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

COST Action TD1105

WGs and MC Meeting at Cambridge, 18-20 December 2013

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Year 2: 1 July 2013 - 30 June 2014 (*Ongoing Action*)

Research and Innovation Needs of WG1

UNIVERSITY of OULU
OULUN YLIOPISTO

Prof. Jyrki Lappalainen,

WG1: Sensor Materials and Nanotchnology (Vice-Chair)

University of Oulu / Finland

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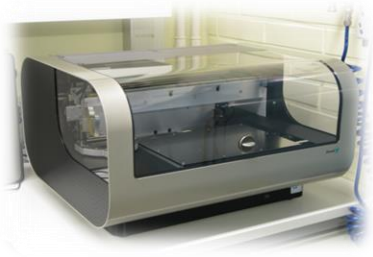
Challenges in Air Quality Control

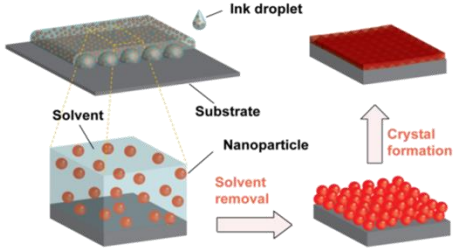
Background / Problem statement: [What is the scientific context and what challenges are the Action WGs/SIGs addressing?]

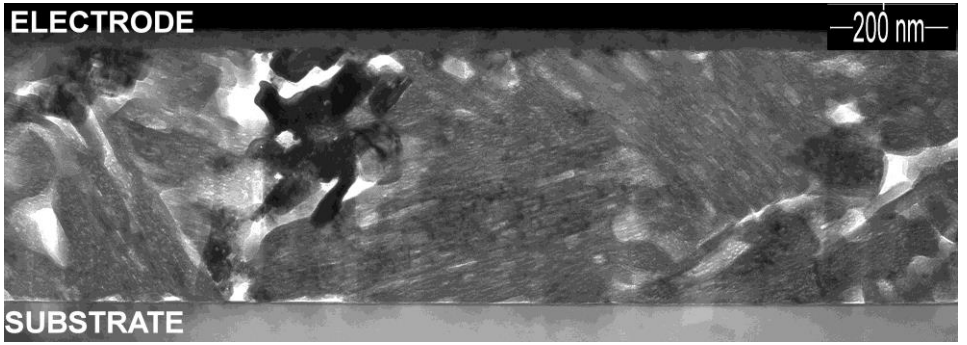
- **Background / Problem statement:**
  - Development of new sensitive and selective gas sensor materials for environmental quality control, public safety issues, medical, automotive applications, air conditioning system setups in aircrafts, spacecrafts, vehicles, houses, etc.
- **Brief reminder of MoU objectives:**
  - Study the sensitivity of nanostructured MO films to harmful gases, *e.g.* NO_x, NO_2, H_2, and VOC's
  - Utilizing grain size and phase transition effects
  - Fabrication of sensors on flexible substrates PET/PEN substrates using printing techniques

