Materiale nanostructurate: aplicatii practice in nanomedicinia si bio-senzoristica

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Si

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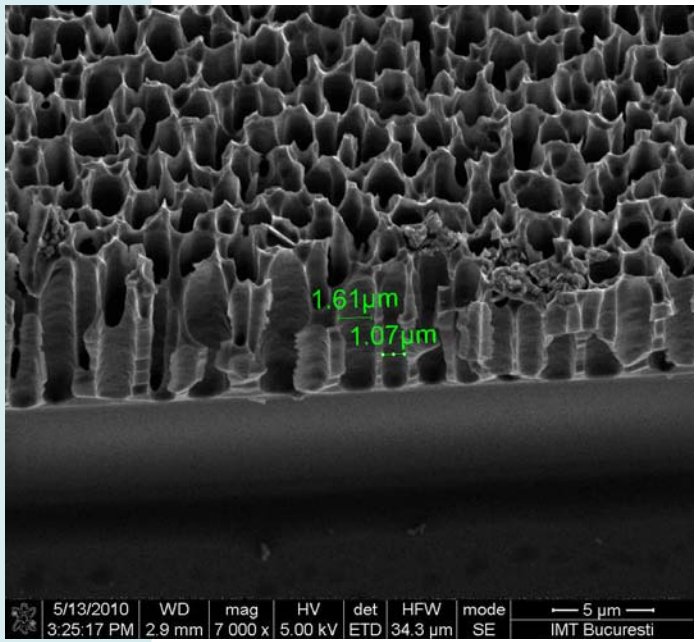
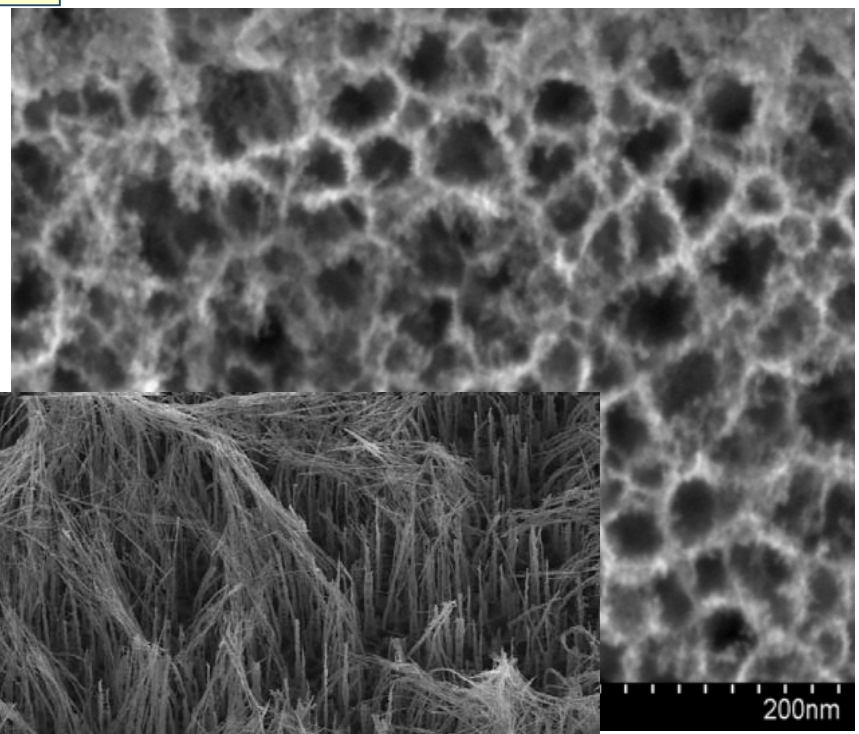
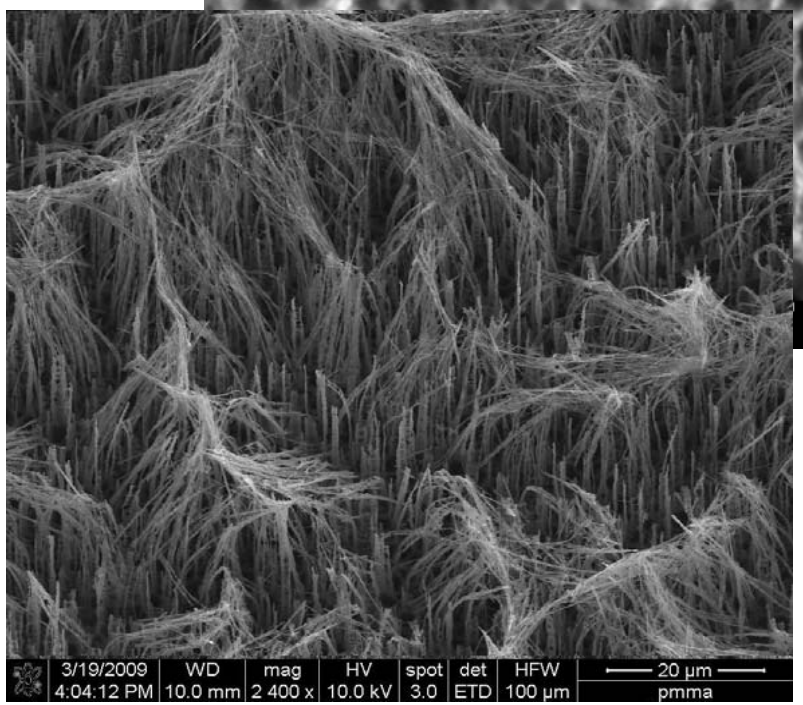
macro-PS (1- 2 µm)

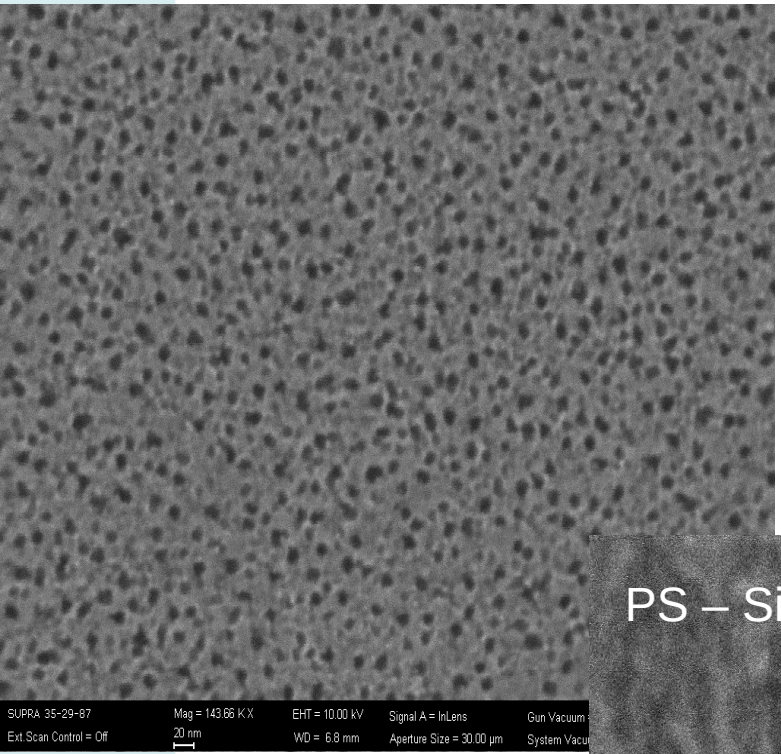


meso-PS
(50 - 100 nm)

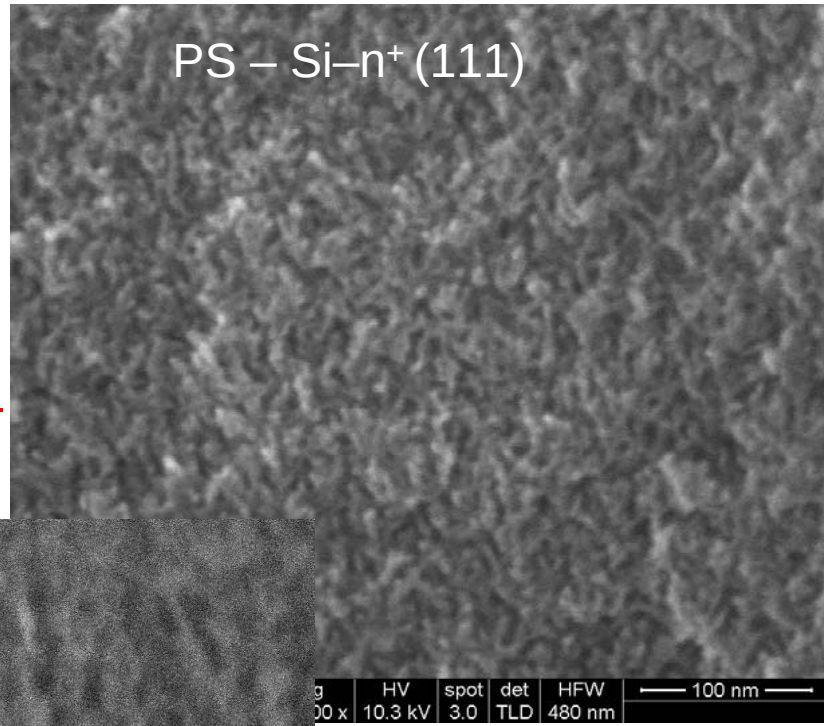


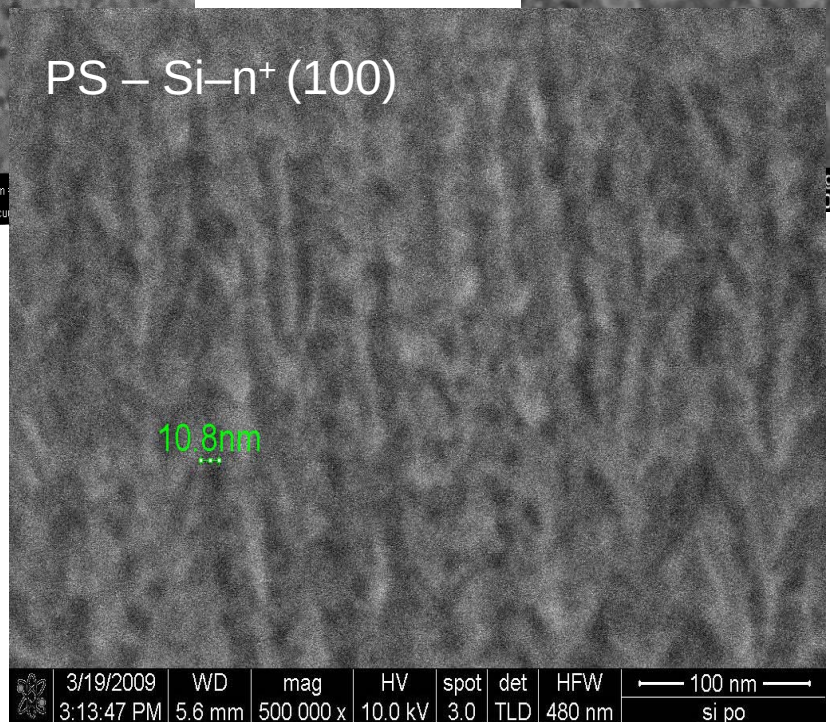


SEM - PS morphology



nano-PS
(< 15 nm)





Si

Si substrate

- **type and level of doping;**
- **crystallographic orientation**

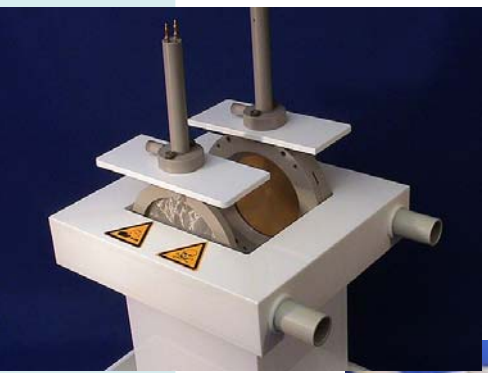
Pores & fibrils size depends on:

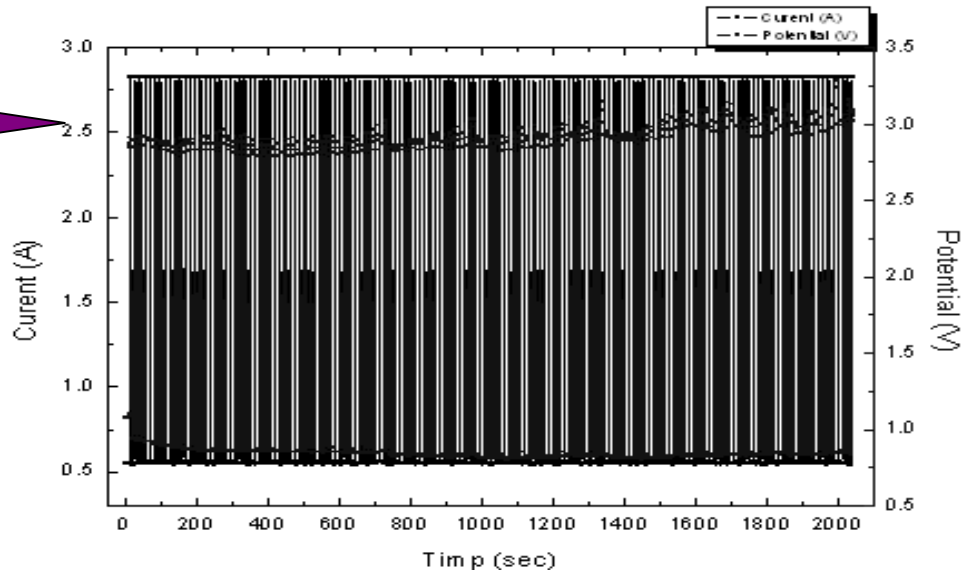
Process parameters

- **electrolyte type / HF concentration;**
- **current density;**
- **illumination conditions.**

Porous silicon – PS - is obtained by electrochemical dissolution of silicon in HF

PS layers, have been obtained using the A.M.M.T etching system for 4'' Si wafers with programmable power supply and dedicated software for time-based current profiles.





