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

COST Action TD1105

1ST TRAINING SCHOOL

Universitat de Barcelona, Spain, 13 - 15 June 2013

organized by UB, MIND-IN2UB - Dept. of Electronics and CSIC-IDAEA

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

Year 1: 2012 - 2013 (*Ongoing Action*)

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COST is supported by the EU Framework Programme

ESF provides the COST Office through a European Commission contract

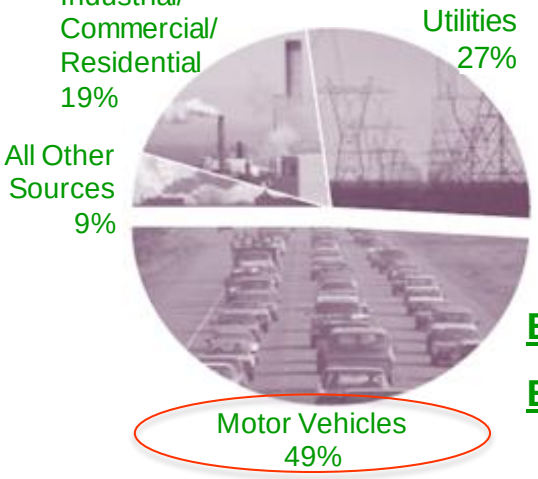
Expertise in Sensor Materials & Nanotechnologies

- **Expertise 1 statement:** Sol-gel and electrochemical synthesis of metal-oxide nanoparticles (e.g. ZrO_2, ZnO_2, In_2O_3 etc.) and their electrochemical functionalization with Au nanoparticles.
- **Expertise 2 statement:** Chemical, structural and morphological characterization of nanostructured materials by XPS, XRD, SEM and TEM.

Current research activities

SYNTHESIS AND ANALYTICAL CHARACTERIZATION OF NANOCOMPOSITES FOR NO_X SENSORS

➢ **Where does NO_X come from?**

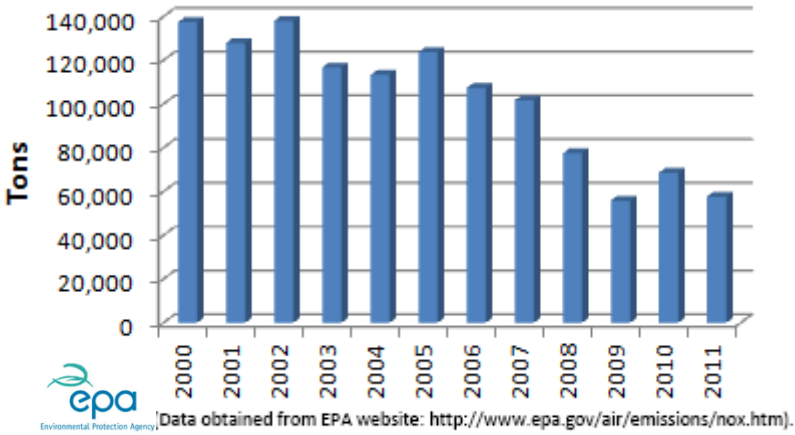


➢ **NO_X VEHICLES EMISSION LIMITS:**

EURO 5 (present- August 2014) **180 mg/km**

EURO 6 (from September 2014) **60 mg/km**

Annual NO_X emissions



Strict emission standards and the increasing awareness have induced the growth of exhaust sensor market.

LIMITATIONS: ***Current gas sensors address only a partial set of sensing needs.***

- **Sensitivity/Detection Limit**
- **Selctivity**
- **Kinetic response**
- **Temperature range**
- **Stability and Reproducibility**
- **Life Time**

Current research activities

PLAN OF WORK: ***To develop novel metal-oxide nanostrucutres as active materials for NOx sensing***

