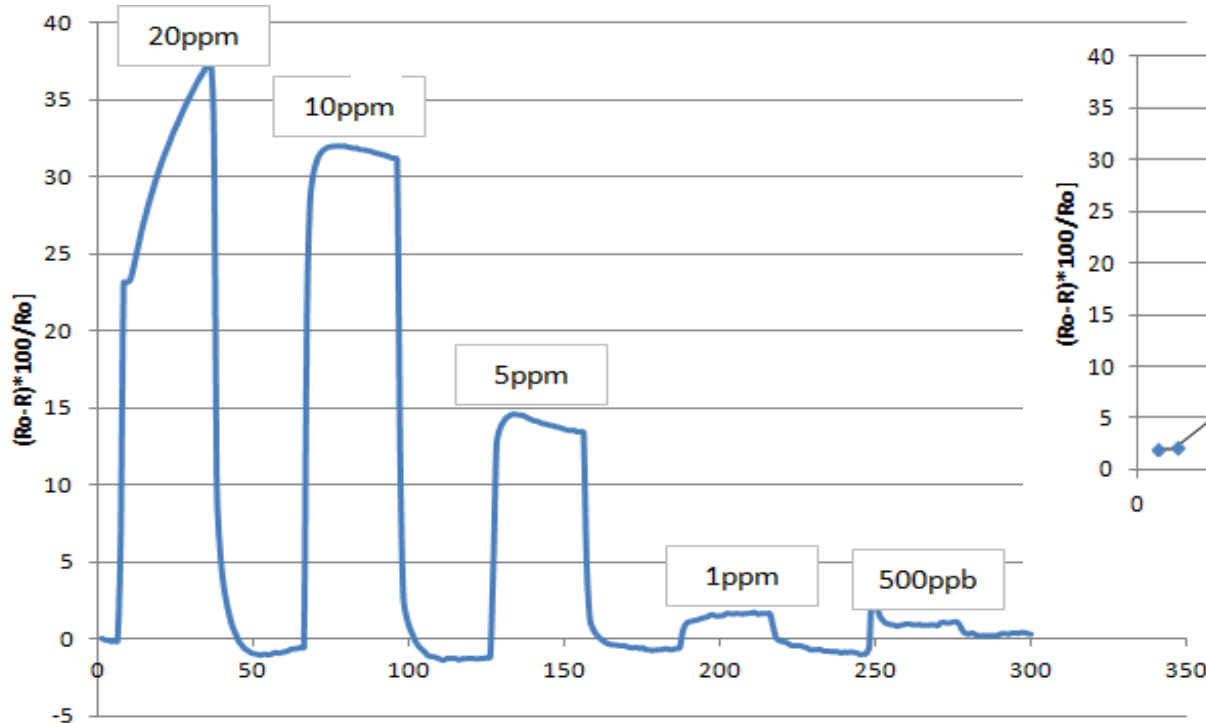
Toxic gas/vapour detection: conductometric sensors

ZnO NANOSTRUCTURES GROWTH



Toxic gas/vapour detection: conductometric sensors

RESPONSE TO BENZENE OF PROTOTYPE WITH ZnO NANOSTRUCTURES



Detection ranges:

