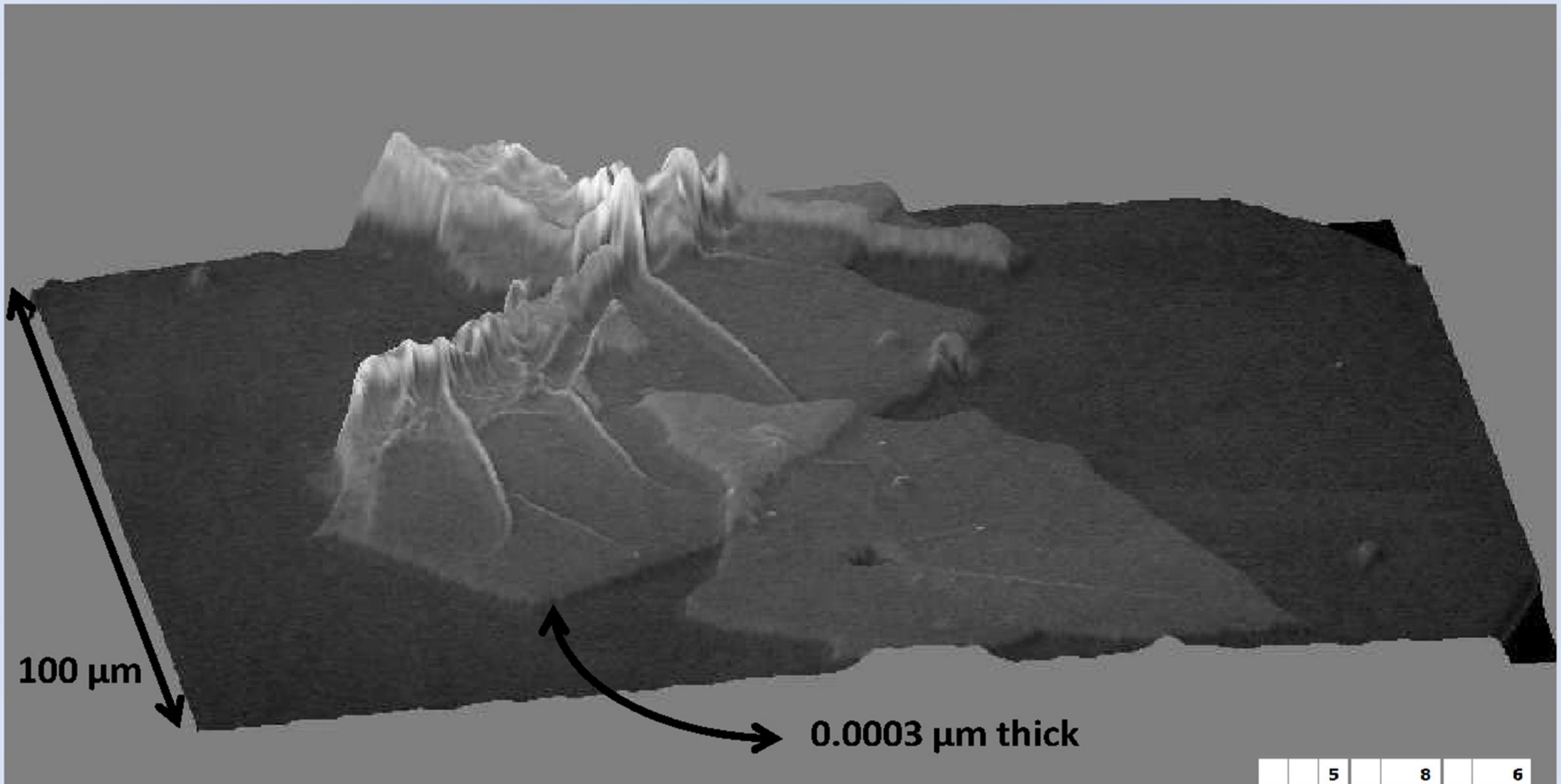
Content

Puzzle: which technique was used ?
(graphene oxide monolayers)



(you may also chose sudoku grid)

		5			8			6
6		7			2		1	9
9	1	2		3	6			
	4							5
8	5	6				9	7	3
2							4	
			4	9		1	5	2
1	2		6			4		8
5			2			6		

