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COST Action TD1105

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New Sensing Technologies for Indoor and Outdoor Air Quality Control

ENEA - Brindisi Research Center, Brindisi, Italy, 25 - 26 March 2014

ELECTRODEPOSITED NANOSTRUCTURED MATERIALS FOR GAS SENSING

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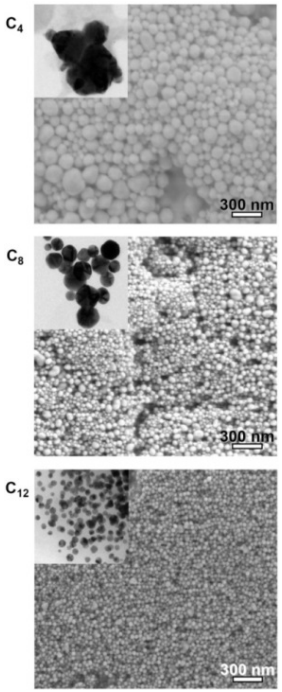
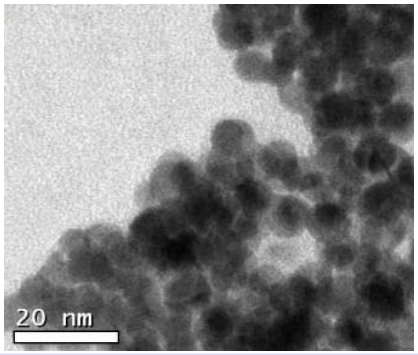
Outlook

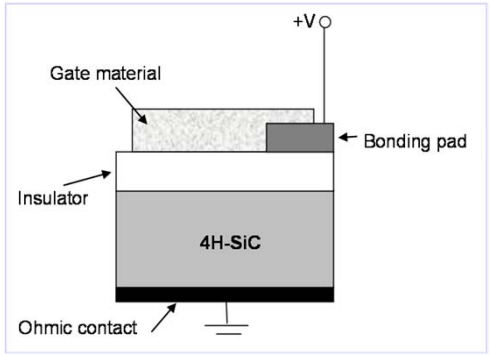
- Background - Motivations
- Sacrificial Anode Electrosynthesis (SAE) of metal nanoparticles
- SAE electrodecoration of sol gel prepared Metal Oxides
- Electrodeposition of metal nanoparticles on carbon nanotubes

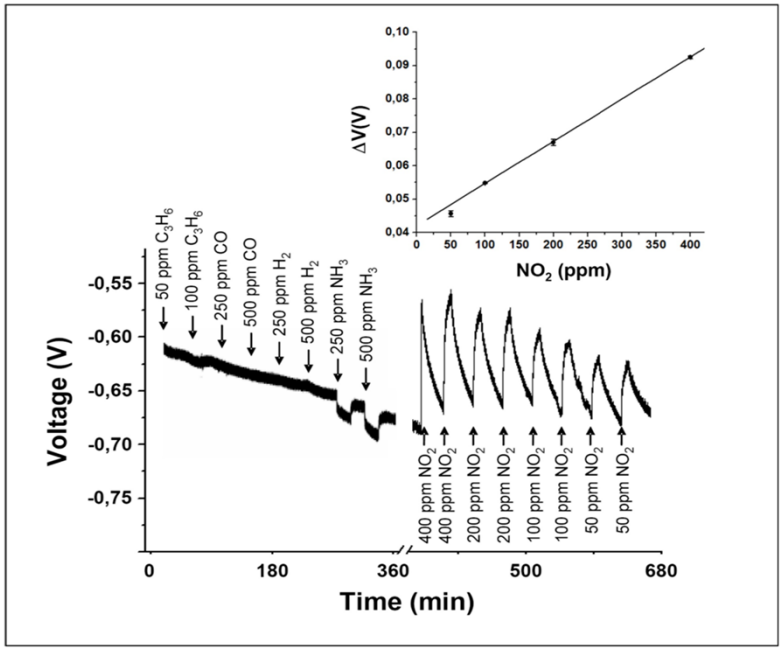
Background - Motivations

- Automotive Exhaust Gas Sensors (NOx, HCs, CO, etc) based on catalytic metal nanoparticles supported on other nanomaterials (2 Natl. projects running on the topic)
- Previous experience on gold nanoparticle NOx sensors









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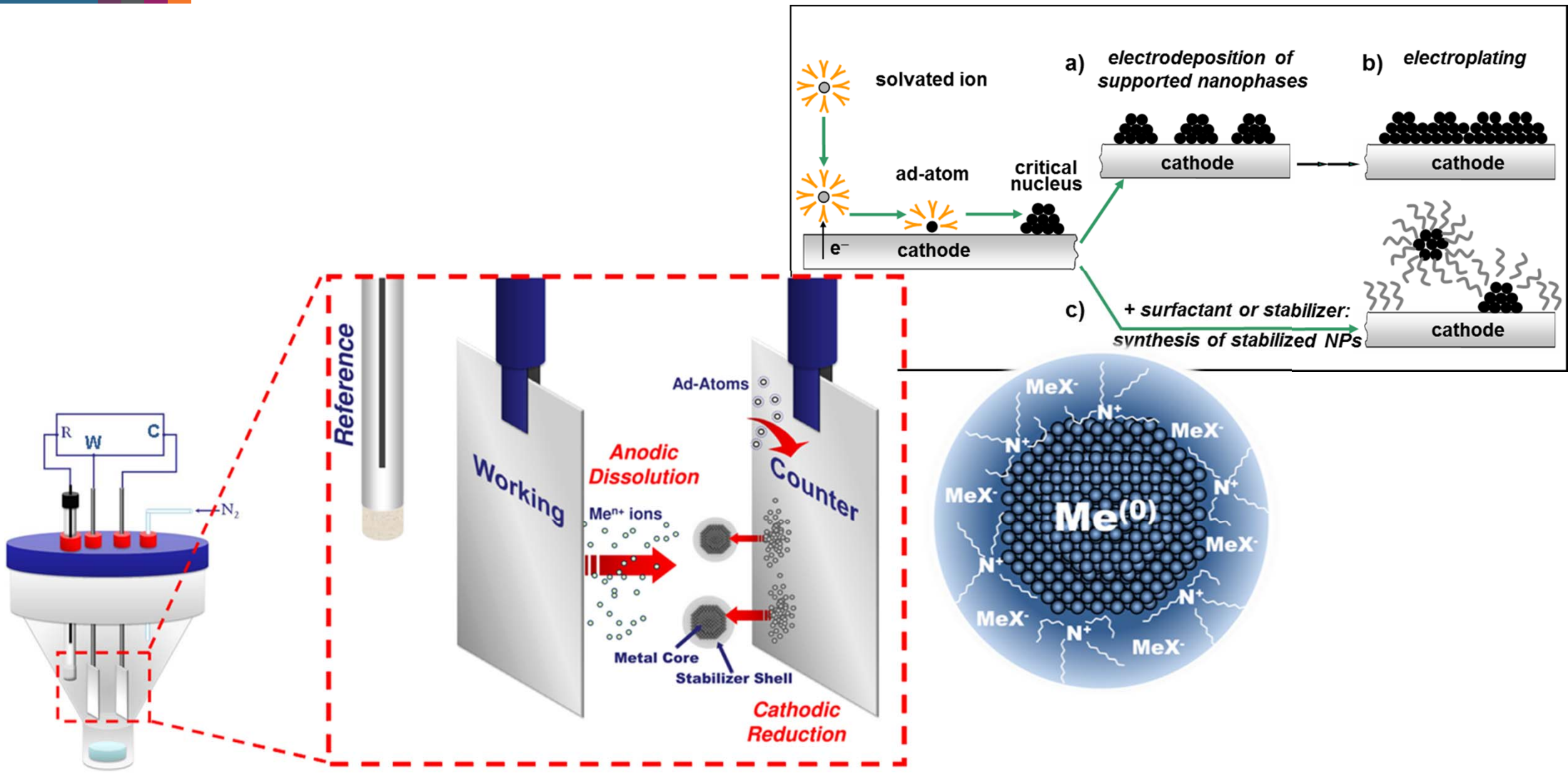
Sacrificial Anode Electrosynthesis