Current-potential-time diagram for 150 cicles (0.554 A, 10 sec, 2.825 A, 4 sec).

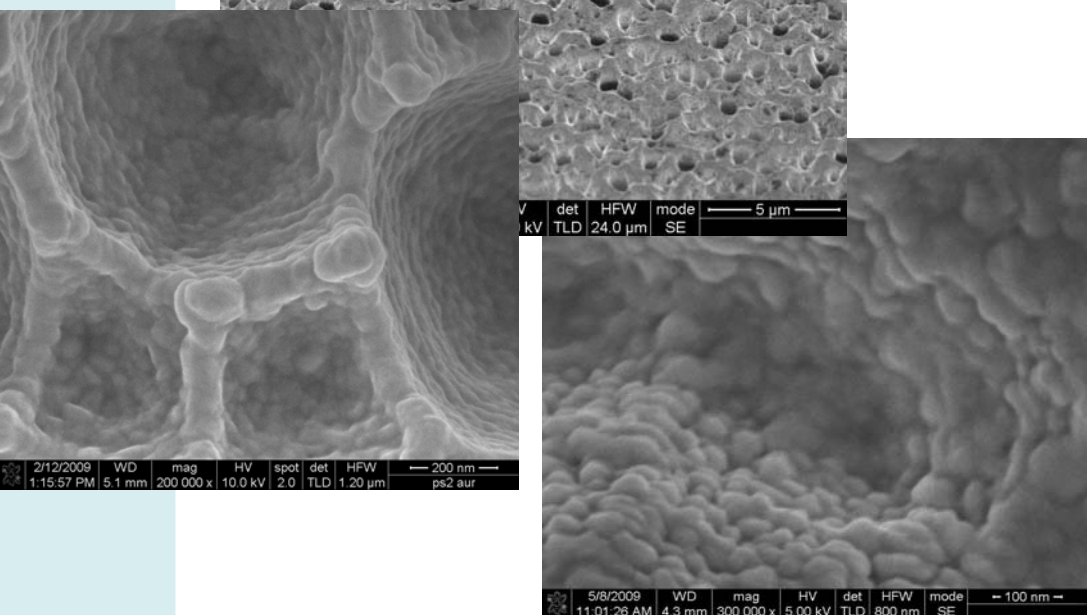
Si

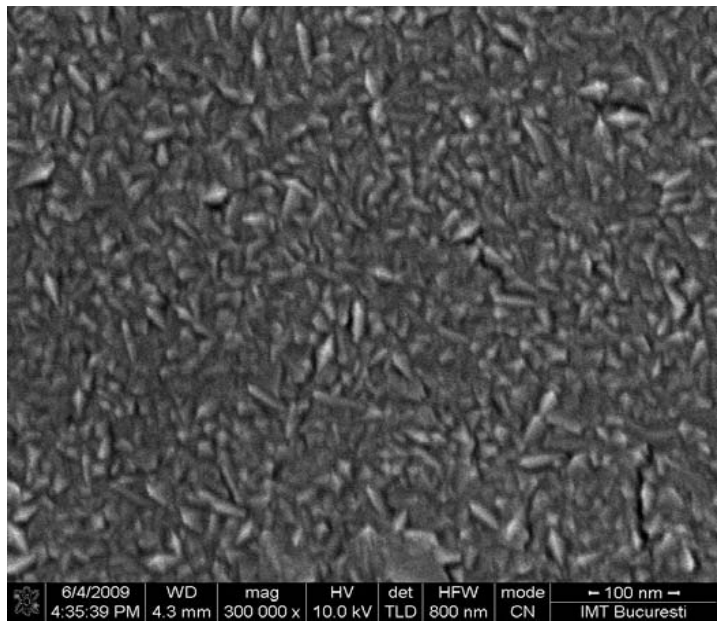
Nano-structured metallic thin films (NP-PVD) on PS substrate

Au thin films - 100 nm – cathodic sputtering system

Pt thin films - 100 nm e-beam deposition system

Si

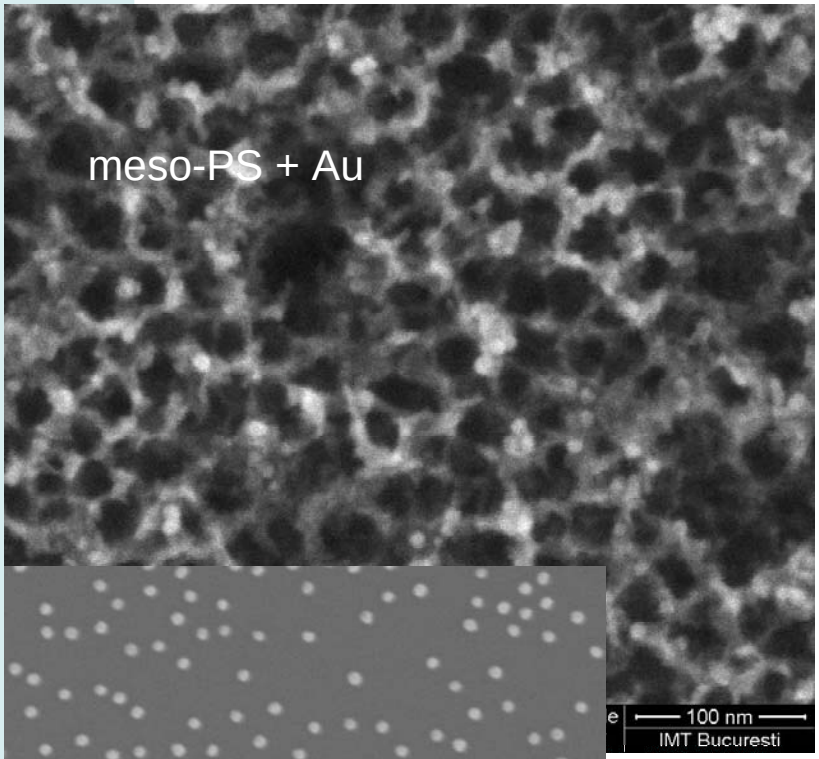


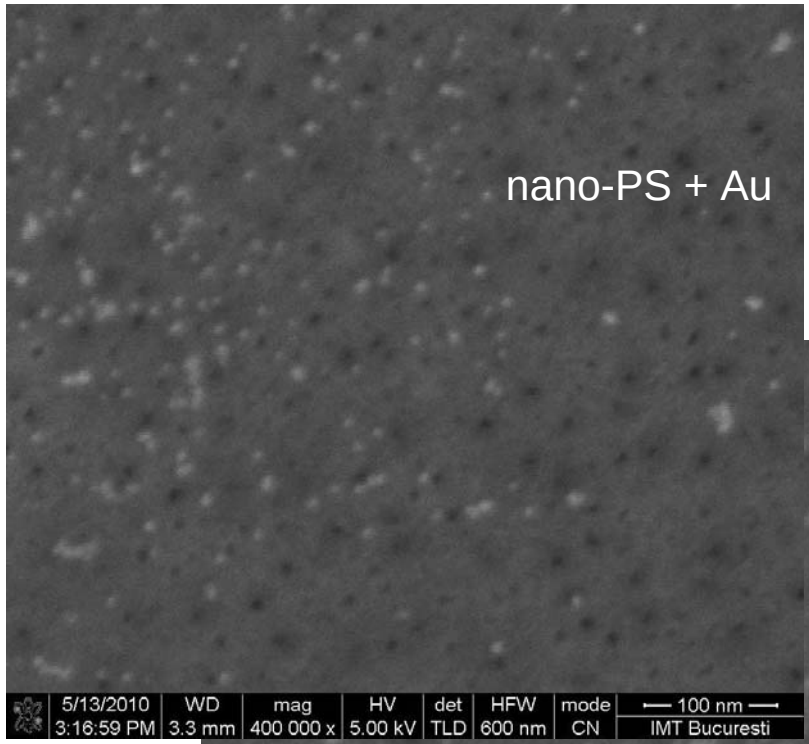


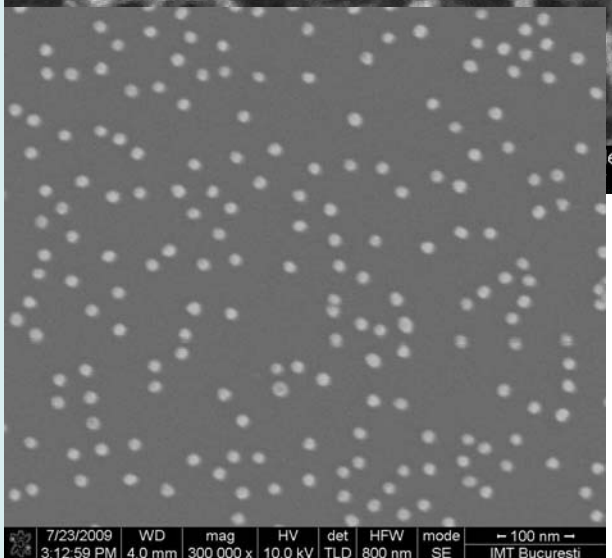
Metallic nanoparticles (NP) on PS substrate

Si

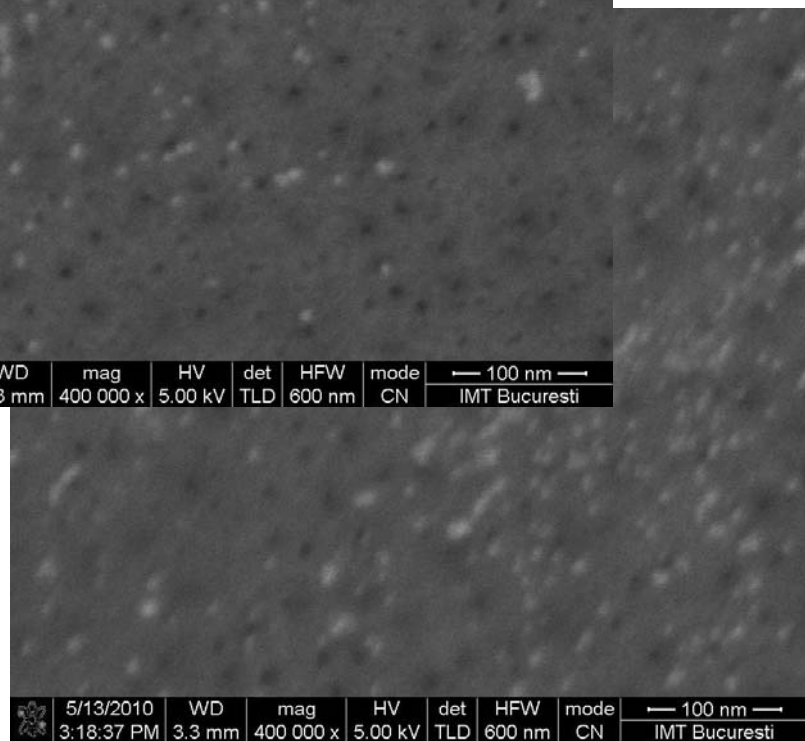
Au NPs





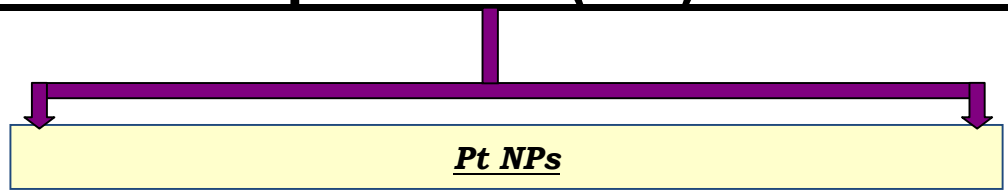


Colloidal Au

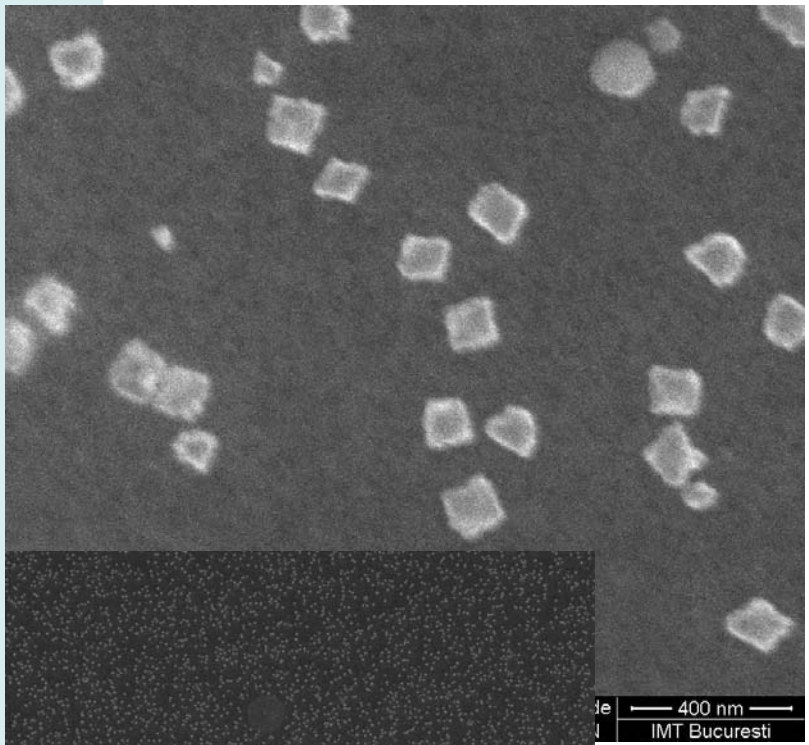


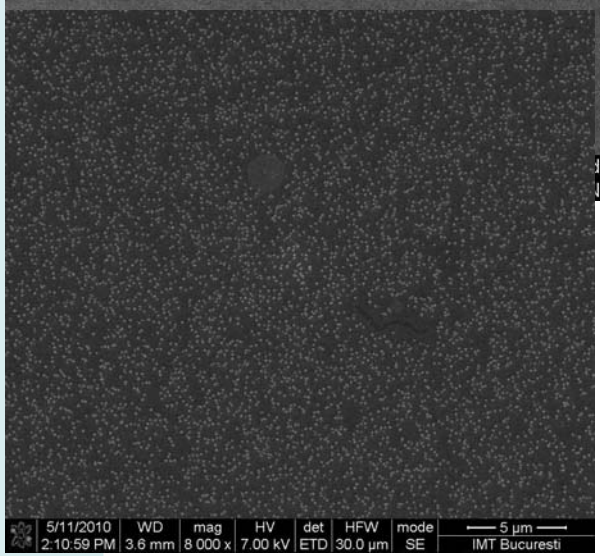
Metallic nanoparticles (NP) on PS substrate