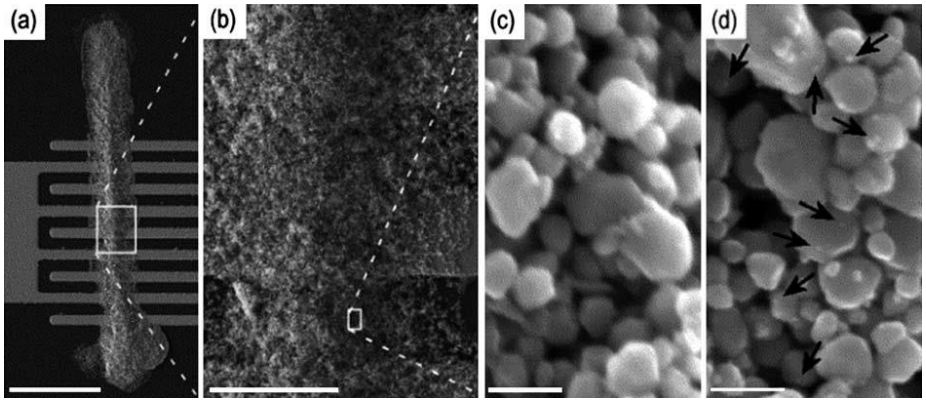
Research Goals in Air Quality Control

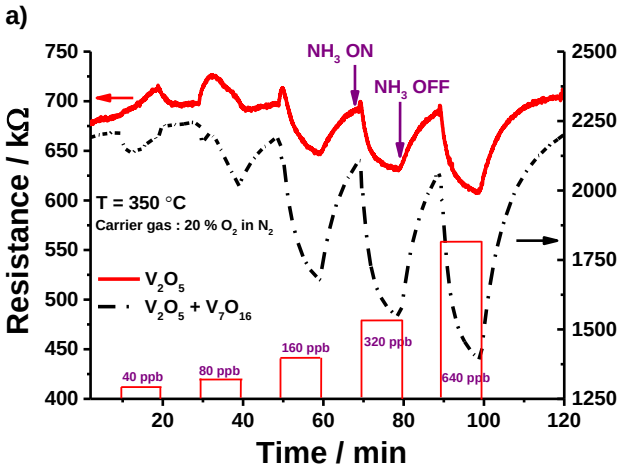
- **Background / Problem statement:** [What is the scientific context and what research goals are the Action WGs/SIGs addressing?] – **Lappalainen et al.**
  - **Inkjet-printing and low-temperature processing of decorated WO_3 nanoparticles on various substrates for selective gas sensing**
  - **PLD of mixed phase V_2O_5 and V_7O_{16} porous nanostructured MO thin films for ppb-level NH_3 sensing for selective catalysis reactions**







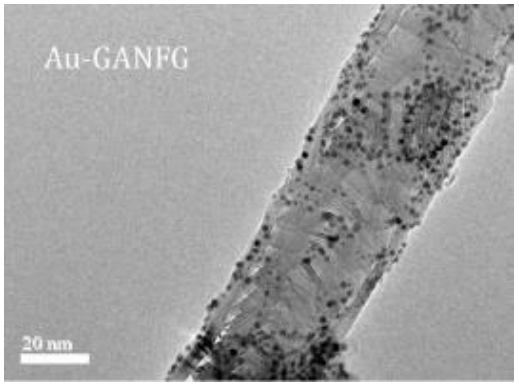




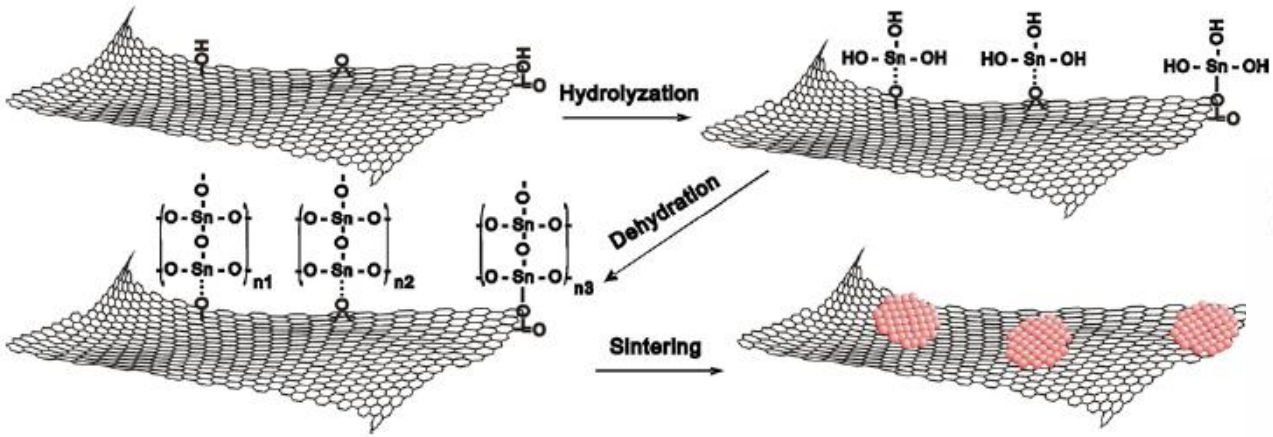
Research Goals in Air Quality Control

- **Background / Problem statement:** [What is the scientific context and what research goals are the Action WGs/SIGs addressing?] – **Llobet et al.**