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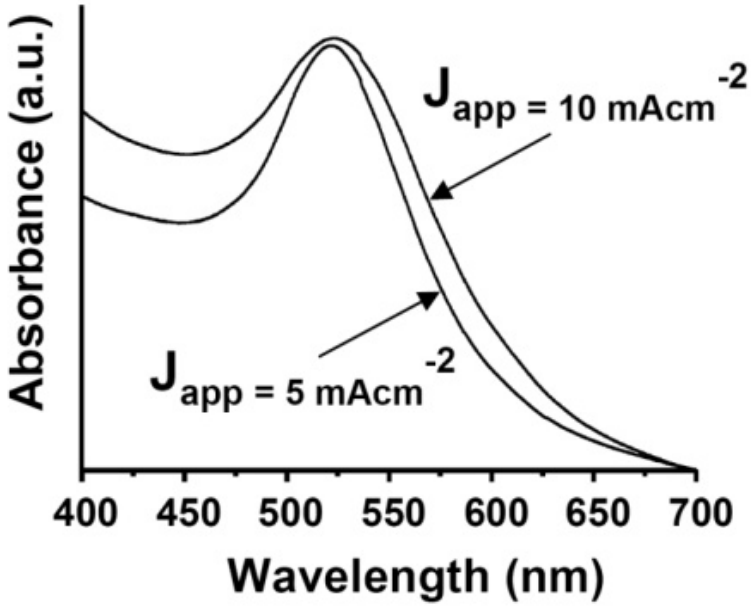
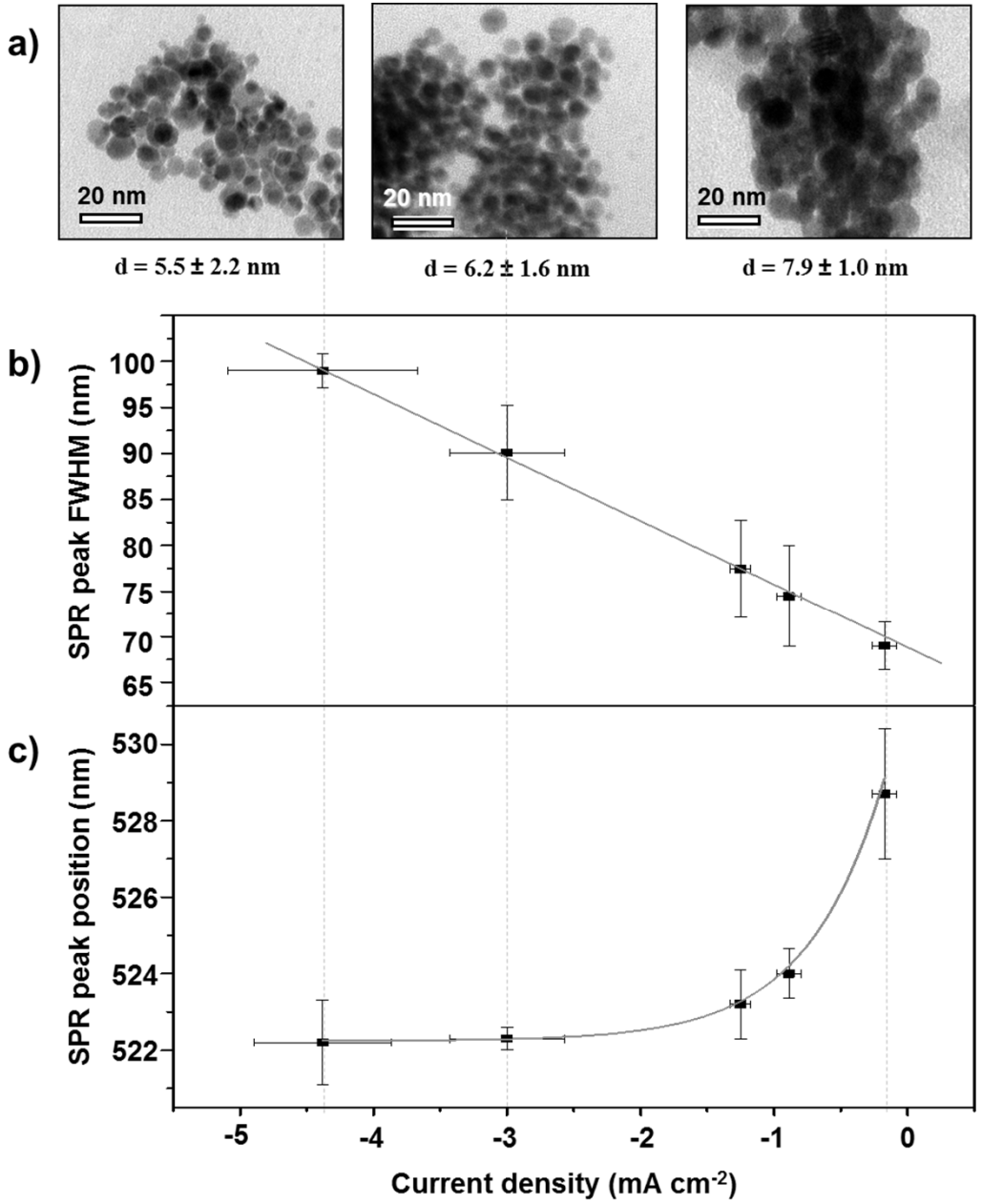
Sacrificial Anode Electrosynthesis





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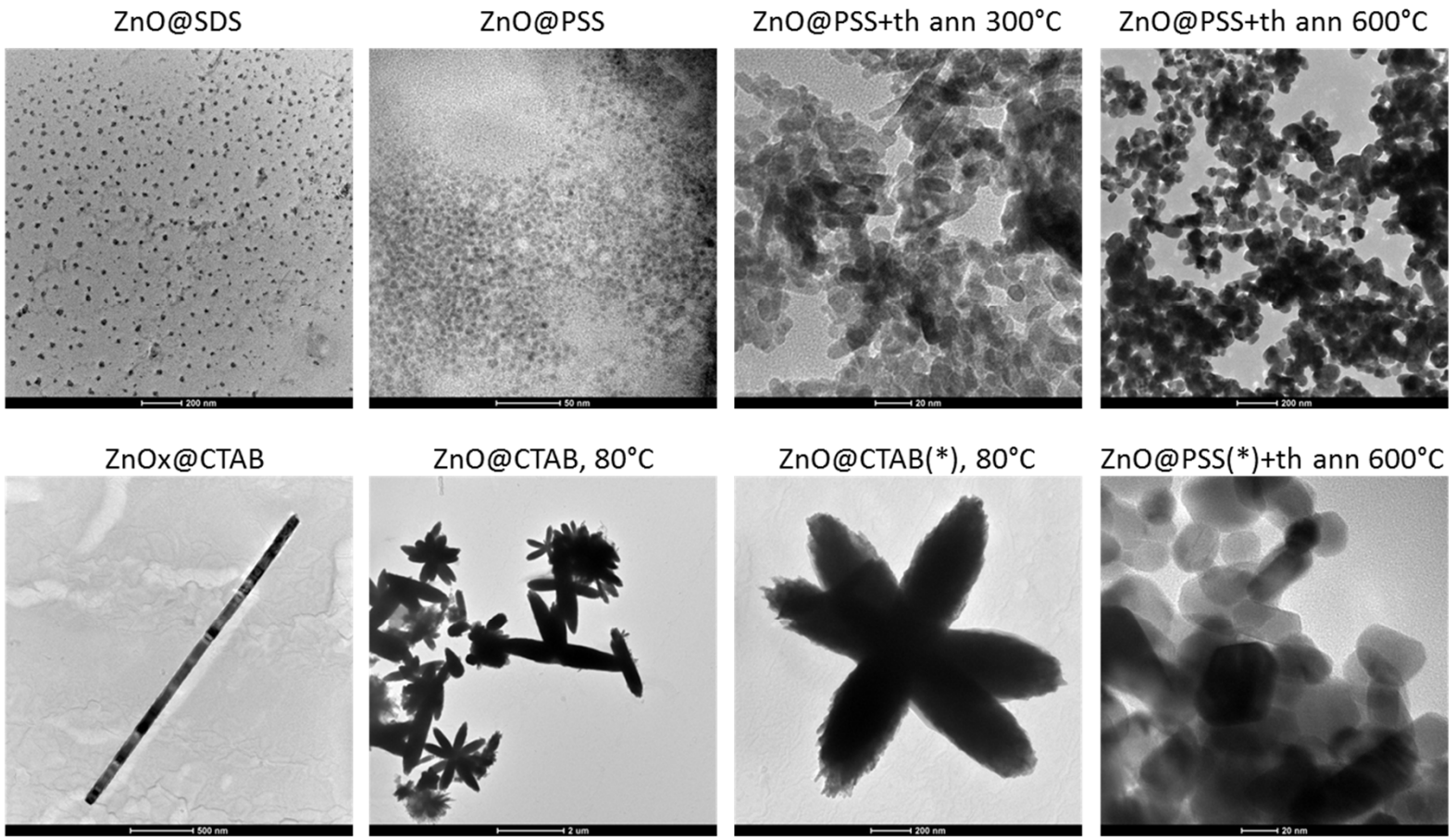
Sacrificial Anode Electrosyntesis



*R.A. Picca, D. Hötger, M.C. Sportelli

SAE electrodecoration of Metal Oxides

PLAN OF WORK:

To electrodecorate sol gel prepared metal oxides (MOx) by means of catalytic metal nanoparticles (<10nm)

"Au – Metal Oxide Composite Nanoparticles"