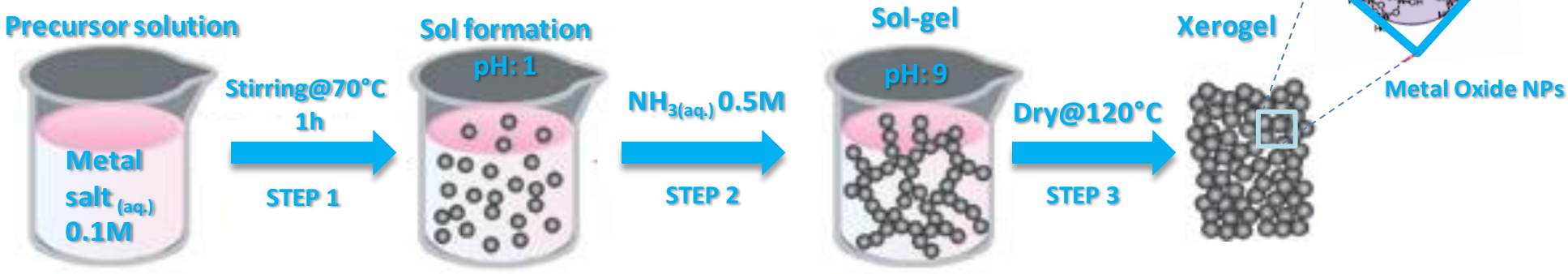
✓ Wet-chemical (sol-gel, electrochemistry) synthesis of Metal Oxide Composite nanoparticles (ZrO_2, ZnO, In_2O_3) with different morphologies, shape (nanoparticles, nanorod, etc.).

✓Surface electrochemical decoration of Metal Oxide with NPs catalyst (e.g. Au) to improve gas sensing properties.

✓Chemical, structural and morphological characterization of nanocomposites by X-ray photon electron spectroscopy (XPS), X-ray Diffraction (XRD), Scanning electron microscopy (SEM) and Transmission electron microscopy (TEM).

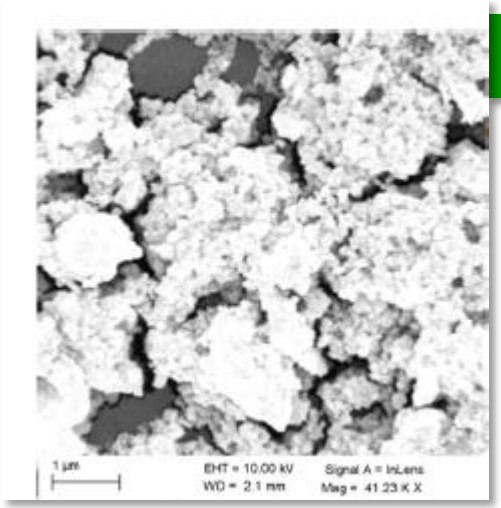
Achieved RESULTS and future activities

1. Sol-gel M-Ox syntesis



1) $\equiv M\text{-}X + H\text{-}OH \longrightarrow \equiv M\text{-}OH + H\text{-}X$ 2) $2 \equiv M\text{-}OH \longrightarrow \equiv M\text{-}O\text{-}M \equiv$ 3) $n \equiv M\text{-}O\text{-}M \equiv \longrightarrow MO_{X\,(nanoparticles)}$

