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

COST Action TD1105

4th International Workshop *EuNetAir* on *Innovations and Challenges for Air Quality Control Sensors*

FFG - Austrian Research Promotion Agency - Austrian COST Association

Vienna, Austria, 25 - 26 February 2016

FP7 PROJECT MSP – MULTI SENSOR PLATFORM FOR SMART BUILDING MANAGEMENT: STATUS & PROGRESS

Speaker Affiliation Logo

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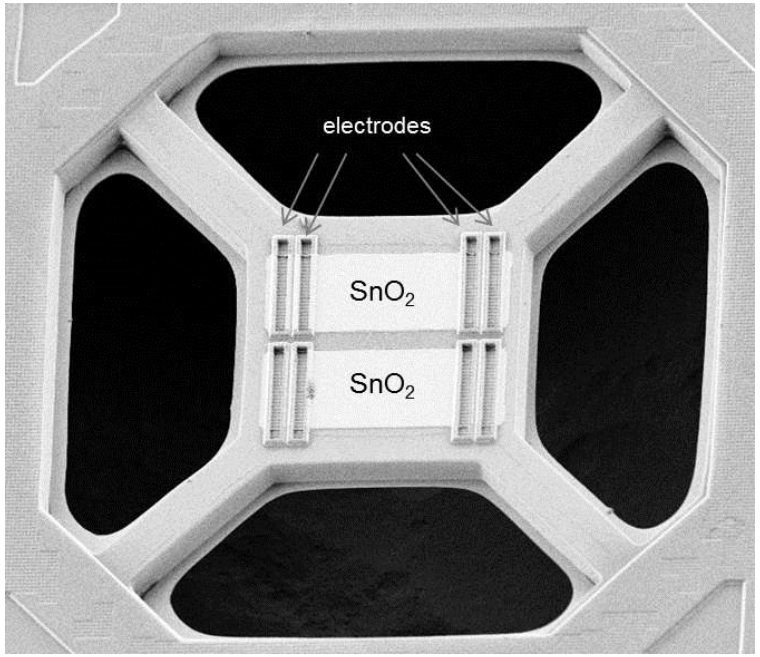
Outline

1. MCL & System Integration
2. Overview of MSP-Project
3. Achievements & Highlights 1
4. Summary & Outlook

1. MCL & SYSTEM INTEGRATION

Thin film & nanowire sensors & nanoparticles

CMOS integrated!



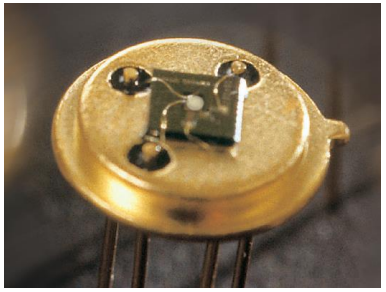
- SnO_2-thin films
- SnO_2-NWs (n-type)
- CuO-NWs (p-type)
- ZnO-NWs (n-type)

Target gases:
CO, H_2, H_2S, O_3
CO_2, VOCs, NO_2
in dry and humid air

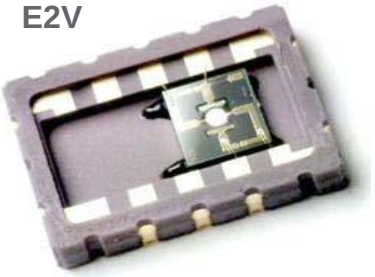
- Conventional devices
- Cross selectivities
- High power consumption
- Mostly for professional use only

Figaro Engineering

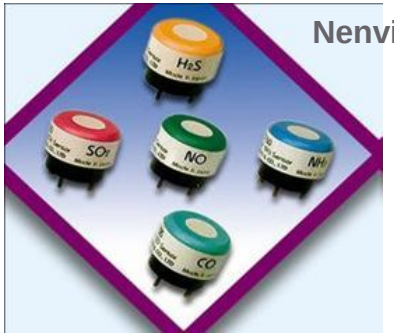
Applied Sensor

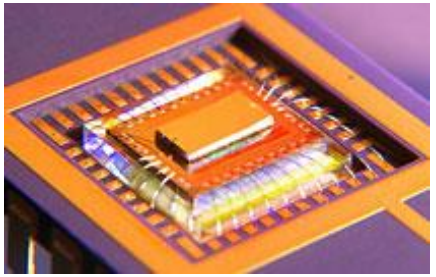


E2V

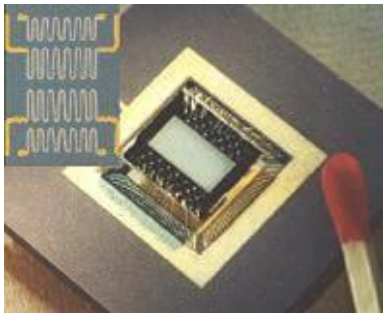


Nenvitech





Micronas

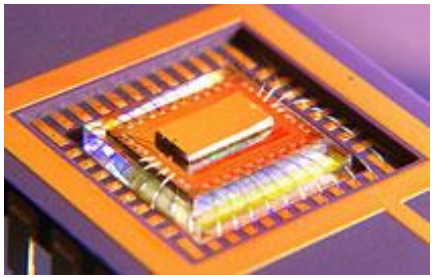


Sysca

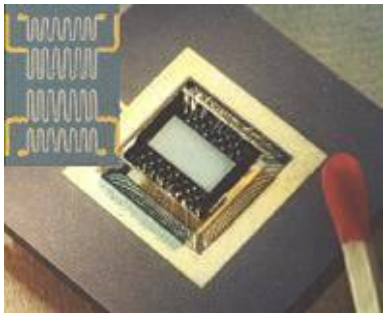
- Conventional devices
- Cross selectivities
- High power consumption
- Mostly for professional use only

Most of today‘s gas sensors are not smart devices – no integration with CMOS technology!

Nenvitech



Micronas

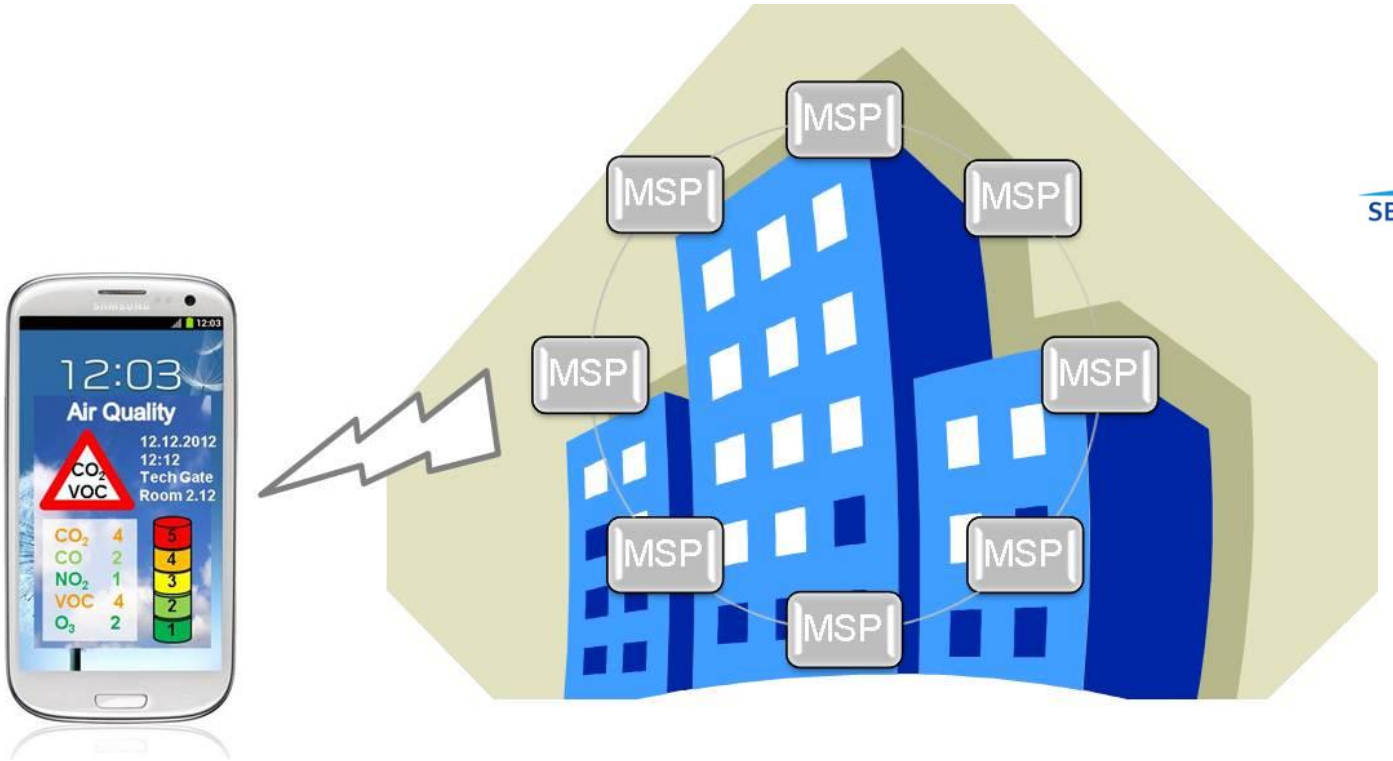


Sysca

CMOS-Integration is key for new applications!