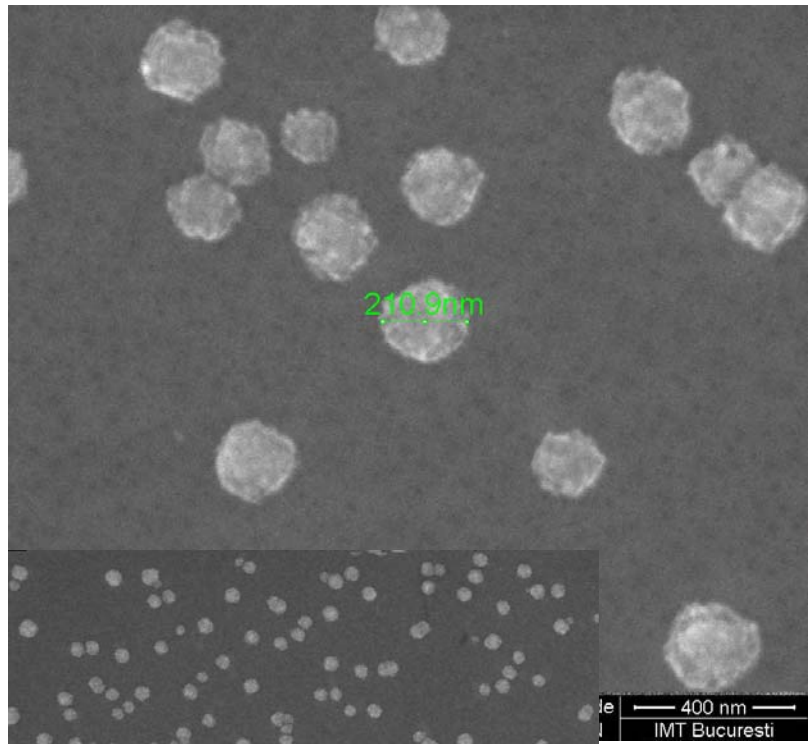
Si

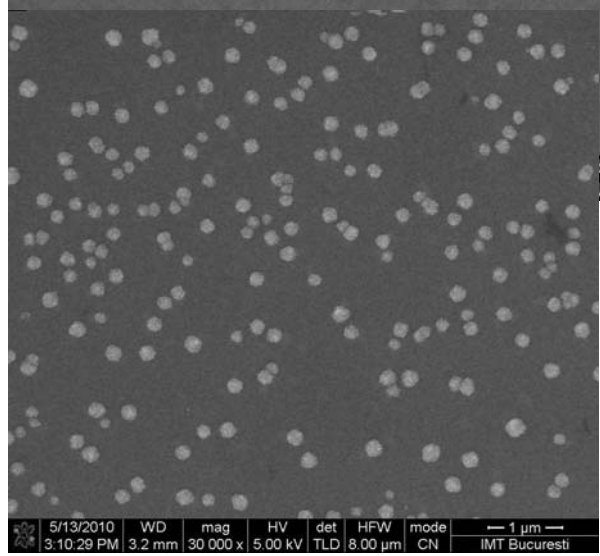


nano-PS + Pt

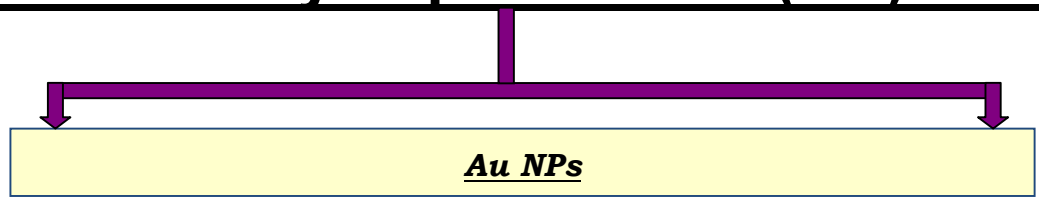




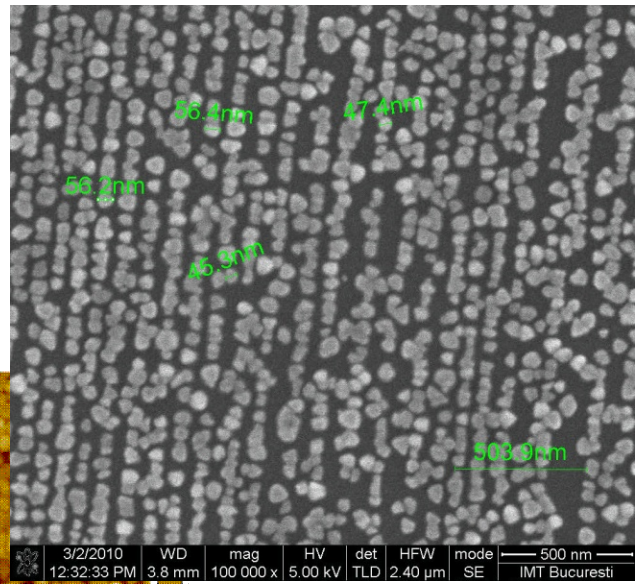




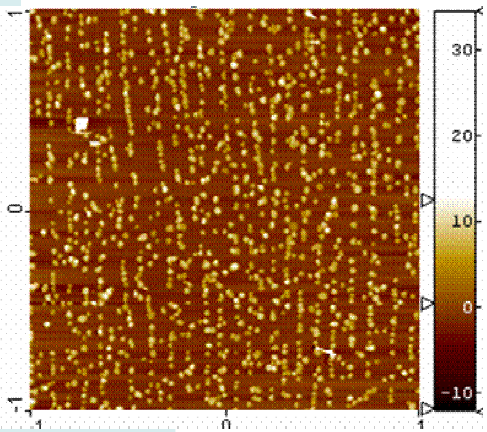
Electrochemically deposited Au (NP) on Si substrate

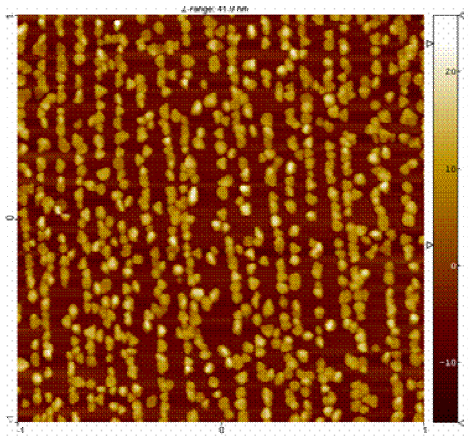


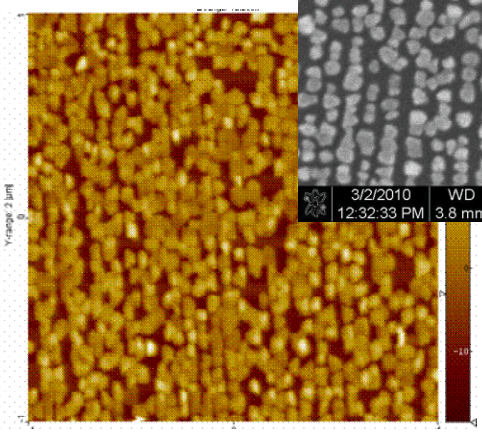
Substrate preparation: H_2SO_4:H_2O_2= 1:3 v/v; Si(111)-H; (NH_4F 40%); $(NH_4)_2SO_3$; 15 min. Electrochemical deposition of gold nanoislands (0.1mM $KAu(CN)_2$, 0.2mM NaCN, 2M NaOH, pH=14).



AFM images of gold-nano-islands on n-type silicon (111) substrates







(a) 4s –2V and 10s –1,5V

I=10 nm
D= 50 nm

(b) 4s –2V and 30s –1,5V

I=50 nm
D= 70 nm

(c) 4s –2V and 100s –1,5V

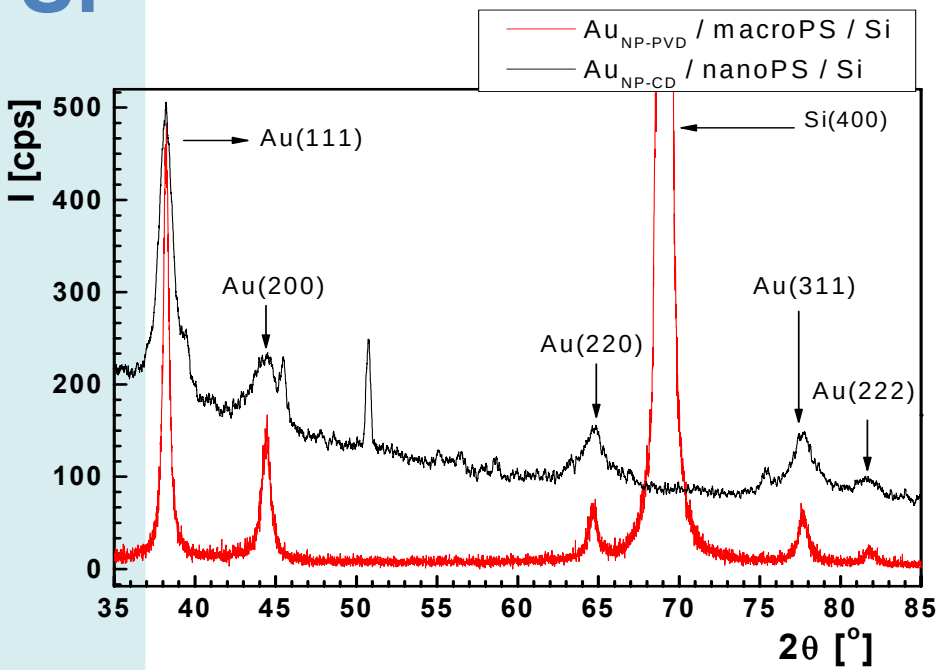
I=80 nm
D= 100 nm

Au nano-islands are prepared by electrochemical deposition on silicon.

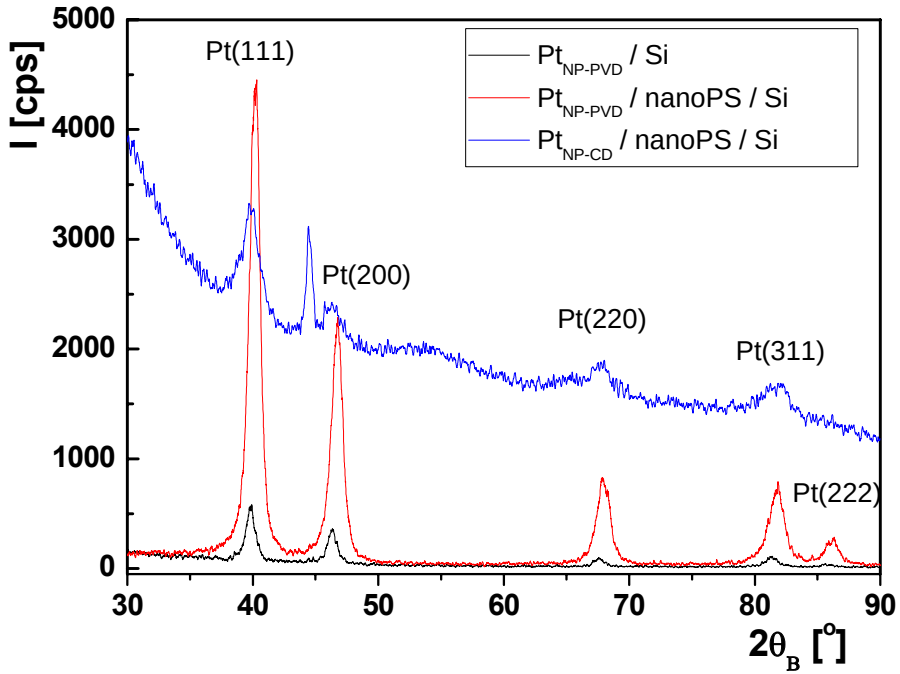
X-ray diffraction

The microstructural characterisation of AuNP-PVD on macroPS and AuNP-CD on nanoPS.

Si



GIXRD X-ray diffraction spectra (ω = 0.35°) of samples as function of both deposition method and substrate nature



-XRD reveals the high intensity ratios between (111) diffraction pattern and the peaks assigned to (200), (220), (311), (222), and (400) reflections of fcc structure of gold, indicating that the faces of these nanoparticles were primarily composed of (111) planes.

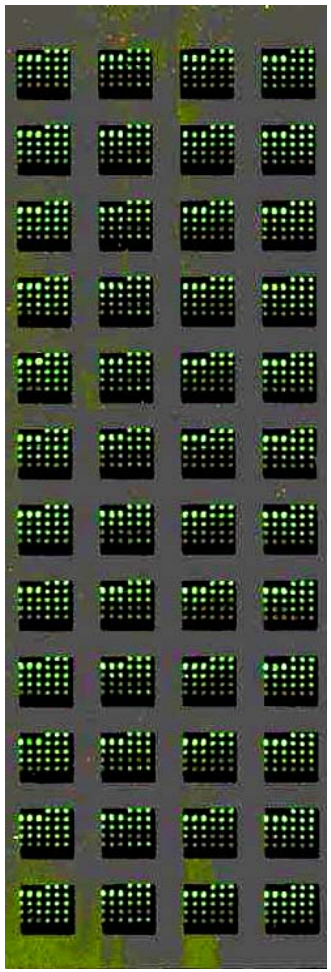
- $Pt_{NP\text{-}PVD}$ / *Si :* no preferential texture;
- $Pt_{NP\text{-}PVD/CD}$ / *PS / Si :* indicates a better defined degree of crystallization with no preferential orientation.