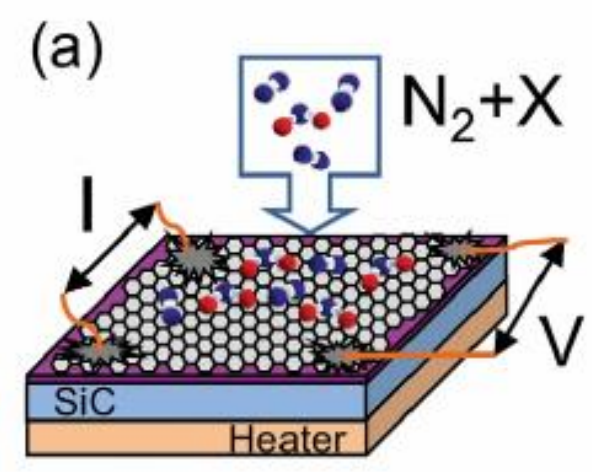
- **Latest developments SnO_2/graphene nanocomposites; RGO+5 nm SnO_2 NPs., working temperature: 210ºC, LOD for benzene: 5ppb.**
- **Latest developments Au or Pd-doped carbon nanofibres.**
- **High response for NH_3 and fast recovery of Pd-decorated carbon nanofibrse for flexible sensors operated at RT.**



S. Claramunt et al., *SNB* 187 (2013) 401



F.L Meng et al., Analytica Chimica Acta 736 (2012) 100



I. Yezhokin et al., APL. 103, 053514 (2013)

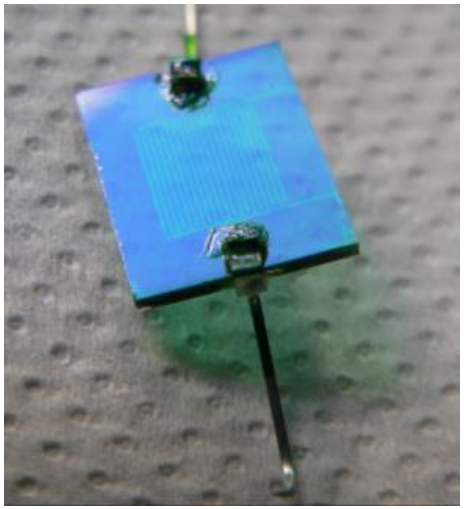
Research Goals in Air Quality Control

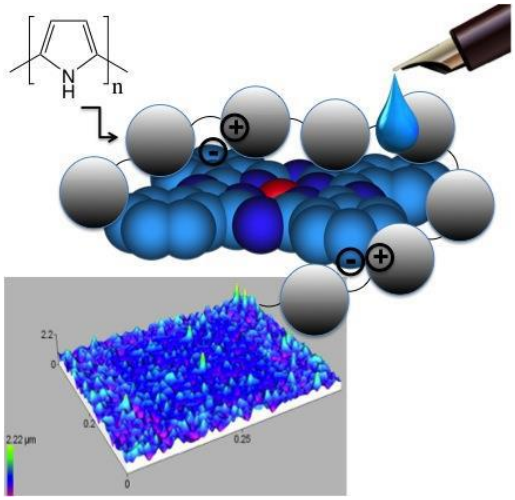
- **Background / Problem statement:** [What is the scientific context and what research goals are the Action WGs/SIGs addressing?] – **Bouvet et al.**

- **The tuning of properties by molecular engineering: morphology, roughness and specific surface, hydrophilicity or hydrophobicity, processability, electrical properties**