Au-ZnO

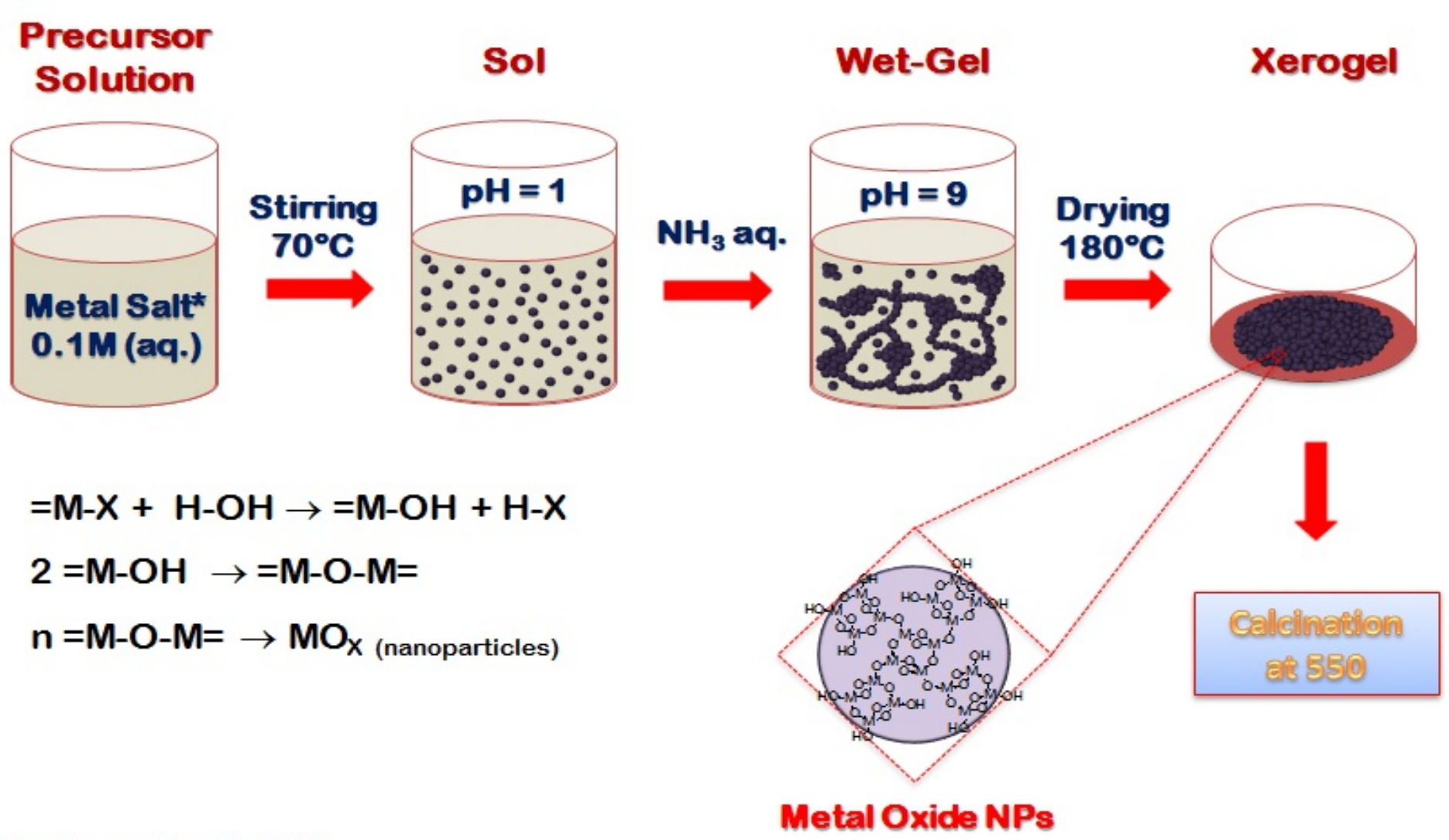
Au-ZrO_2

Au-In_2O_3

Au-ZrO_2-In_2O_3 ($ZrInO_X$ with different Zr:In ratios)

etc..

I step. MOx syntheses: Sol-Gel Method



$$=M\text{-}X + H\text{-}OH \rightarrow =M\text{-}OH + H\text{-}X$$

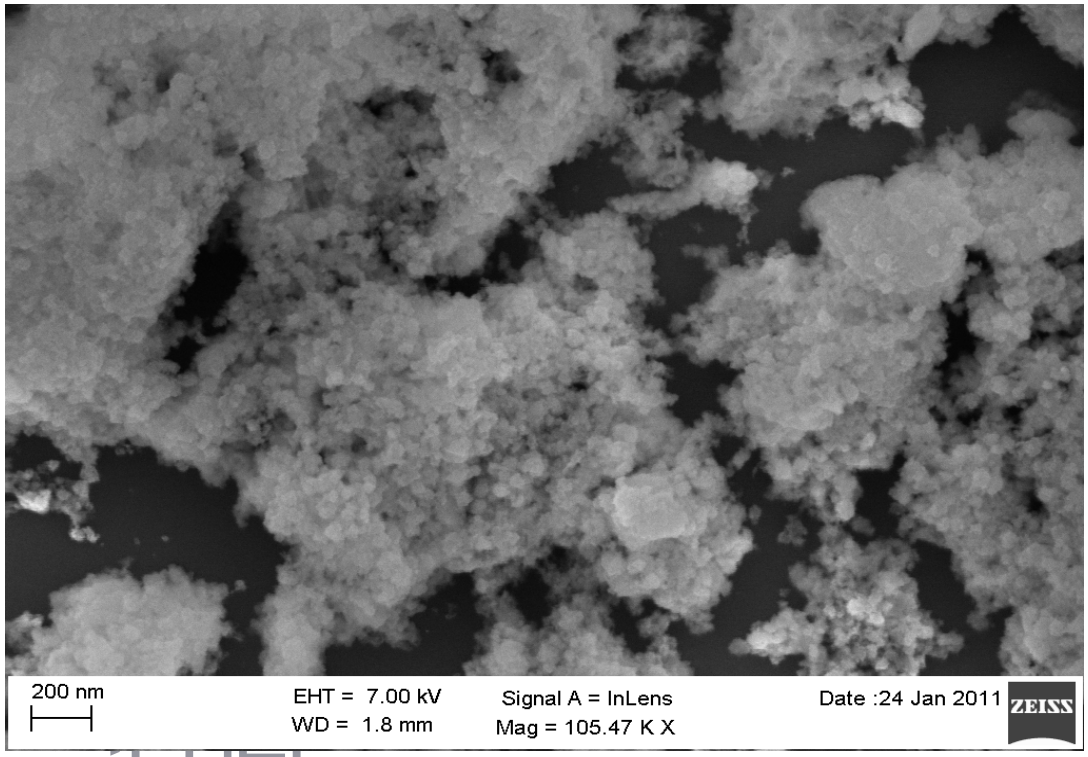
$$2\ =M\text{-}OH \rightarrow =M\text{-}O\text{-}M=$$

$$n\ =M\text{-}O\text{-}M= \rightarrow MO_X \text{ (nanoparticles)}$$

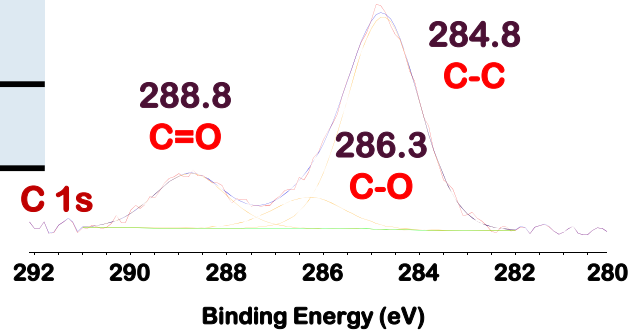
* $InCl_3$ and/or $ZrOCl_2$

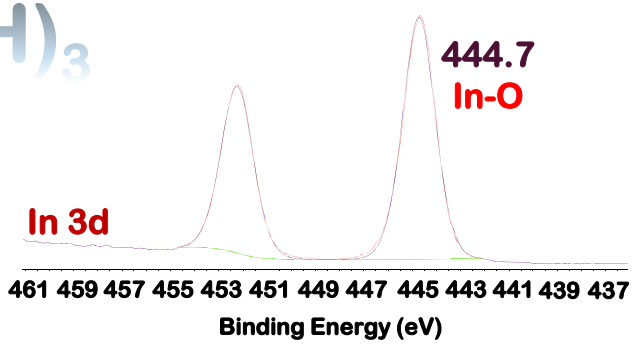
In_2O_3: As-prepared

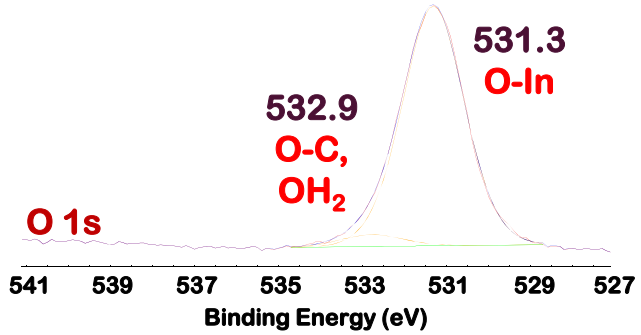
% C	% In	% O-In	% O-C, OH_2, etc	O/In
18.3±0.1	19.9±0.4	57.5±1.4	3.8±1.4	2.9