Practical applications

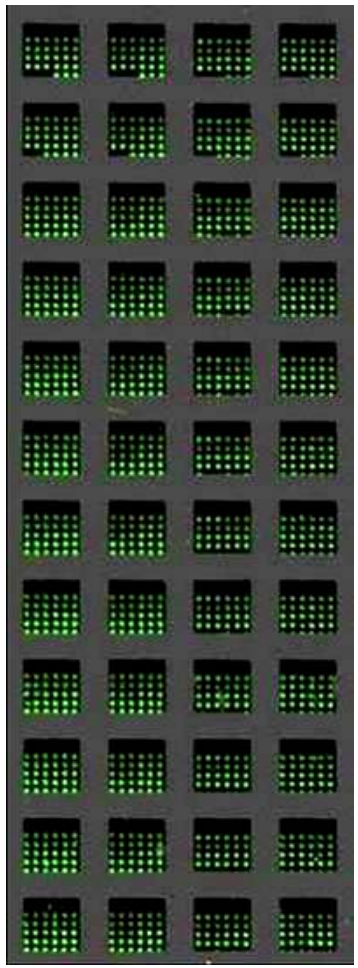
Microarray technology

Si

ALD -slides

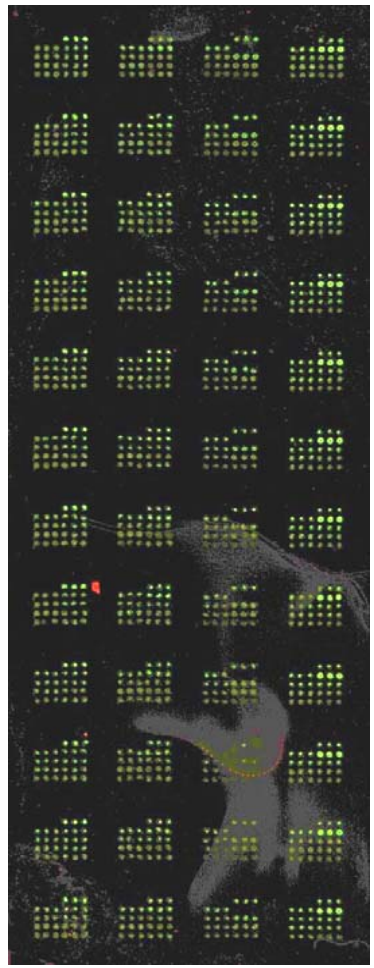


GLASS

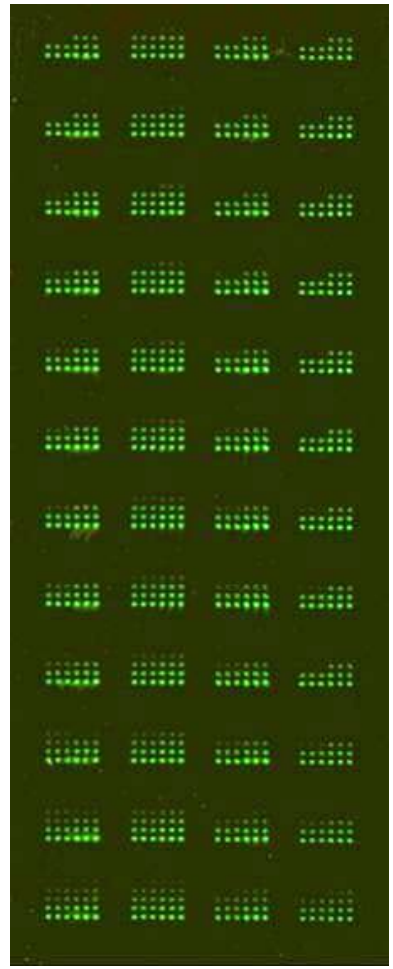


PS

p-L-lysine slides



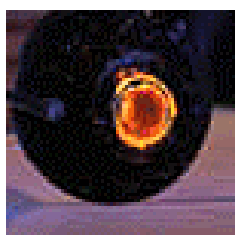
PS

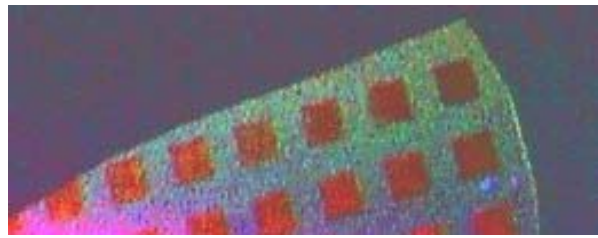


GLASS

Photoluminescence

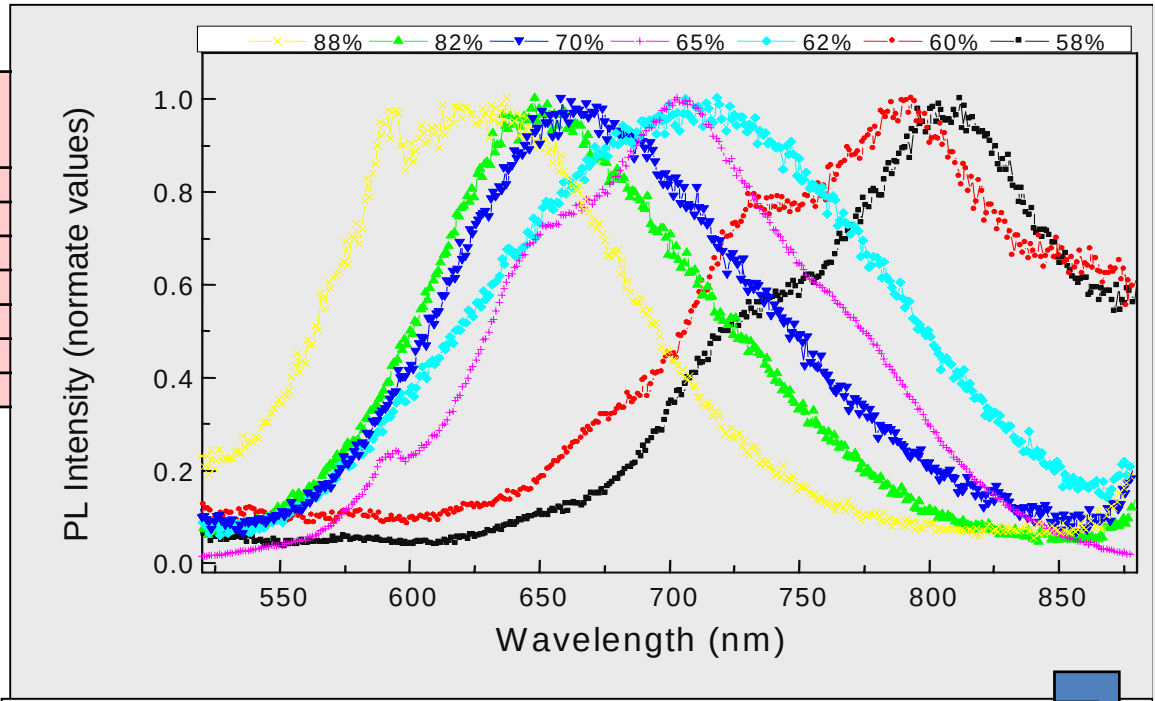
The orange - red photoluminescence of nanoPS is clearly visible when the wafer illuminated by UV light.





No.	Concetration HF (%)	Current density (mA/cm²)	Time (min)	Porosity (%)
1	25	15	6	58
2	25	20	6	60
3	25	25	6	62
4	18	15	6	65
5	18	20	6	70
6	15	15	6	80
7	15	25	6	88

Si



Photoluminescence spectra of PS / Si-p samples with different porosities (58% - 88%)

- the PL peaks for high porosity PS samples are centred around 650-720 nm, in visible range due to quantuum confinement and surface states effects;
- a shift of the PL peak position towards high photon energies with the increase of the PS porosity is observed;

The PL emission from PS is observable at wavelengths ranging from the UV to the IR, the normalized spectra recorded for different experimental samples demonstrate the dependence on porosity.

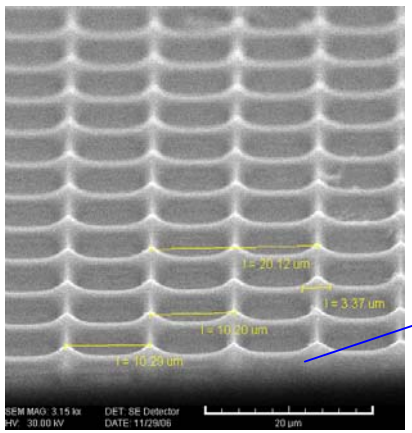
Si microstructuration and porosification

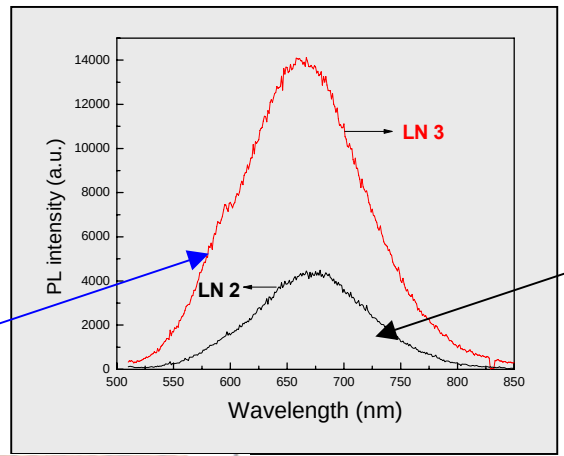
Si

Silicon substrate was micropatterned prior porosification process as:

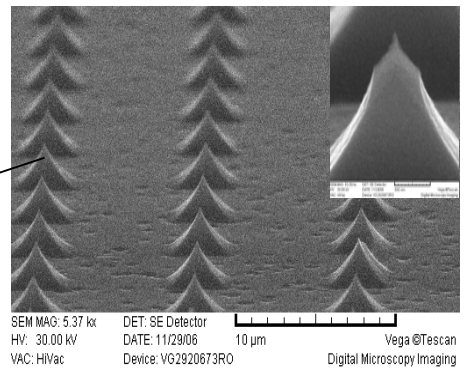
an **array of** pyramids (right) or as **semi-circular cavities** (left);