- **One way: to combine materials for improving chemosensing!**

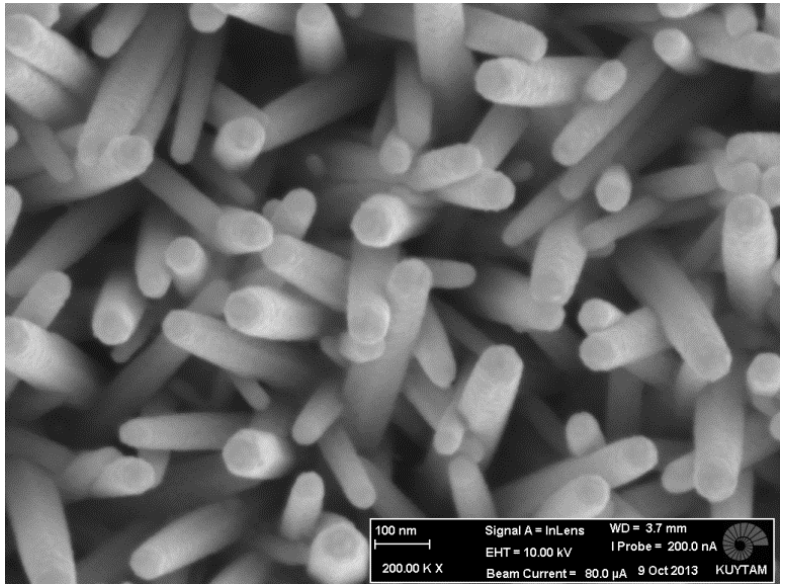
- **Humidity-insensitive ammonia sensors**
- **Molecular Semiconductor- Doped Insulator (MSDI) heterojunctions as new conductimetric transducers**
- **New polymer/macrocycle hybrid materials (e.g. PPy/sulfonatedPc)**
- **Bioelectrochemical sensors for detection of odorants with OBP**

