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

COST Action TD1105

WGs and MC Meeting at Rome, 4-6 December 2012

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

Year: 2012-2013 (*Starting Action*)

Prof. Jyrki Lappalainen

WG1: Sensor Materials and Nanotechnology (Vice-Chair)

University of Oulu / Finland

UNIVERSITY of OULU
OULUN YLIOPISTO

COST is supported by the EU Framework Programme

ESF provides the COST Office through a European Commission contract

Scientific context and objectives in the Action

- **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

University of Oulu

Founded in 1958

6 faculties

17 000 students

3 000 employees

Total funding EUR 208 million

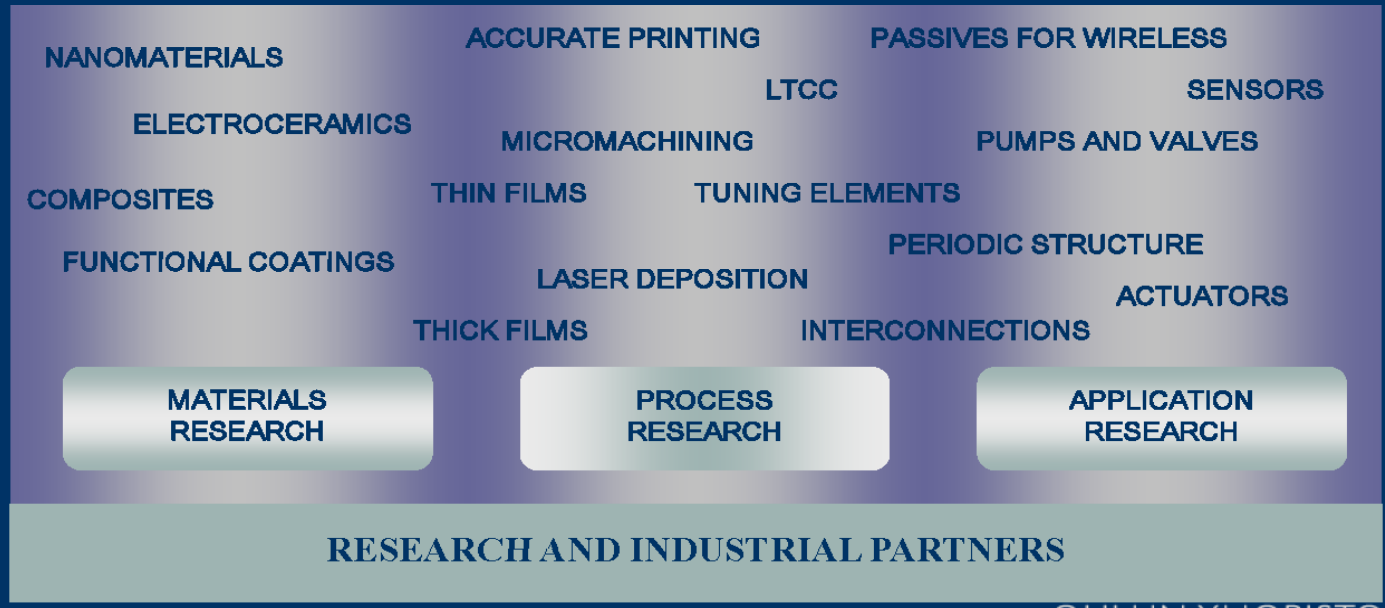
Among the largest universities in Finland with an exceptionally wide scientific base

OULUN YLIOPISTO
UNIVERSITY of OULU

Microelectronics and Materials Physics Laboratories

DESCRIPTION OF THE LABORATORY

- employees ~ 50 (Dec. 2008)
- 3 Professors, Chief Engineer, 3 Chief Assistants, Assistants, Laboratory Engineer, Secretaries
- projects funded by Tekes, EU, NIC, Academy of Finland
- over 40 industrial partners



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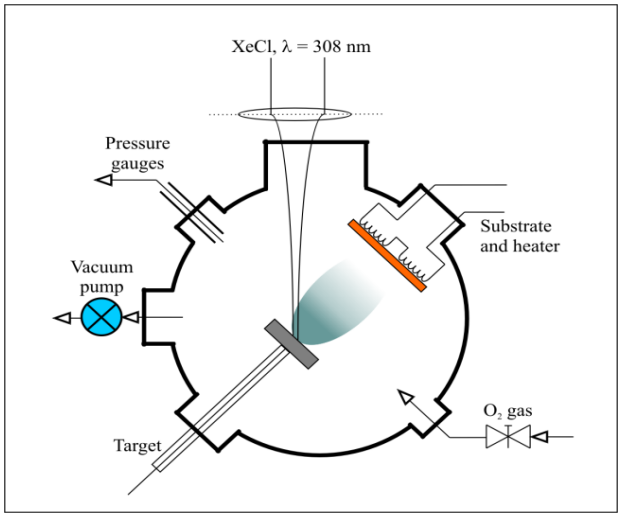
Functional electroceramic thin films

