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

COST Action TD1105

WGs and MC Meeting at ISTANBUL, 3-5 December 2014

Action Start date: 01/07/2012 - Action End date: 30/06/2016

Year 3: 1 July 2014 - 30 June 2015 (***Ongoing Action***)

MSP for Air Quality in Building Technology Applications

MULTI SENSOR PLATFORM

Project No: 611887

SEVENTH FRAMEWORK PROGRAMME

SIEMENS

Oliver von Sicard

Anton Köck

Function in the Action: Invited Expert

Siemens AG / Germany

MCL MATERIALS CENTER LEOBEN

cost EUROPEAN COOPERATION IN SCIENCE AND TECHNOLOGY

EuNetAir

European Network on New Sensing Technologies for Air-Pollution Control and Environmental Sustainability

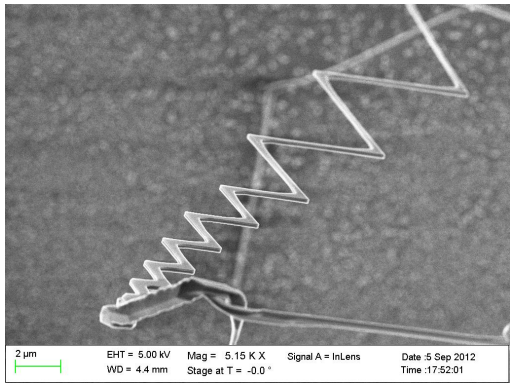
COST is supported by the EU Framework Programme

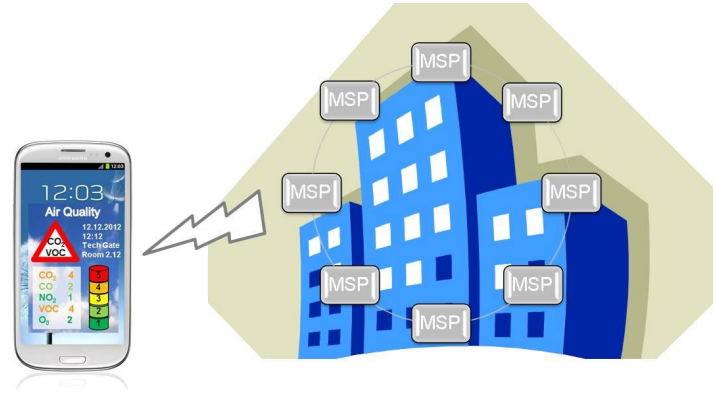
ESF provides the COST Office through a European Commission contract

Outline

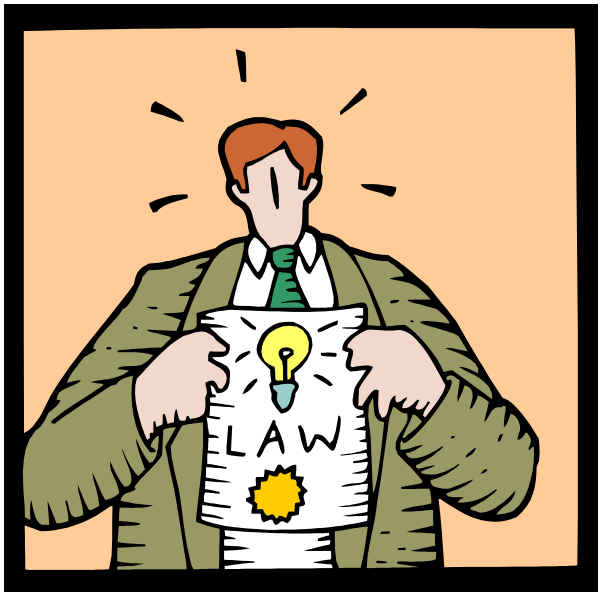
- Building Technology Applications
- HVAC
- MSP Project overview
- MSP-specific KETs
- Summary&Outlook

MULTI SENSOR PLATFORM





What drives building technology industry?



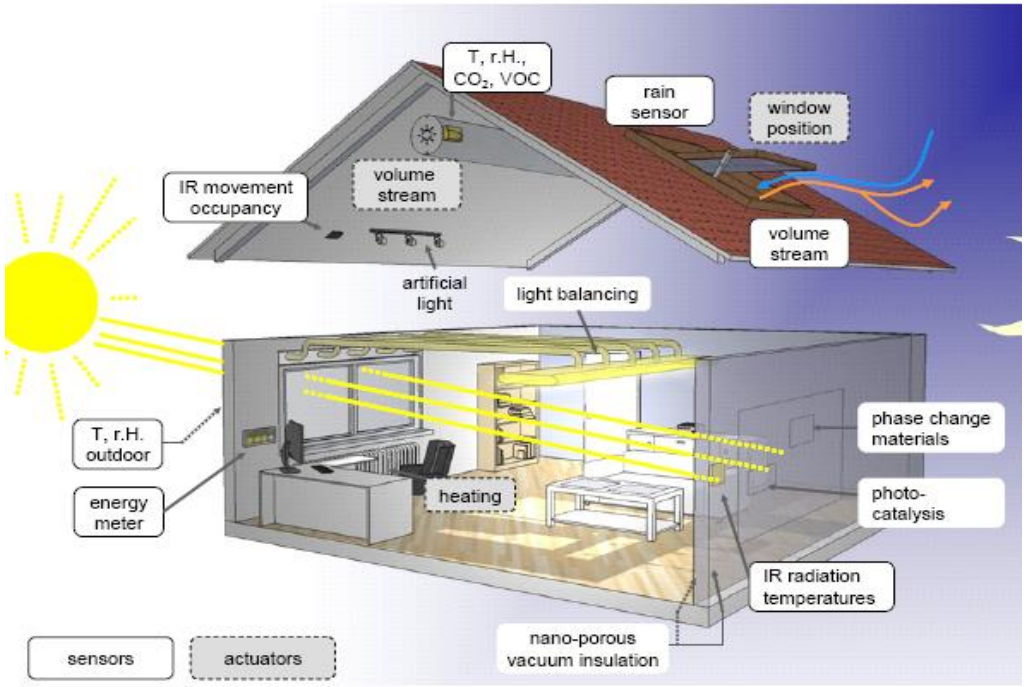
- Benefit for the customer
- Unique selling point / being better than the competition
- Save energy
- Save maintenance costs / total lifecycle costs
- Fulfill domestic & international laws

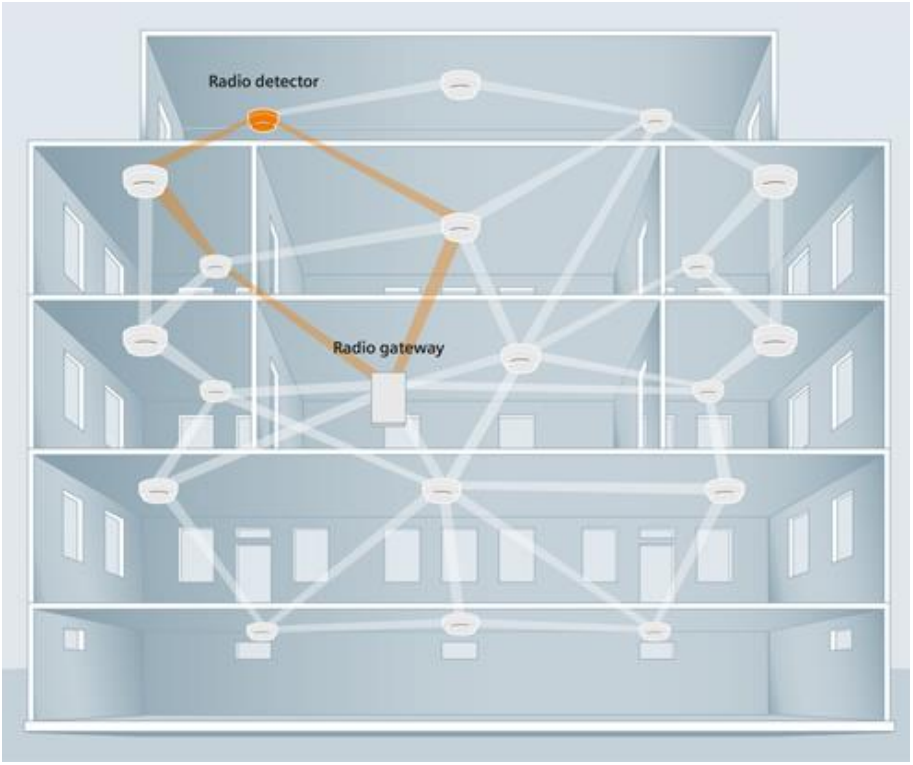
Industry is driven by money and regulations

EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

Application fields in buildings

Building Automation and Fire detection

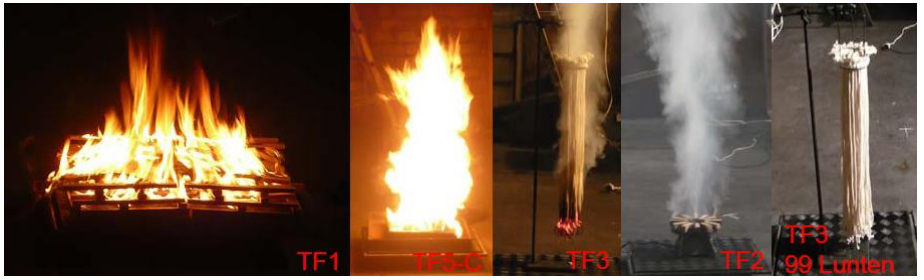




Both applications require:

- **low cost / low power / small size**
- **reliable / stable (long term)**

…Sensors



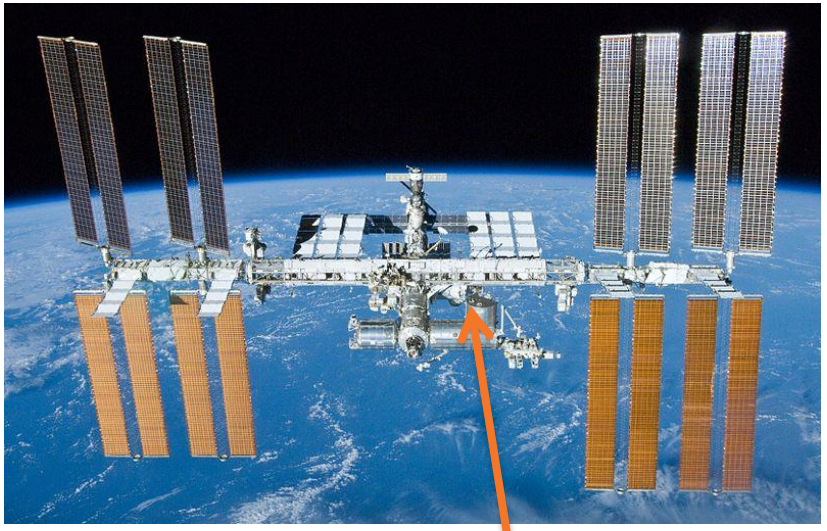
Energy Consumption of buildings

Energy used for Heating Ventilation Air Conditioning (HVAC) makes up 20% of total energy consumption in Europe

Source: Clear-Up

Outdoor Enviromental Monitoring (OEM)

A building is no sealed bubble
Filters in HVAC systems filter out particles, but not gas molecules
→ Maintanance costs for filters increase when filtering strongly polluted air



Source: Nasa

Non-standard building with non-standard ventilation

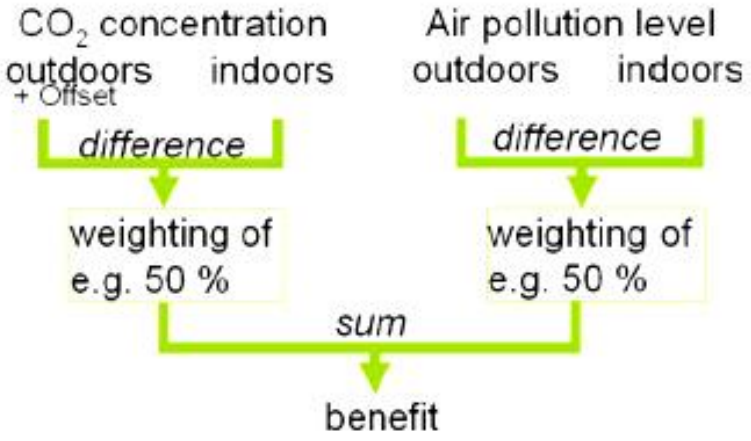
When would you open the window?

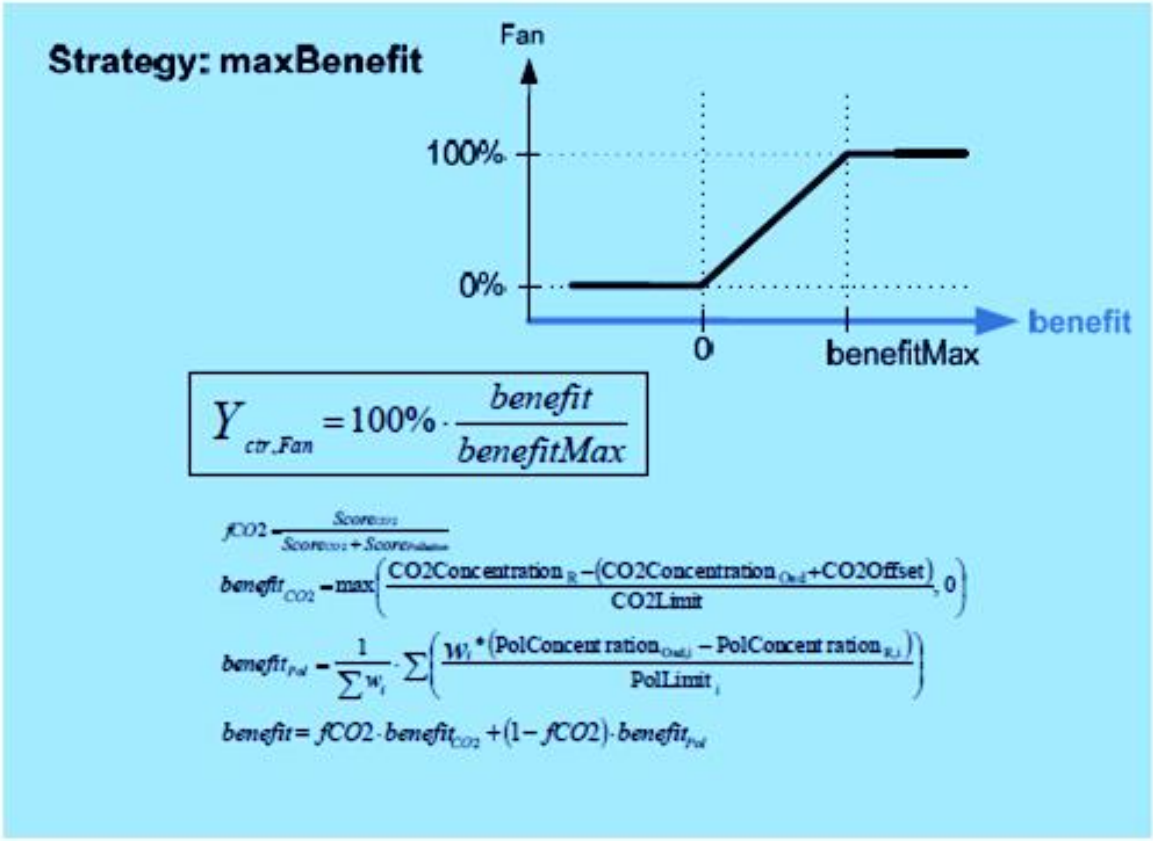
Author: Bobak Ha'Eri; wikimedia commons; **(CC BY-SA 2.5)**