$In(OH)_3$



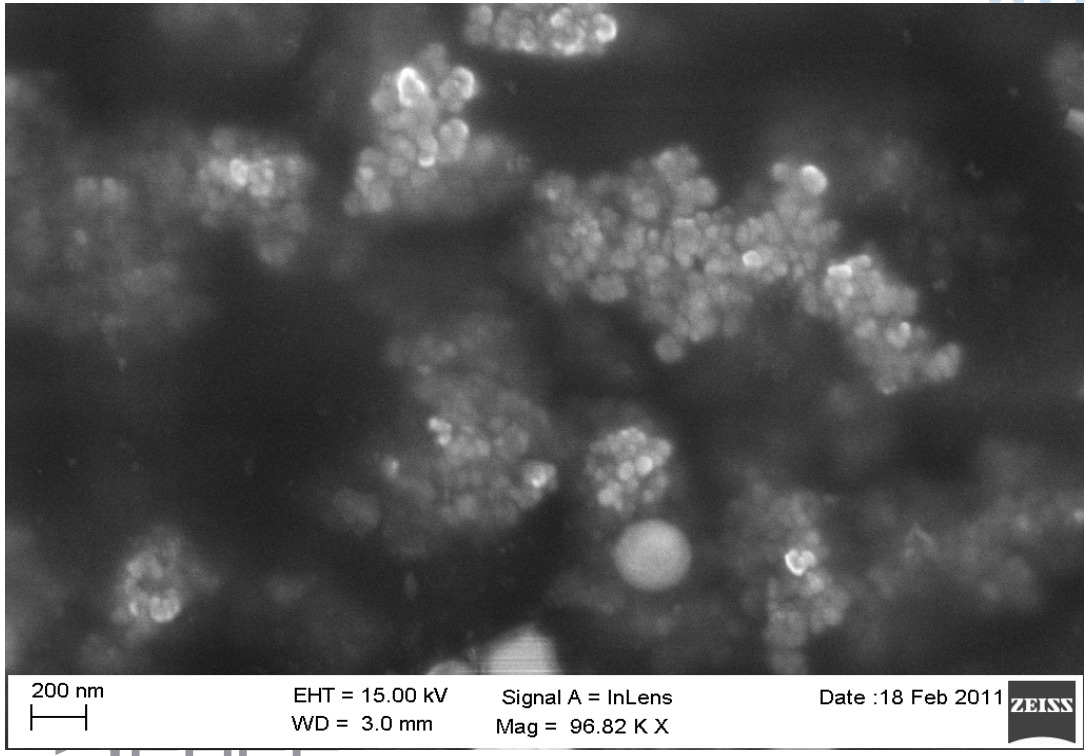


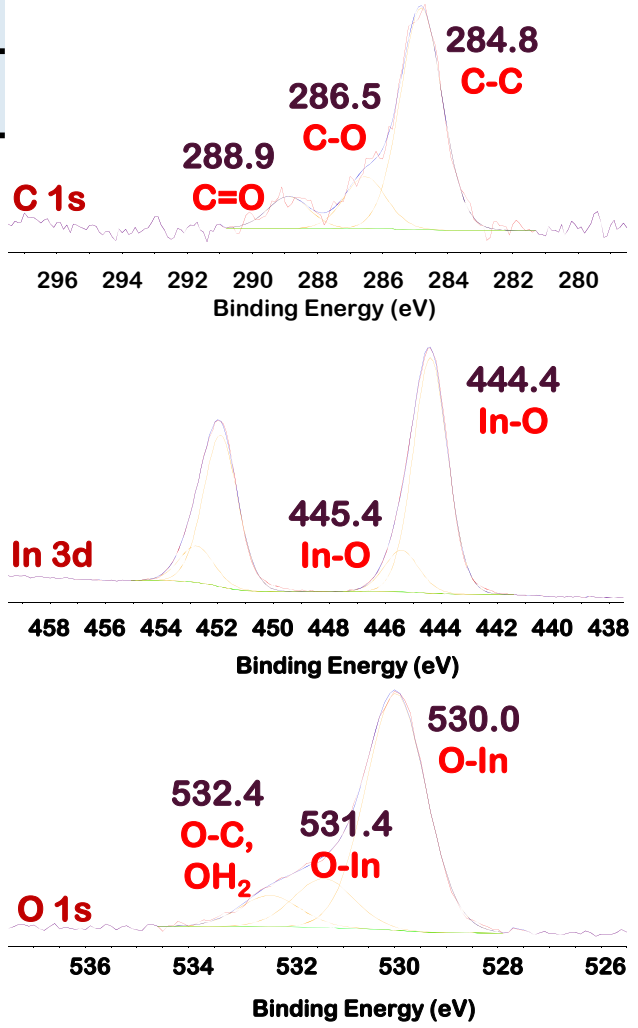


In_2O_3: Calcined

% C	% In	% O-In	% O-C, OH_2, etc.	O/In
17.6±0.3	33.8±0.4	44.1±1.4	4.1±0.6	1.3

In_2O_3





ZrO_2: As-prepared & Calcined

% C	% Zr	% O-Zr	% O-C, etc.
33.1±1.0	14.5±0.3	46.9±1.2	5.5±1.2

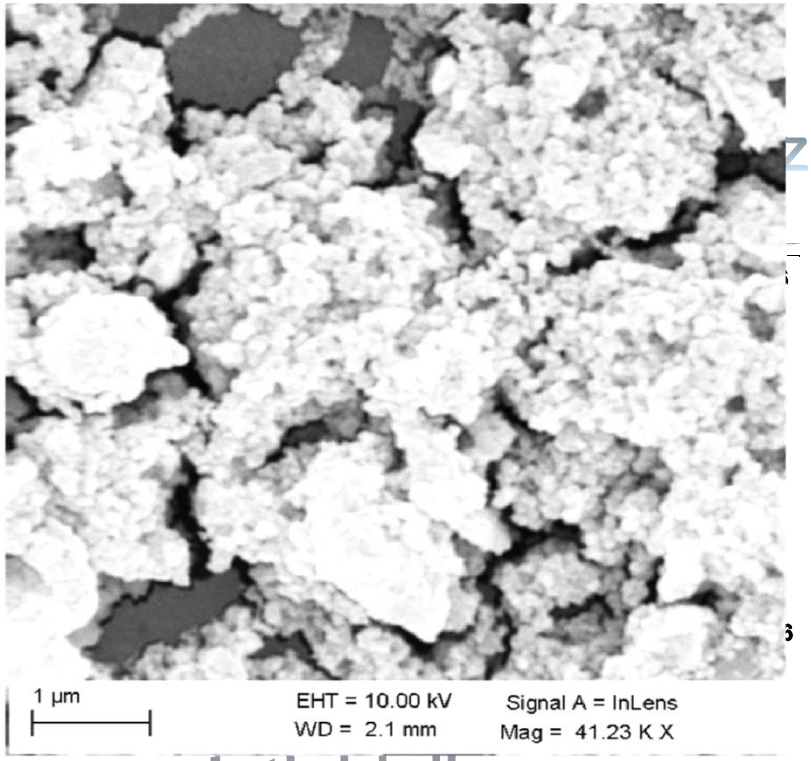
O/Zr
3.2

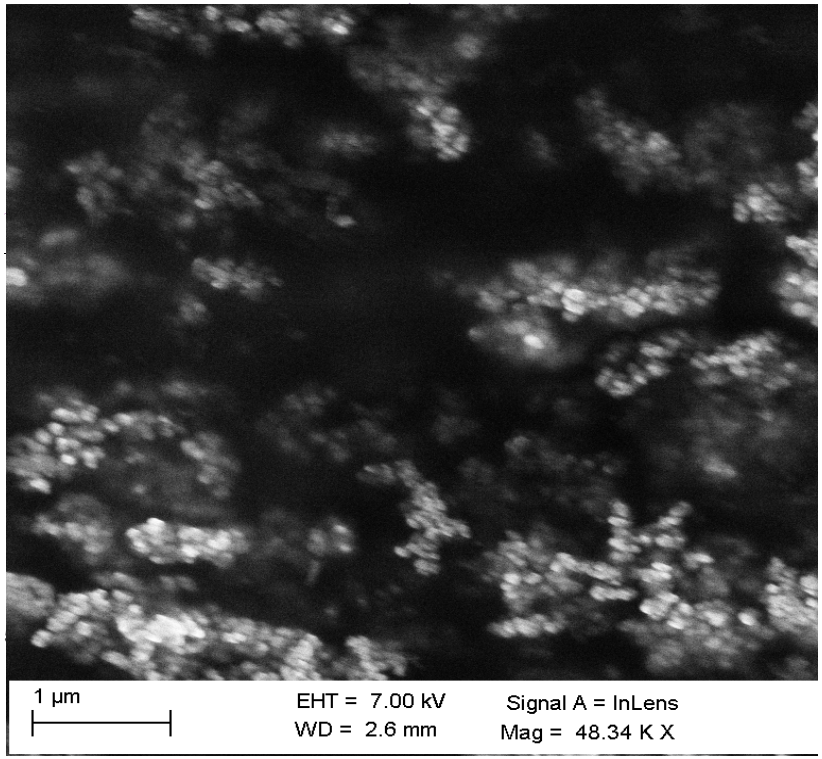
$ZrO_2/Zr(OH)_4$

% C	% Zr	% O-Zr	% O-C, etc.
20.2±0.3	25.3±0.3	49.7±1.2	4.8±1.0