Prof. Jyrki Lappalainen, Dr., Docent



***Ceramics with some functionality*:**

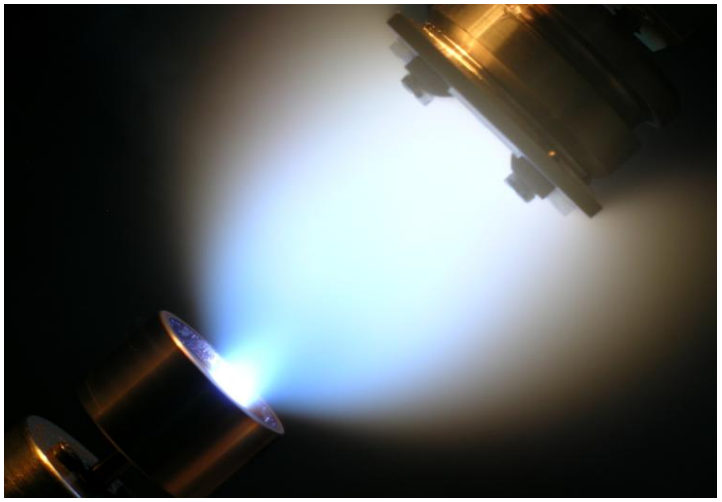
- **Ferroelectricity: PZT, PLZT, $BaTiO_3$, $SrTiO_3$**
- **Metal-insulator-transition: VO_2, V_2O_5**
- **Ionic / electronic conductivity: CeO_2**
- **Gas sensing: WO_3**
- **Others: ITO, ZnO, AZO, Sr_2MnWO_6,…**

***Effects of microstructure*:**

- **from amorphous to nanocrystal, polycrystal, or epitaxial thin films, and back to artificial materials, like superlattices**
- **size effects on functionality, response improvement, tailoring of the properties**

***Pulsed Laser Deposition* (PLD):**

- **XeCl-excimer laser**
- ***in situ* deposition, RT deposition, and RTA heat treatments**



Functional electroceramic thin films

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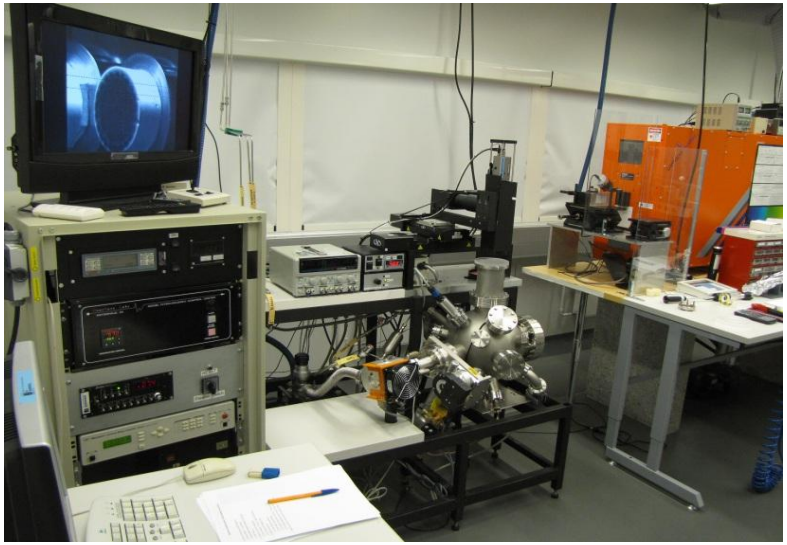
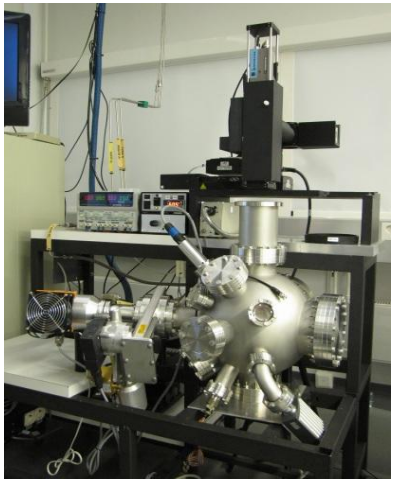
Pulsed Laser Deposition (PLD):

- XeCl-excimer laser (LamdaPhysik 201)
 λ = 308 nm (248 nm optional)
•τ = 25 ns, E_{max} = 400 mJ, f_{max} = 10 Hz
•optics with continuos energy adjustment
•computer controlled micromovement stage for laser beam guiding and scanning

- Custom modified PLD chamber (K.J. Lesker)
UHV capability (~10^{-7} mbar)
computer controlled rotating two-target system
sample holder ϕ = 1inch, T_{max} = 900 °C
gas atmosphere control from ~0.0005 mbar
QCM rate/thickness monitor

- Fully computerized target motion, gas atmosphere and profile, temperature profile, and laser controllers in order to perform automatized PLD procedures.