- Life Style Applications in Smart Phones & Watches
  Environmental monitoring, O_3, UV-A/B,…

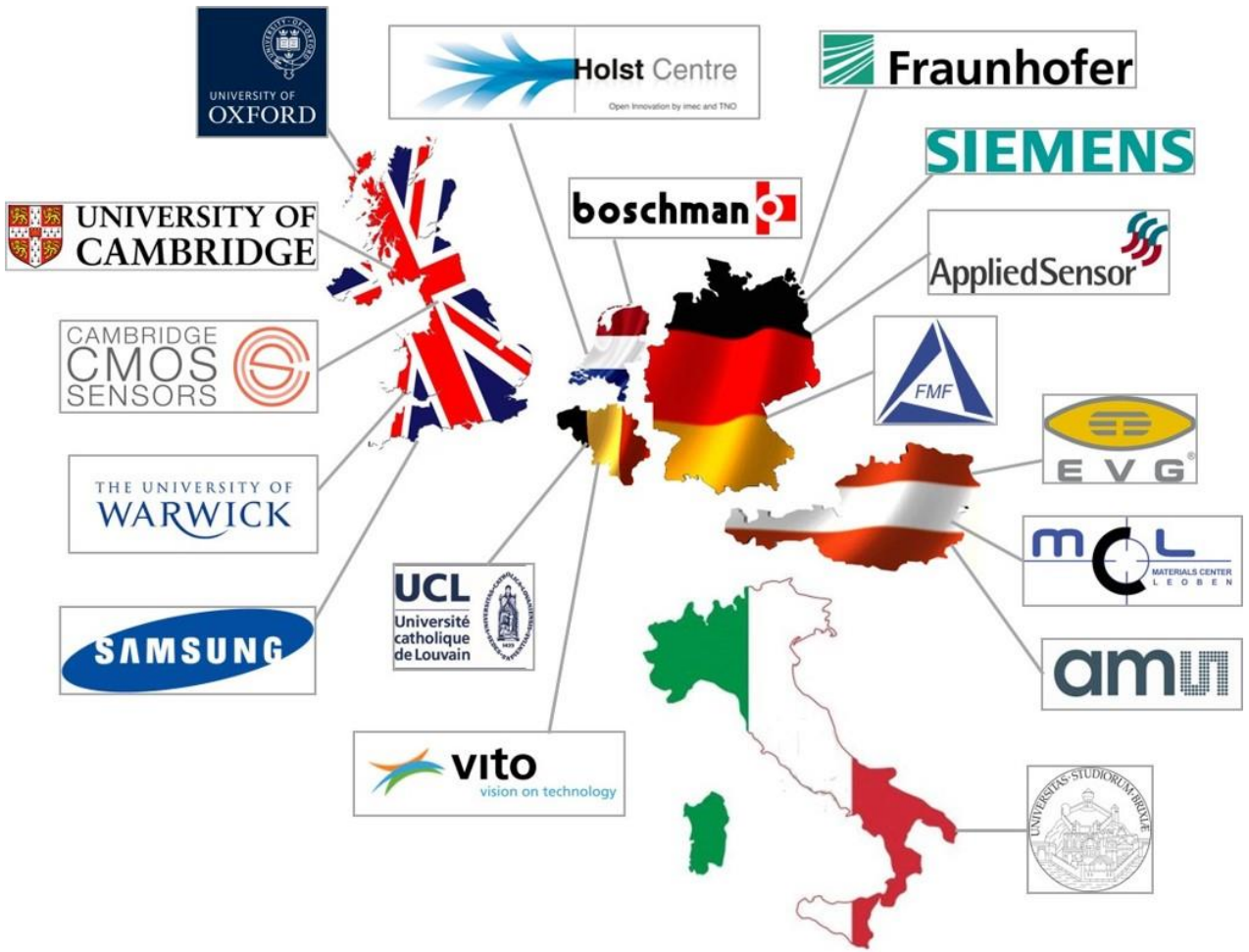
MSP - Multi Sensor Platform for Smart Building Management



SEVENTH FRAMEWORK PROGRAMME

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

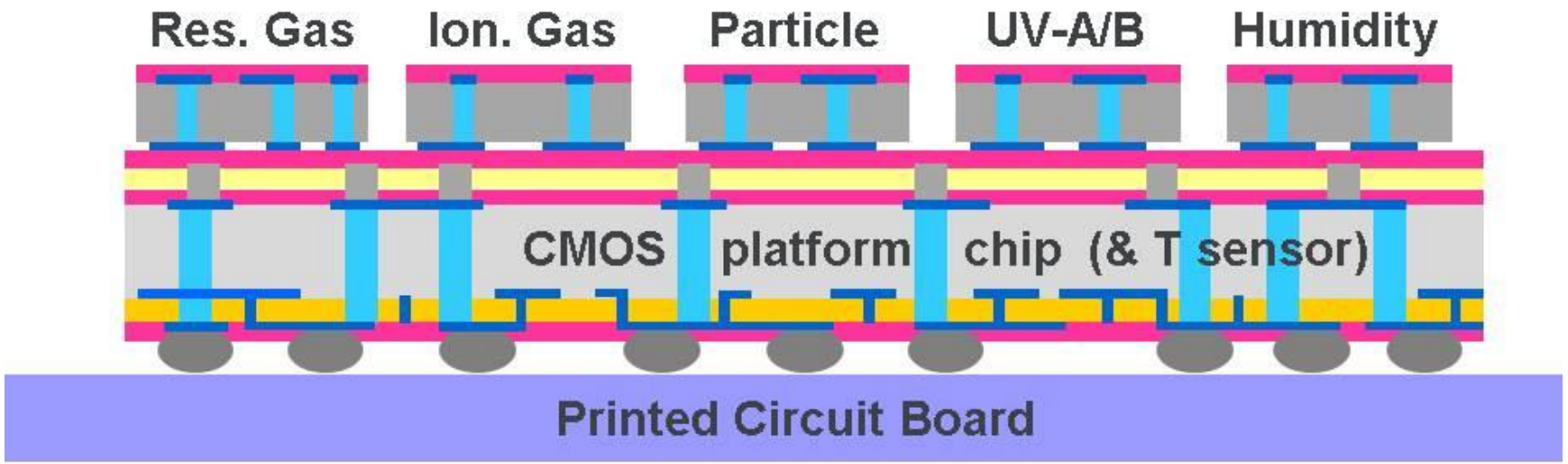
MSP CONSORTIUM



- 17 partners
- 6 countries
- € 18.5 Mio
- 1/9/2013 start
- 3 years

GOAL OF MSP-PROJECT

- Development of smart 3D-integrated multi-sensor systems enabling indoor and outdoor environmental monitoring!