OEM for HVAC → makes a lot of sense

New Strategies for HVAC

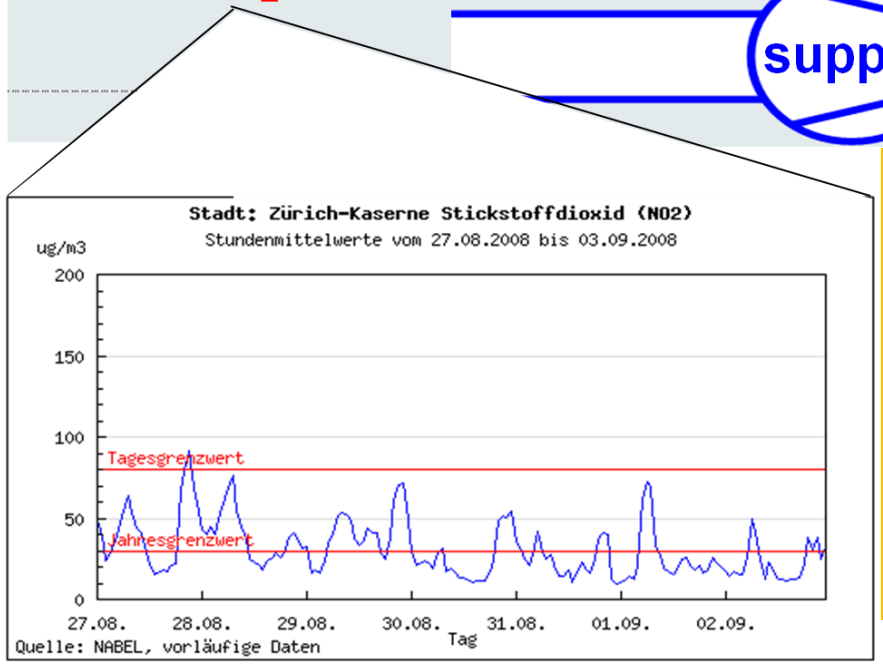
Ventilation control strategy “max benefit”





Source: ClearUp

Indoor air quality and OEM for HVAC



Simple Rules…

1) Check outside air quality
2) Switch on ventilation only when outside air is clean

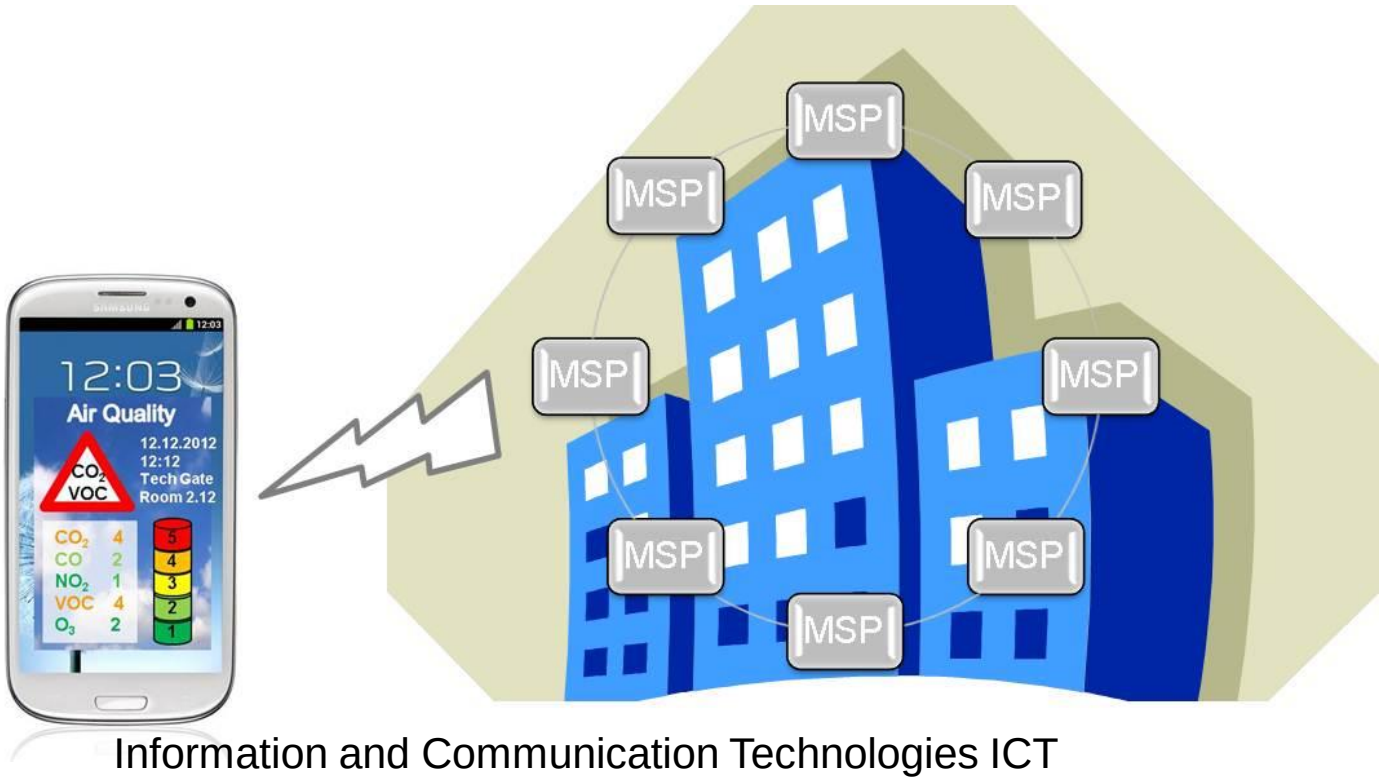
… need reliable sensors

MSP Project

Multi Sensor Platform for Smart Building Management

Industry needs sensors!

→ MSP is targeting that need!