Current needs for graphene imaging

Qualify/monitor graphene production

Control/monitor graphene sheet deposition/organization

Give local number of graphene sheets in graphene layers

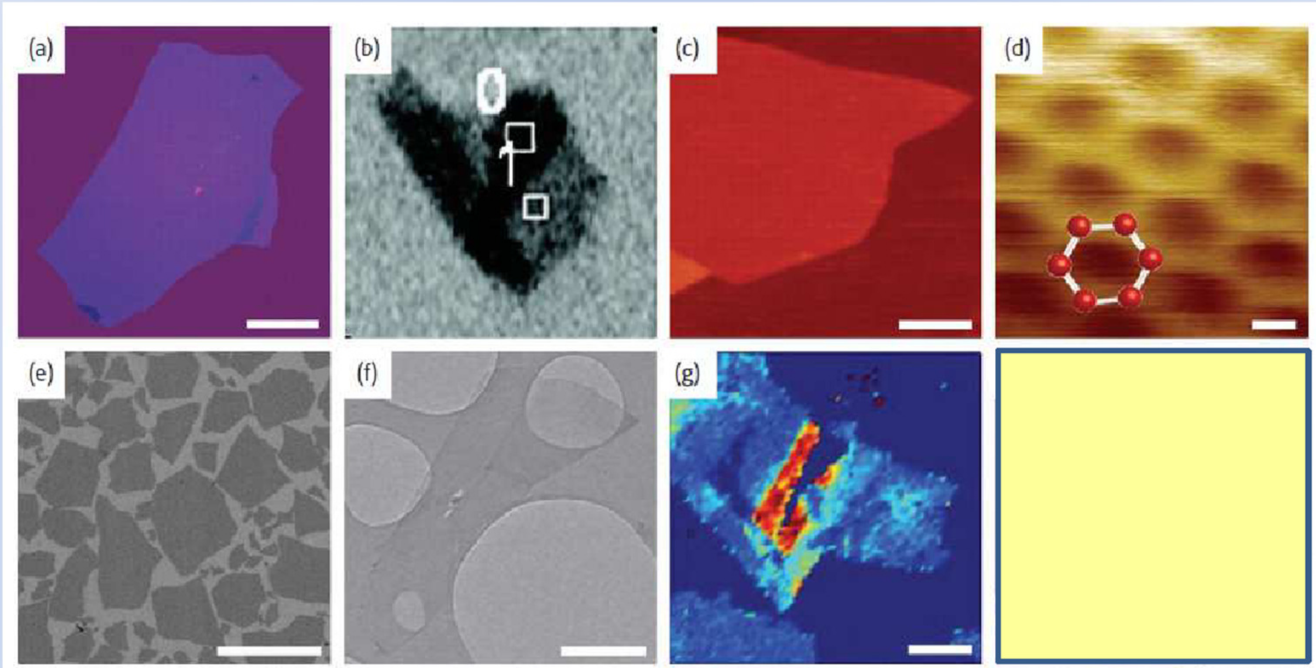
See graphene in water (Preparation and use)

Probe/monitor graphene chemistry

Visualize intercalation of impurities

Probe local conductivity

Main current Imaging Techniques



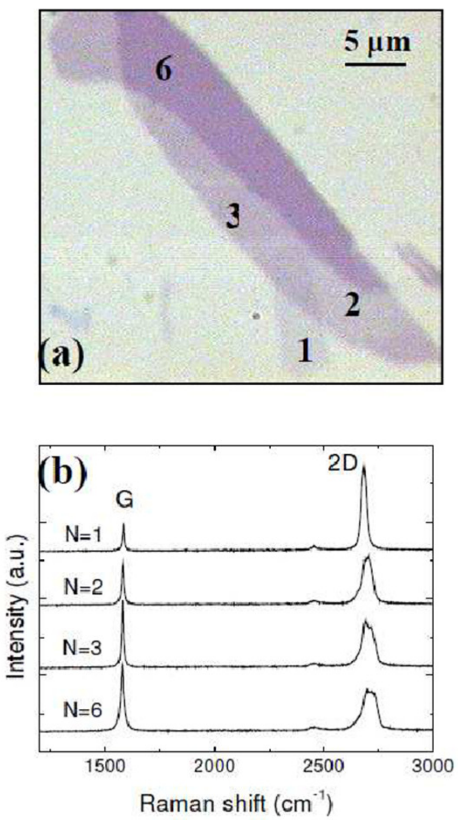
Si/SiO2 substrate	(a)	Interference - Scale bar	=	20 µm
	(b)	Ellipsometry -		?
	(c)	AFM-		1 µm
	(d)	STM-		0.0001 µm
	(e)	SEM-		20 µm
	(f)	TEM-		0.5 µm
Si/SiO2 substrate	(g)	Raman imaging		3 µm

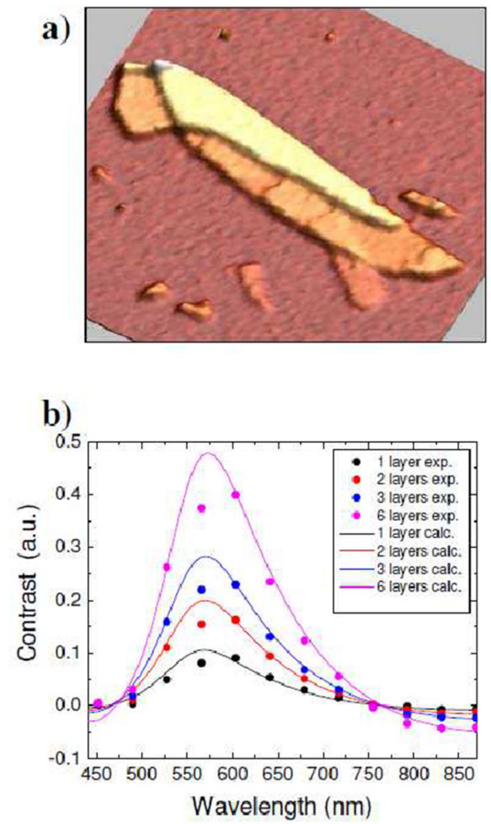
From Kim, Kim and Huang, Materialstoday 13 (2010) 28