C_6H_6 : 10ppb-1ppm

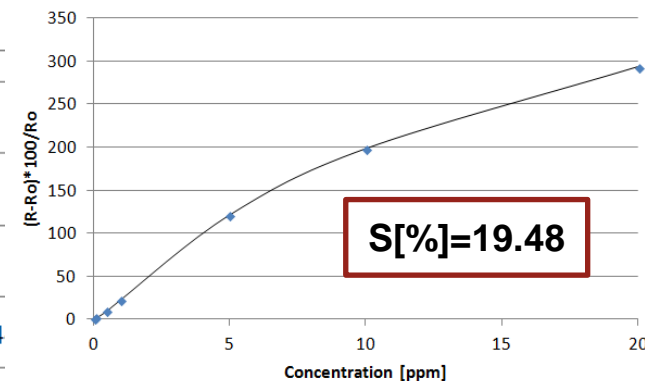
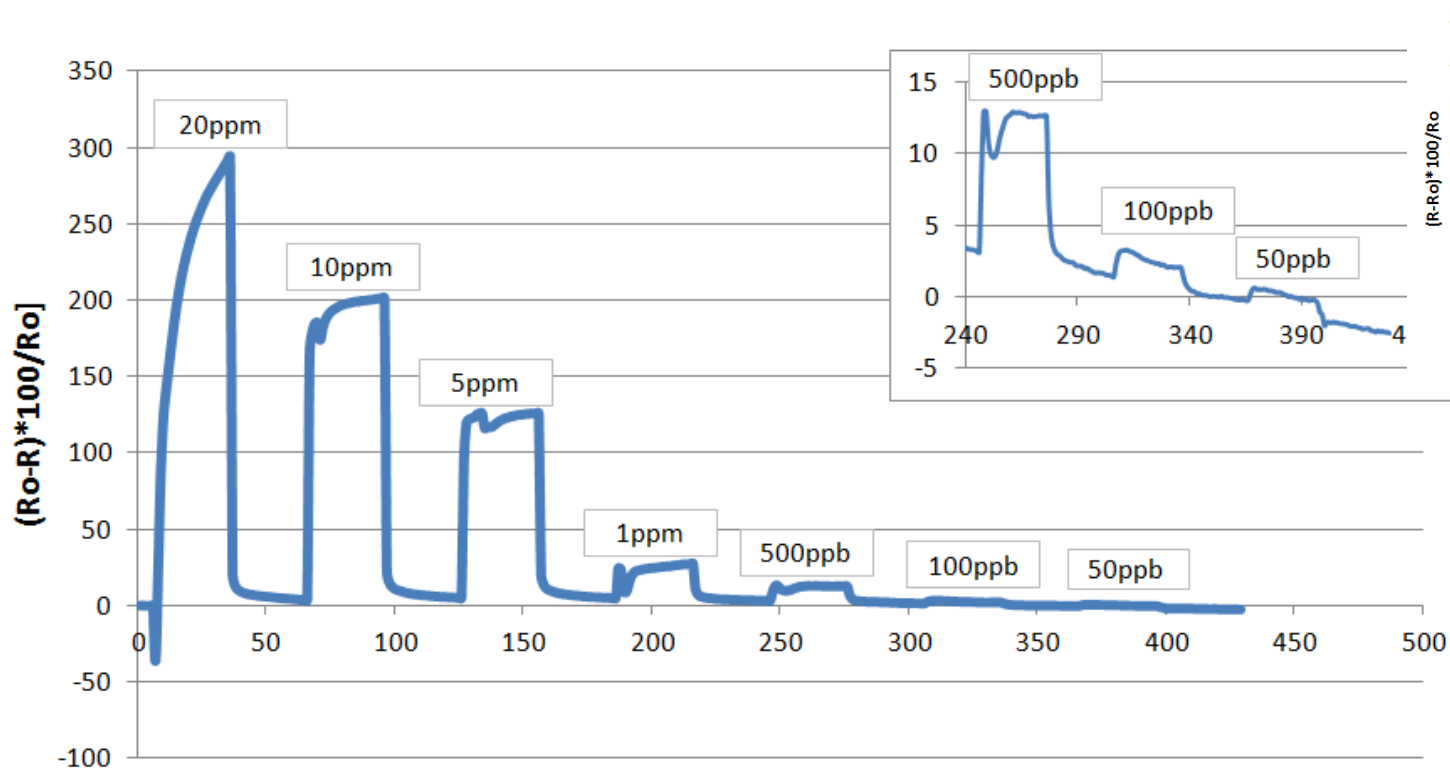
OSHA:

STEL: 5 ppm

Action Level: 500 ppb

Toxic gas/vapour detection: conductometric sensors

RESPONSE TO NO_2 OF PROTOTYPE WITH ZnO NANOSTRUCTURES



Detection ranges:

HCHO: 50ppb-1ppm

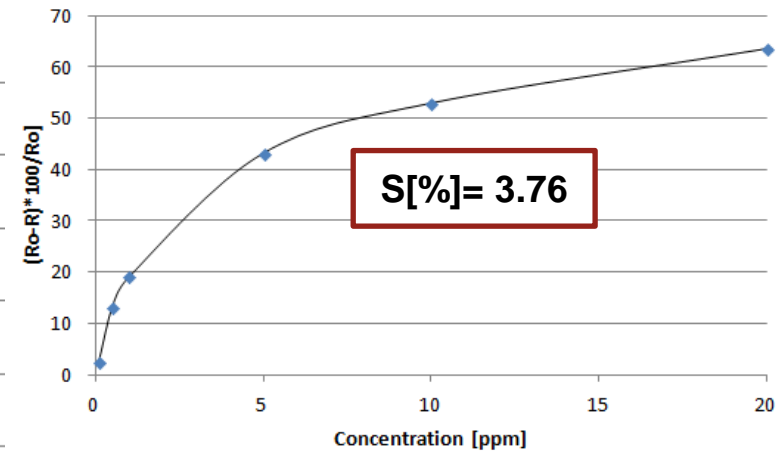
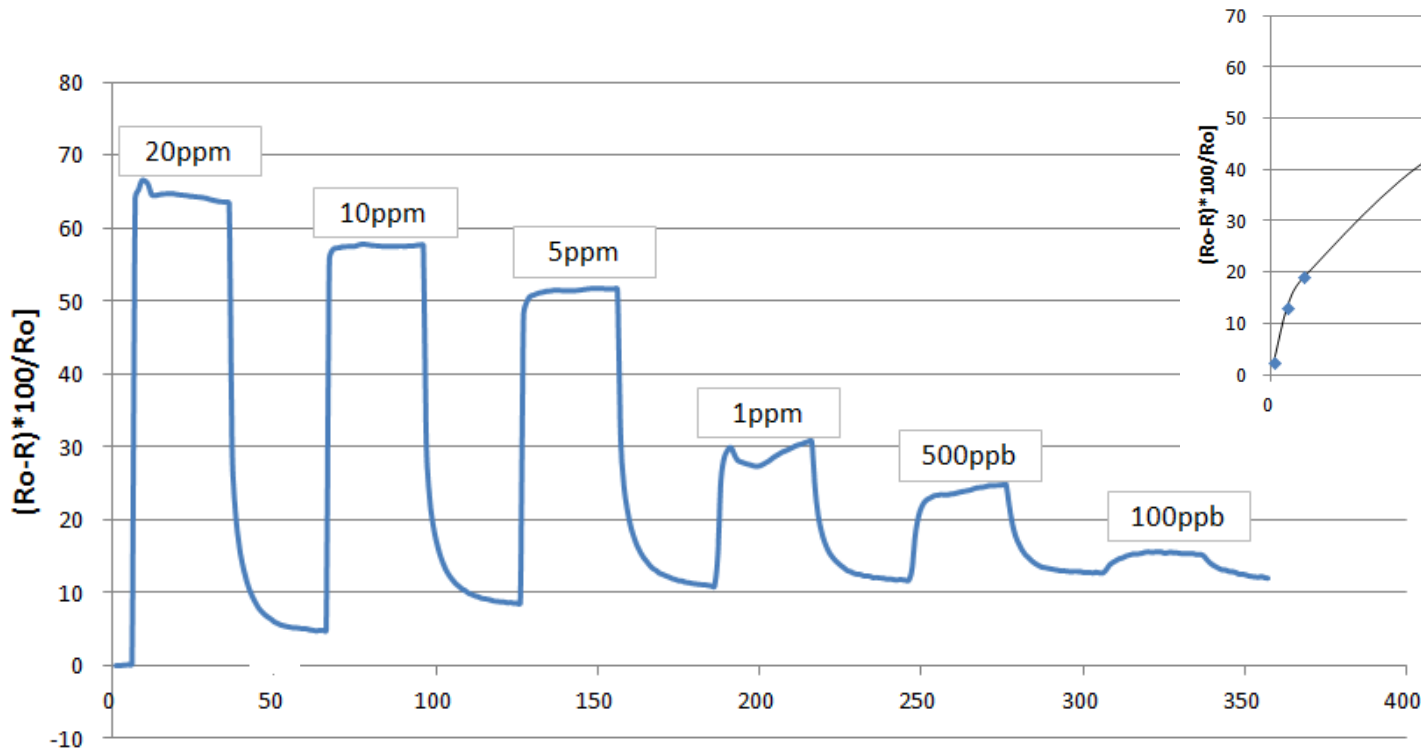
OSHA:

STEL: 2 ppm

Action Level: 500 ppb

Toxic gas/vapour detection: conductometric sensors

RESPONSE TO **FORMALDEHYDE** OF PROTOTYPE WITH ZnO NANOSTRUCTURES



Detection ranges:

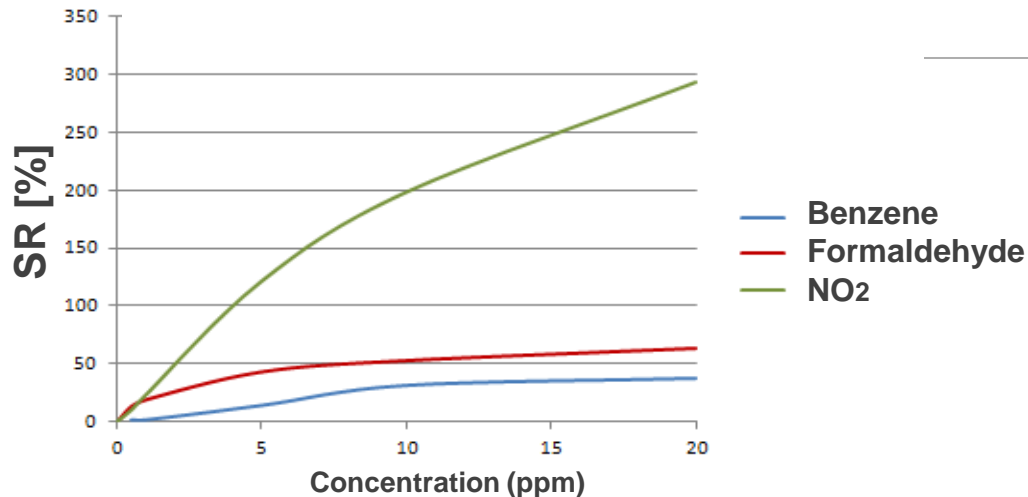
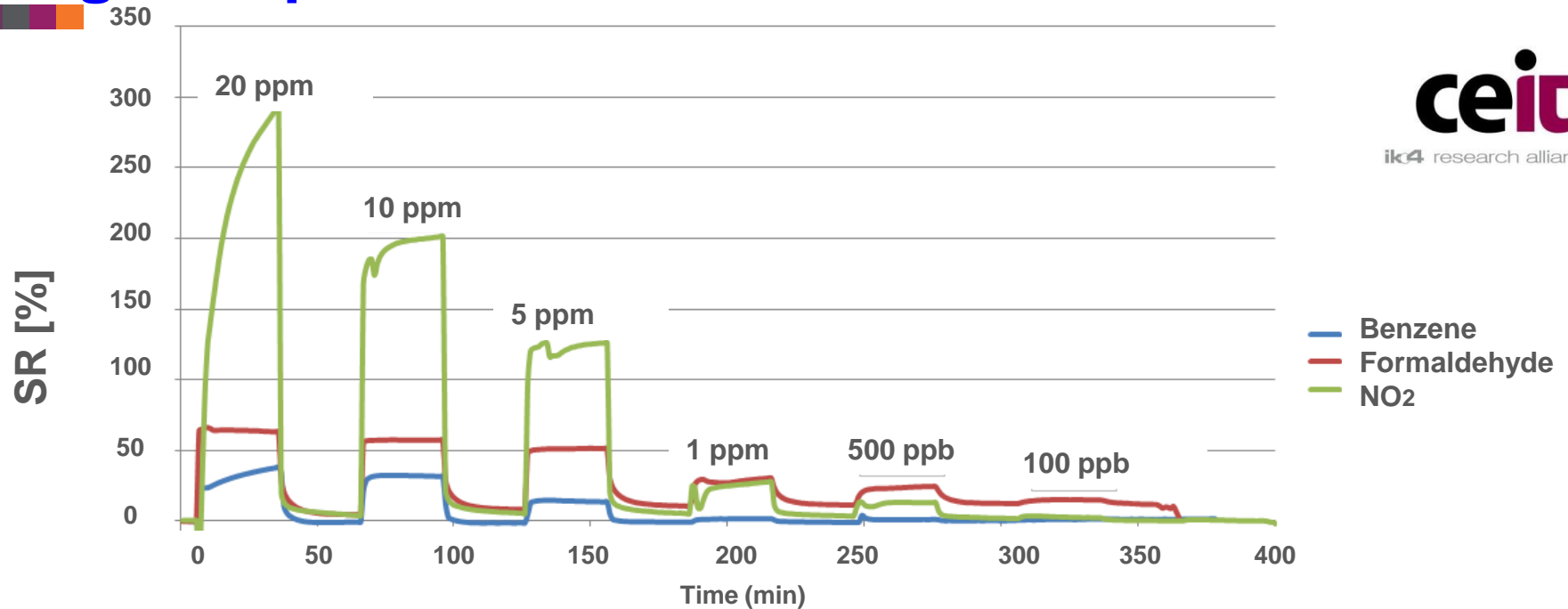
HCHO: 50ppb-1ppm

