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

COST Action TD1105

WGs and MC Meeting at LINKOPING, 3 - 5 June 2015

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

LOW TEMPERATURE CO-FIRED CERAMIC PACKAGE FOR LAB-ON-CHIP APPLICATION

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EUROPEAN COOPERATION IN SCIENCE AND TECHNOLOGY

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

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Scientific context and objectives in the Action

- **Background / Problem statement:**

  Our group is developing a lab-on-chip application which will be used for evaluation of cytotoxicity of nanomaterials

- **Brief reminder of MoU objectives:**

  Our group is involved with WG1 (Sensor Materials and Nanotechnology)

  Our objective is to develop new sensor applied in cell viability monitoring during nanoparticle exposure to evaluate the safety of nanomaterials

Current research activities of the Partner (1/2)

- Low temperature co-fired ceramic package for CMOS capacitance sensor chip designed to detect surface attachement and morphology of adherent cells as viability indicator

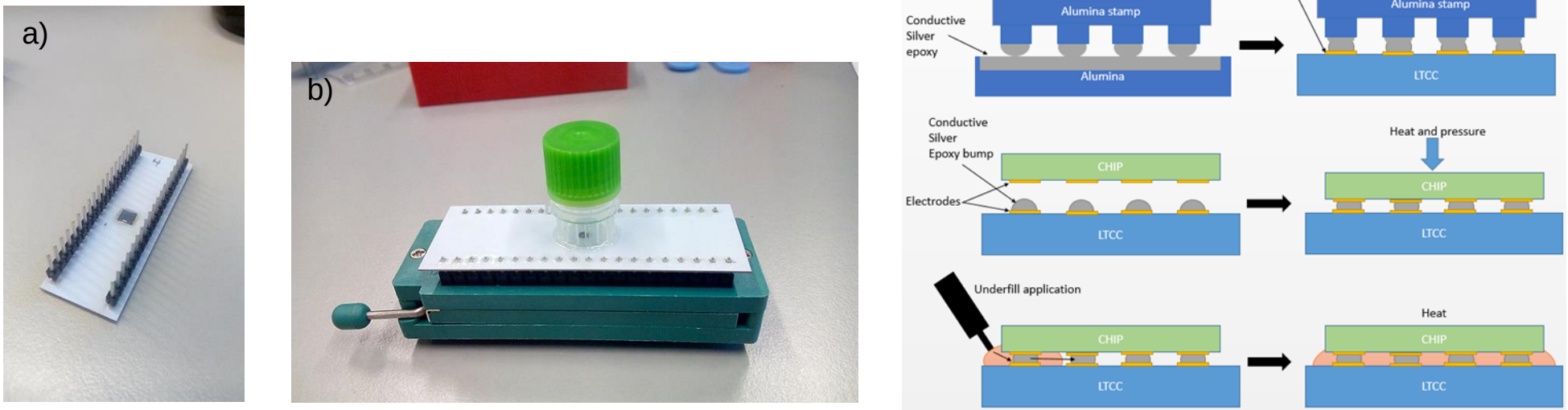


Figure 1. a) The sensor chip "flip chip bonded" on LTCC substrate; b) Cell vial on the top of the ZIF connected LTCC module; c) Scheme of the process steps to bond the chip on LTCC substrate

Current research activities of the Partner (1/2)

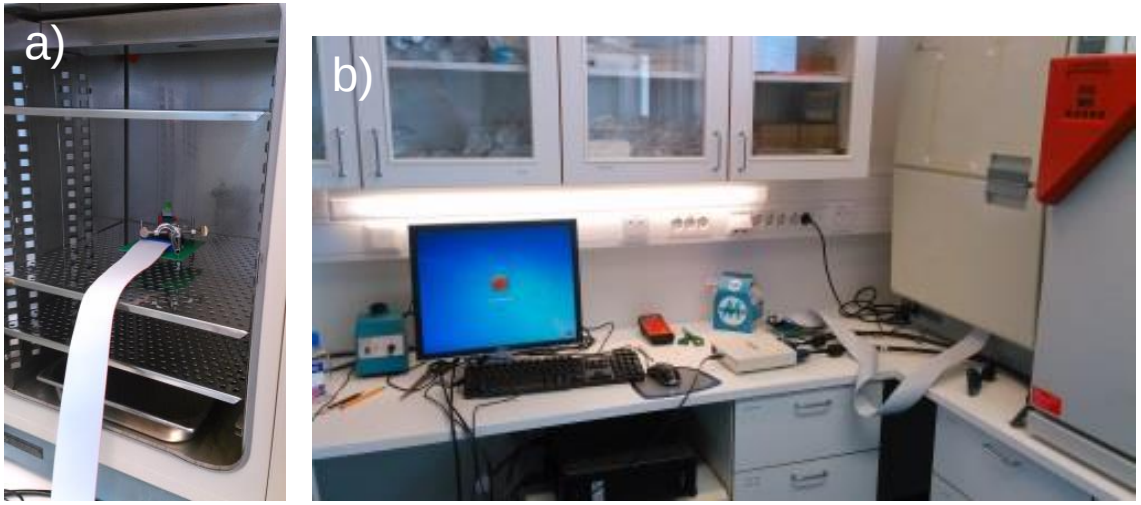


Figure 2. a) The sensor on LTCC module integrated on PCB inside cell cultivation incubator; b) The measurement set up outside the incubator including powering and adjusting PCB, DAQ and controlling computer and software