Target Parameters

Indoors

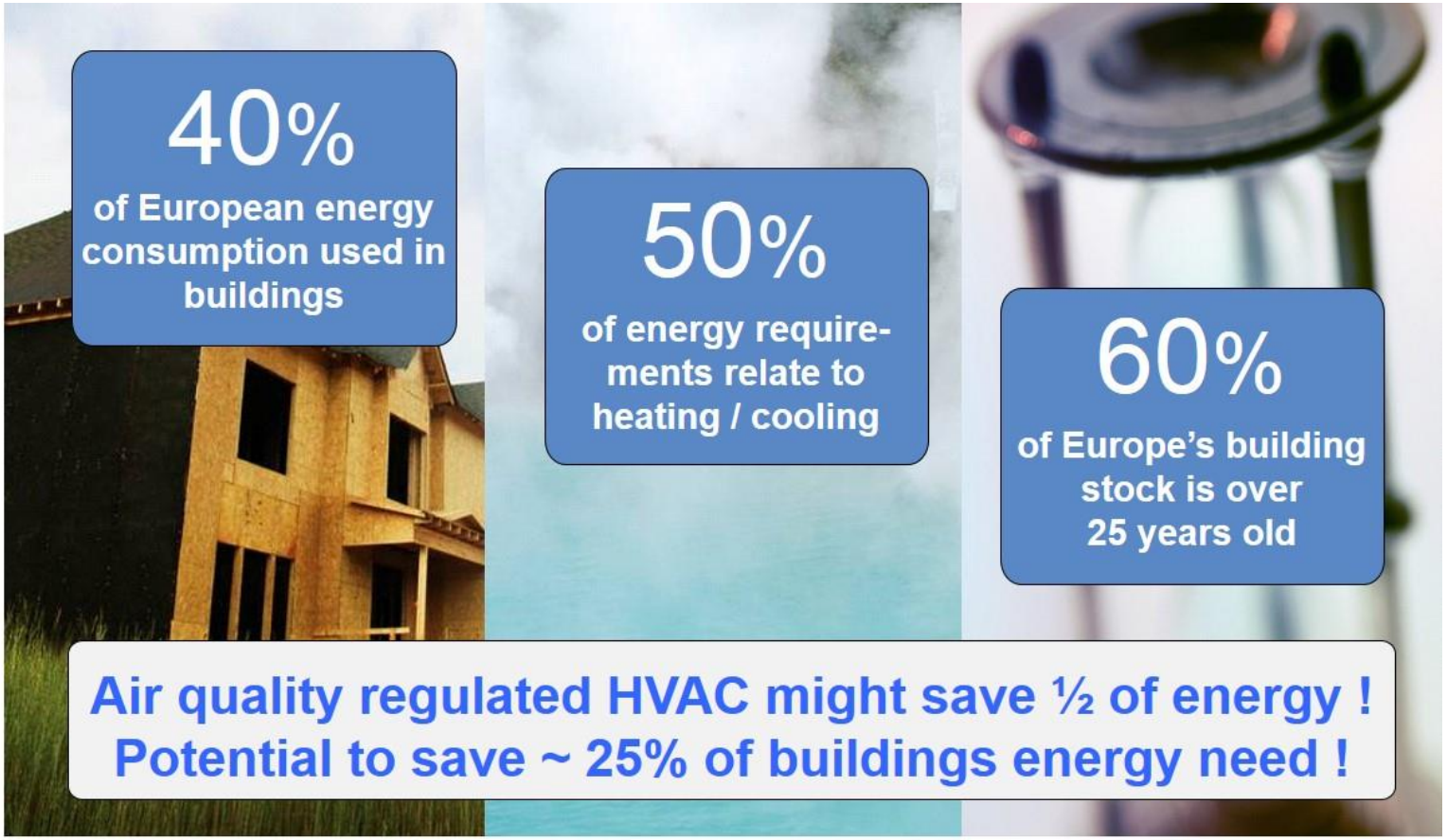
CO, CO_2, VOCs, PM

Outdoors

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

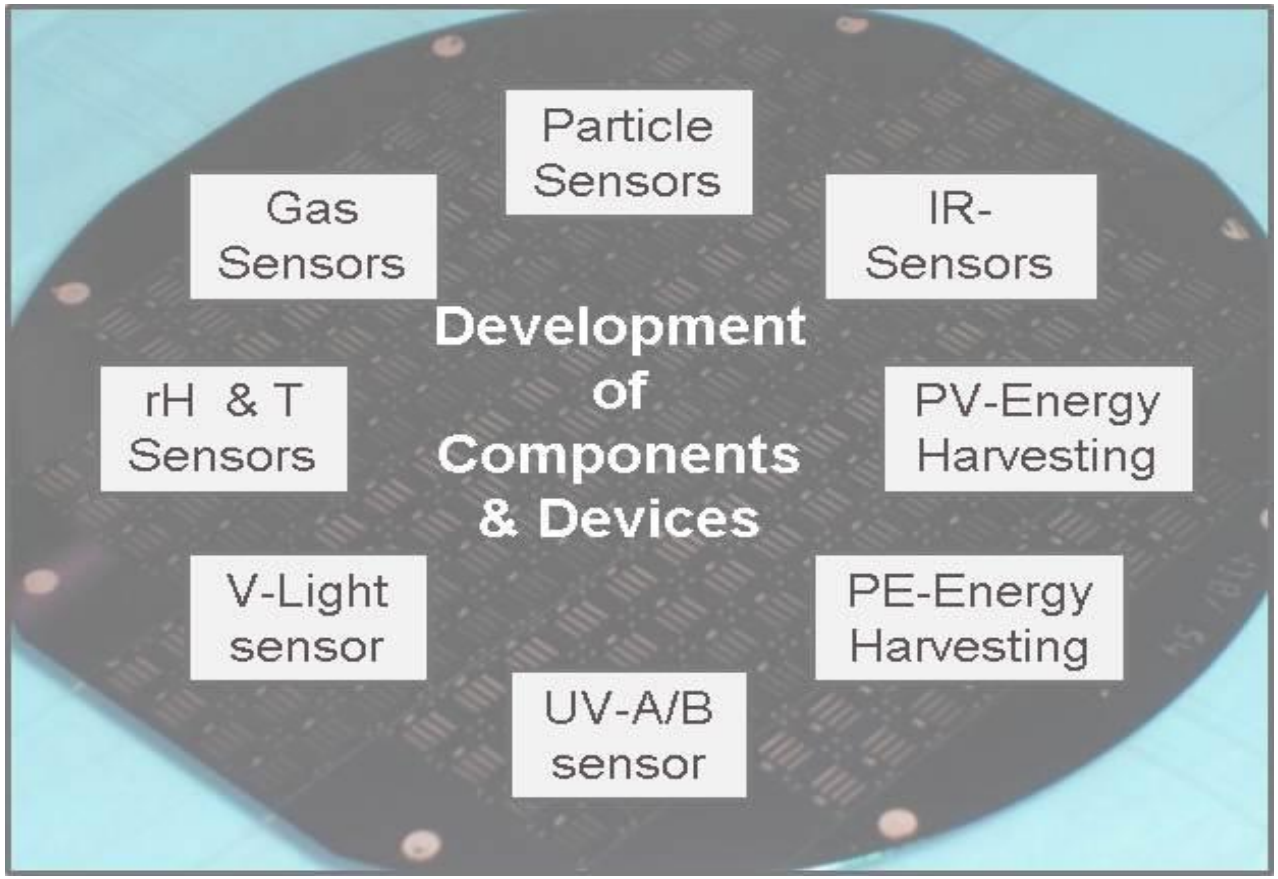
- Air Quality Monitoring

Smart Building Management: VOCs, CO_2,…



Energy Efficiency improvement potential in buildings in Europe (source: Siemens, 2011)

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



SENSORS & DEVICES

- 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

- Development of process & manufacturing chains enabling flexible „plug-and-play“ 3D integration of sensors and devices on CMOS platform chips
- The concept is based on rigorous employment of Through-Silicon-Via (TSV) technology
- The fabrication approach is based on the multi-project-wafer (MPW) service
- This shall be the enabler for take-up of Key Emerging Technologies (KETs) in particular by SMEs
- Development of novel components & devices for 3D-integration
- Development of wireless communication for networks and handheld devices

- 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

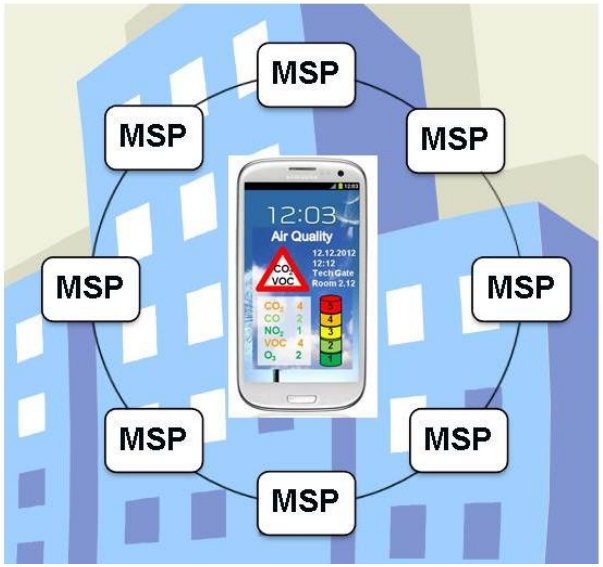
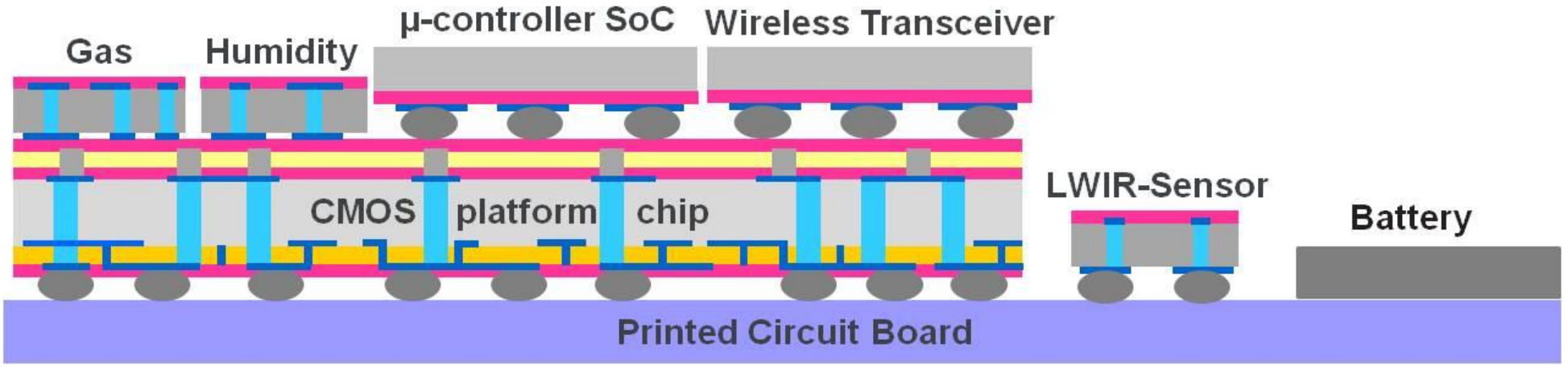
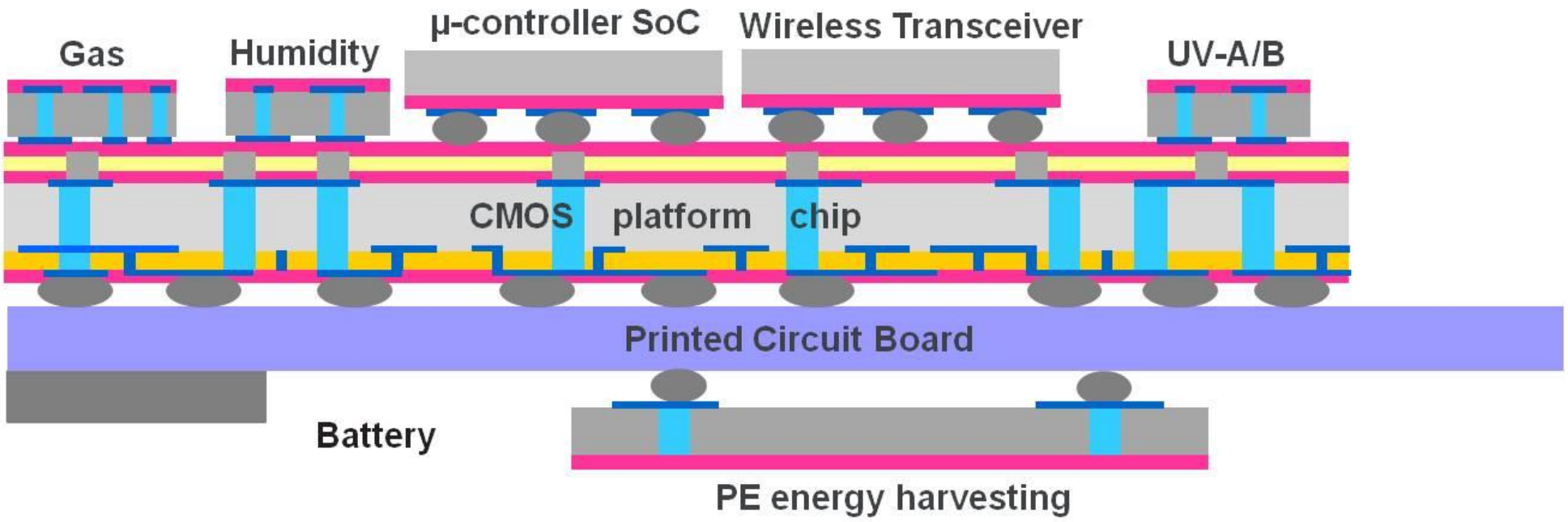



Fig.2a: MSP for Smart Building Management.	*Fig.2b: MSP for Wearable Wristwatch.*	*Fig.2c: MSP for Outdoor Environmental Monitoring.*

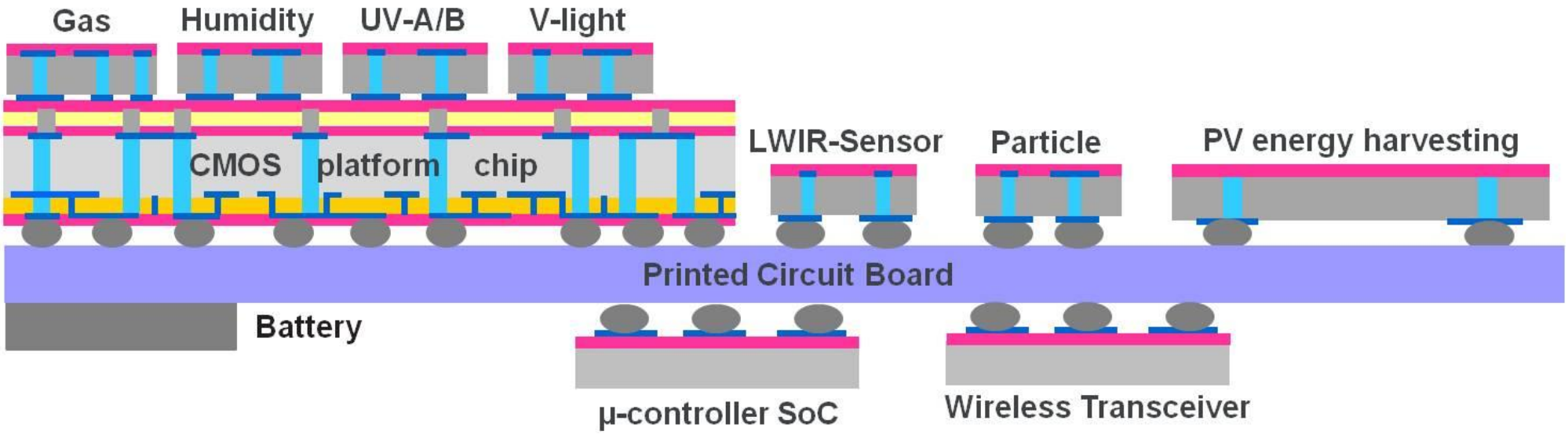
- MSP Device for Smart Building Management