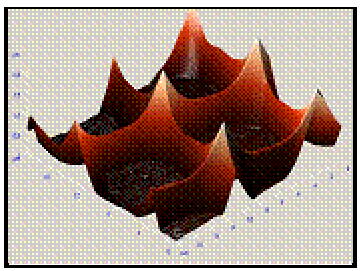
LN3 interconnected lines

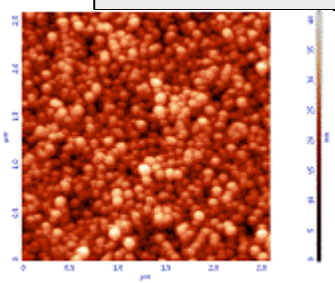


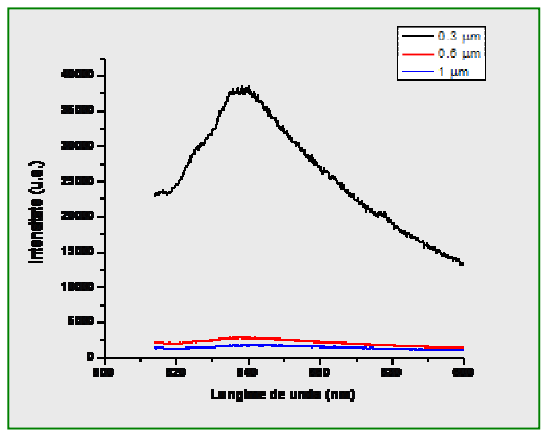


LN2 pyramidal structures





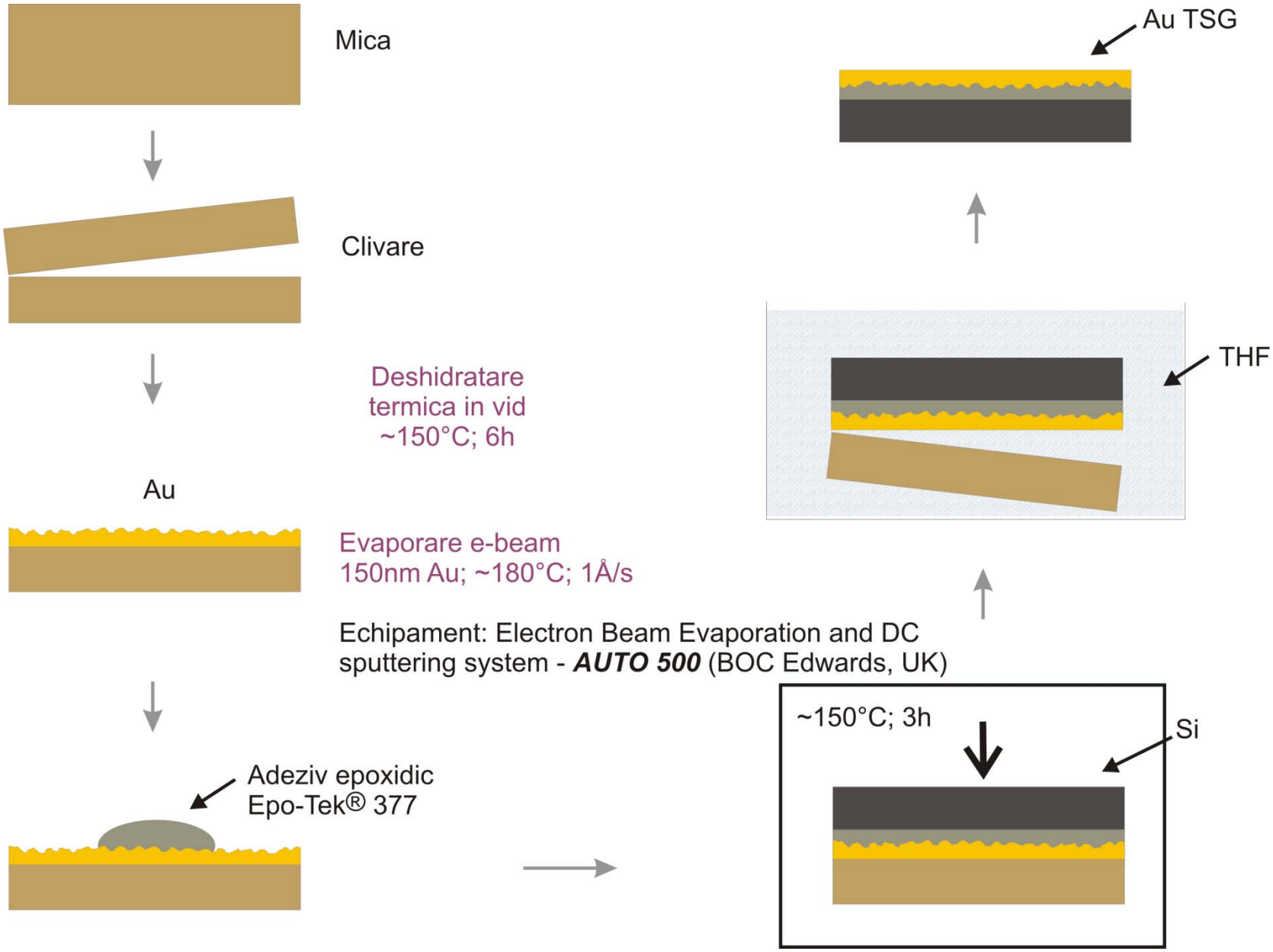




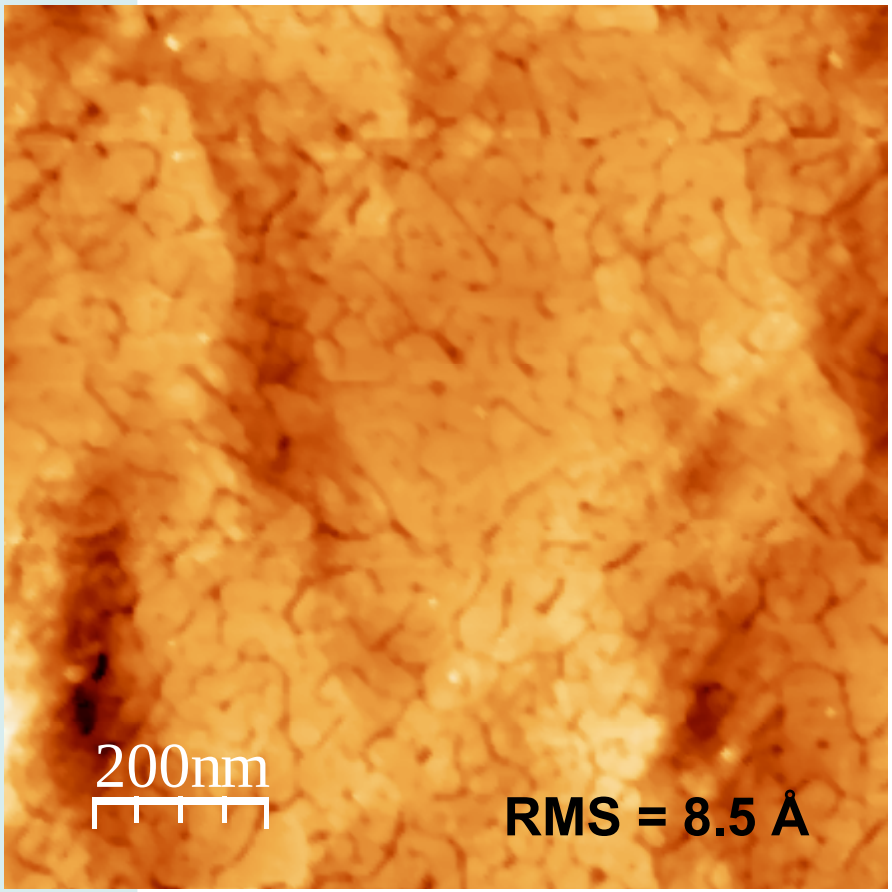
• **similar recording conditions were** (488 nm frequency of excitation and 87 mW nominal power)

• **the intensity of PL emission is three times larger in the case of semicircular microcavities** leading to an important improvement of detection.

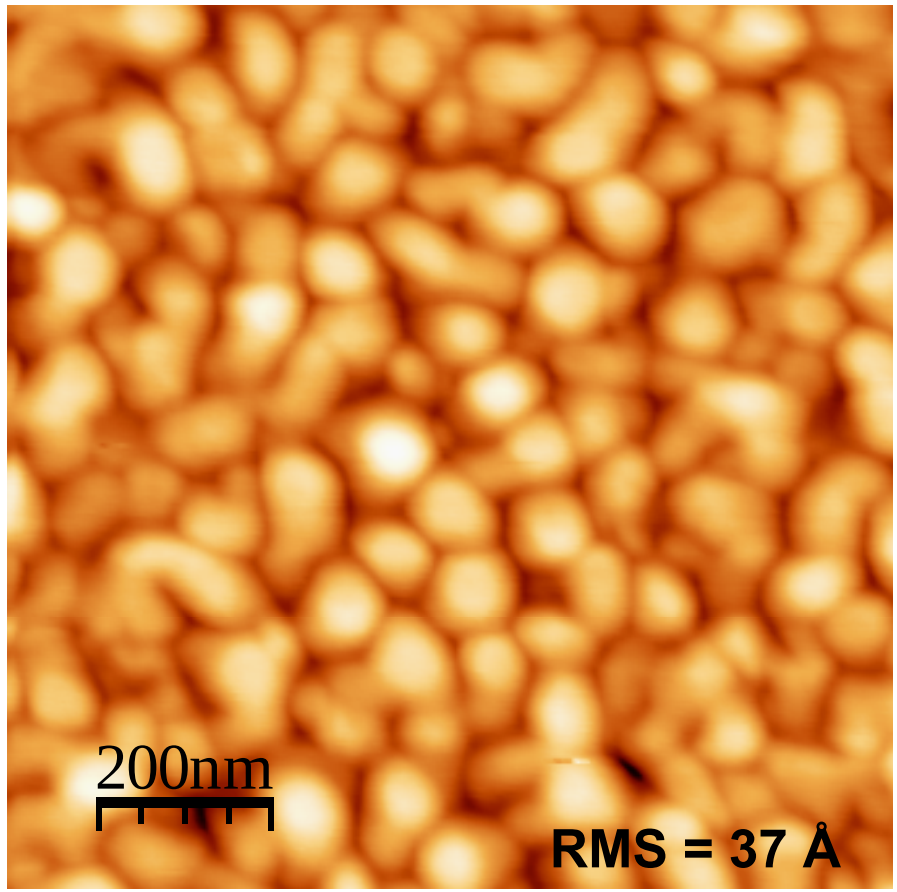
TSG - "template stripped gold"