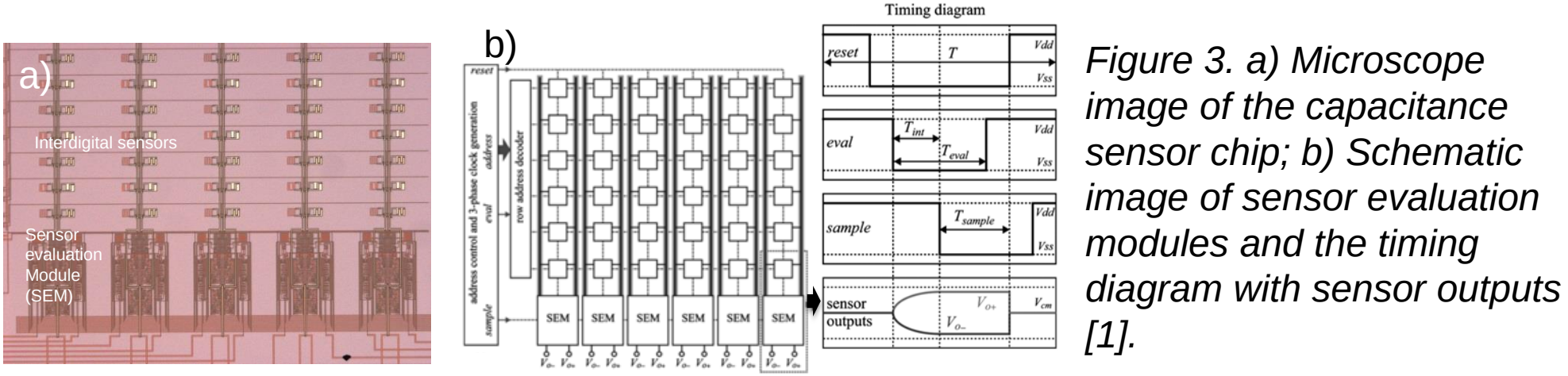
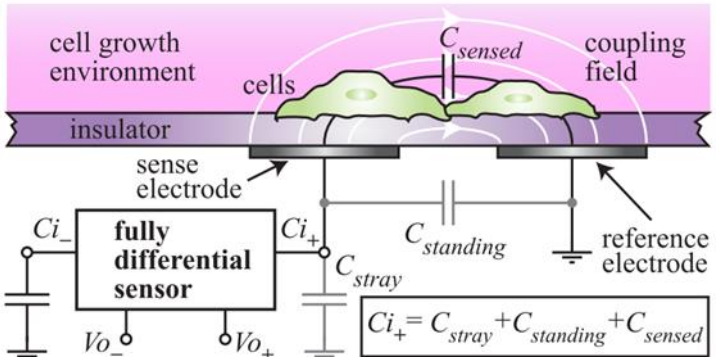


Figure 3. a) Microscope image of the capacitance sensor chip; b) Schematic image of sensor evaluation modules and the timing diagram with sensor outputs [1].

[1] Prakash SB and Abshire P (2009) A Fully Differential Rail-to-Rail CMOS Capcitance Sensor With Floating-Gate Trimming for Mismatch Compensation. IEEE Transaction on Circuits and Systems-I: Regular Papers 56:975-986.

Current research activities of the Partner (1/2)



$$\Delta C_i = C_{i+} - C_{i-}$$

$$\Delta V_o = V_{o+} - V_{o-} \approx 2 \cdot A_c \cdot V_{step} \cdot \frac{T_{int}}{T_{pw}} \cdot \frac{\Delta C_i}{C_{int}} + \Delta V_{os}$$

$$\Delta V_o \propto \Delta C_i$$

Figure 4. Sensor block diagram of the fully differential capacitance sensor chip and equations demonstrating the sensed capacitance correspondence to output signal as voltage.