Information and Communication Technologies ICT
FP7-ICT-2013-10

EUROPEAN COOPERATION IN SCIENCE AND TECHNOLOGY

Project No: 611887

MSP Project

Target Parameters for Indoor & Outdoor Air Quality

Indoors

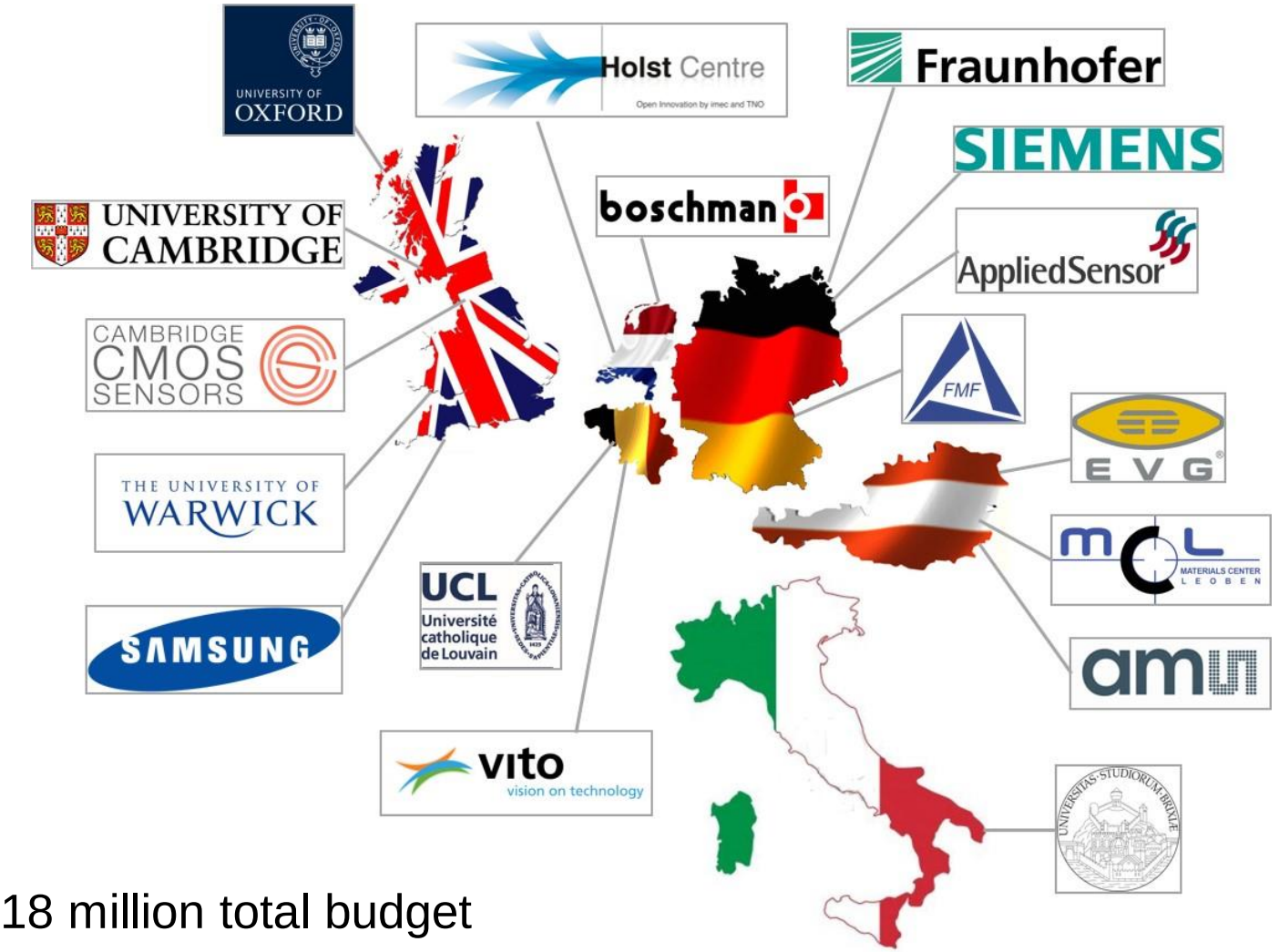
CO, CO_2, VOCs, PM

Outdoors

NO_2, O_3, CO, PM_{10}, $PM_{2.5}$, UFPs

MSP Project

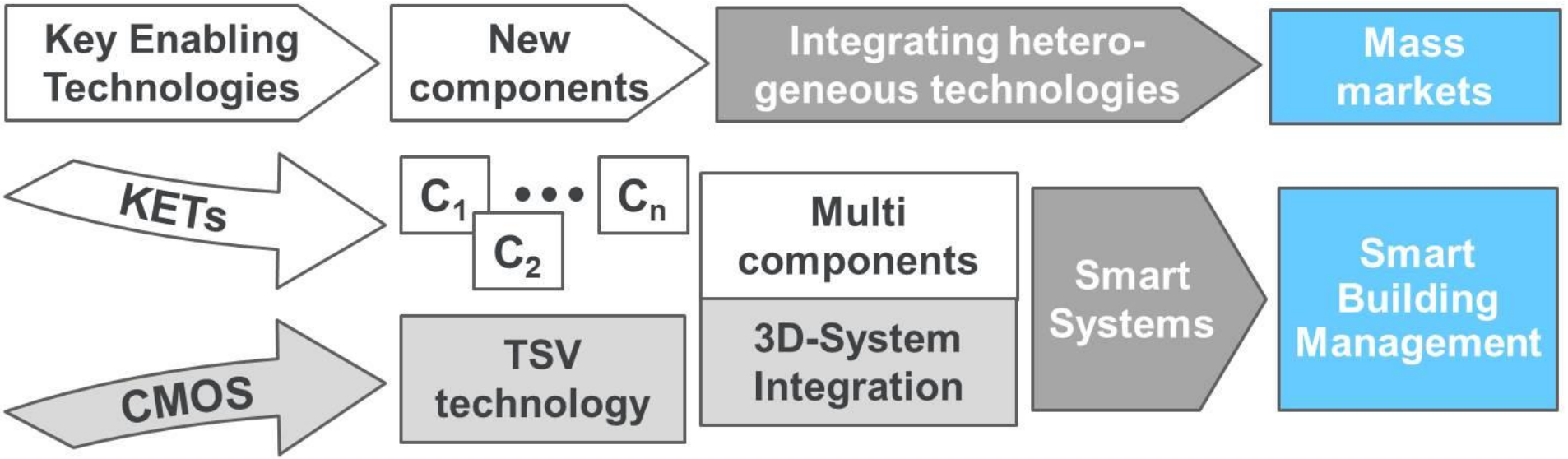
Consortium of 17 partners from 6 countries



3 years, €18 million total budget

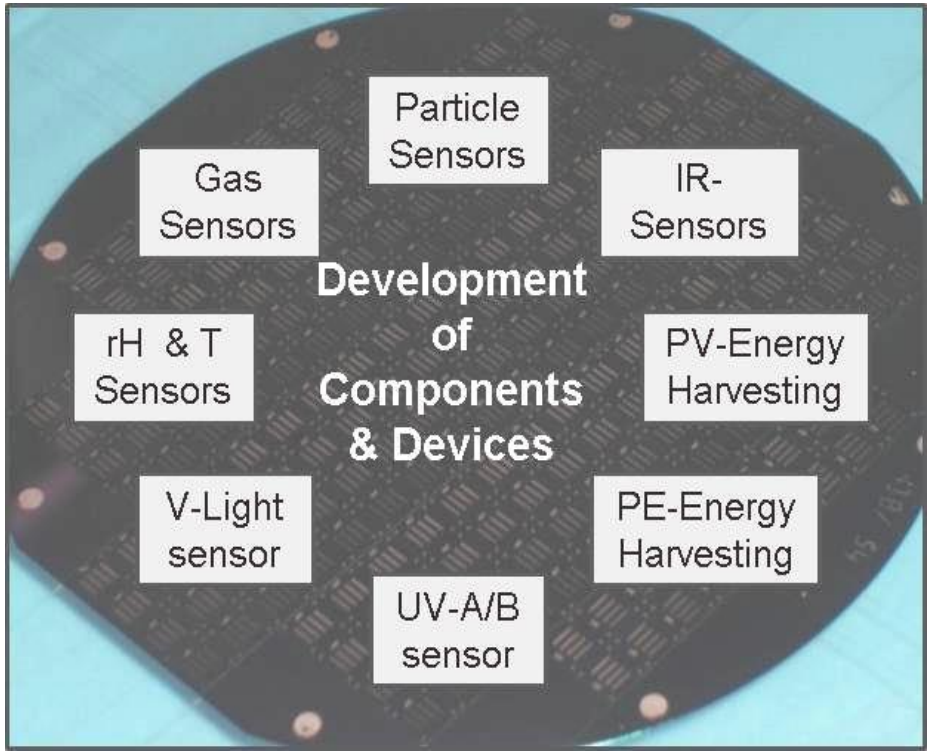
MSP Project
Concept & Objectives

- CMOS technology as sound foundation to ensure cost efficient mass fabrication
- Take-up of Key Enabling Technologies for new components and devices
- Integrating heterogeneous technologies for realization of smart systems



MSP Project
Concept & Objectives

- Development of novel components & devices as „tool-box“ for 3D-system integration

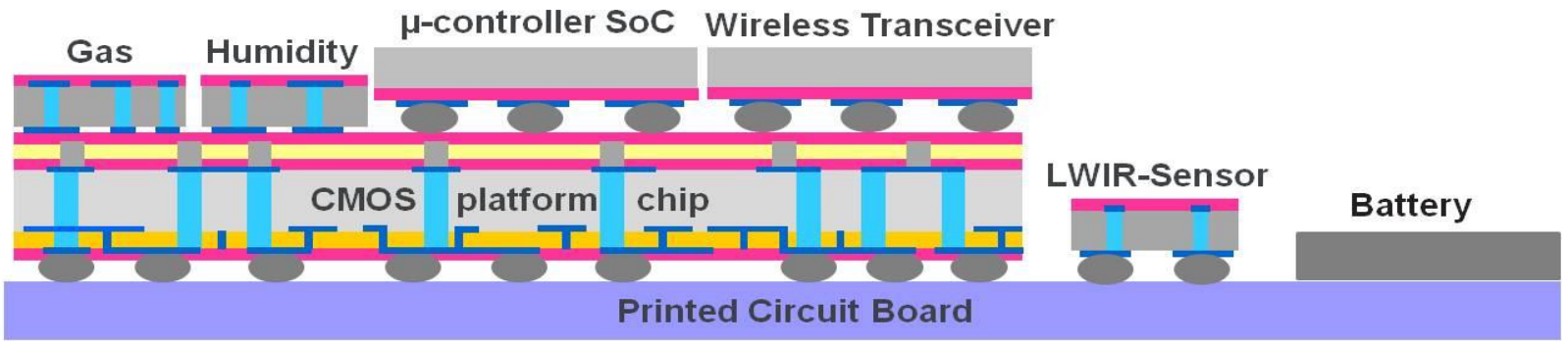


- Gas sensors and rH-sensor based on SnO_2, CuO, ZnO,WO_3,…-NWs, (bi)metallic NPs, Graphene, CNTs, & AlGaN/GaN
- Thin film bulk resonator (FBAR) particle sensor
- Thermopile IR-sensors
- Photovoltaic energy harvester with interdigitated Back contact (IBC) structure
- Piezoelectric energy harvester based on ZnO-NWs and PVDF films
- SiC- and ZnO-NW based UV-A/B sensor