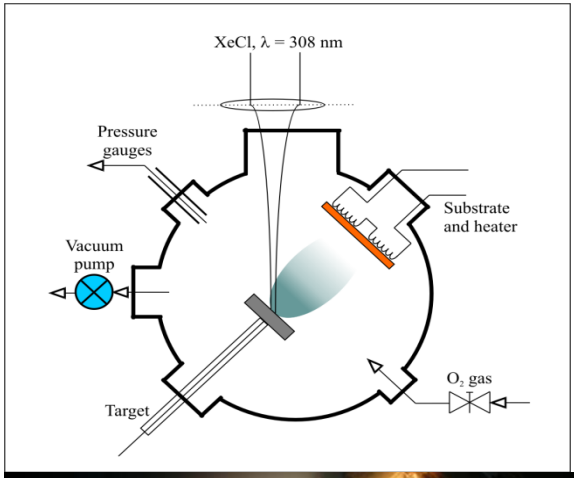


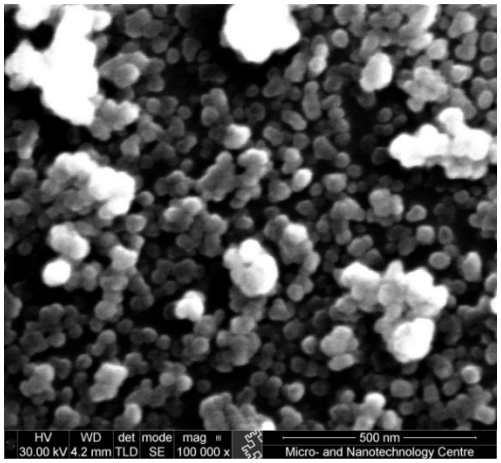
Current research activities of the Partner (1/2)

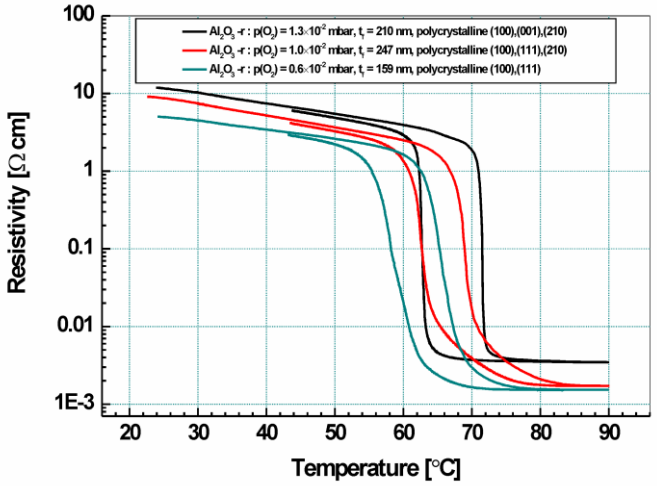
- Current research topics at the partner organization:

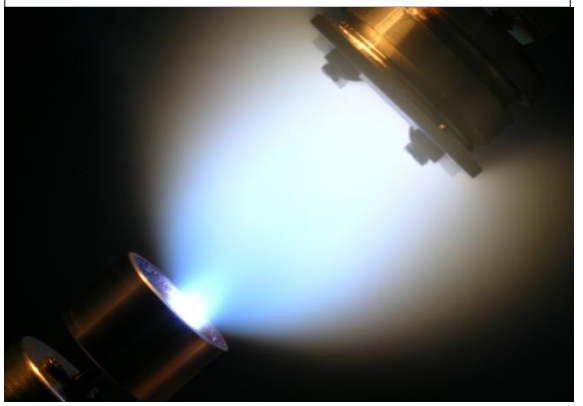
Pulsed Laser Deposition (PLD) of WO_3,VO_2,V_2O_5 nanoparticles for selective *gas sensing*:

- **WO_3** nanoparticles using room temperature PLD growth process and utilization of ferroelectric ε-WO_3 phase!
- **VO_2** nanoparticles utilizing metal-insulator-transition (MIT) effect in gas detection with improved selectivity!
- **Vanadium-oxide** mixed-phase and heterojunction structures!