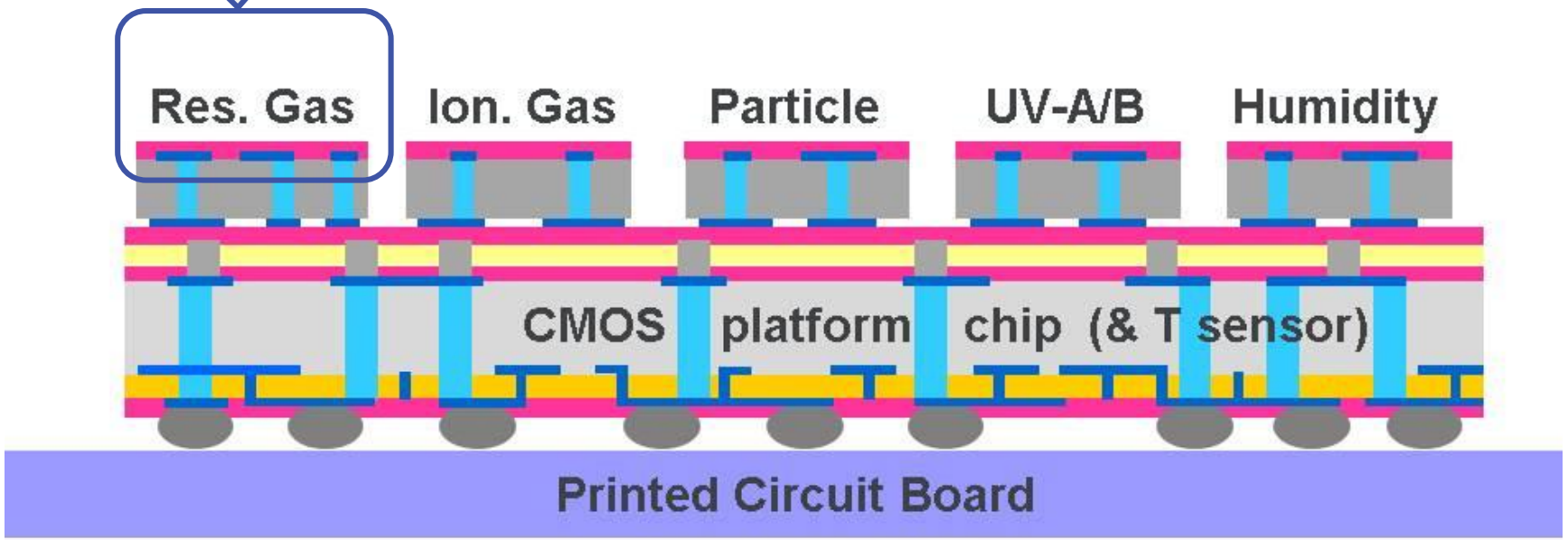
- MSP Device for Wearable Wristwatch Application



- MSP Device for Outdoor Environmental Monitoring

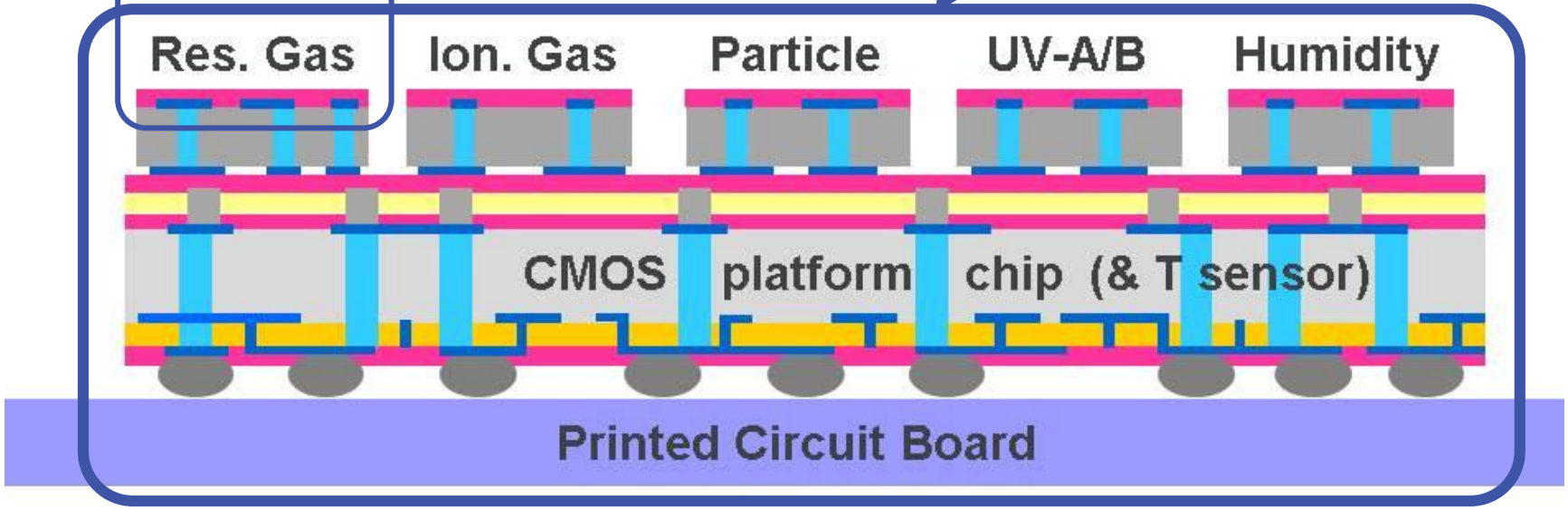


1st level:
CMOS–Integration of gas sensitive nanocomponents



1st level:
CMOS–Integration of gas sensitive nanocomponents

2nd level:
3D–Integration of different sensors to a system

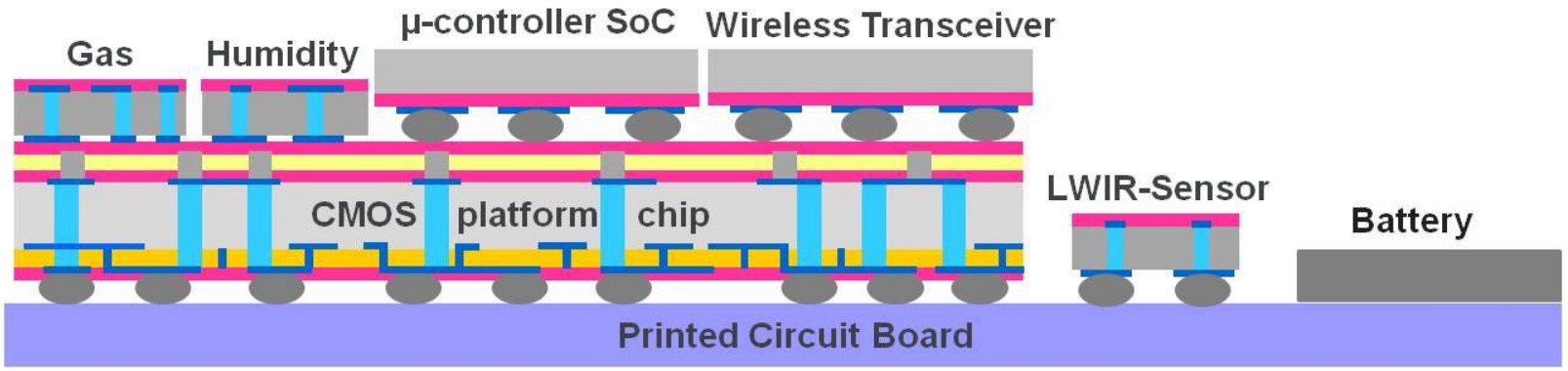


But: 3D-Integration results in considerable restrictions !

- TSVs require wafer thinning !
- Handling wafer is required !
- Additional etching steps from the backside
- Overmoulding results in stress / strain
- Fragile µhp and NWs can break due to strain / stress !
- Solder balls and/or bumping (when?)
- Dicing – how and when ?
- Handling of dies with µhp for D2D-bonding (how?)
- The overall process flow is key to success !!

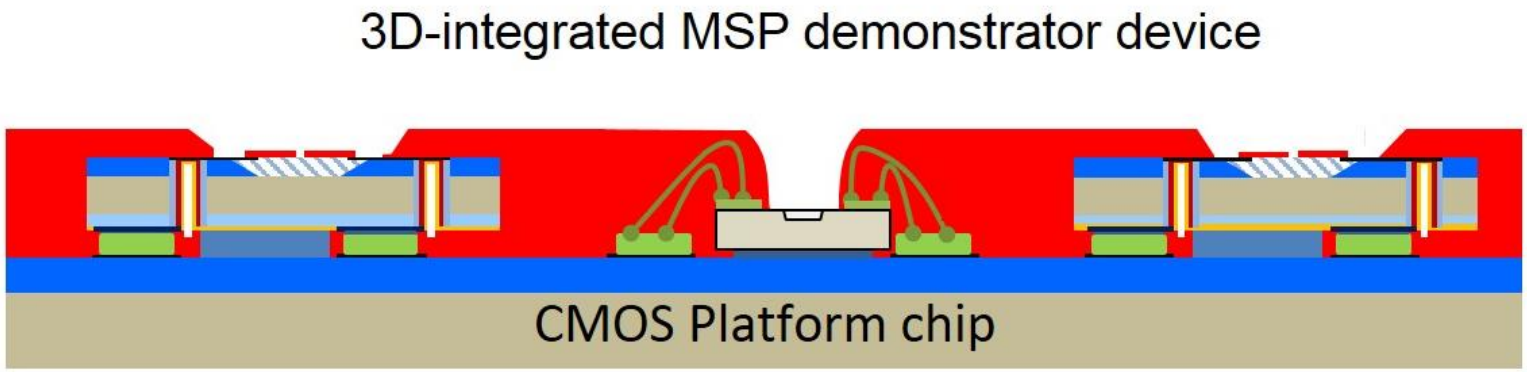
3. ACHIEVEMENTS & HIGHLIGHTS Y1

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



3. ACHIEVEMENTS & HIGHLIGHTS Y1

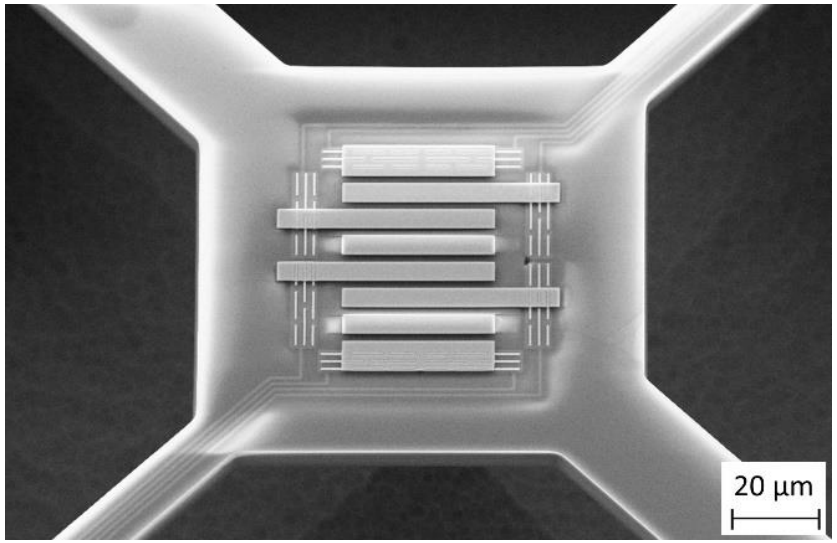
- We have moved from ppt.-presentation to real devices !