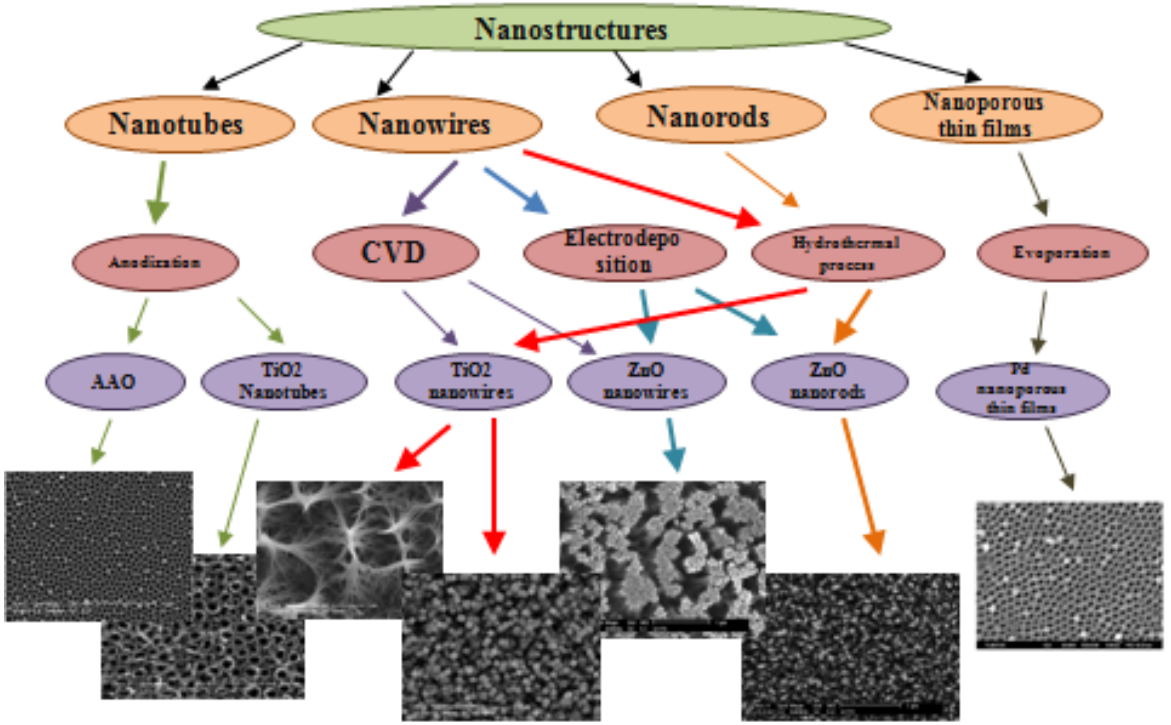




Research Goals in Air Quality Control

- **Background / Problem statement:** [What is the scientific context and what research goals are the Action WGs/SIGs addressing?] – **Özturk et al.**
  - **Hydrothermal synthesis of various microstructures of ZnO nanostructures, also with Cr- and Ni-modifications on seed layer coated glass substrate**
  - **Optimization of sol-gel spin-coating process for ZnO nanorods**

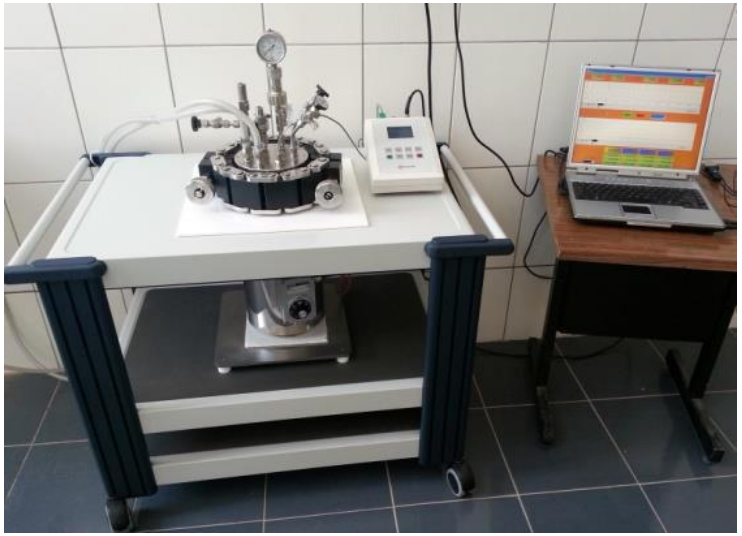




Research Goals in Air Quality Control

- **Background / Problem statement:** [What is the scientific context and what research goals are the Action WGs/SIGs addressing?] – **Rusti et al.**

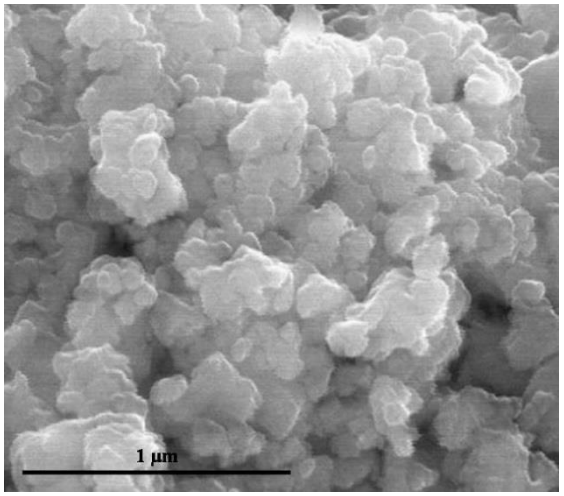
- **Doped $Ba_xSr_{1-x}TiO_3$ nanostructured materials with potential for H_2S detection**
- **Gas sensistivity originates from Cu-doping, bimodal size distribution**
- **Hydrothermal synthesis and thick-film processing; low-cost mass-production processes**