MSP Project

3D-Integration of sensor components

- Platform chip as basic “LEGO™” building block for 3D-integration of MSP Multi Sensor Systems
- Development of processes and technologies for 3D-integration of sensors and devices
- “Other than CMOS compatible materials” (GaN, CNTs,…)



MSP Device for Smart Building Management

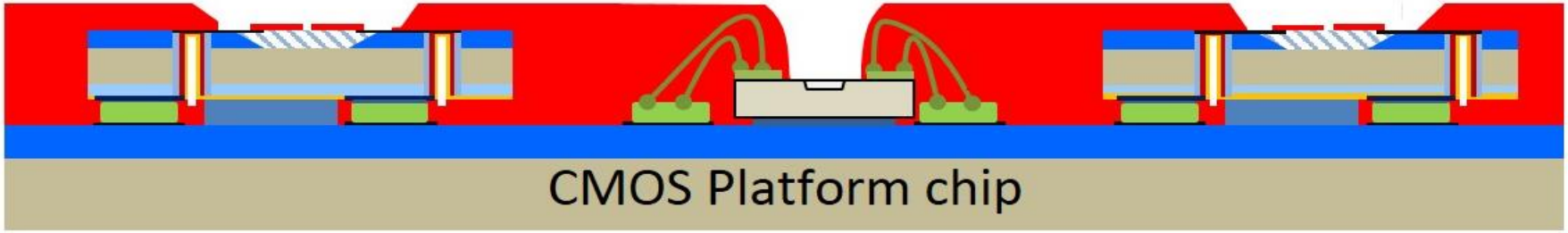
GA no: 611887

MSP Project

Achievements after first year

- **We have moved from ppt.-presentation to real devices !**

3D-integrated MSP demonstrator device

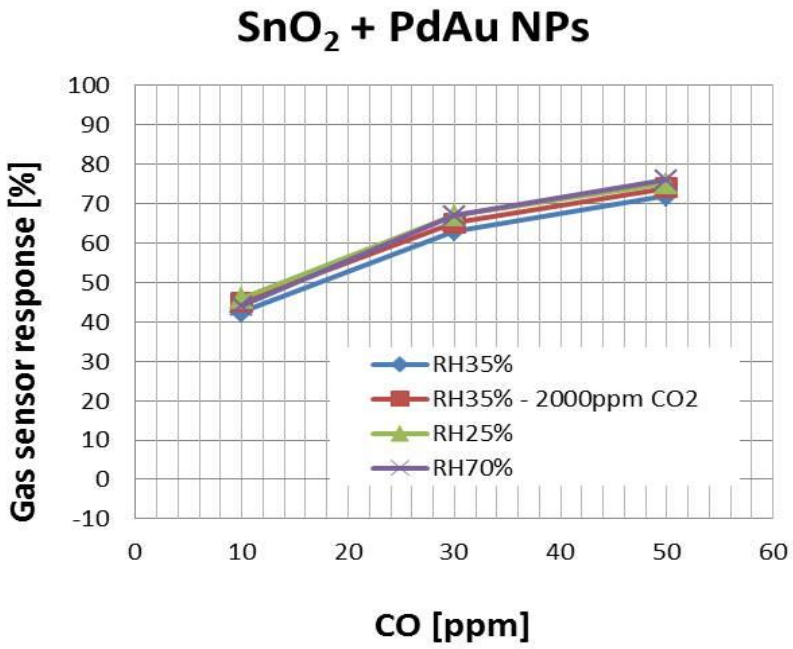


MSP-specific KETs

Nanotechnology as key enabling technology

Examples

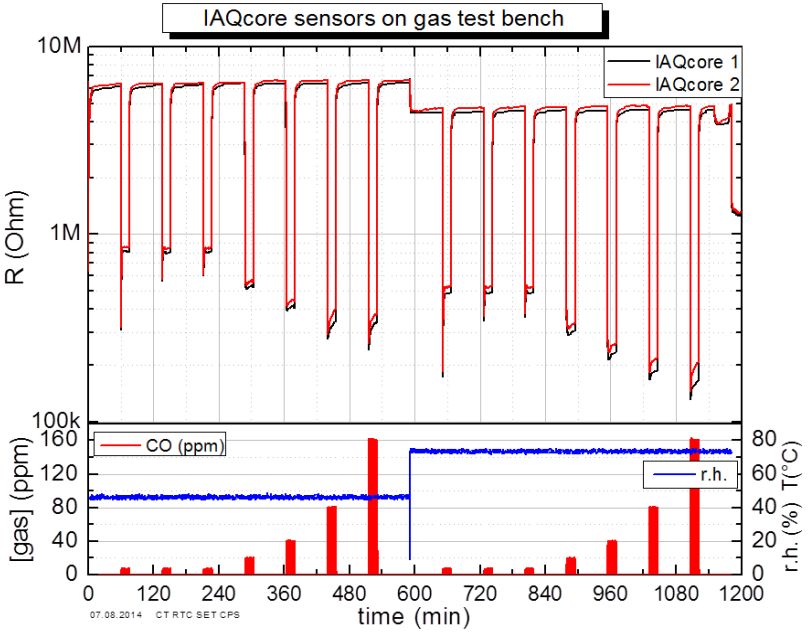
- AppliedSensor (APPS): SnO_2 film
- Material Center Leoben: SnO_2 thin film + (SnO_2, CuO, ZnO)-NWs
- IMEC: GaN/AlGaN
- Uni Cambridge: Graphene & CNTs
- ALU-FR: (bi)metallic Nanoparticles
- Uni Brescia: SnO_2, CuO, ZnO, RuO-NWs
- Uni Oxford: piezo-electric energy harvester



MSP-specific KETs

Applies Sensor SnO_2 film

- fast and strong response to CO →even to low concentrations (10ppm CO)
- Very small influence of r.h. on the sensitivity
- good comparability between different sensors of the same type
- Sensors commercially available!
- Hotplate used as „platform“ for innovative layer developements (NWs, NPs…)