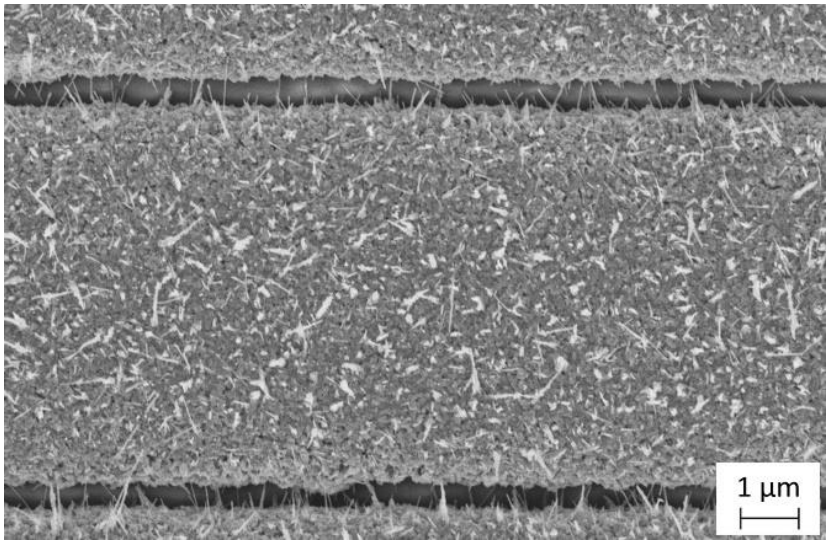


We have elaborated the „big picture“ !

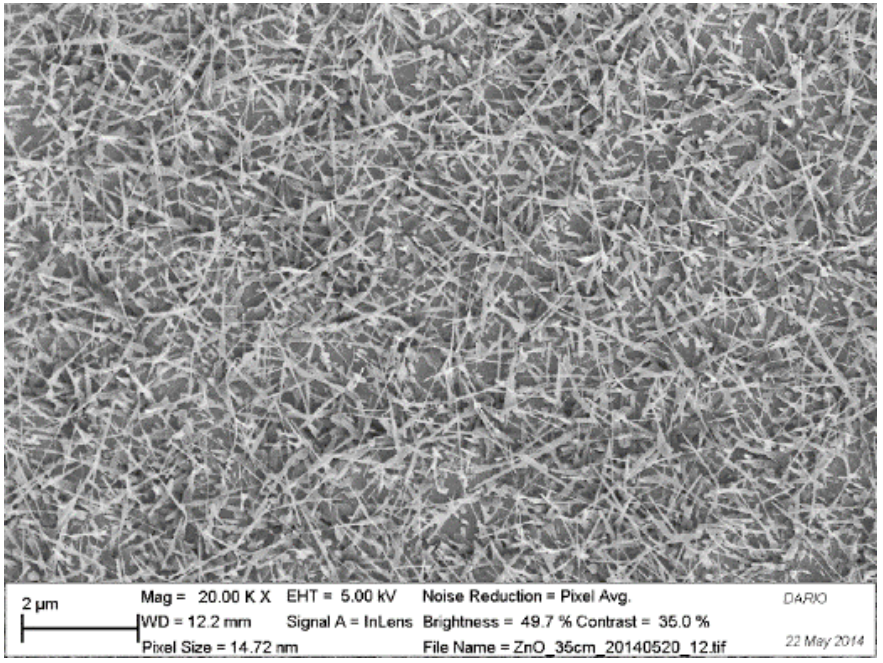
- Requirement specifications have been defined by end-users
- Impressive progress in the development of components and devices, a variety of highly sophisticated sensors based on graphene or nanowires has been developed
- Key design rules and parameters of the TSV structures have been elaborated
- The CMOS platform chip (Gen 1) has been designed
- A wireless system level architecture has been developed with best-in-class performance at world's lowest power consumption
- Elaboration of 3D-integration concepts including devices with TSV-based contact plugs and components requiring wire bonding
- Elaboration of preliminary process flows for overmolding and packaging.