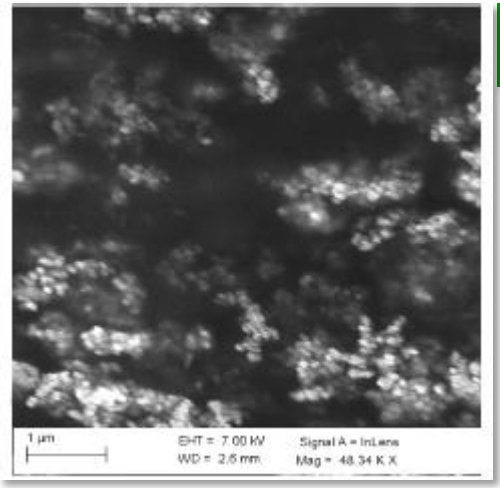
➢ **ZrO_2 *as prepared***



O/Z $_{(XPS)}$= 3.2

$ZrO_2/Zr(OH)_4$

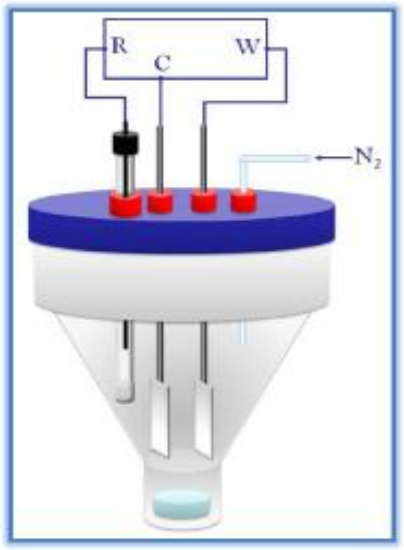
➢ **ZrO_2 *calcinated@550°C***



O/In $_{(XPS)}$= 2

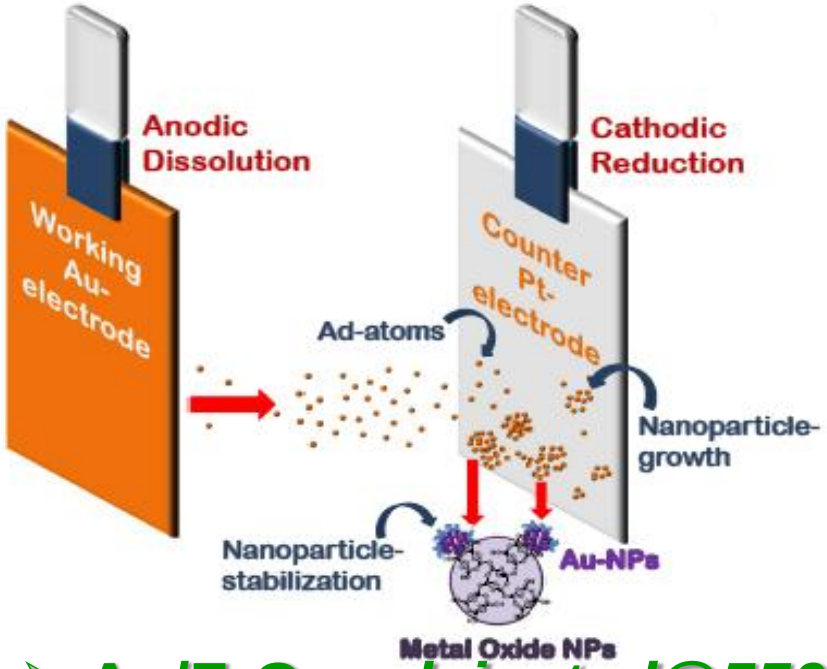
ZrO_2

Innovation: Electrochemical Au-functionalized M-Ox NPs

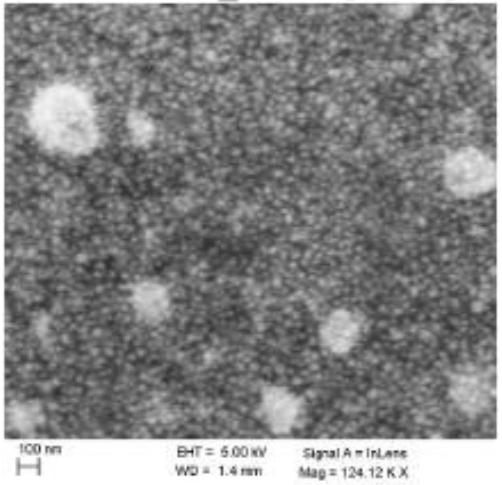


$$M_{(bulk)} \rightarrow M^{n+} + n\,e^-$$

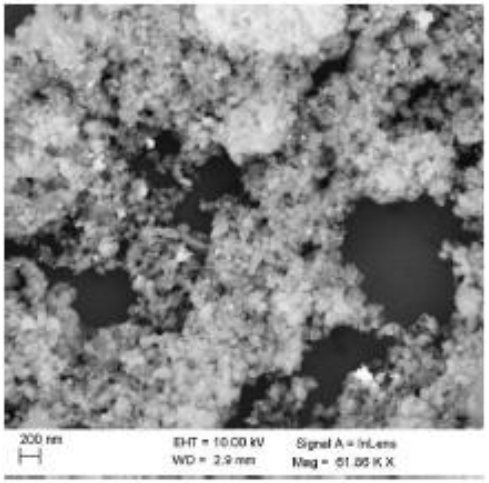
$$M^{n+} + n\,e^- \rightarrow M_{(nanoparticles)}$$



- **Au/ZrO_2 *as prepared***



- **Au/ZrO_2 *calcinated@550°C***



CONCLUSIONS

- Wet-chemical synthesis and electrochemical Au NPs functionalization of M-Ox nanocomposites thermally stable at high operation temperature (500°C).

Future Plans

- Sensor fabrication and testing of synthesized nanostructures as active materials for NOx sensor in collaboration with Dr M. Penza (ENEA, Unità Tecnica Tecnologie dei Materiali, Brindisi).
- Material and device optimization.
- In situ control of NOx sensing mechanism.