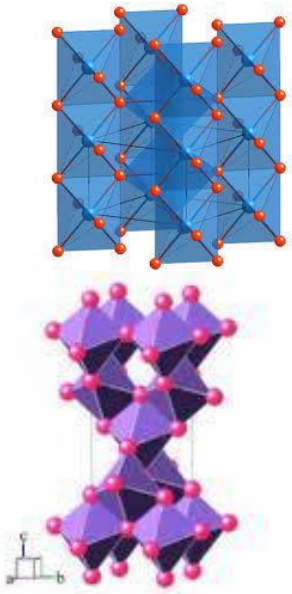


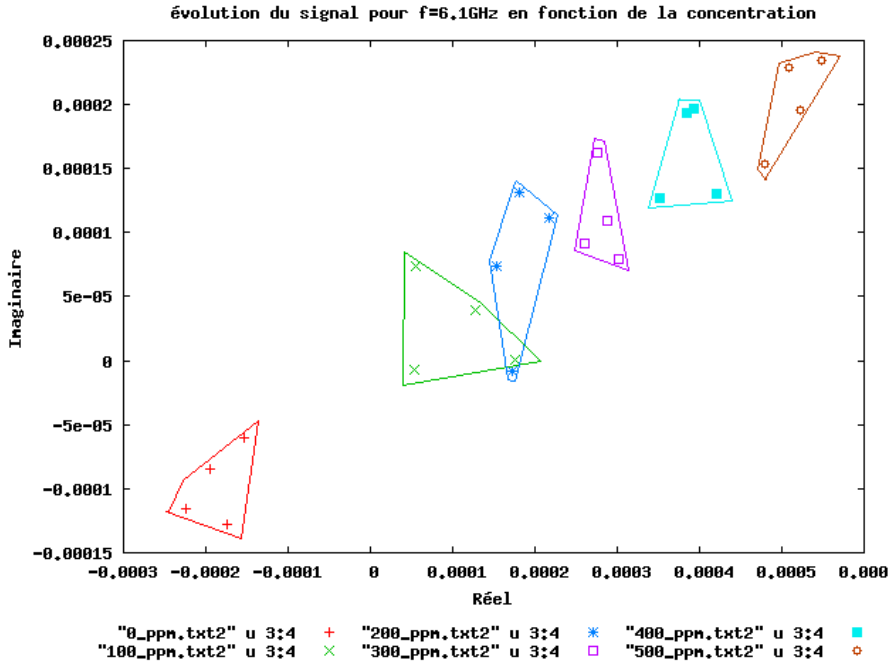
Research Goals in Air Quality Control

- **Background / Problem statement:** [What is the scientific context and what research goals are the Action WGs/SIGs addressing?] – **Rossingnol et al.**

- **Microwave thermohydrolysis assisted fabrication of SnO_2 and TiO_2 nanopowders**
- **Gas sensistivity measurements also upto microwave frequencies**
- **Different gas concentrations can be deduced from impedance response of the sensor by separating real and imaginary parts of the spectrum**







WGs Recommended Literature in Air Quality Control

- **Background / Problem statement: [Recommended literature; something to start with:]**
  - **B. Kumar et al., Nano Letters 2013, 13, 1962**
  - **G. Chen et al., Applied Physics Letters 2012, 101, 053119**
  - **J. Kukkola et al., Journal of Materials Chemistry 2013, 22, 17878**

Priority Innovation Requirements in Air Quality Control

- **Research directions as WGs PRIORITIES for Action TD1105:**
  - Other materials; biomaterials, entsymes, antibodies, etc.
  - Molecular, organic/inorganic materials:
    - Heterostructures of semiconductors and polymers, Schottky junctions
  - Processing innovations of low cost and/or mass-production sensors:
    - Printing techniques; inkjet printing, spin-coating, etc.
    - Template assisted growth of nanostructures
    - Influence of processing technique on sensor response
  - Chemical modification of materials for tuning properties for selectivity and specific applications
  - Combination of different approaches and defining the the state art of technologies available, for example, to realize smart sensor materials

CONCLUSIONS

- **Research directions as WGs R&I NEEDS for Action TD1105:**
- Selectivity improvement using various material structures, functionalizations, and combinations, device structures.
- To stabilize the structure and morphology of sensing materials for a higher stability of the response of sensors.
- Knowledge of the physiochemical interaction phenomena and modeling of the sensor ‘s gas response, including gas transformation, surface reactions, etc.
- Few materials should be chosen, e.g. one metal oxide prepared as nanoparticles and one molecular material deposited as thin films.
- In order to obtain a confident opinion on the performance of a material, in terms of stability and reproducibility of the sensing response, the **inter-laboratory reproducibility of materials** should be studied.
- The effect of RH on the response of sensors must be studied, not only at one particular value, but also in a broad RH range.