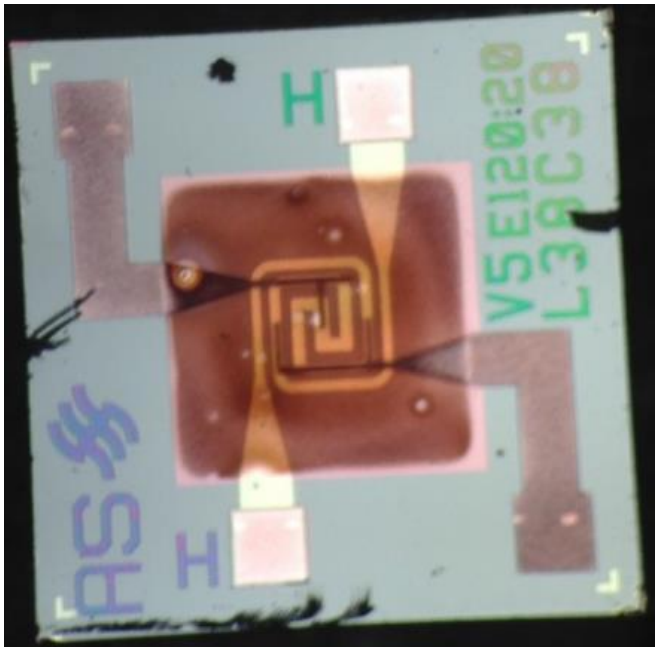
- CuO-NW gas sensor on AMS CMOS µhp



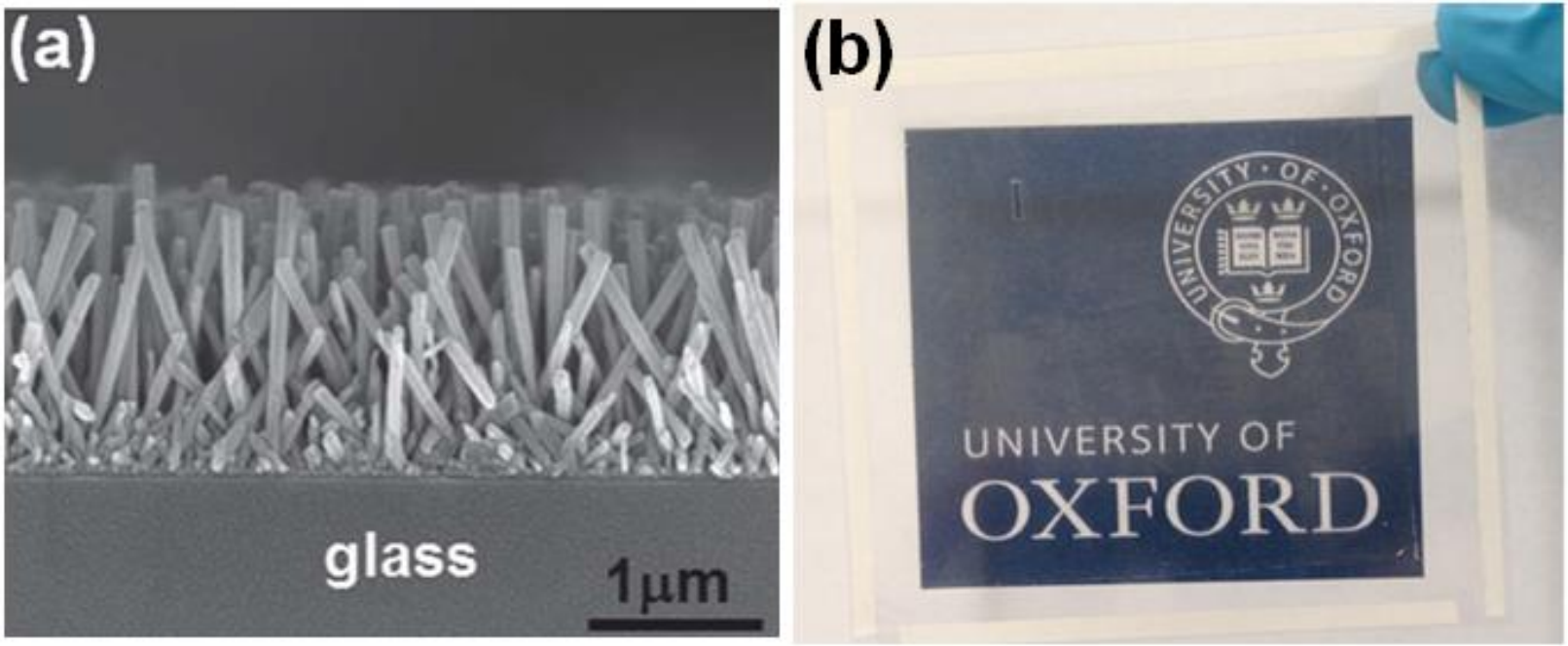


- ZnO-NWs synthesized on APPS µhp

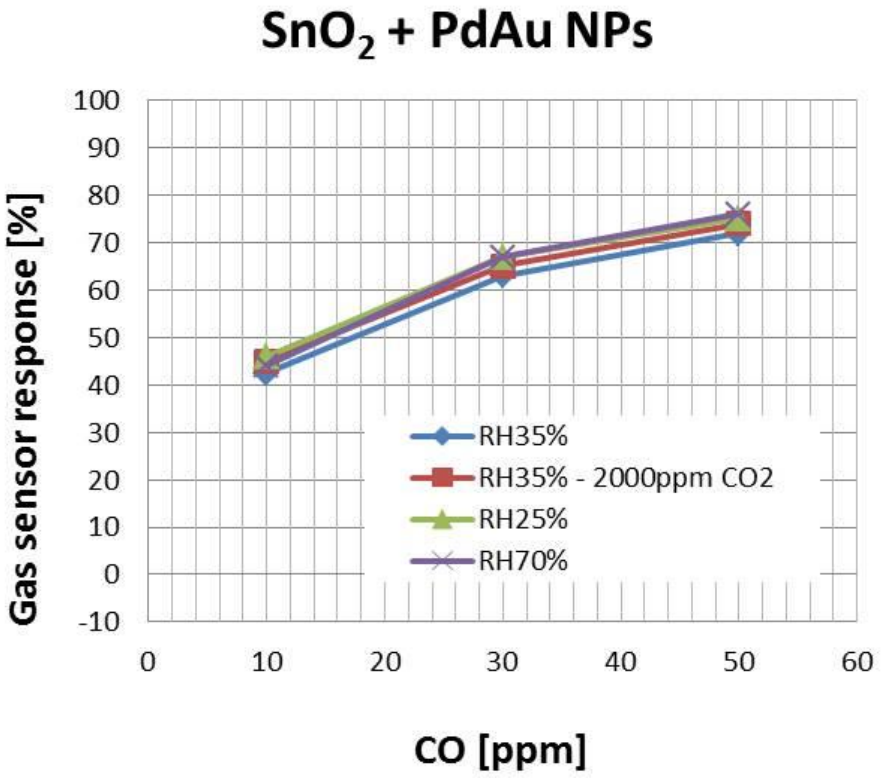


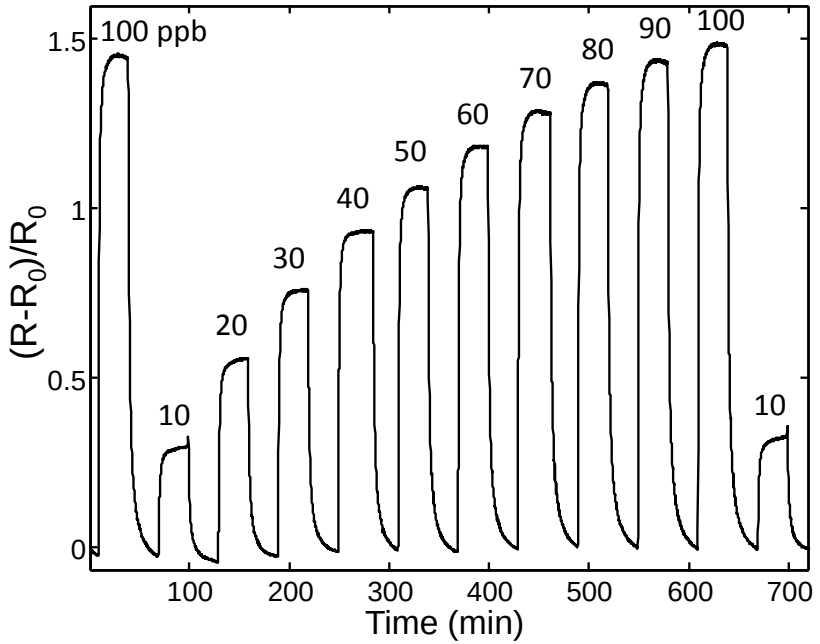


- PE energy harvester based on ZnO-NWs and PVDF-films

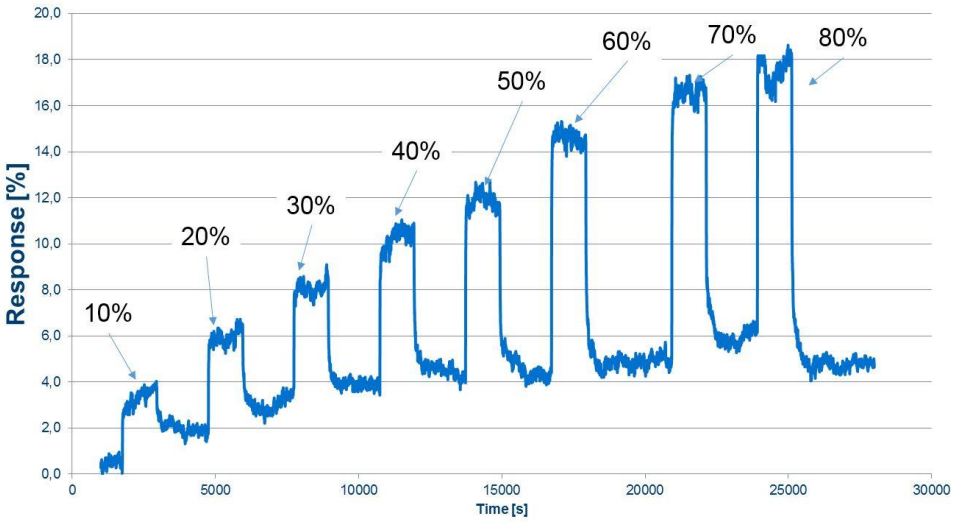


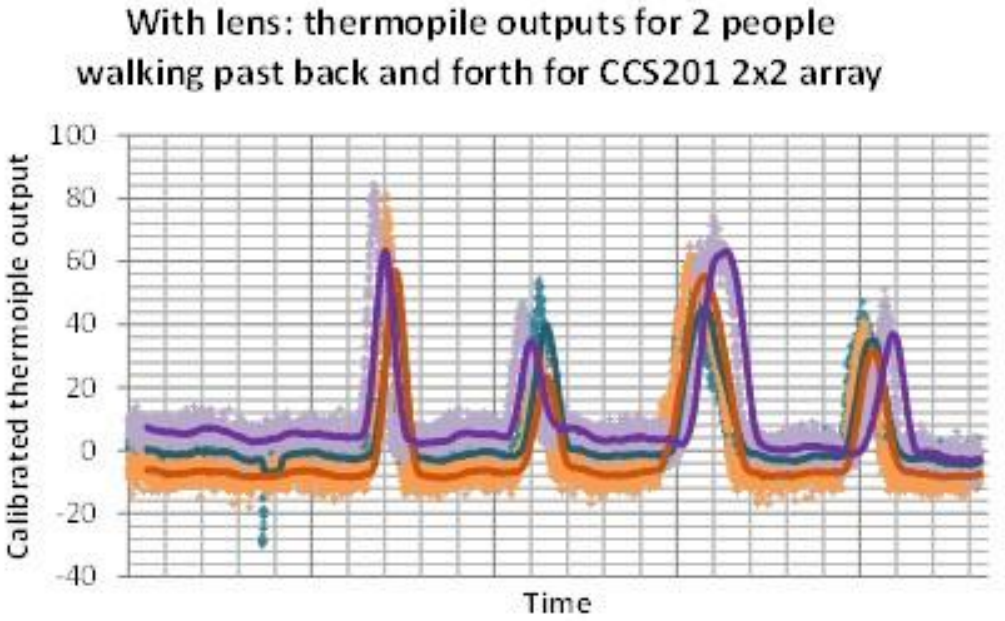
- Response of SnO_2-gas sensor functionalized with AuPd-NPs to CO
- Response of AlGaN/GaN gas sensor to NO_2





- Graphene gas sensor response to humidity
- IR sensor based on thermopiles

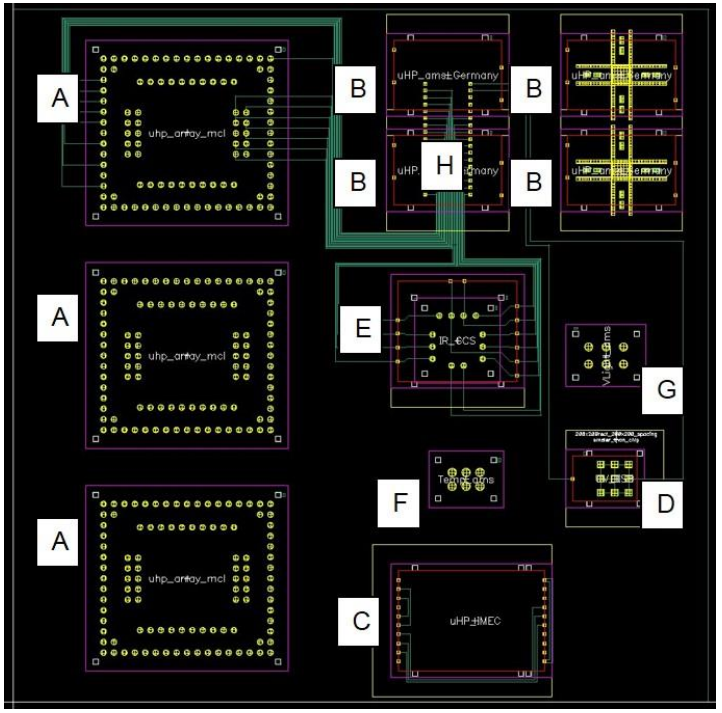




3. ACHIEVEMENTS & HIGHLIGHTS Y2

- P2: Sensor devices on PC2 are fixed (full size 2 x 2 cm^2)

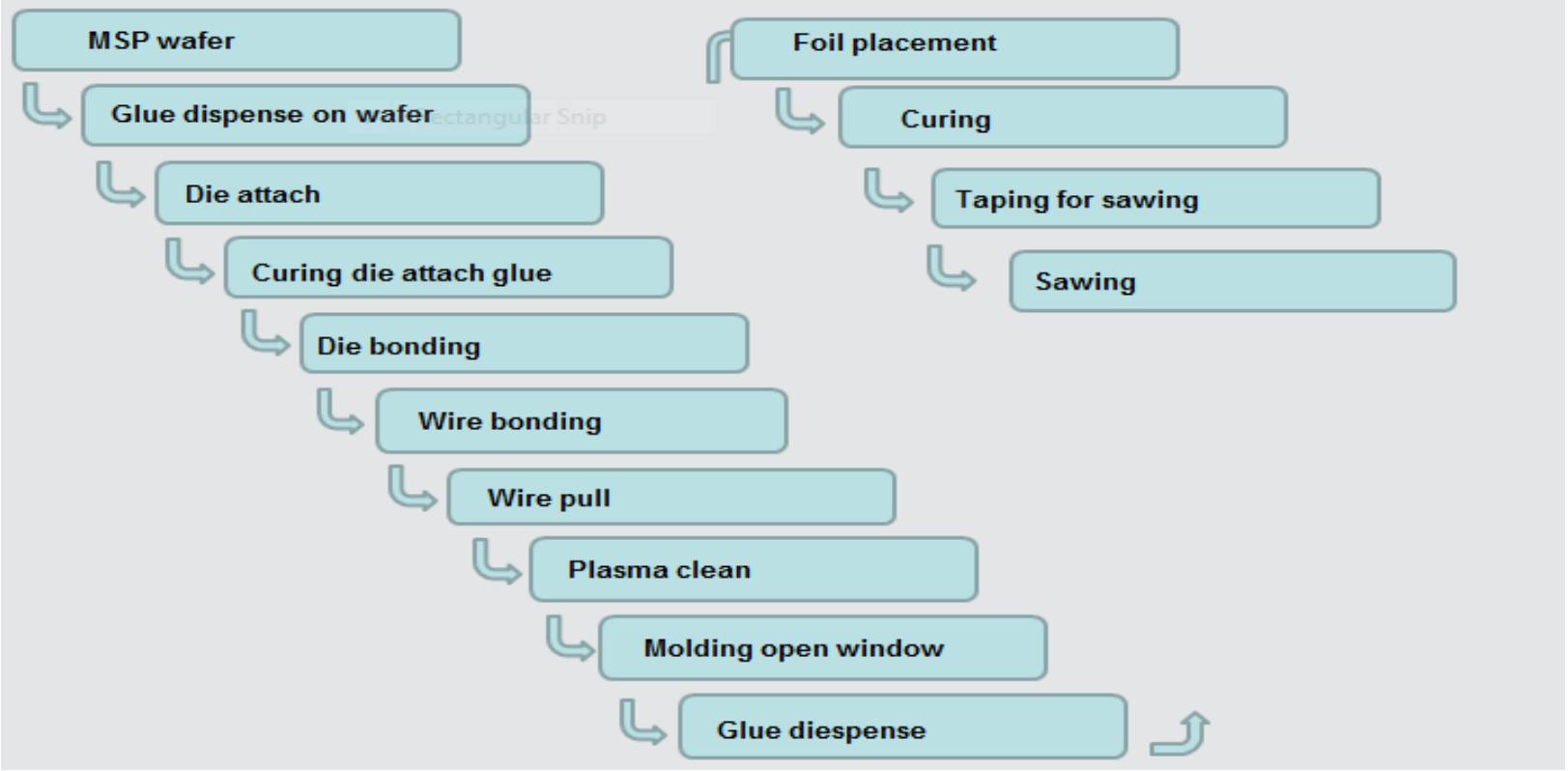
Sensor types	Kind of 3D stacking	Label
3 gas sensor µhp array chips (MCL/AMS)	TSV, Overmolded	A
4 gas sensor µhp chips (APPS)	Wirebonded	B
1 gas sensor µhp (IMEC)	Wirebonded, Overmolded	C
1 UV-A/B sensor (FHG-IISB)	Wirebonded, Overmolded	D
1 IR sensor array chip (CCS)	TSV, Overmolded	E
1 temperature sensor (AMS)	Flip Chip, Overmolded	F
1 V-light (AMS)	TSV, Overmolded	G