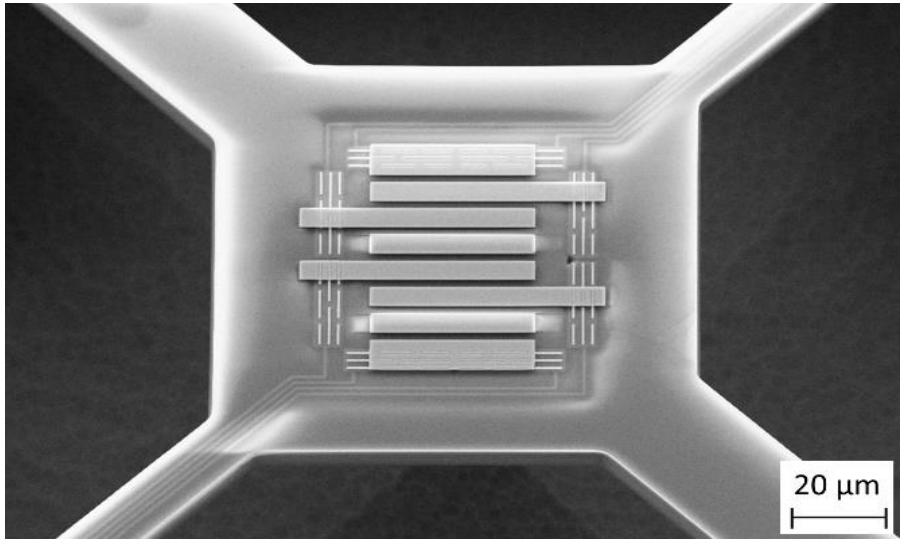


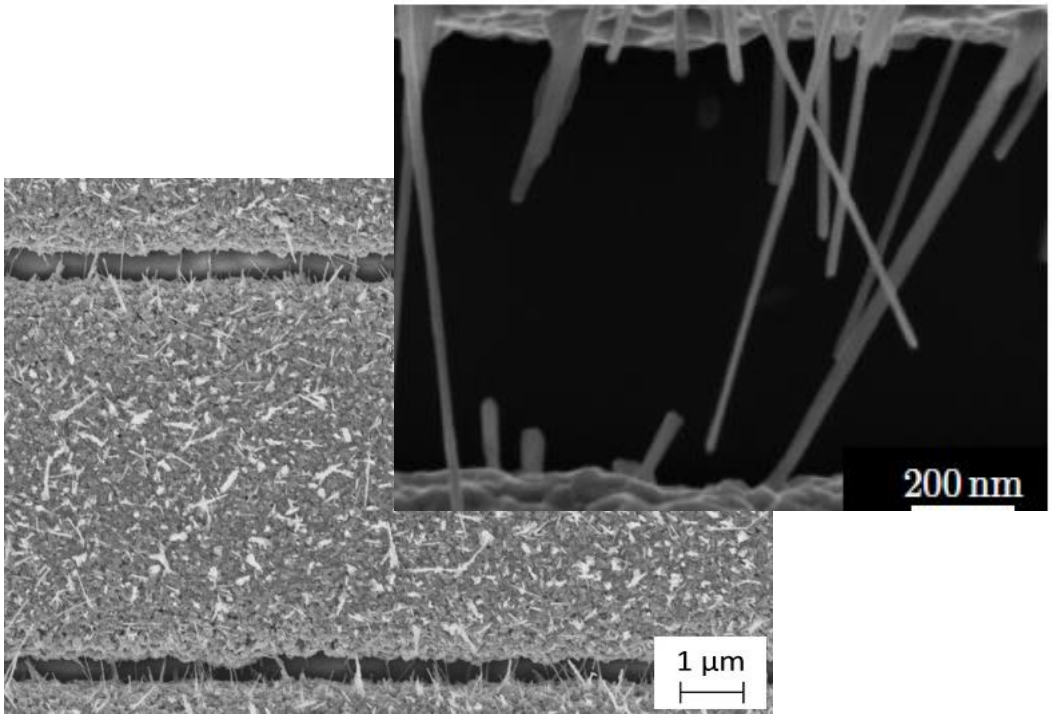
Response to CO at different humidities

MSP-specific KETs

Material Center Leoben: SnO_2 film & NWs

- CuO-NW gas sensor on AMS CMOS µ-hotplate



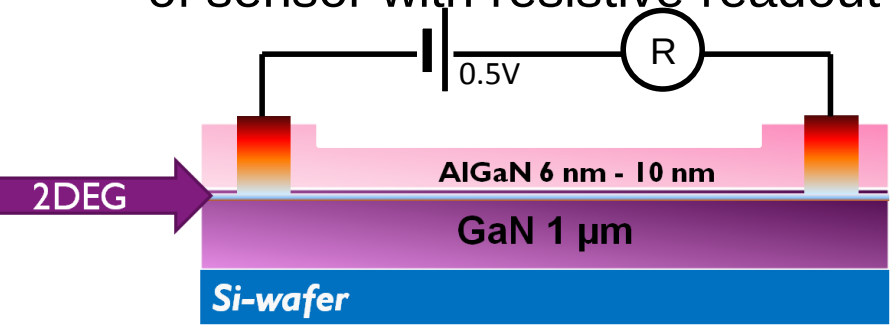


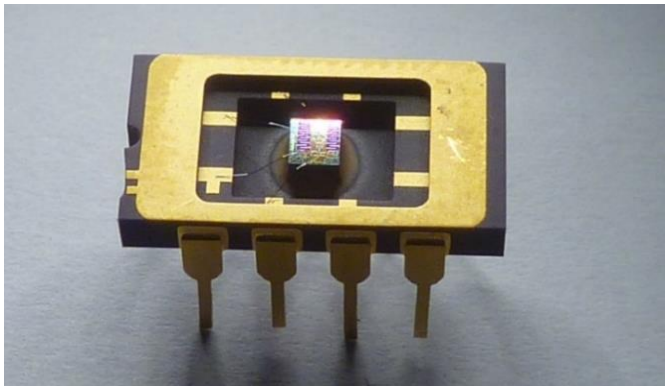
Copper-Oxide nanowires grown on µ-hotplate from MCL
Receipe: 500 nm Cu on CMOS - Gap 2µm + Thermal oxidation process on CMOS µhp + 350°C for 1h in air (< 400°C!)

MSP-specific KETs

IMEC: GaN/AlGaN

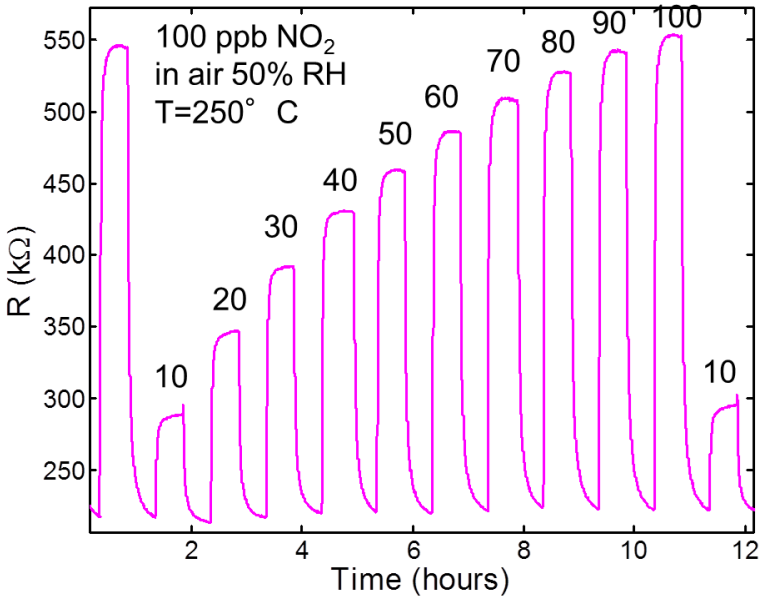
- AlGaN/GaN heterostructure-based devices can be used as an adsorptive-type of sensor with resistive readout





High NO_2 sensitivity with power HEMT based sensors ; Response and recovery times < 2 min at 300°C

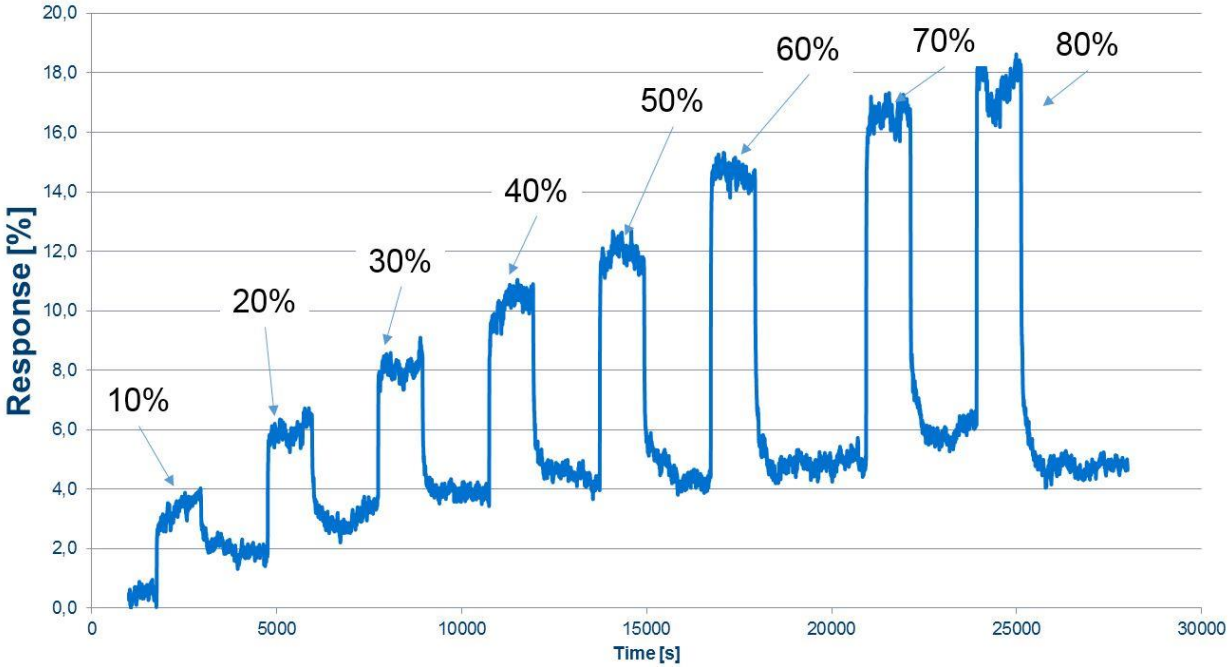
WHO Guideline values NO_2:
20 ppb annual mean
100 ppb 1-hour mean