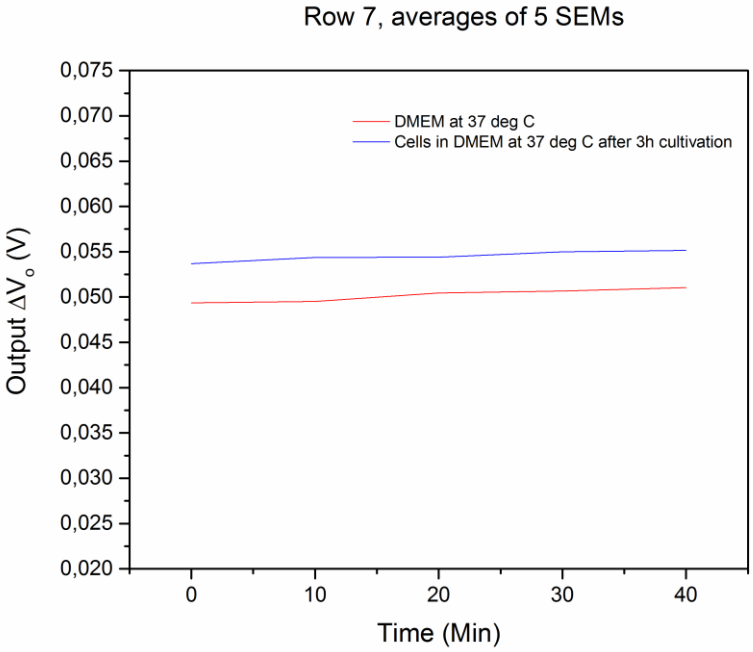


Figure 5. Preliminary sensor measurements with the LTCC packaged sensor chip and cells; blue curve only cell growth media on top of the chip; red curve cell growth media and BEAS2B cells on top of the chip after 3 hours of deposition. Note that the cells are in sedimentation stage, proper attachment takes place in 24 hour. Data taken from sensor row 7 as average of 5 SEMs.Data point taken in every 10 minutes.

Current research activities of the Partner (1/2)

- **Brief list of ongoing research topics of the Partner:**
- Suitable biocompatible packaging materials and methods for CMOS sensor chip
- Suitable sensors for health status of mammalian and plant cells
- Cytotoxicity evaluation of nanomaterials

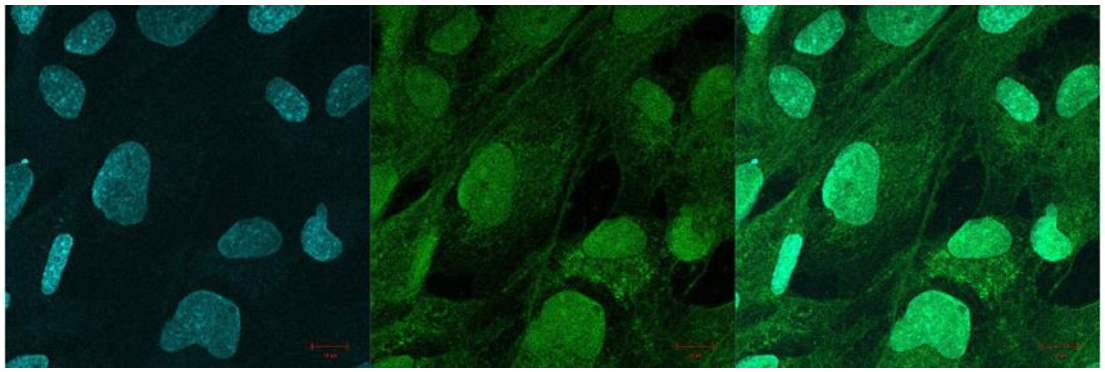


Figure 6. BEAS2B cells on packaged dummy chip, size of the cells are 10 – 30 µm

Research Facilities available for the Partner (2/2)

- **Research Facilities:**
- Research is done in collaboration with University of Oulu, Linköping University and University of Maryland
- Research is mainly implemented in the clean room and cell cultivation laboratory facilities at the University of Oulu
- Research collaboration includes electrical engineers, biochemists, chemists/materials scientist

Research Facilities available for the Partner (2/2)

- **Research Facilities:**
- In the electronics packaging research standard materials (LTCC, PCB, ceramic packages) and methods (wire bonding, flip chip bonding, conductive adhesives) are used.
- Microscopic tools (optical, scanning electron microscope) are used to inspect the quality of the package, electrical measurements (resistance monitoring) are used for reliability testing
- For the cell studies, standard assay kits and optical tools are used for reference data
- At some point, we may have to use animal testing to verify the results

Suggested R&I Needs for future research

- **Research directions as R&I NEEDS:**
- Since our research is highly multidisciplinary, it would be highly beneficial if the mobility of experts and their knowledge would be enhanced.
- Allocate resources to finance small workshops?

Suggested R&I Needs for future research to Action WGs/SIGs General Assembly

- **Research directions as WGs R&I NEEDS for Action TD1105:**
- Nanomaterial safety; not much is known about the health effects and nanomaterials are entering the consumer market
- New air quality indication methods; plant cells?

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