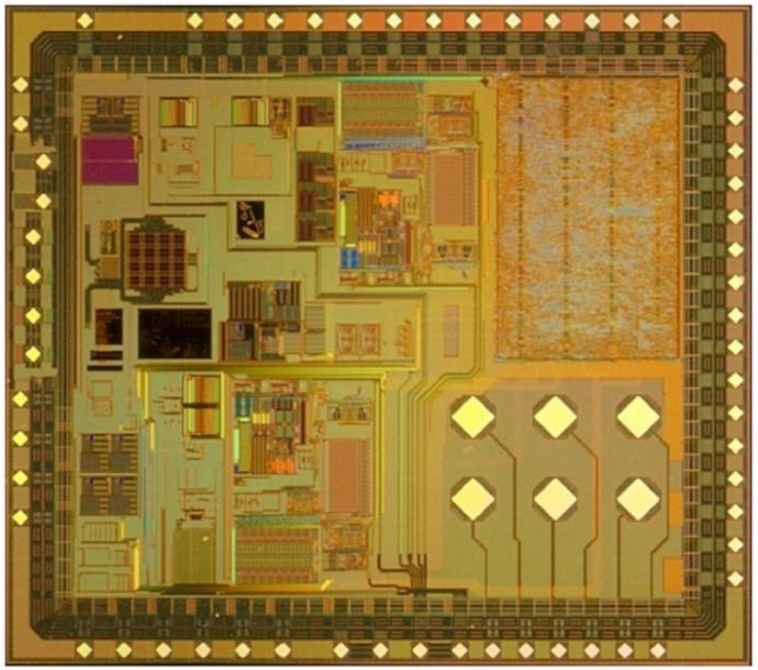
We have elaborated the „big picture“ No2!

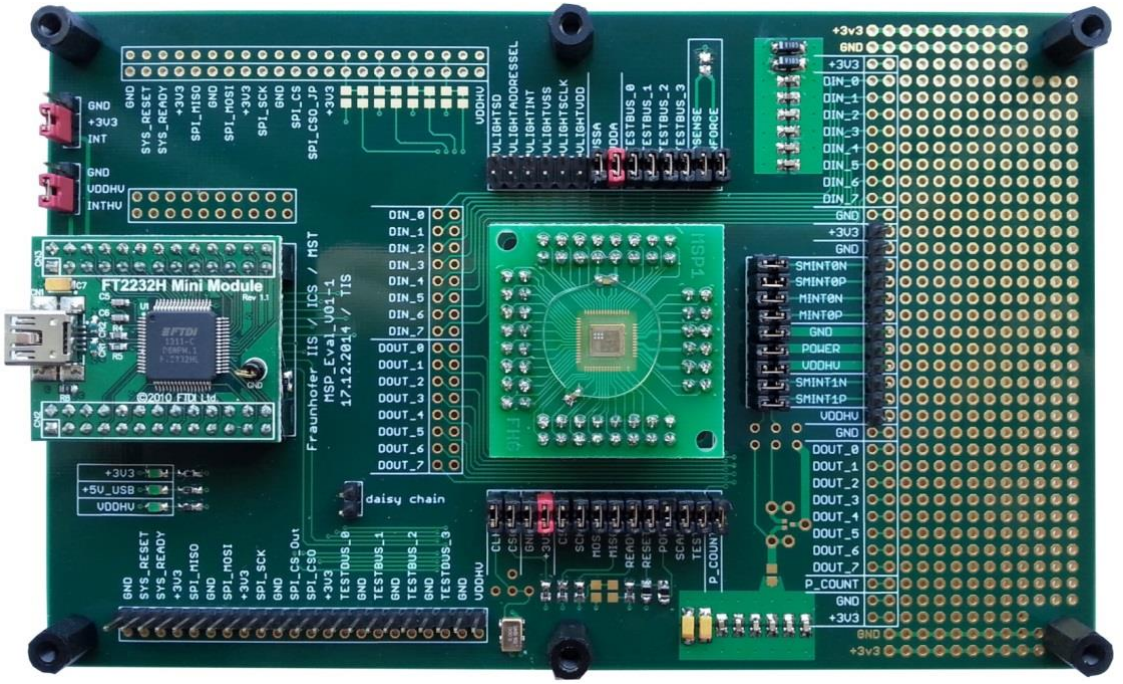
Examples:

- The CMOS platform chip (Gen 1) has been fabricated
- Development of D2D & D2W integration process flow

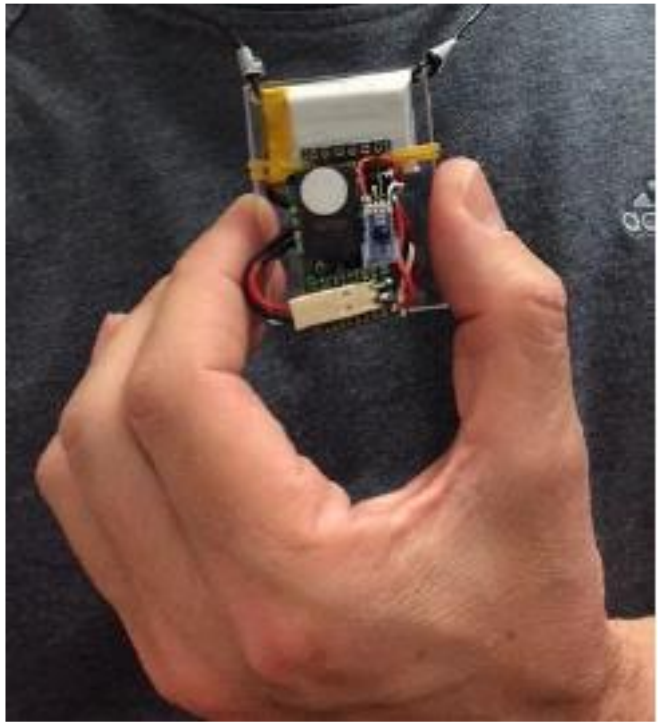


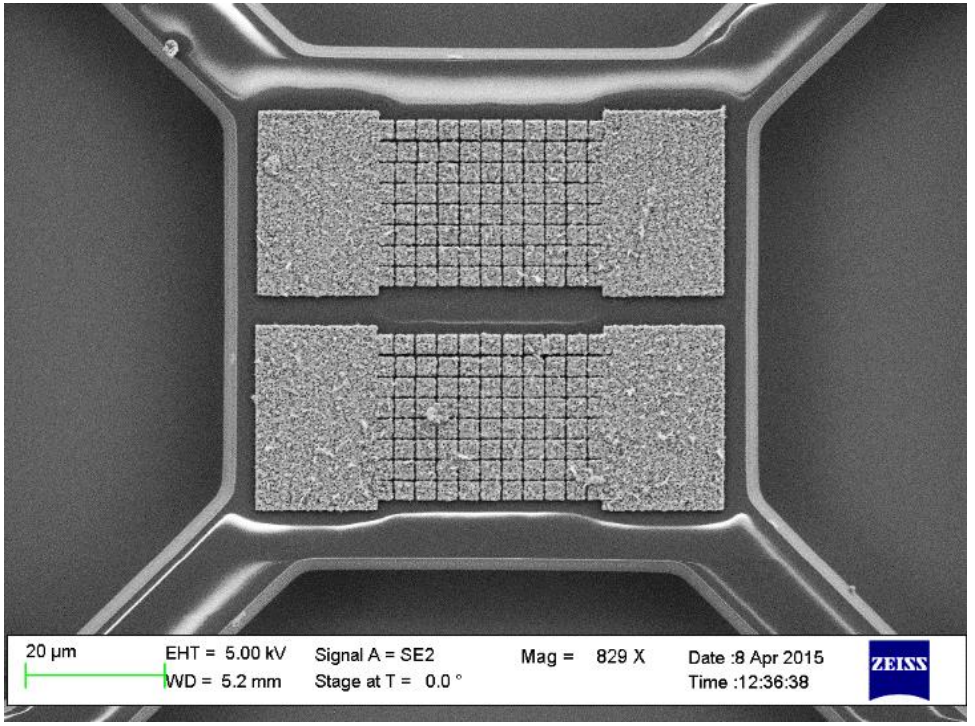
- PC1 platform chip with TSV connections for V-light sensor
- Eval-kit board for successfully operating all MSP sensor devices