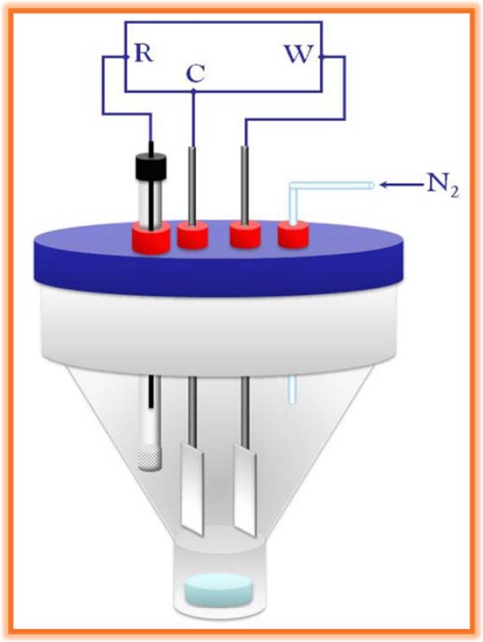
O/Zr
2.0

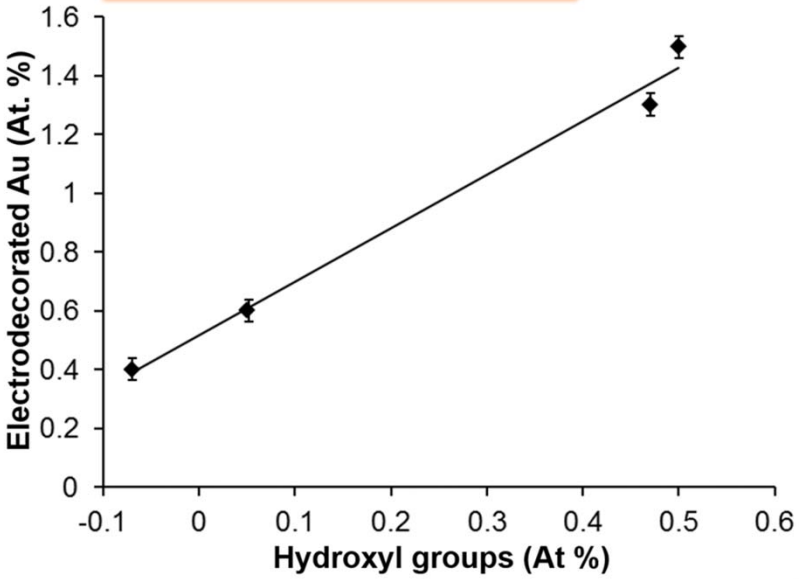
ZrO_2

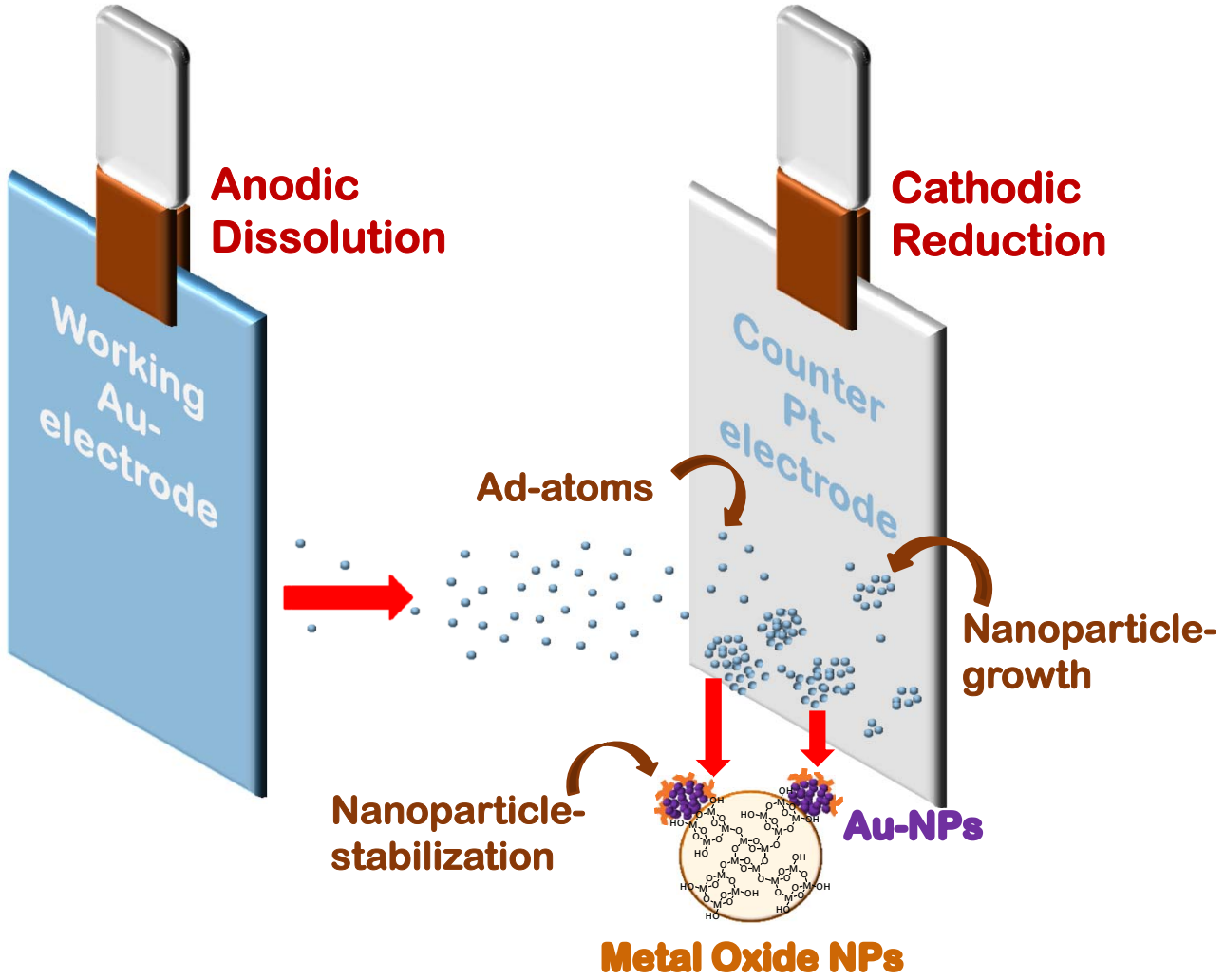




II step. Au-NPs Electrosynthesis onto the MOx particles







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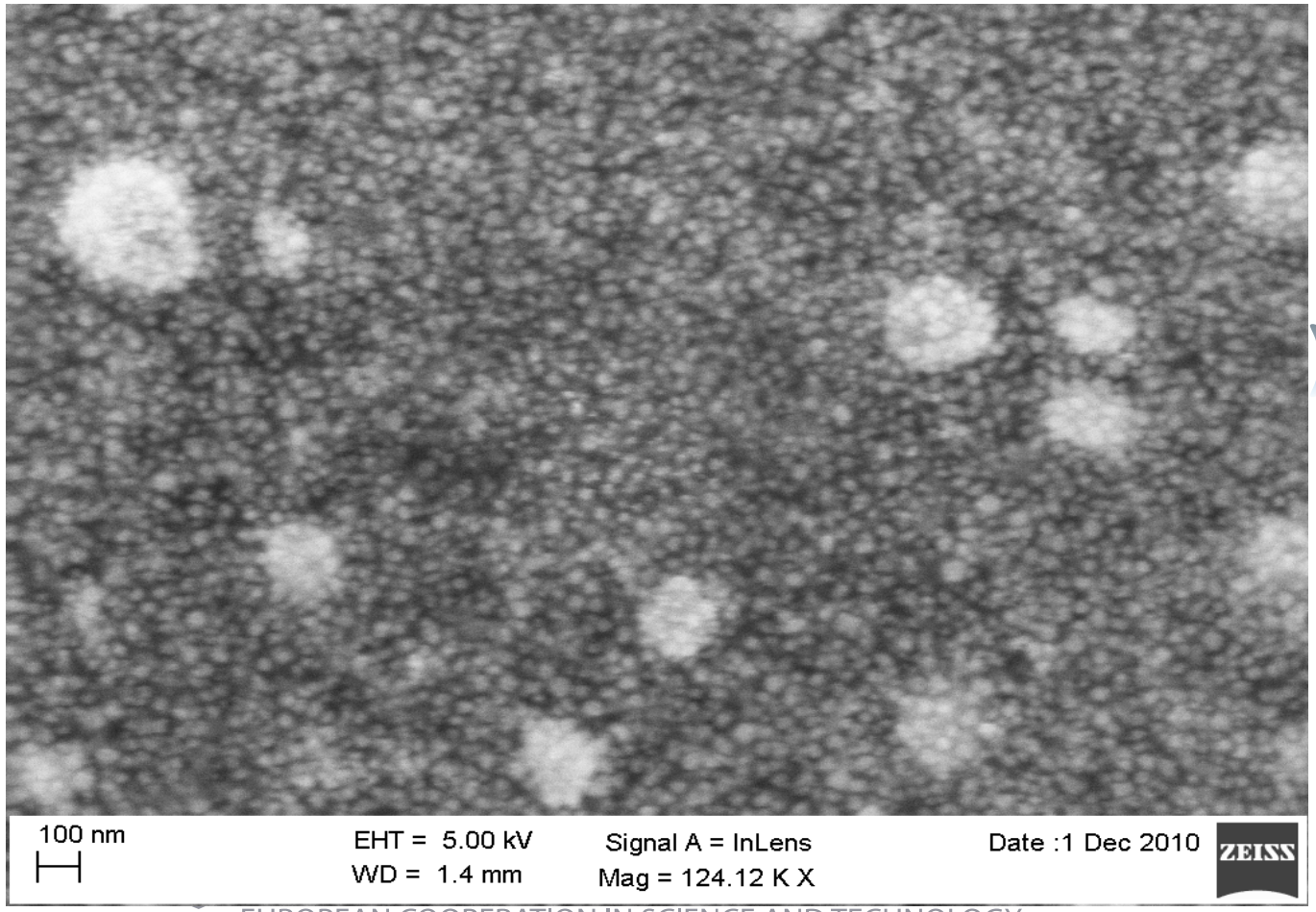
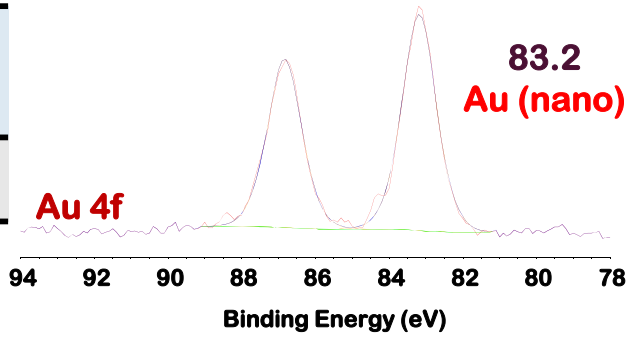
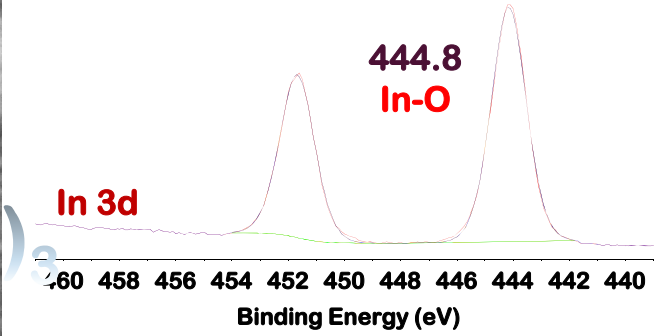
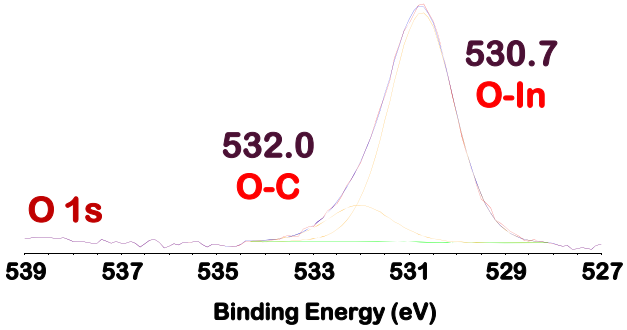
Au-In_2O_3: As-prepared