STM – Scanning Tunneling Microscopy



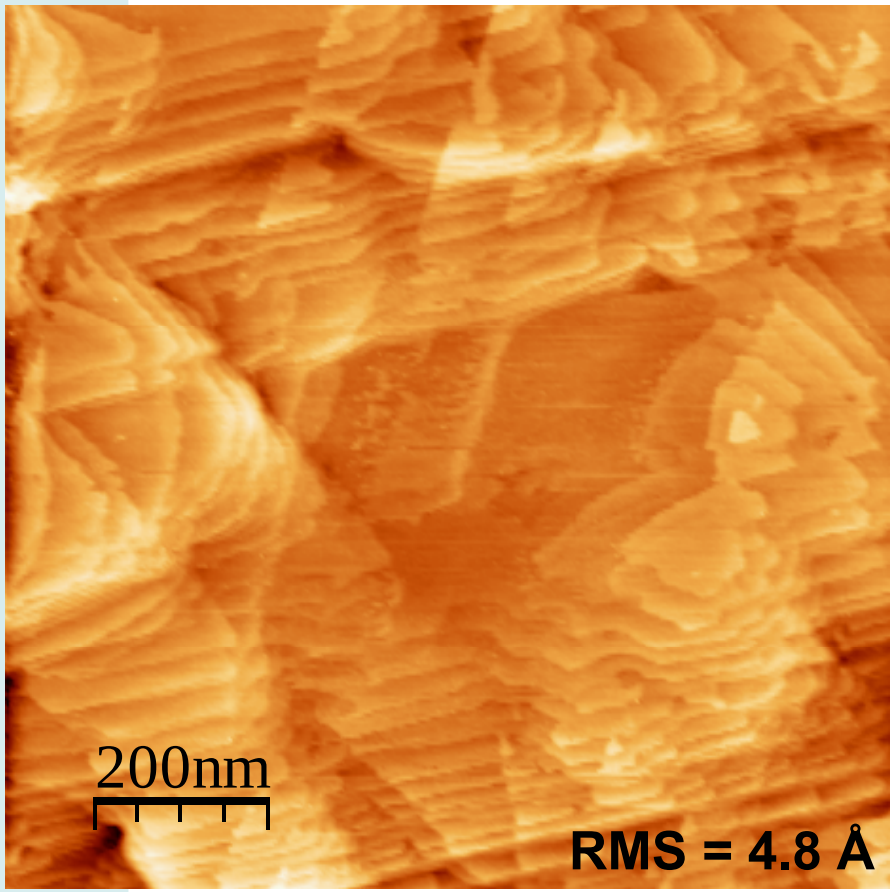
Au/mica - *TSG*

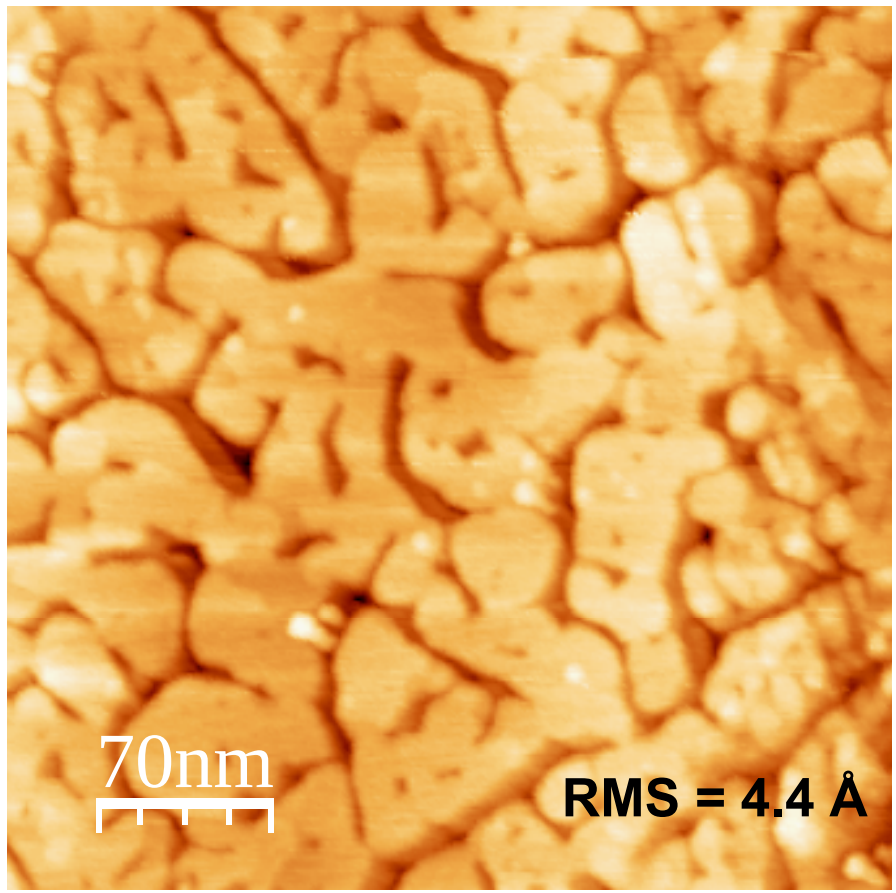


Au/Si

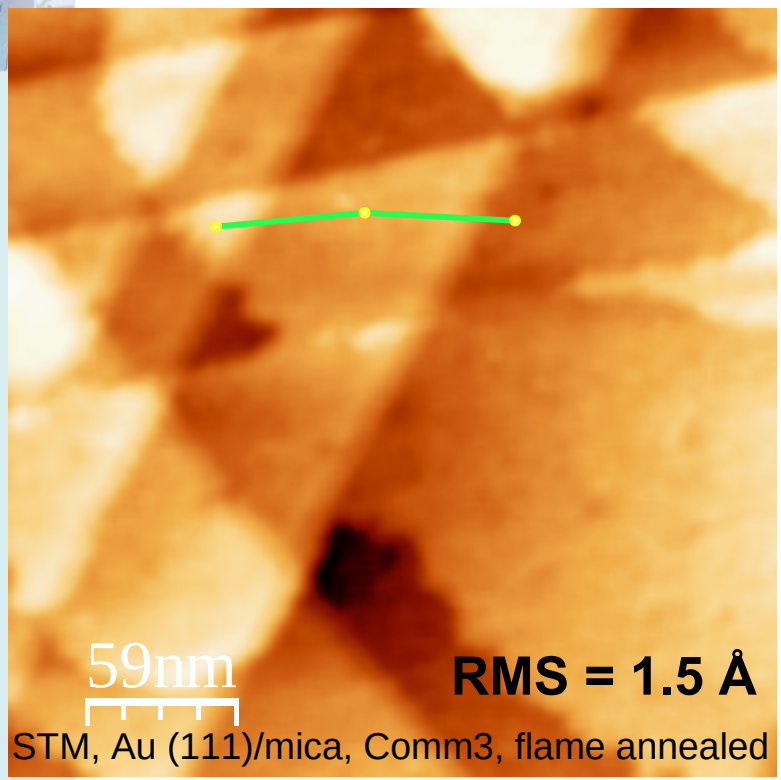
STM, Au (111)/mica

Flame annealed *vs*. non-flame annealed

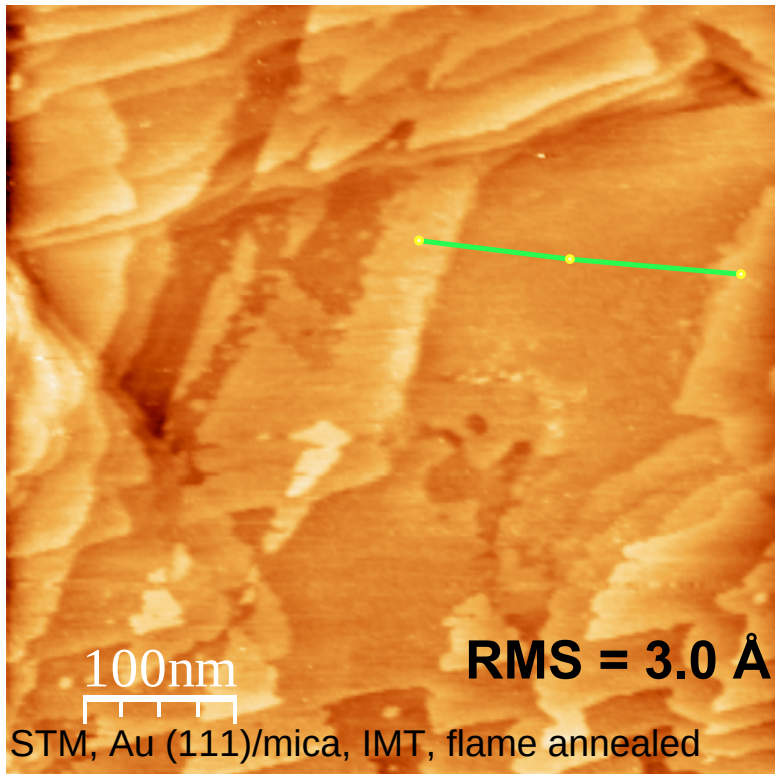




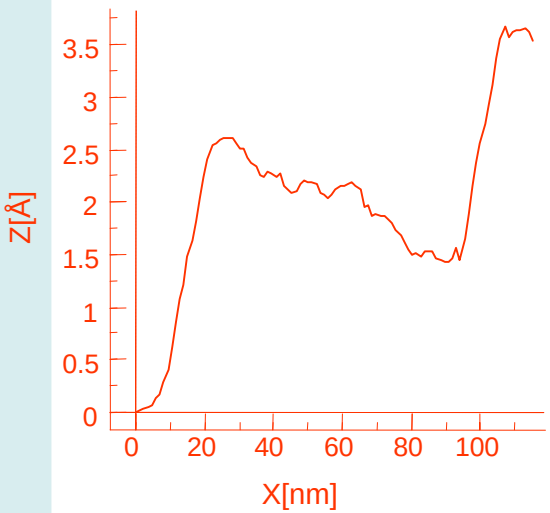
STM, Au (111)/mica - flame annealed

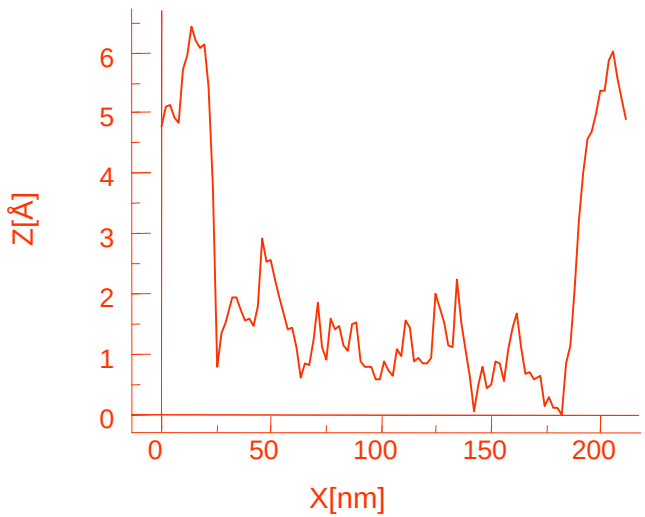


STM, Au (111)/mica, Comm3, flame annealed

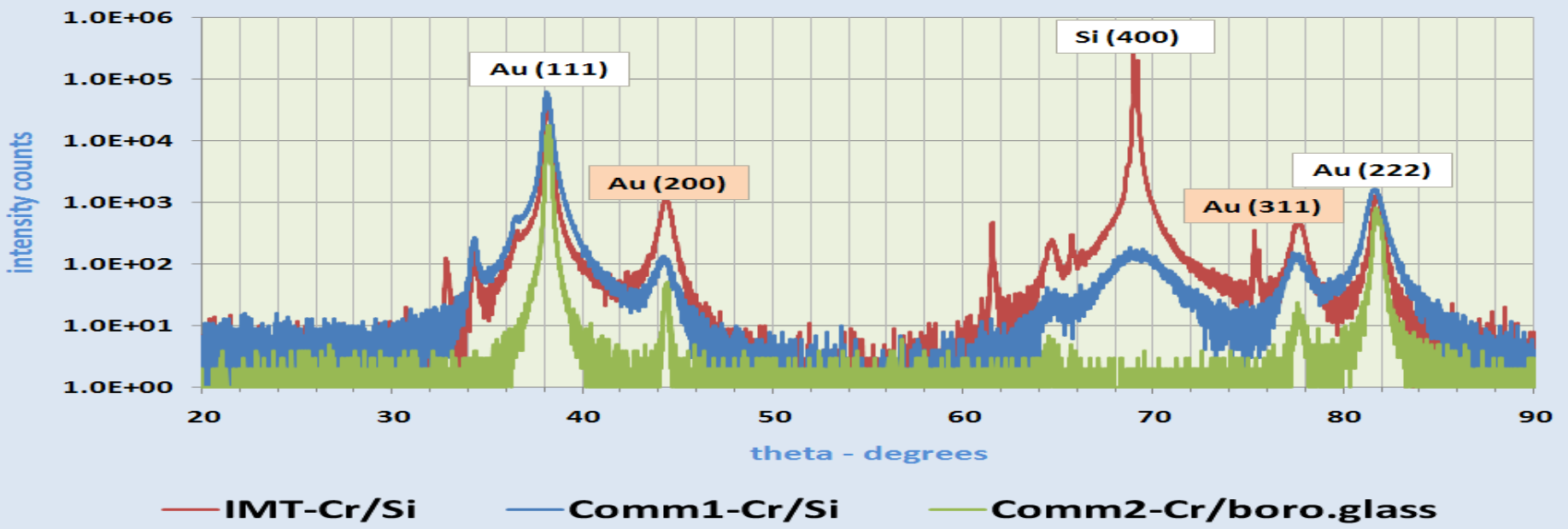


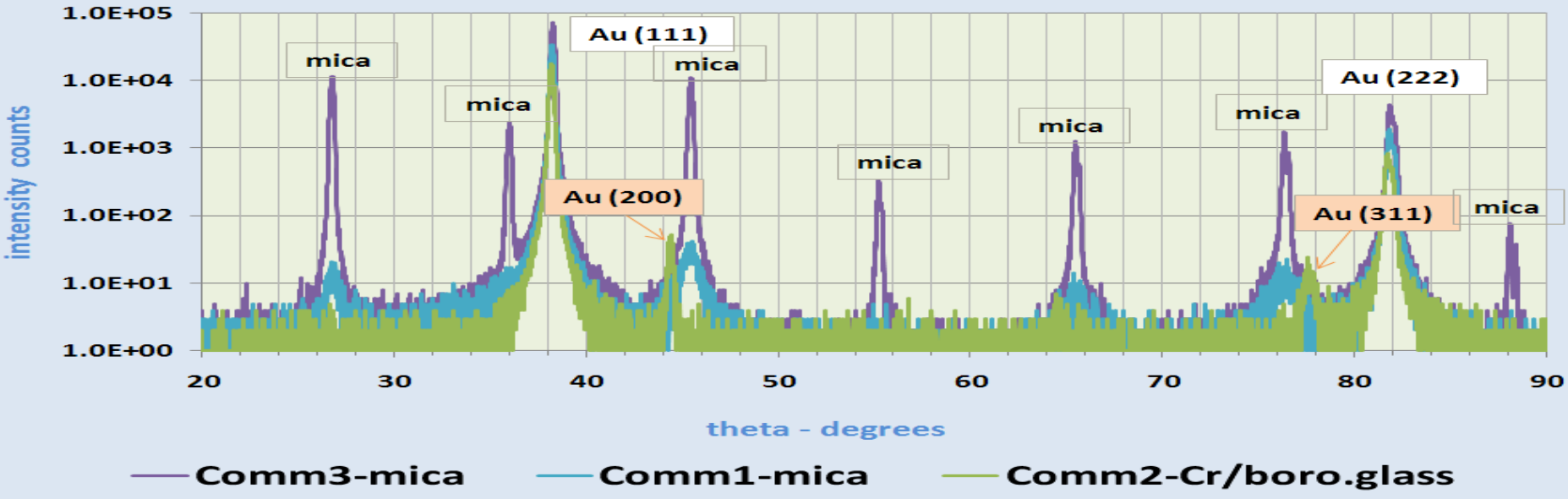
STM, Au (111)/mica, IMT, flame annealed