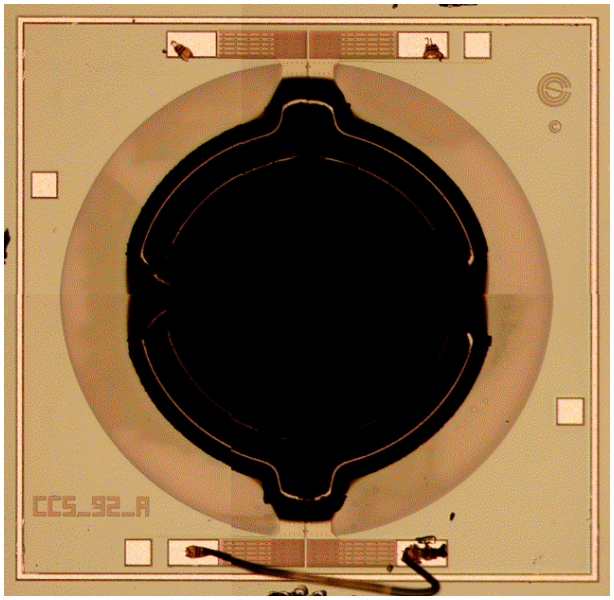


MSP-specific KETs

Uni Cambridge: Graphene based rh. sensor

- UCAM characterized their preliminary graphene based rH sensor and has been able to demonstrate rH-sensitivity



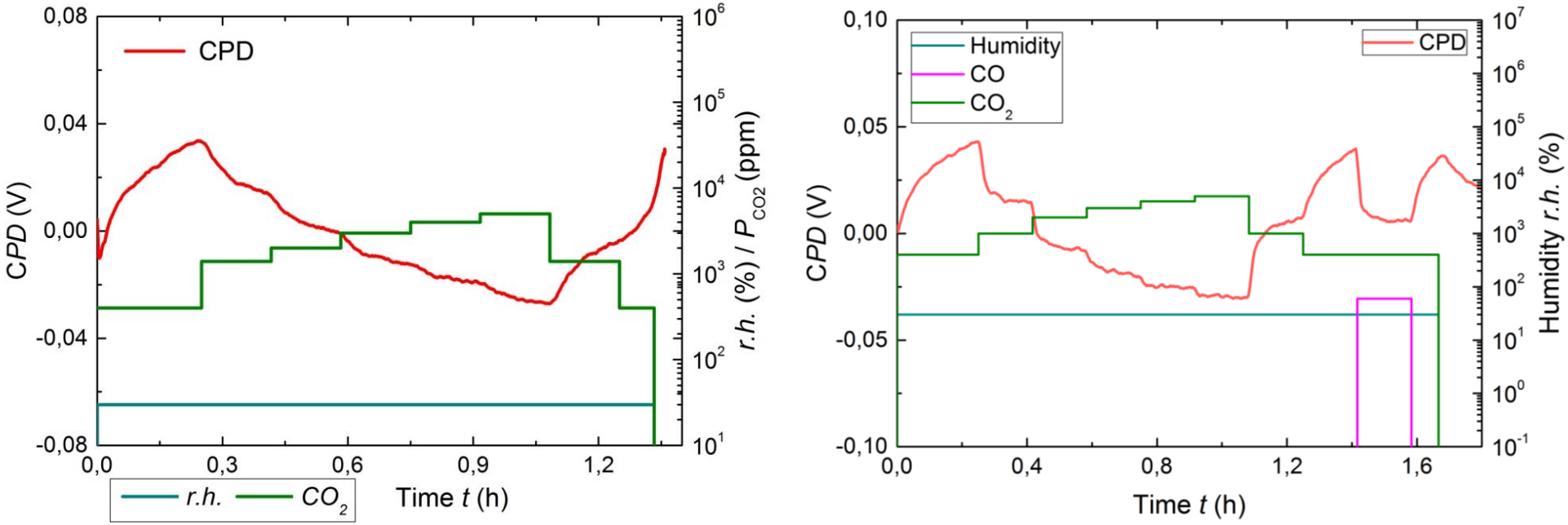


Response of a graphene based gas sensor to humidity at room temperature

MSP-specific KETs

Uni Freiburg: NP-based sensors

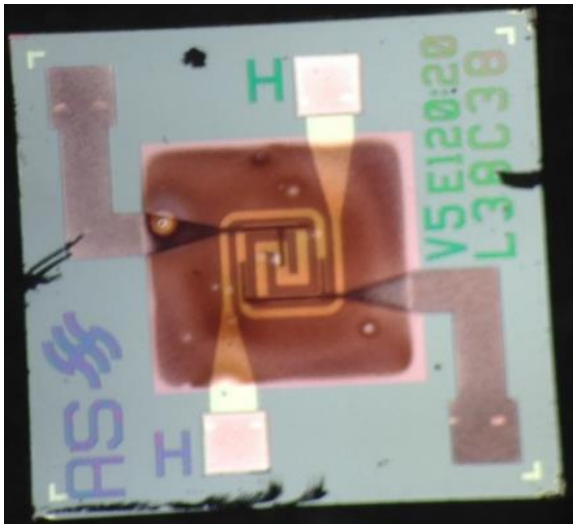
- Development of CeO2- and CuO-NP based sensing layers for CO2 detection
- A first characterization of the material response using Kelvin probe set-up.



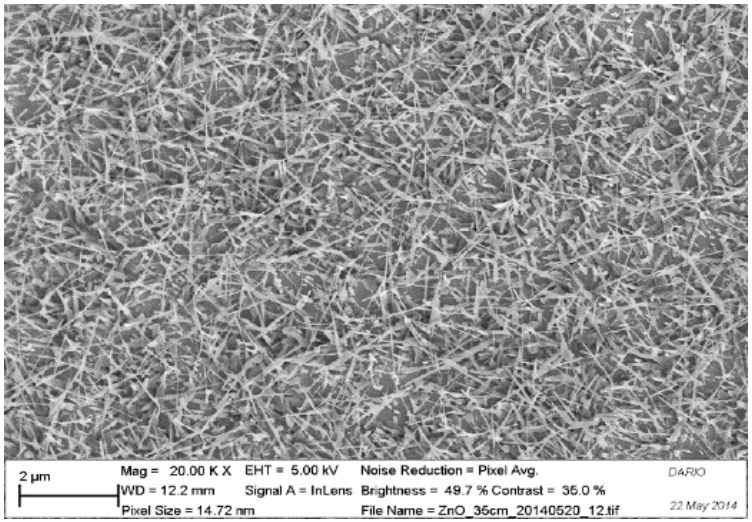
Kelvin probe response of CeO_2-NPs (left) and CuO-NPs (right) to gradual increasing CO_2 concentration from 400 to 5000 ppm (in synthetic air at RT and 30% r.h)