% C	% In	% O-In	%O-C, O-H_2, etc	% Au
37.3±0.9	14.5±0.1	43.1±2.0	6.0±2.0	1.4±0.1



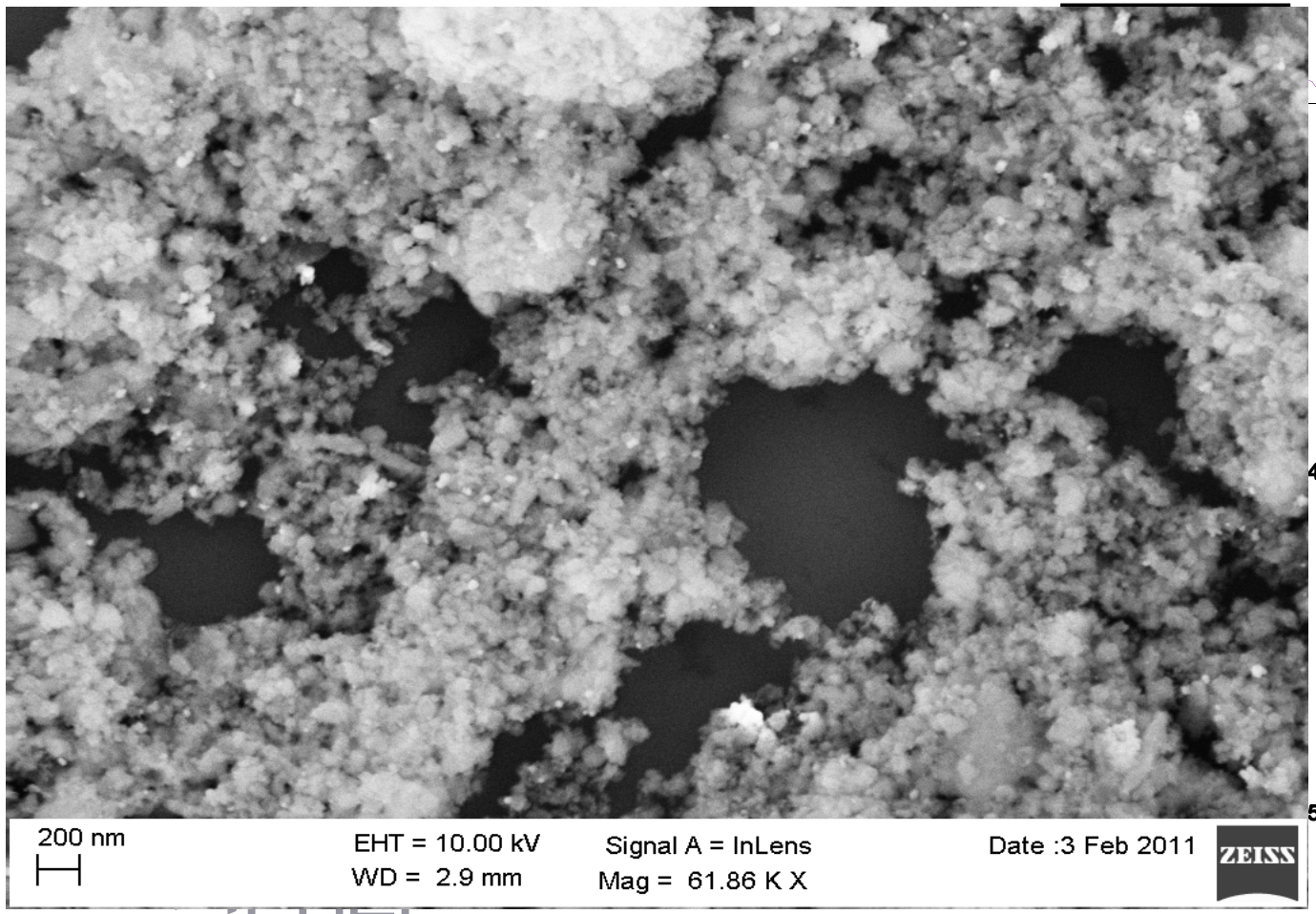


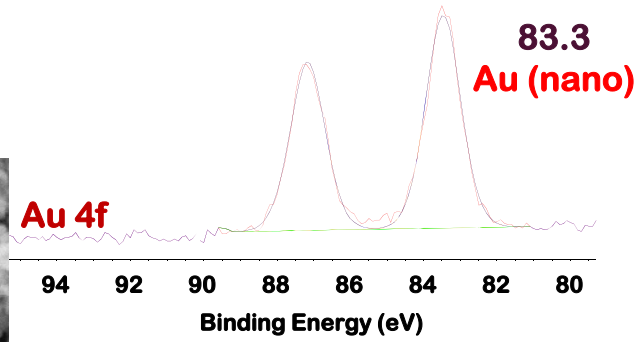


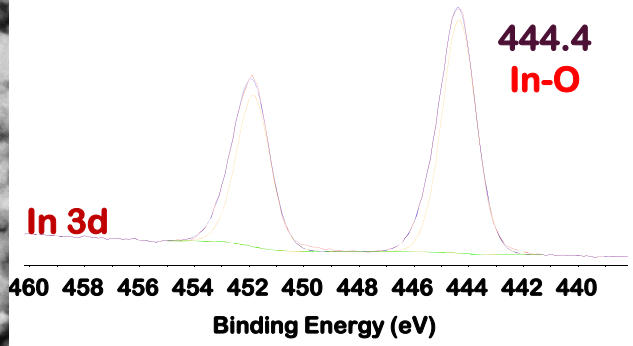


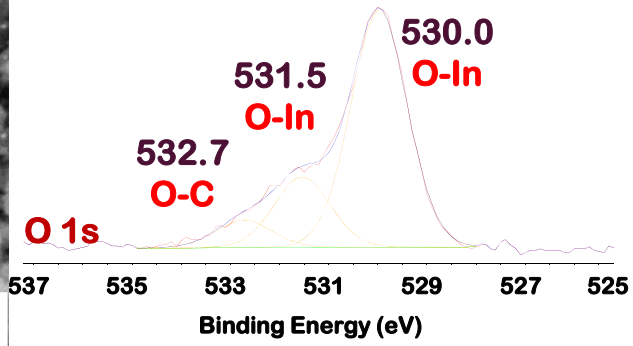
Au/In_2O_3: Calcined at 550°C

% C	% In	% O-In	%O-C, O-H_2, etc	% Au
19.5±1.3	30.5±0.3	42.9±1.4	5.6±0.1	1.5±0.2



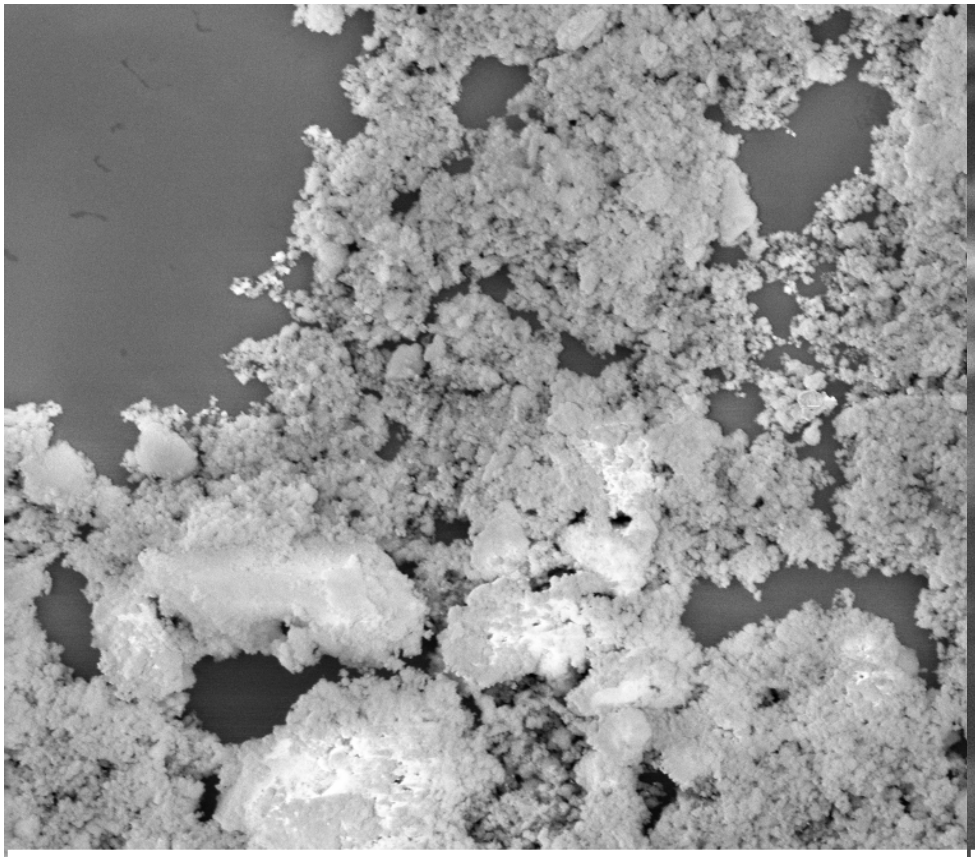


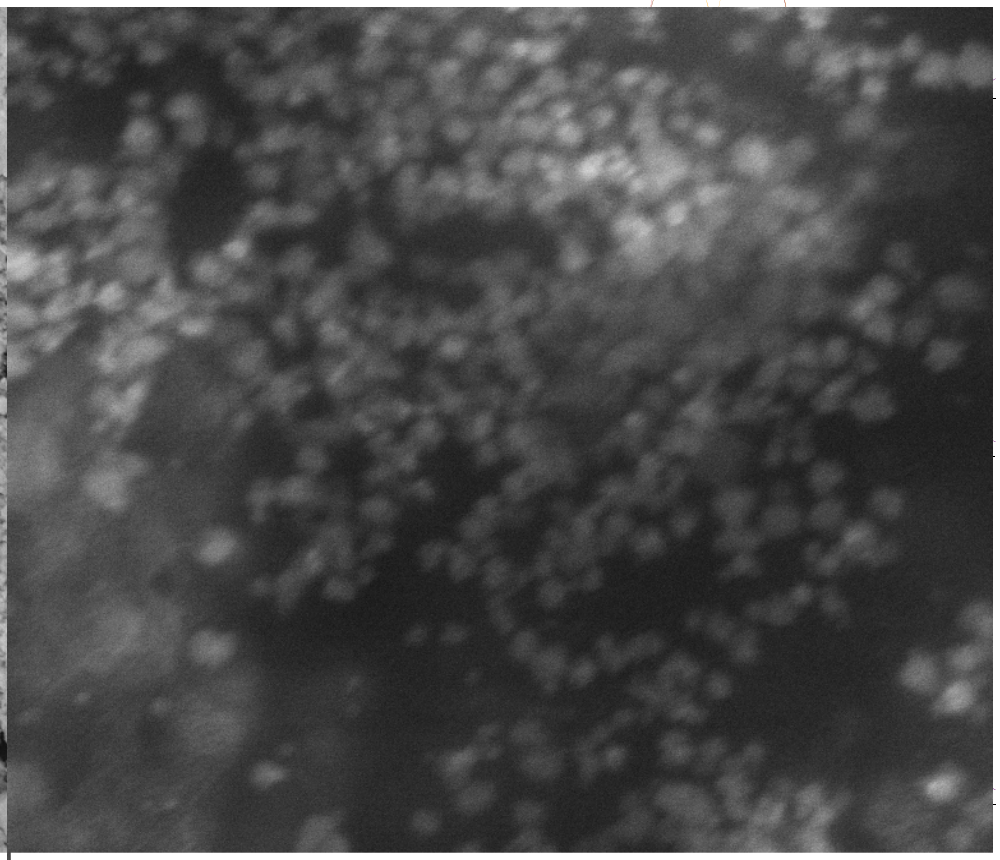




$ZrInO_x$: Mixed Metal Oxides (MMO_x) – As-prepared

% Zr	% In	% O-M	O/M
7.8±0.2	7.9±0.1	46.7±0.8	3.0

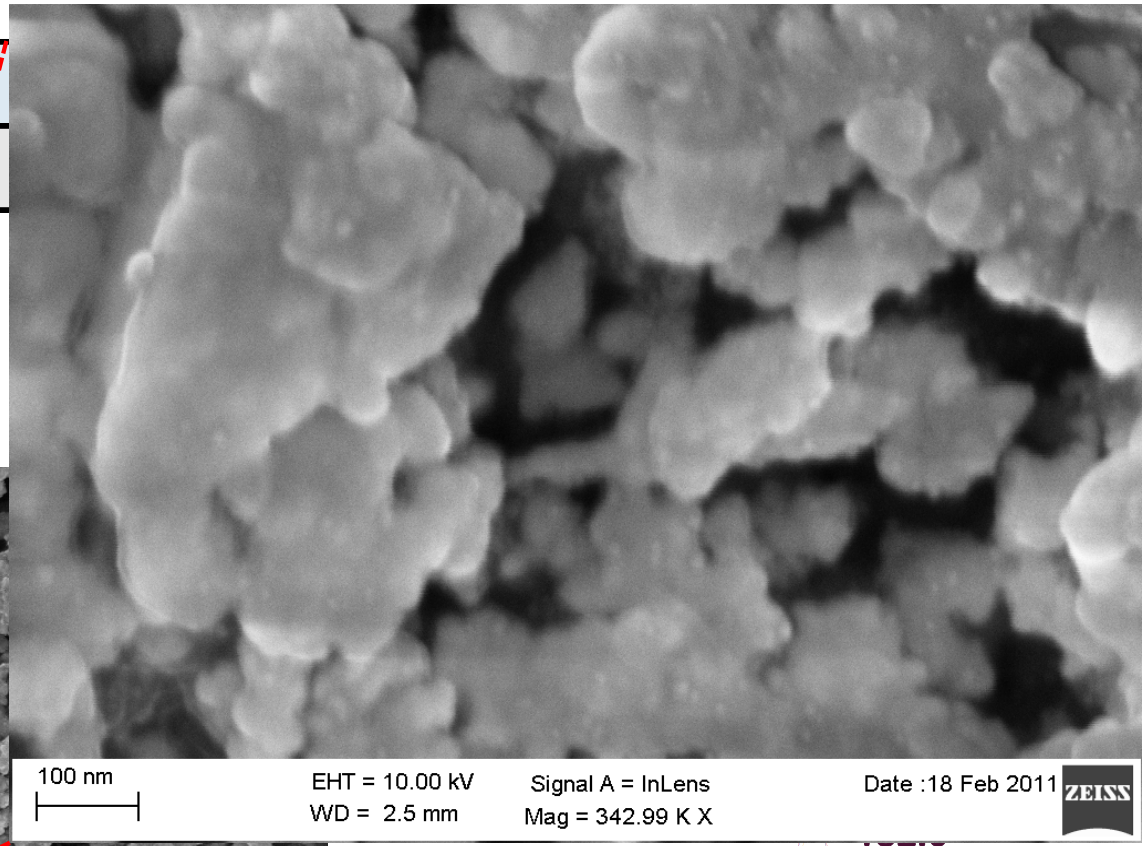


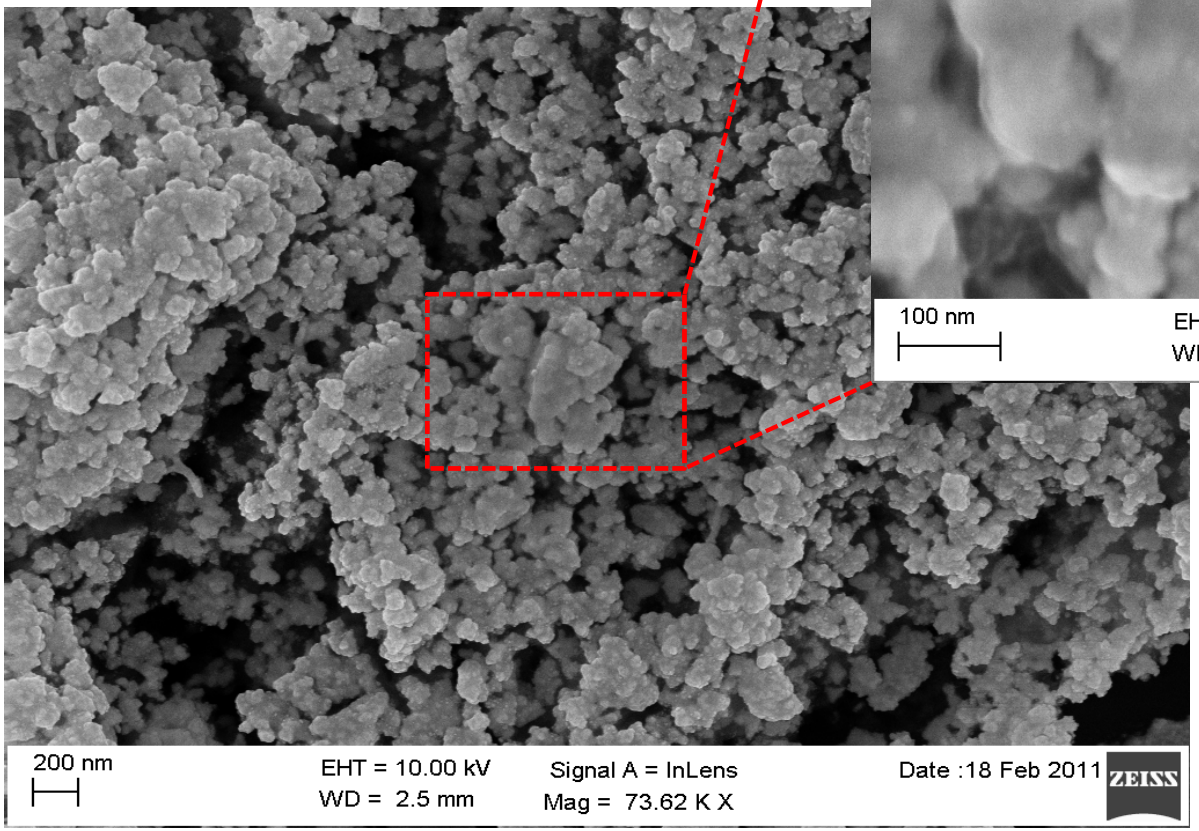


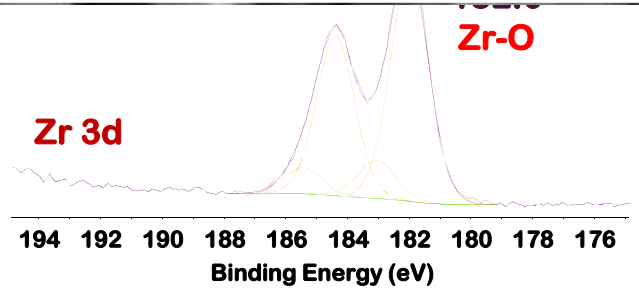