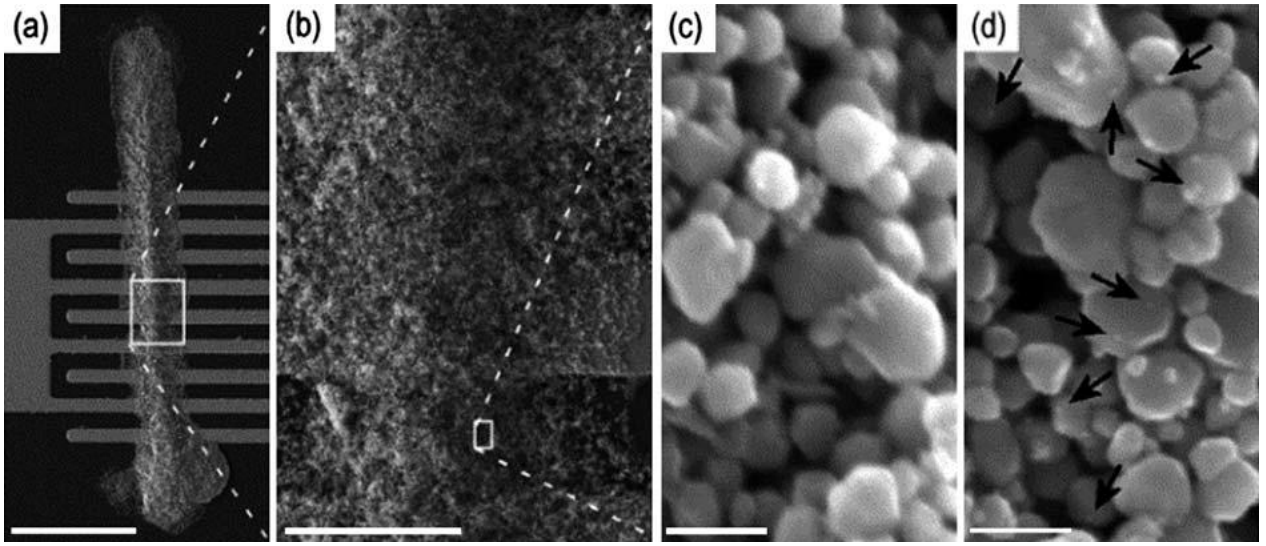


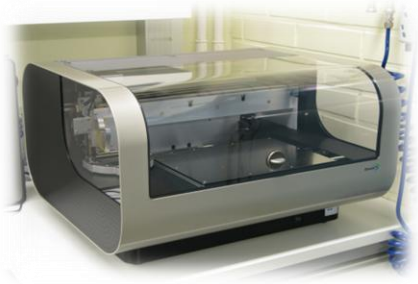
Current research activities of the Partner (1/2)

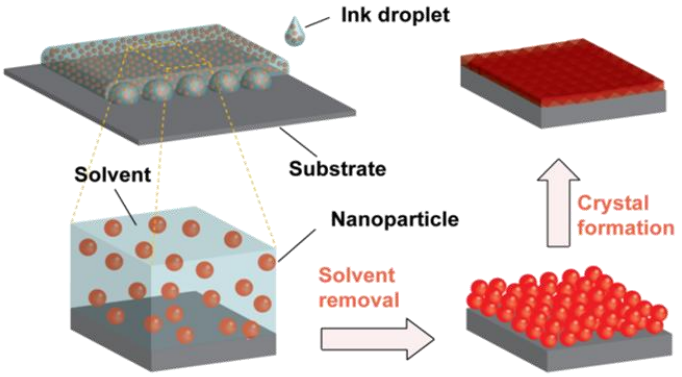
- Current research topics at the partner organization:

Inkjet-printing and low-temperature processing of decorated WO_3 nanoparticles on various substrates for selective gas sensing:

- Fabrication of Ag, Pd, Pt nanoclusters on surfaces of WO_3 nanoparticles using chemical methods!
(J.Mater.Chem. 22 (2012) 17878)







Research Facilities available for the Partner (2/2)

- **Research Facilities:**
  - **Fabrication of nanostructured materials:** Pulsed-Laser-Deposition (PLD), Focused Ion Beam (FIB), CVD for MO nanofibres and CNT's, chemical methods for nanoparticle fabrication.
  - **Materials structure characterization:** XRD, XPS, Raman, FESEM, TEM, SPM, etc.
  - **Electrical, optical, and mechanical characterization:** DC – 50 GHz-range electrical characterization, spectrophotometry, ellipsometry, nanointendation, etc.
  - **Gas sensor measurement setup for basic gases.**

Suggested Priorities for future research

- **Research directions as PRIORITIES:**
- Development of fabrication methods and characterization of WO_3, V_2O_5, VO_2, etc. nanoparticles.
- *Utilization of phase transition effects in gas sensing process*.
- Ink-jet printing of WO_3, V_2O_5, VO_2, etc. nanoparticles on flexible substrates in a low-cost mass-production process.