OSHA:

STEL: 1 ppm

Action Level: 300 ppb

Toxic gas/vapour detection: conductometric sensors



Detection ranges:

Formaldehyde: 50ppb-1ppm

Benzene: 10ppb-1ppm

NO₂: 100ppb-1ppm

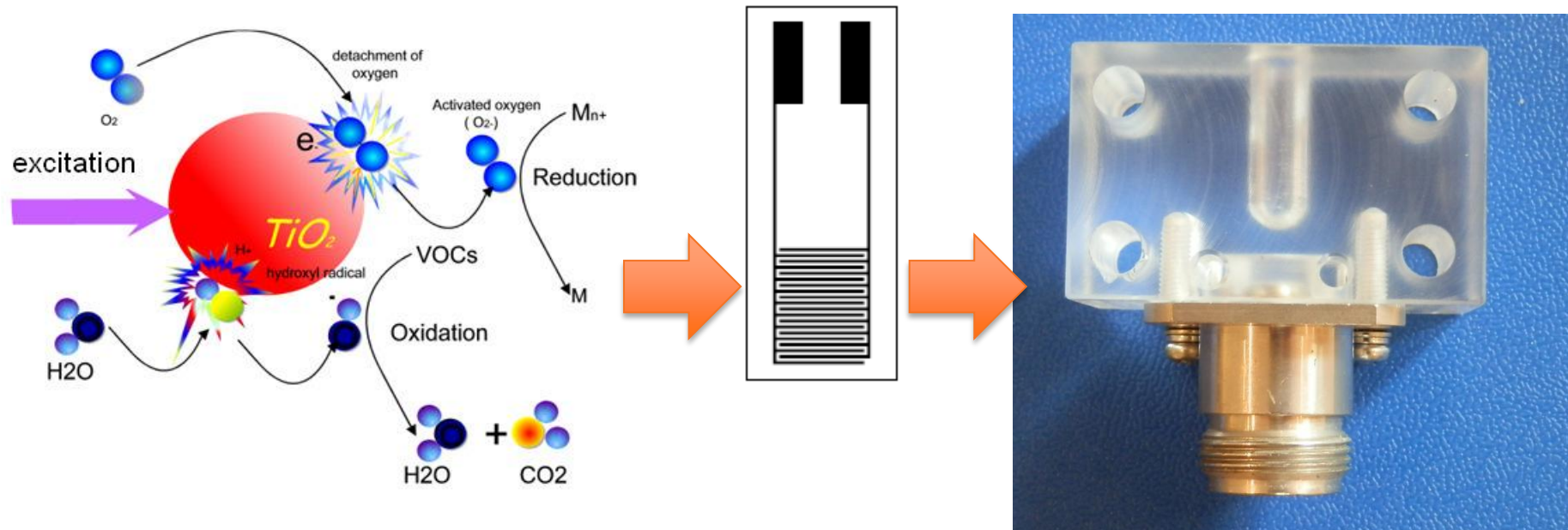
Outline of the presentation

- Introduction: the INTASENSE concept
- System specifications
- Main technological approach:
 - Fluidic platform for air preconditioning
 - Particle detector
 - Toxic gas/ vapour detection
 - Conductometric sensors
 - Impedimetric sensors+UV
- Conclusions and future work



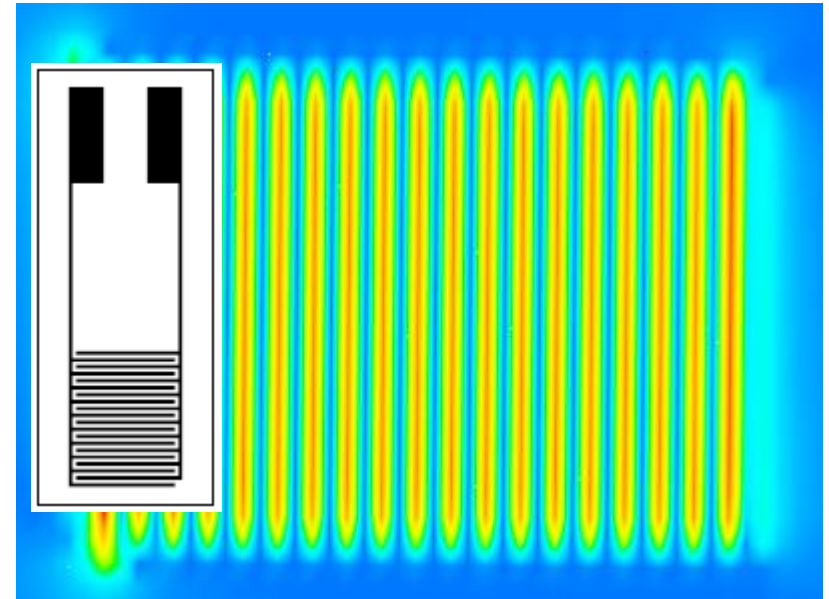
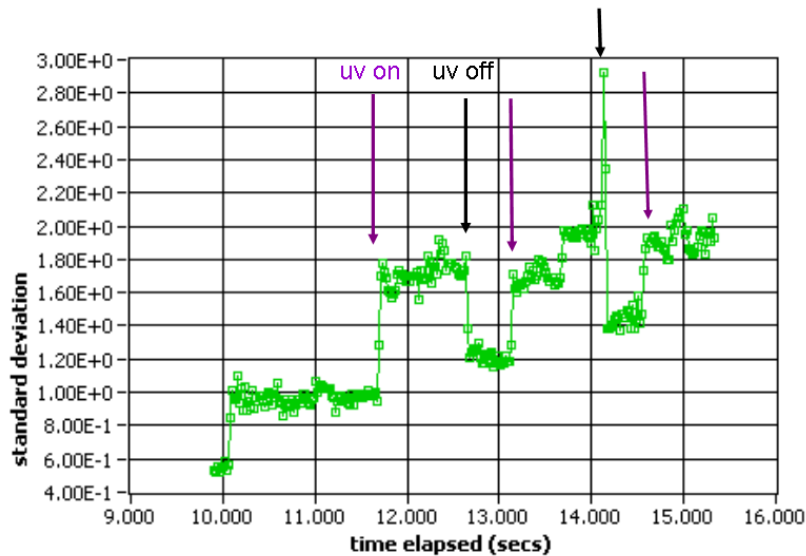
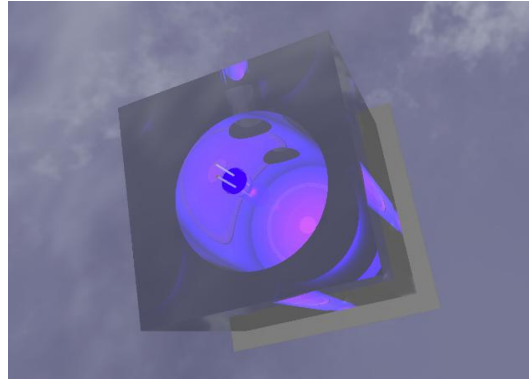
Toxic gas/vapour detection: impedimetric sensors-UV