$ZrInO_x$ and $Au/ZrInO_x$: Calcined

% Zr	% In	% O-M
11.7±0.1	11.4±0.1	46.9±0.6

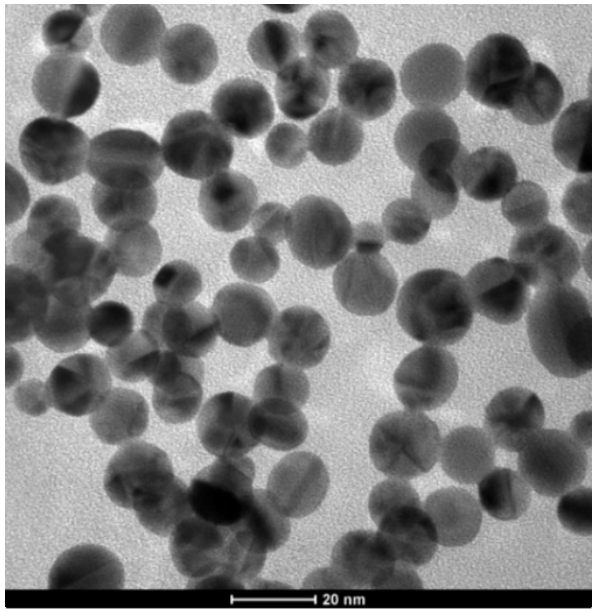
% Au (nano)	% Au (Au_2O_3)
1.1	0.1

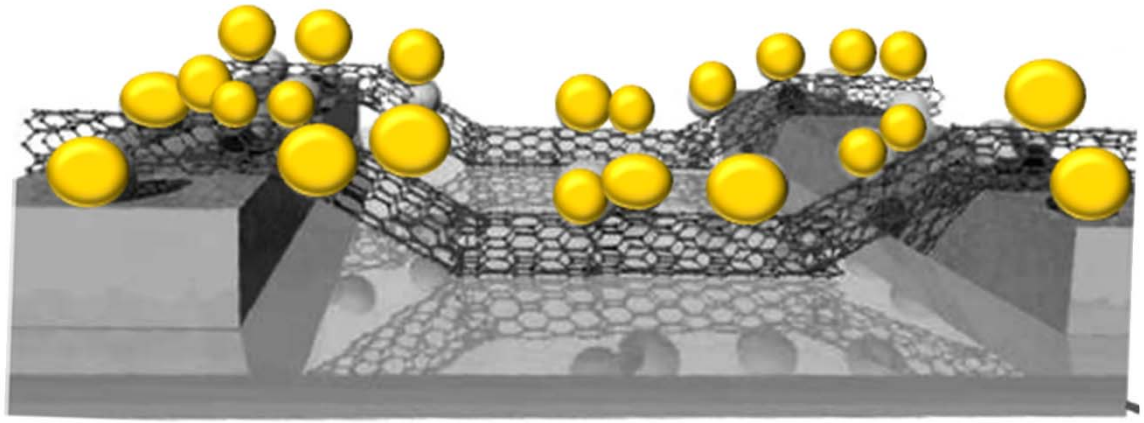


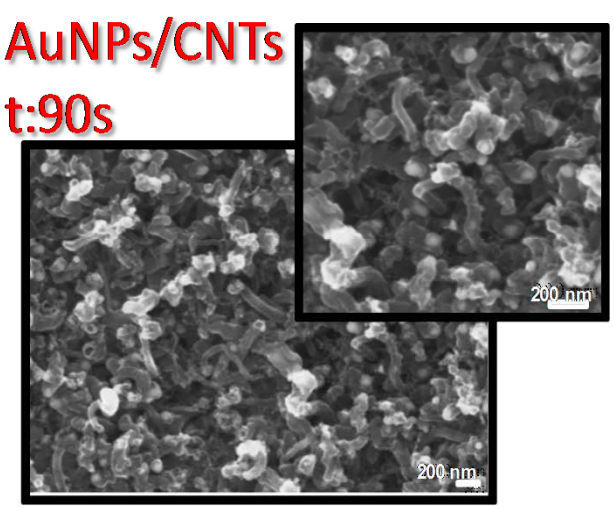


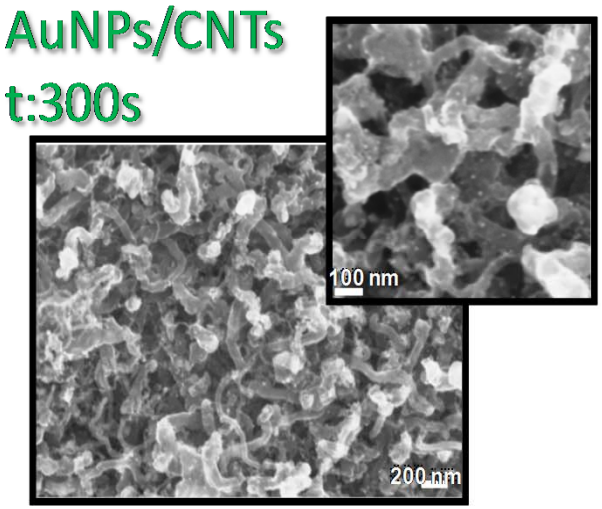


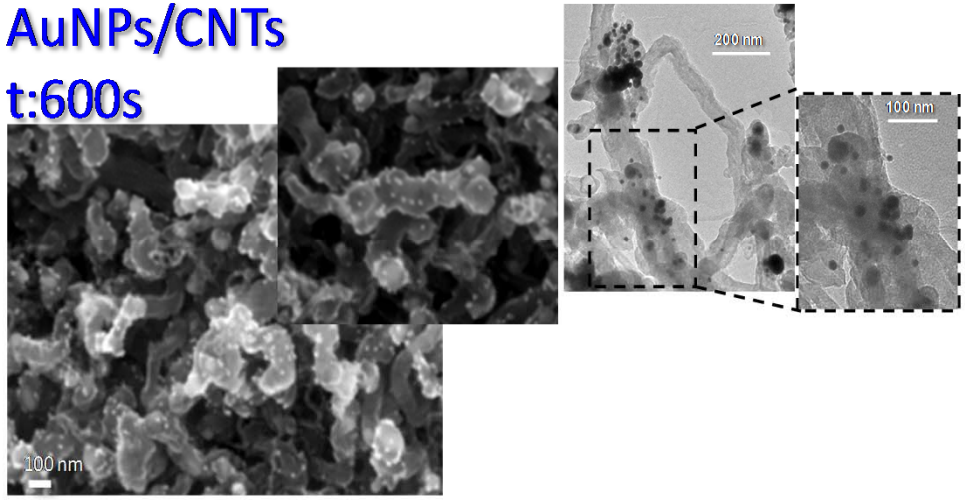
Electro(phoretic) deposition of AuNPs on CNTs(*)











(*) for details pls see poster presentation by Elena Dilonardo, session #7

CONCLUSIONS

- **Electrochemical methods for the size & shape controlled preparation of catalytic metal nanocolloids**
- ***in situ* electrodecoration of metal hydroxides and oxides by Au NPs**
- **Post synthesis electrophoretic deposition of AuNPs on CNTs**
- ***Work is in progress…on sensors fabrication & testing***

Acknowledgements

Financial support by

- M.I.U.R., Programma Operativo Nazionale “Ricerca e Competitività” (R&C) 2007-2013 PON02_00576_3333604: “INNOVHEAD: Tecnologie innovative per riduzione emissioni, consumi e costi operativi di motori Heavy Duty” 2012-2015
- M.I.U.R., Programma Operativo Nazionale “Ricerca e Competitività” (R&C) 2007-2013 PON01_02238 “EURO6. “Elettronica di controllo, sistema d’iniezione, strategie di combustione, sensoristica e tecnologie di processo innovativi permotori diesel a basse emissioni inquinanti” 2011-2015

Thank you!