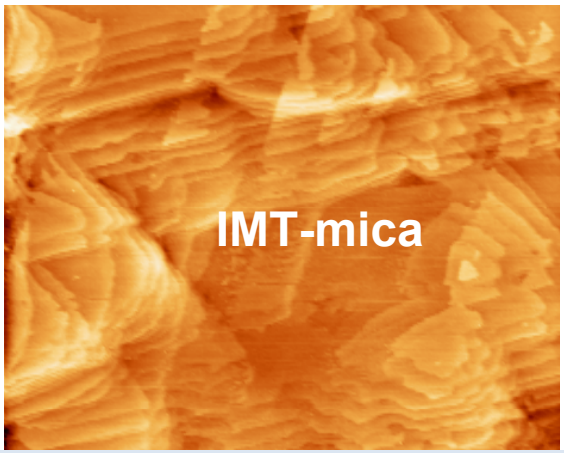


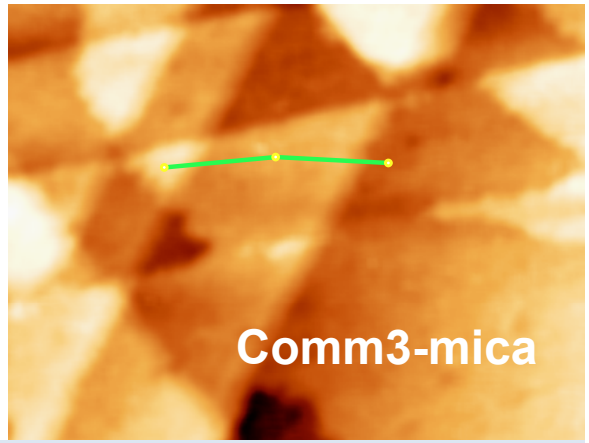
XRD characterisation

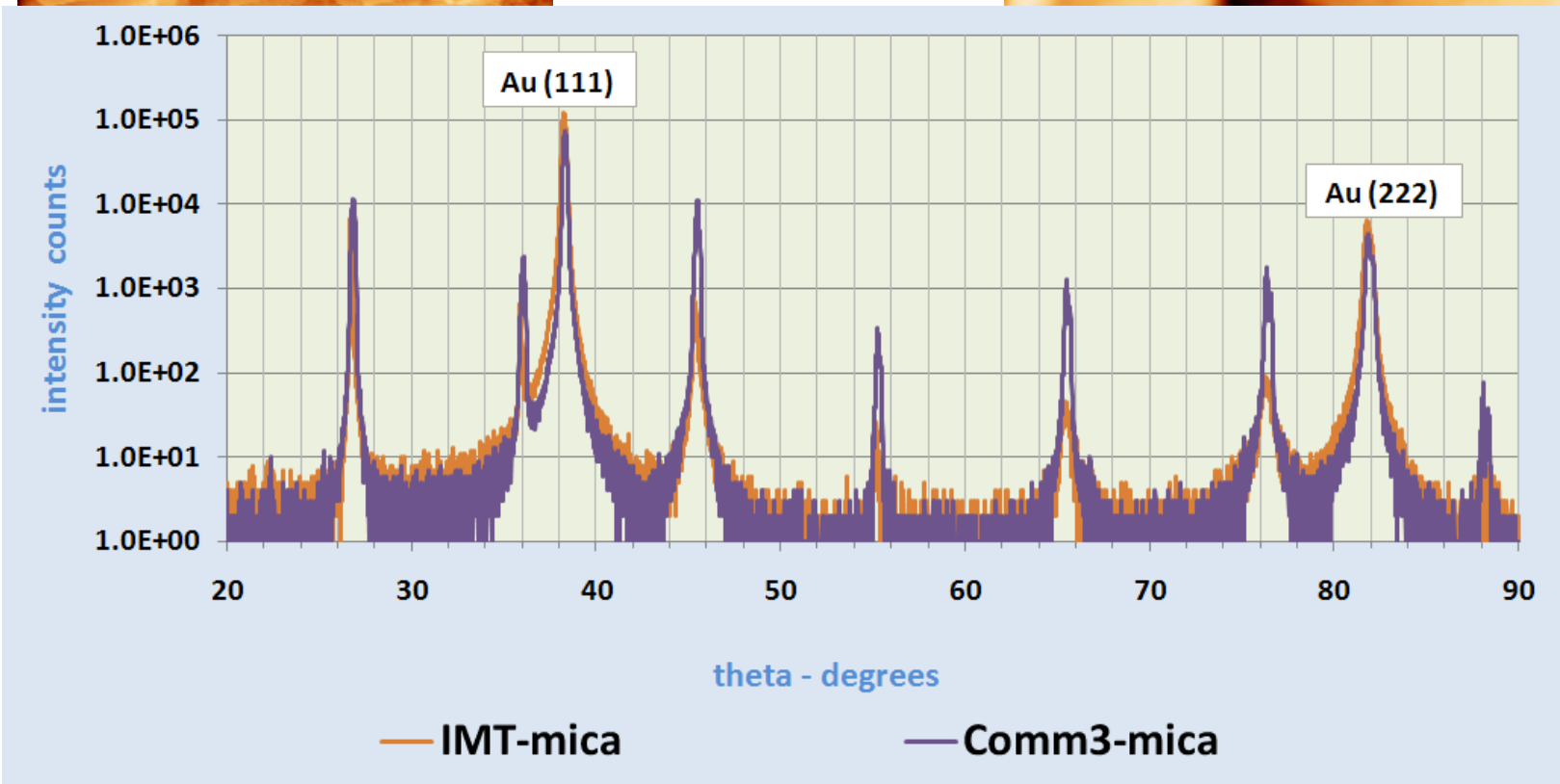




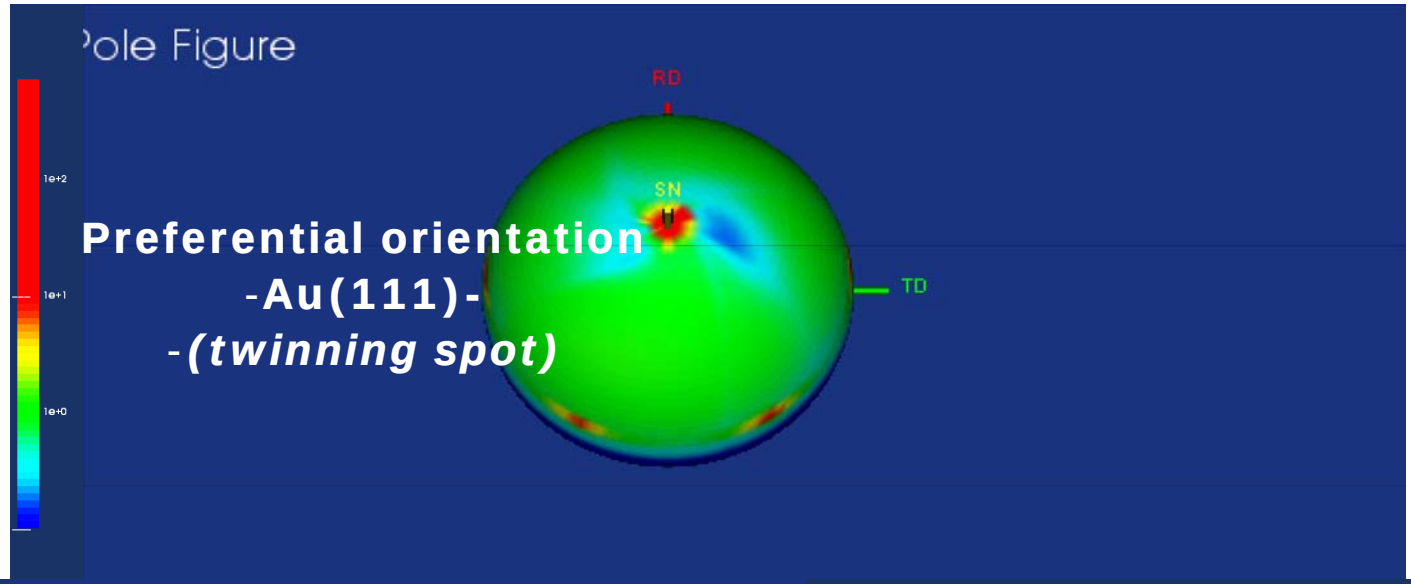
XRD characterisation

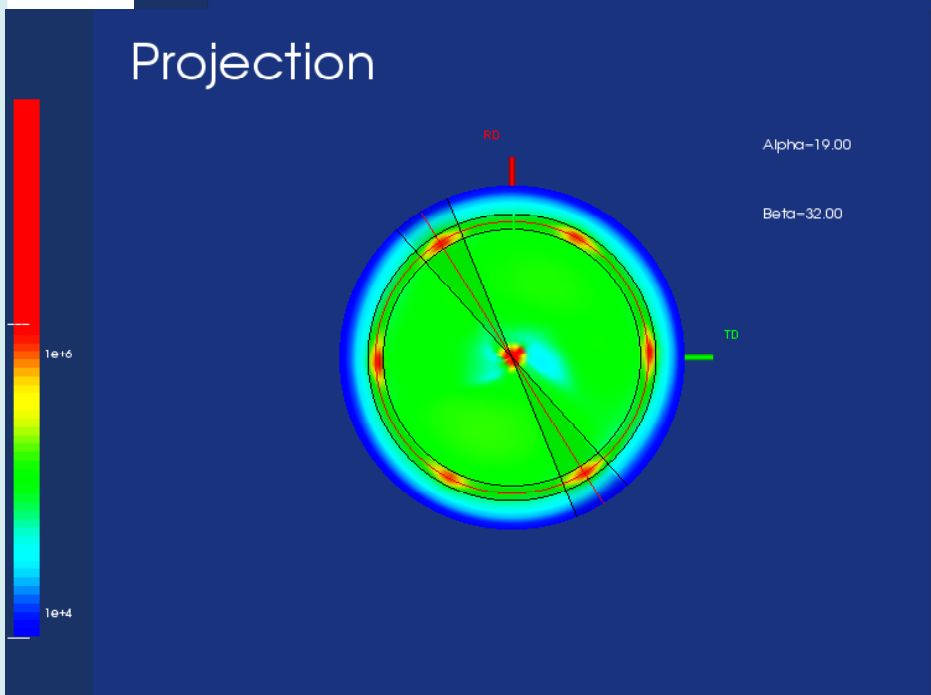


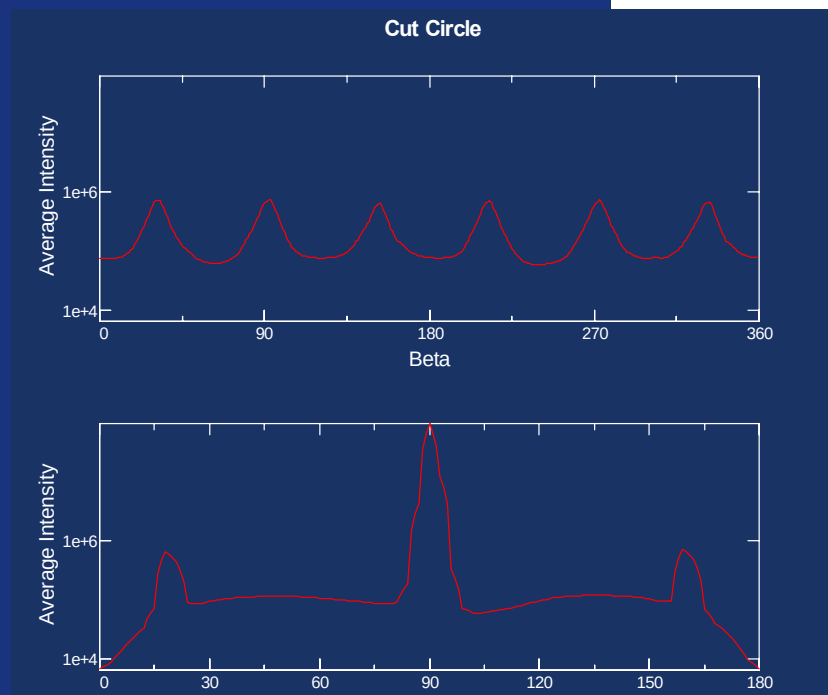




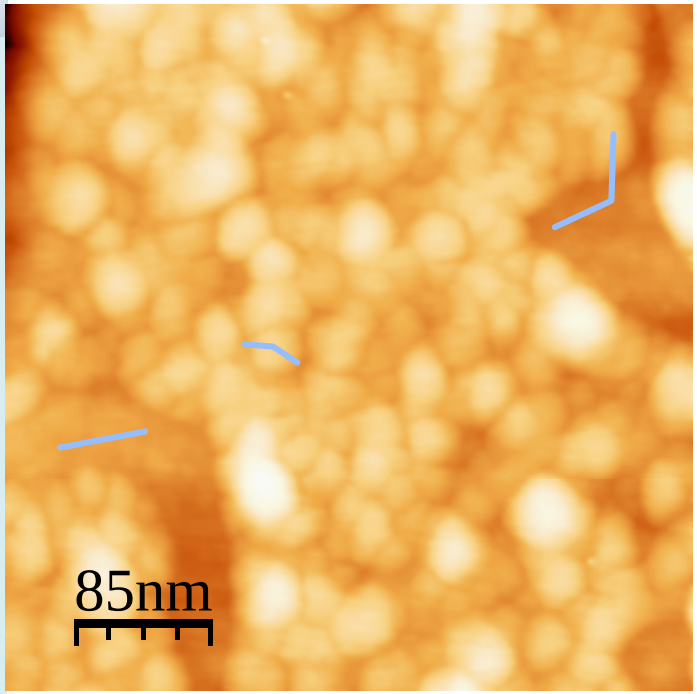
XRD characterisation

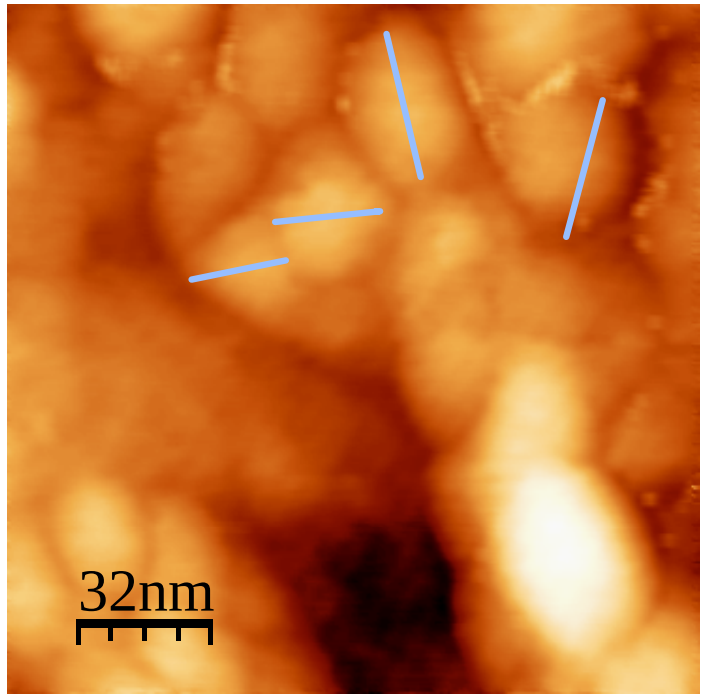


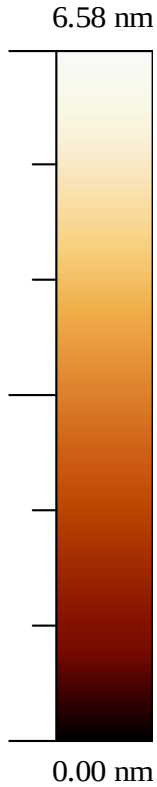


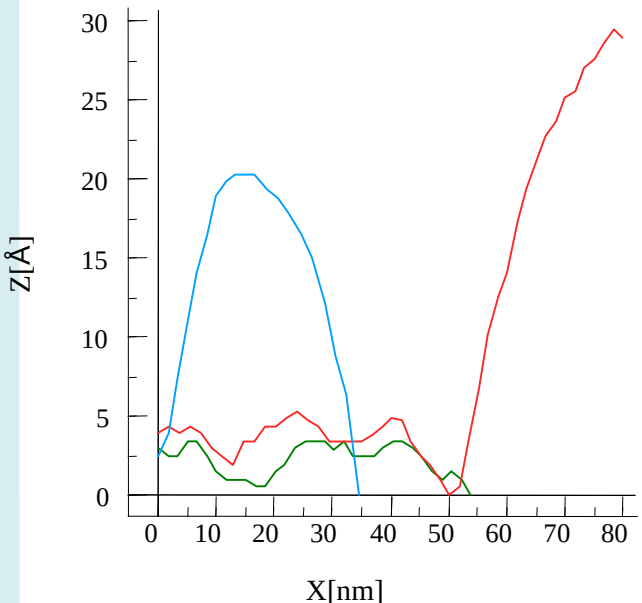


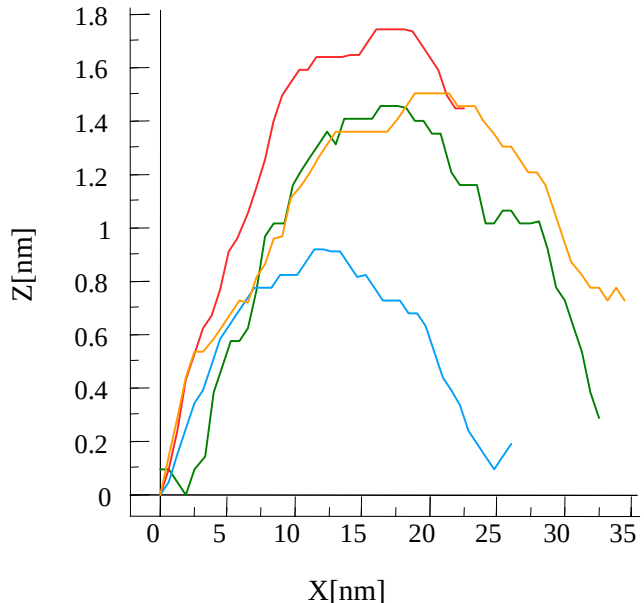
Human Serum Albumine/Au (111)