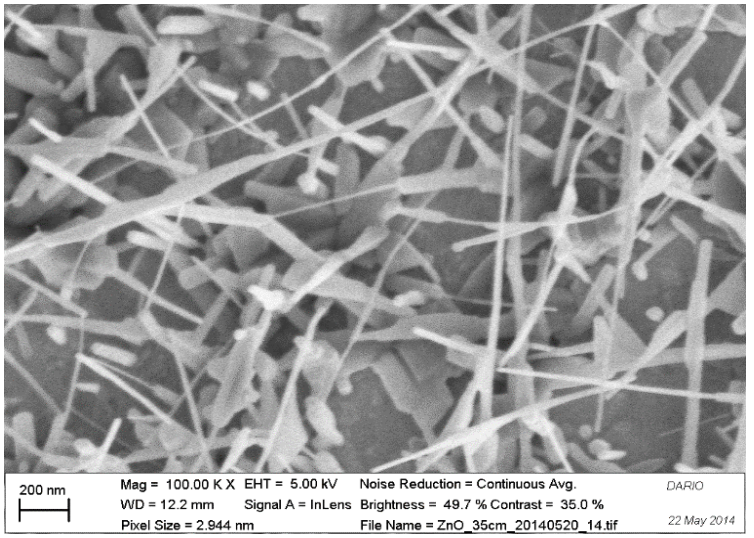
MSP-specific KETs

Uni Brescia: Nanowires grown on APPS hotplate



- Vapour Phase Growth (PVD)
- Thermal Evaporation
- Thermal Oxidation
- Anodization
- Good results on ZnO-NW sensors for the detection of NO_2, O_3



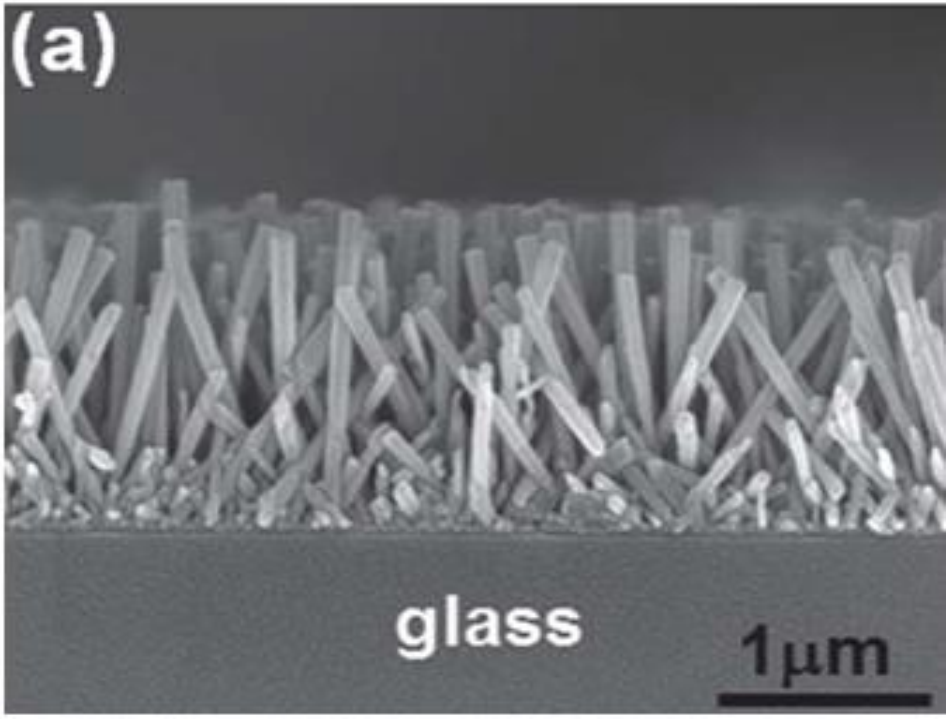


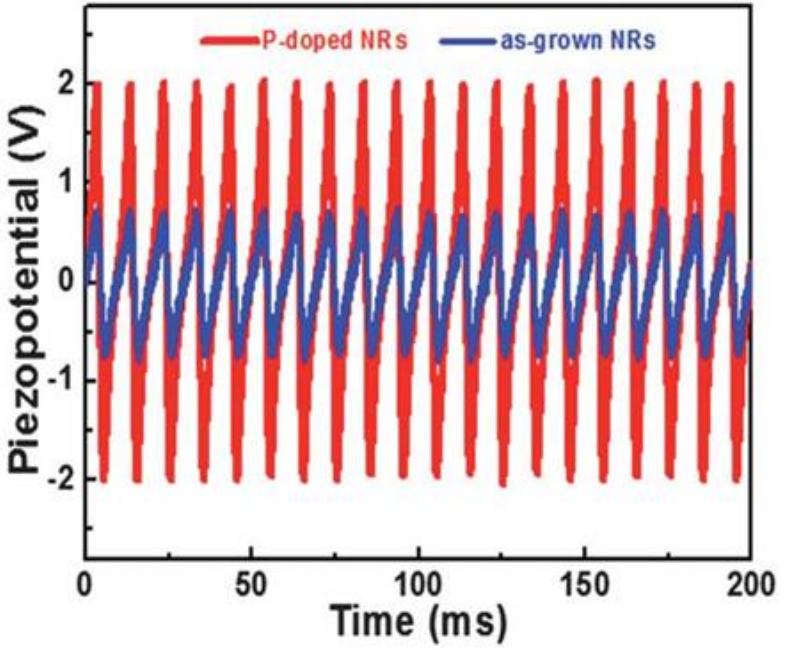
ZnO-NWs synthesized on APPS hotplate

MSP-specific KETs

Uni Oxford: piezo-electric energy harvester

- PE energy harvester based on ZnO-NWs and PVDF-films





The piezoelectric output potential of sound-driven ZnO-NW PE energy harvesters (100 Hz@90dB).

Summary & Outlook

Objective - Demonstrator systems

- **Realization of three specific 3D-integrated MSP demonstrator systems**

MSP Device for Smart Building Management	MSP Device for Wearable Wristwatch Application	MSP Device for Outdoor Environmental Monitoring

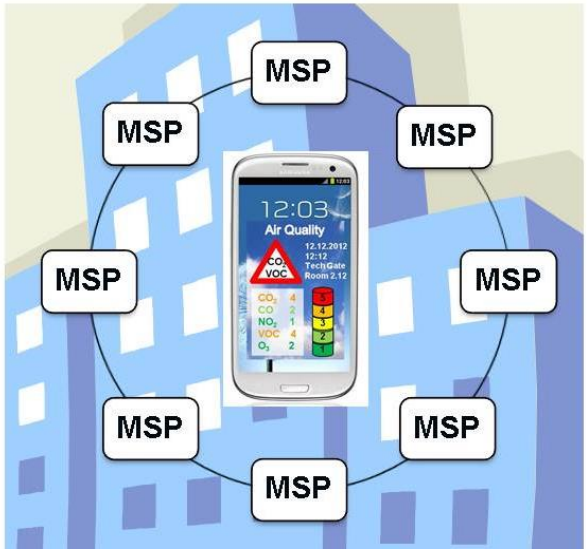
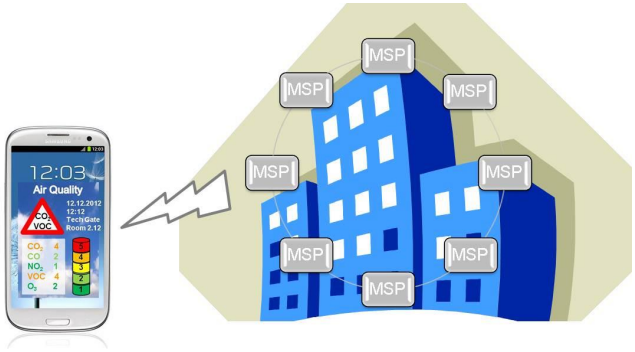



Fig.2a: MSP for Smart Building Management.	*Fig.2b: MSP for Wearable Wristwatch.*	*Fig.2c: MSP for Outdoor Environmental Monitoring.*

Thank you for your attention

Questions?



SEVENTH FRAMEWORK PROGRAMME

Project No: 611887