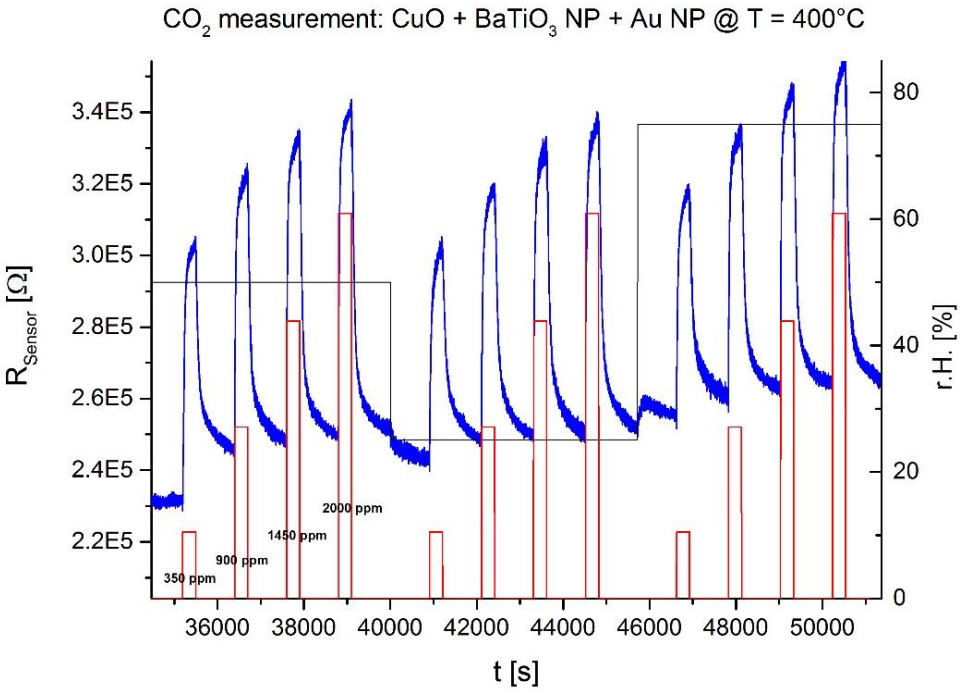


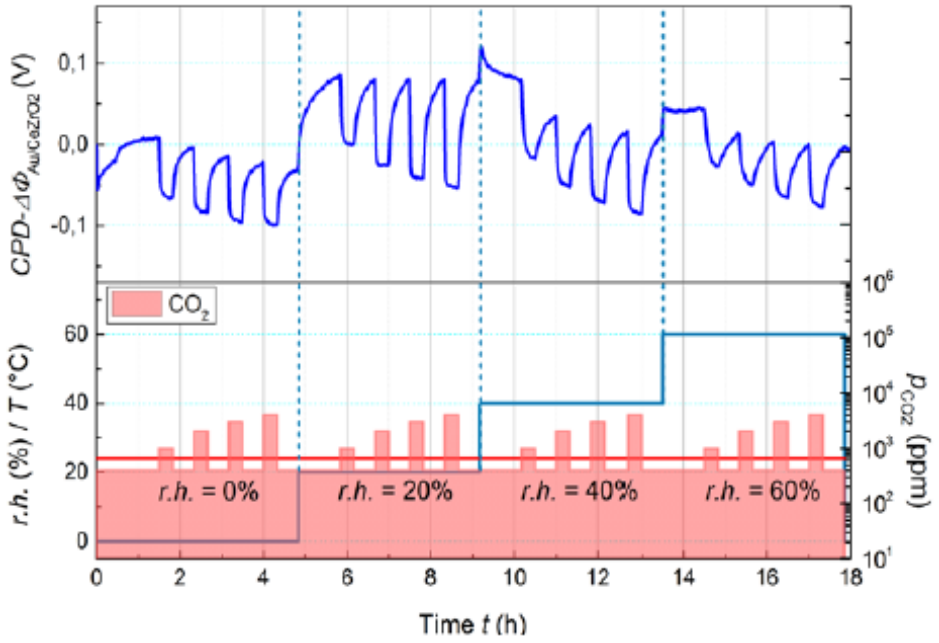
- Neck wearable data logger including an MOx sensor
- ZnO-NW-array implemented on CMOS-fabricated µhp-chip



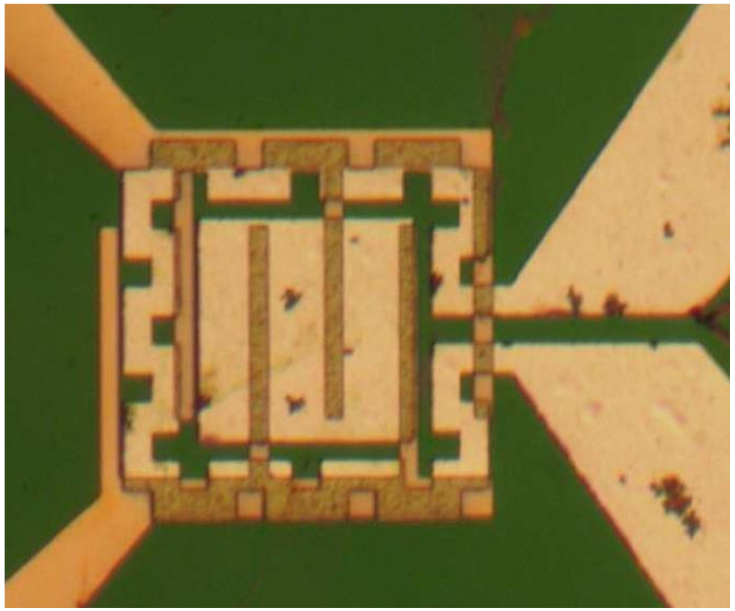


- CuO-NWs/NPs hybrid sensor for CO_2 at different levels of humidity.
- $CexZryO_2$ oxide based Kelvin Probe gas sensor to CO_2 at different levels of humidity





- Graphene-based gas sensor for formaldehyde fabricated on a µhp chip by PDMS transfer process
- P(VDF-TrFE-CTFE) based PE harvester with enough output power for driving 44 LEDs forming the MSP-letters

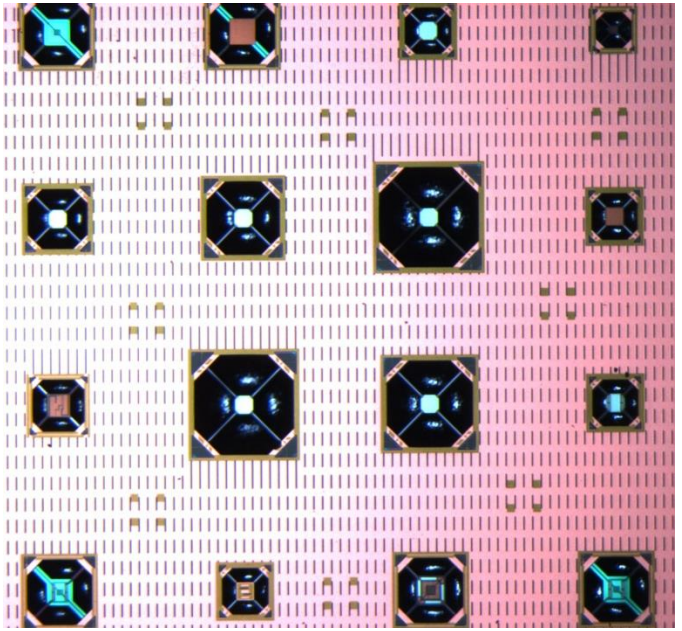


4. SUMMARY & …

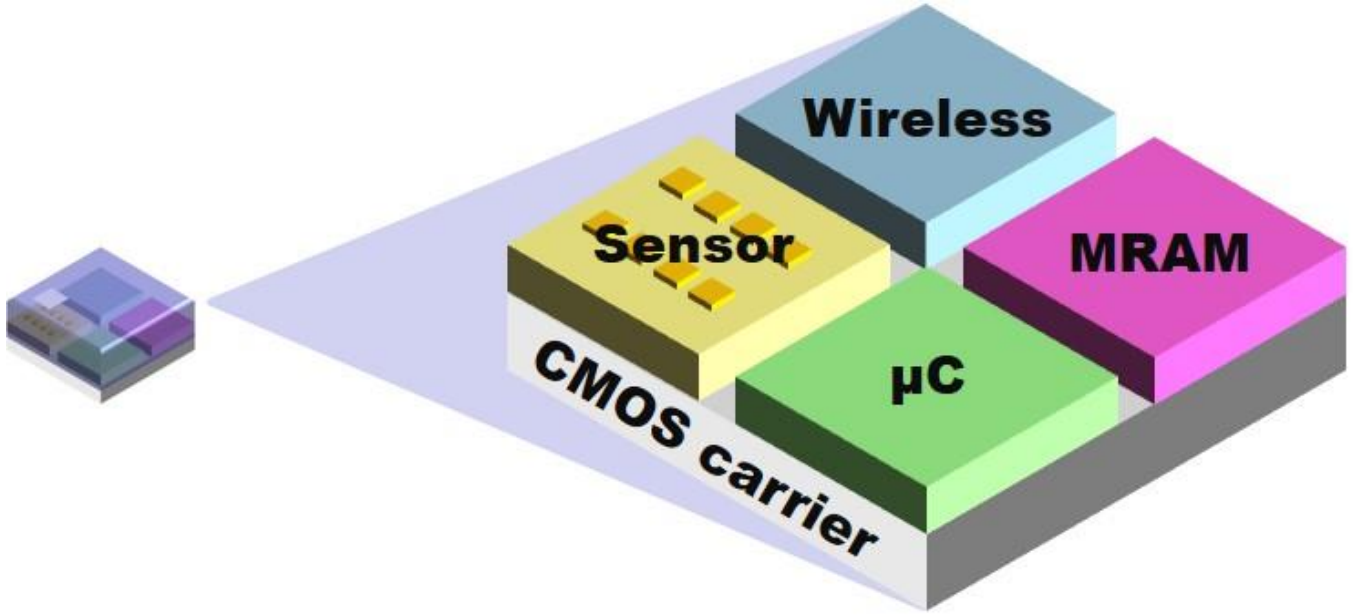
- Successful elaboration of the “big picture” No.2
- All devices being stacked on the PC2 are fixed now
- Impressive progress in the development of sensor devices
- The CMOS PC2 is in production
- Successful elaboration of process flow to overmolded devices (including external tasks) covering full value chain
- A wireless system level architecture has been developed designed to achieve best-in-class performance at world’s lowest power consumption
- MPW service with limited sensor functions has been announced!

4. … & OUTLOOK

- CMOS integration is a must for realization of smart systems !
- CMOS compatible fabrication (& postprocessing) is required for addressing “big markets” in consumer electronics
- Employment of integrated µhp arrays with different sensor materials is key to selective sensing !
- Use of pulsed mode operation in t- and T-domain should be exploited !



- Processing on wafer scale and W2W-approach
- Wireless connection !
- Data processing on board by implementation of µ-processor and memory
- Smart Sensor Systems for Internet of Things !

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2016
2nd International Conference
Functional Integrated nano Systems
27 - 29 June 2016, Graz / Austria

Eurosensors XXXII 2018 in Graz !

Dr. Anton Köck
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Munich and Zurich, January 14th, 2016

Confirmation of hosting the Eurosensors *XXXII*

Dear Dr. Köck, dear Anton

Congratulations!
On behalf of the Eurosensors International Steering Committee (ISC), we are glad to confirm that your bid for hosting the *Eurosensors Conference XXXII* in *Graz* in *2018* has been approved by the International Steering Committee in Freiburg on September 6th, 2015.
Your appointment as the General Conference Chair (GC) of Eurosensors XXXII becomes effective and binding upon return of your signed statement of acceptance (see below). Please return the statement of acceptance within four weeks from now to the Co-Chairs of the ISC (address see above), otherwise your appointment expires.