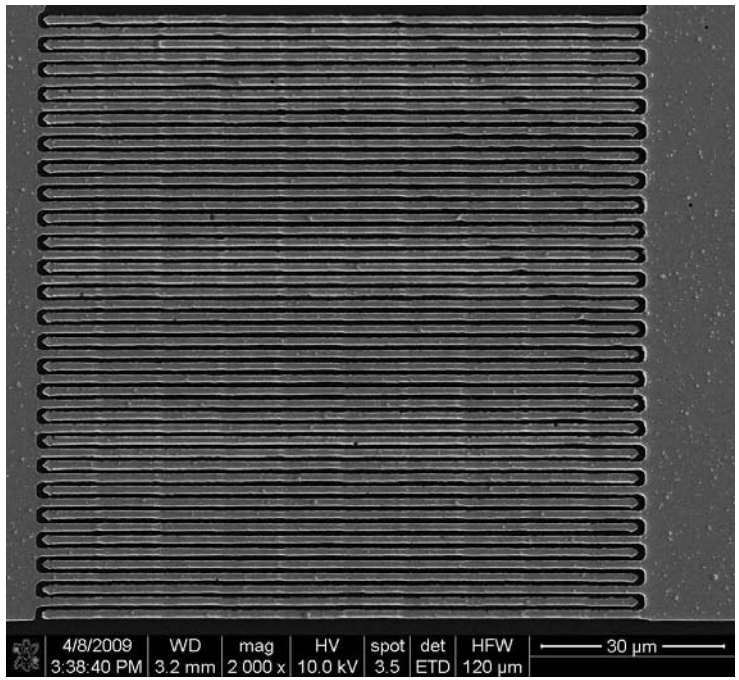






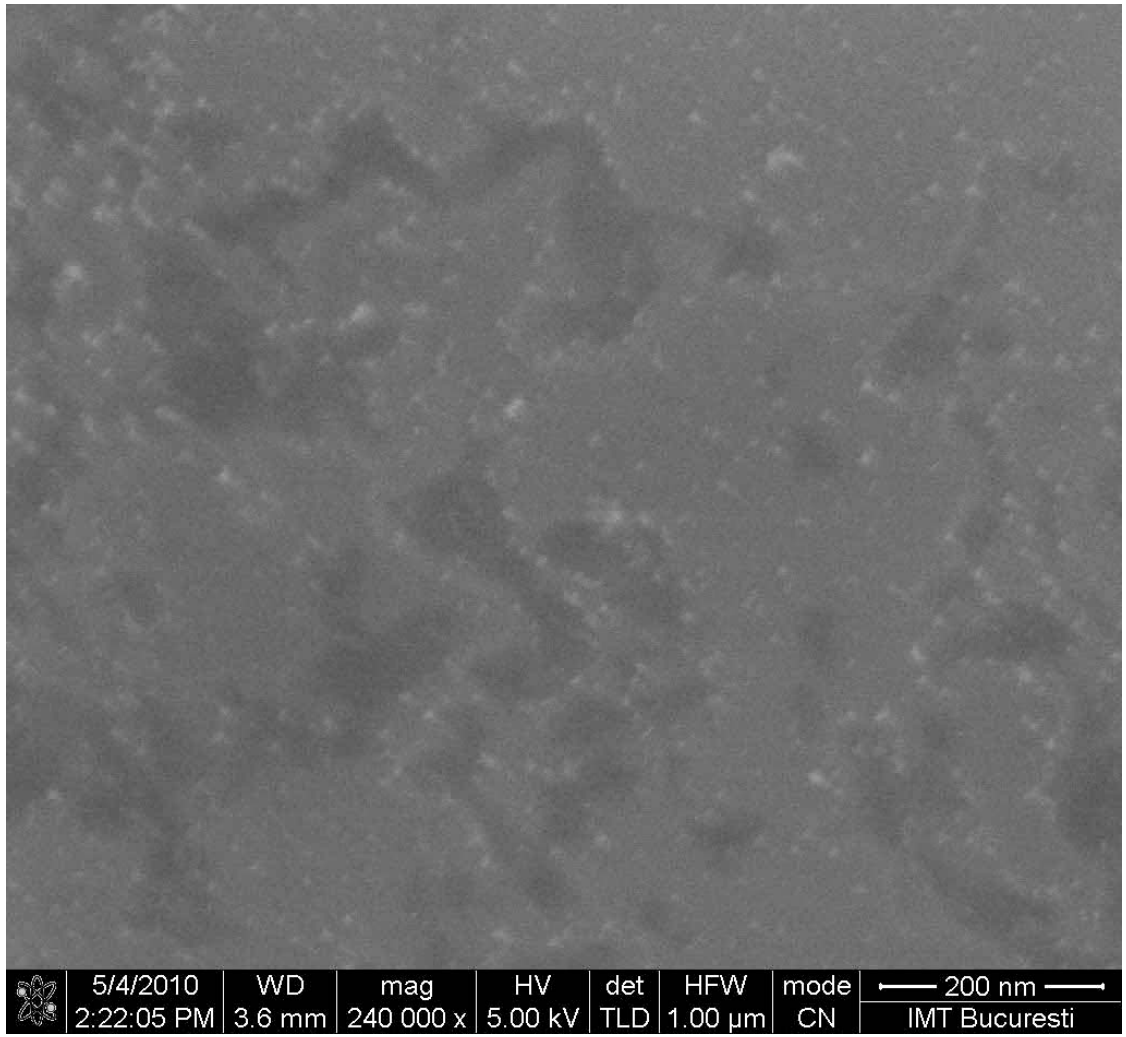
- Graphene – metallic nanoparticles decorated

- Graphene decorated with:
  - Au nanoparticles
  - Ag nanoparticles



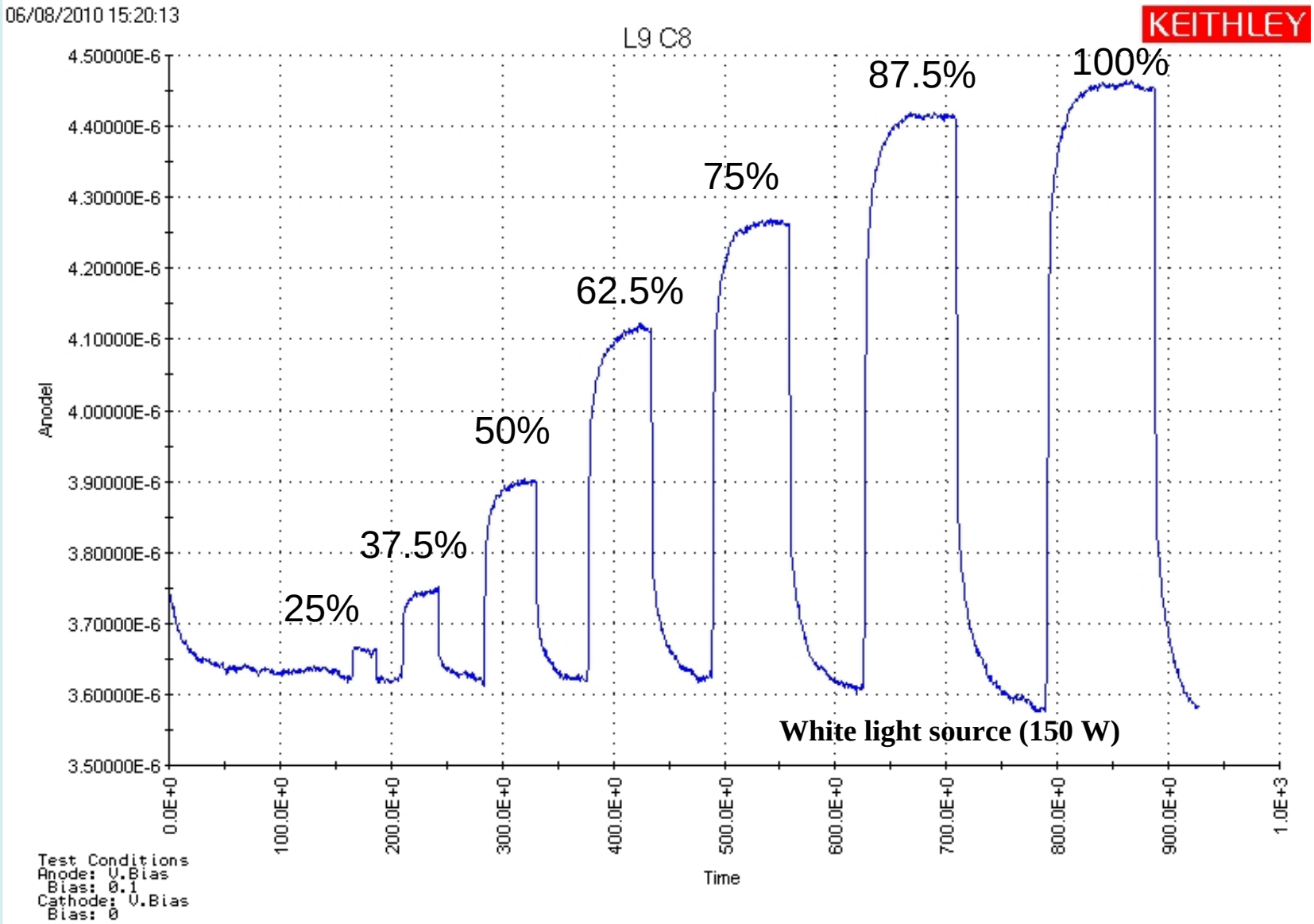
SEM - IDT

•Graphene – Au nanoparticles decorated

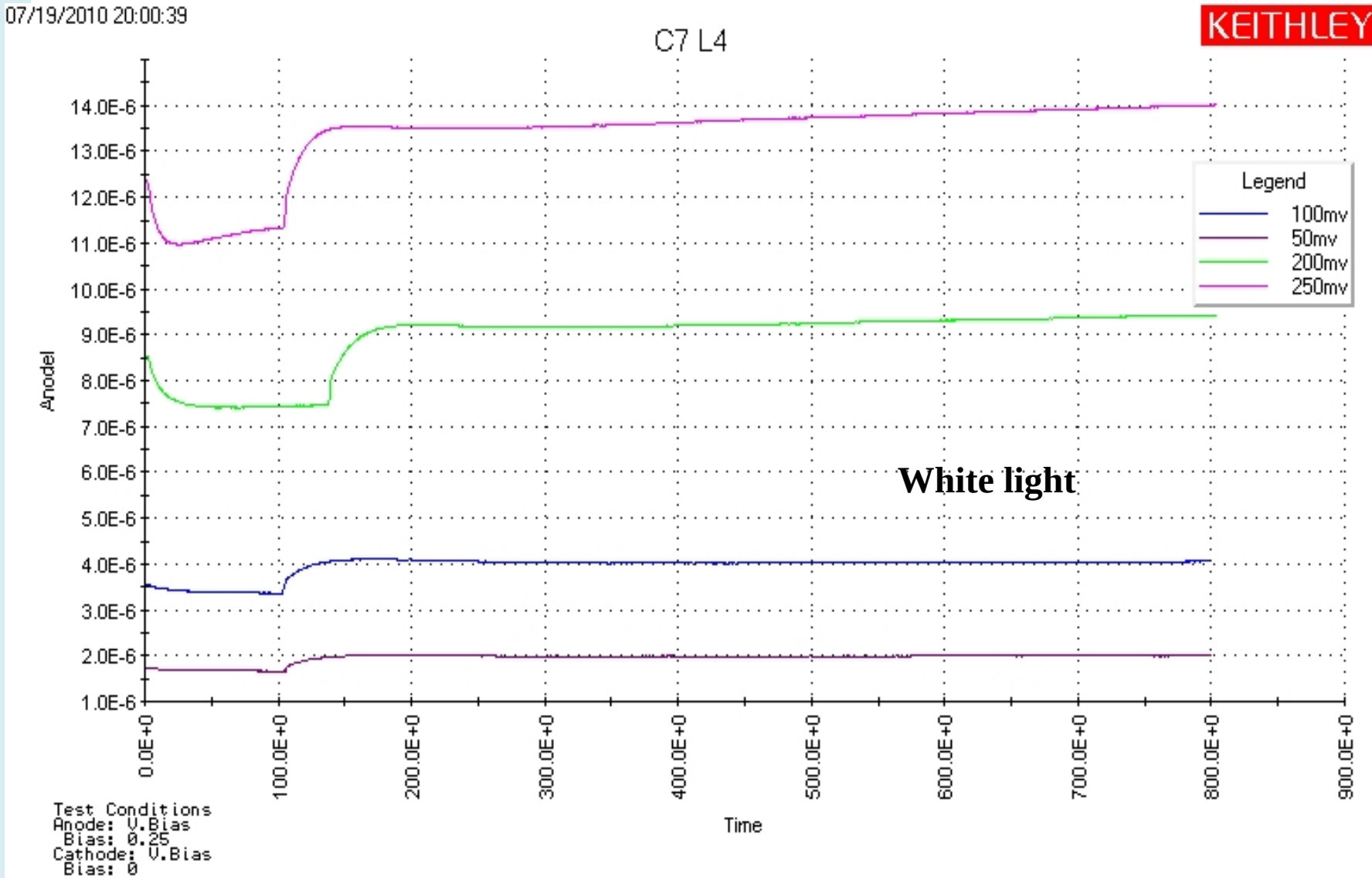


Graphene decorated with nanoAu

Photocurrent
Graphene – nanoAu



Photocurrent
Graphene – nanoAg



Photocurrent
Graphene – nanoAg