Sol-gel obtained TiO_2 coatings as the sensing element.
photo-activation of nanostructured TiO_2 -based catalysts for
sensor applications.







Toxic gas/vapour detection: impedimetric sensors-UV

Photo-activation of nanostructured TiO_2 -based catalysts at high frequency.



Outline of the presentation

- Introduction: the INTASENSE concept
- System specifications
- Main technological approach:
 - Fluidic platform for air preconditioning :: 
 - Particle detector  TECHNISCHE UNIVERSITÄT
ILMENAU
 - Toxic gas/ vapour detection
 - Conductometric sensors  **ceit**
ik4 research alliance
 - Impedimetric sensors+UV  **C-Tech**
INNOVATION
- Conclusions and future work

Conclusions and future work:

Fluidic platform for air preconditioning

- Uniform flow for three channels achieved
- Humidity control achieved
- Enhance compatibility with partners developed sensors
- Miniaturize the device:
 - Smaller pump
 - Thinner filters
 - Removal of sensor housing (place directly into channel)
 - Smaller more reliable differential pressure channel



Conclusions and future work: Particle detector

- Precise and fast measurement principle with room to improve
- Current sensor design is applicable

- For PM1 and below it is necessary to increase resolution
- Intake air flow to be optimized in regard of sensor performance in order to achieve optimal statistical significance of the measured value



Conclusions and future work

Gas/vapour sensing devices

- Sensor prototype has been developed and tested
- Power consumption within expectations
- Sensitivity to target gases in specified ranges

- Characterization of other materials to develop final product with higher selectivity to target gases/vapours
- Combination of different sensor signals through electronics

**European Network on New Sensing Technologies for Air Pollution
Control and Environmental Sustainability - *EuNetAir*
COST Action TD1105**

INTERNATIONAL WG1-WG4 MEETING on

New Sensing Technologies and Methods for Air-Pollution Monitoring

European Environment Agency - EEA

Copenhagen, Denmark, 3 - 4 October 2013

Action Start date: 01/07/2012 - Action End date: 30/06/2016 - Year 2: 2013-2014 (*Ongoing Action*)

**SYSTEM TO CONTROL INDOOR AIR QUALITY IN
ENERGY EFFICIENT BUILDINGS**



IK4 Research Alliance

Gemma García Mandayo (ggmandayo@ceit.es)

Invited Expert

**Ceit and Tecnun (Universidad de Navarra), P.Mikeletegi 48,
20009 San Sebastián, Spain**