Most current OPTICAL Imaging Techniques

Si/SiO_2 substrate +

Raman + Confocal



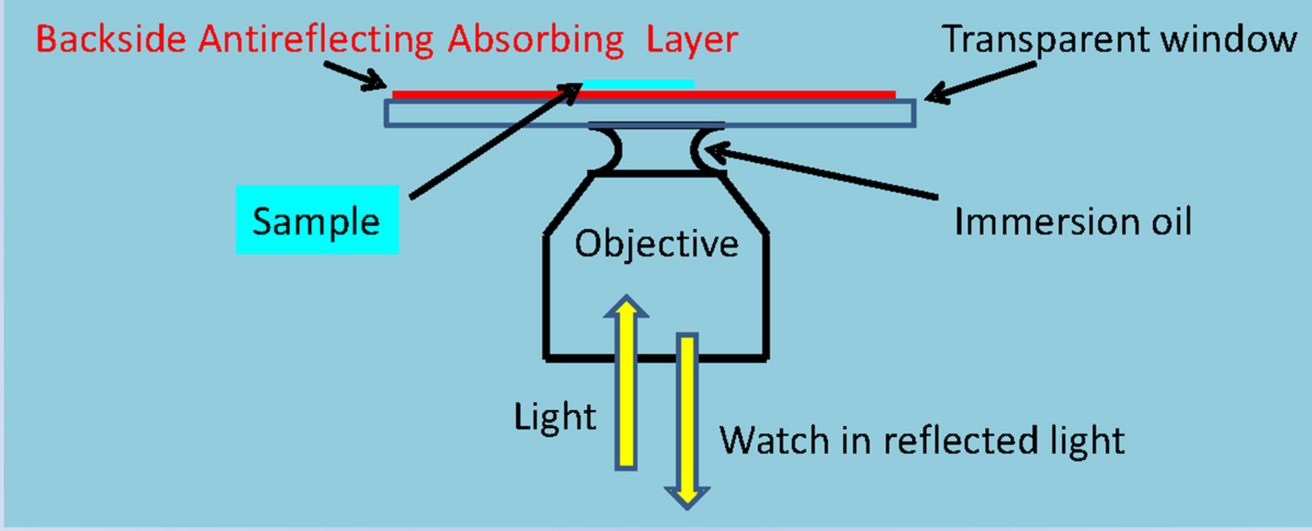


From arXiv:0705.2645v1 [cond-mat.matrl-sci], Casighari et al. 2007

Backside Absorbing Layer Microscopy (BALM)

Lateral resolution 300 nm

Z- Resolution 1 pm



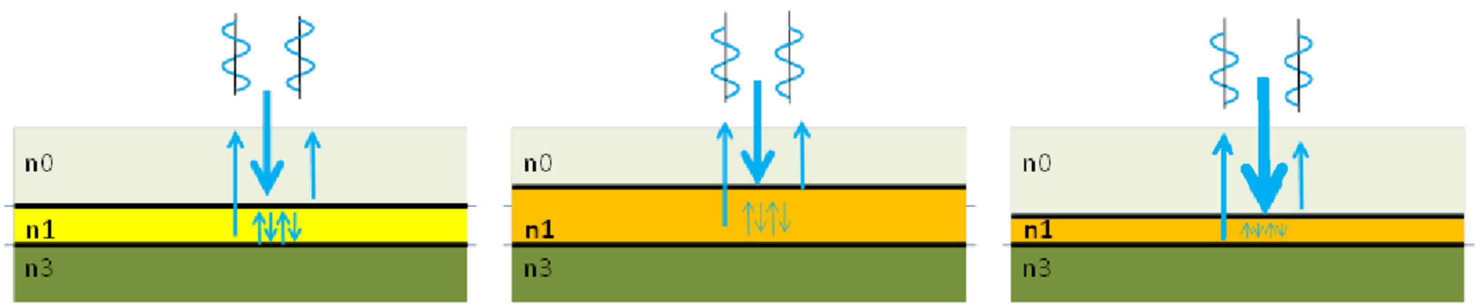
Backside Anti-Reflecting Absorbing Layers

Why is it so sensitive ?

Contrast $= \dfrac{I_{obj} - I_{back}}{I_{obj} + I_{back}}$ Max. with background extinction $I_{back} = 0$ ⇨ AR Surfaces

What is new?

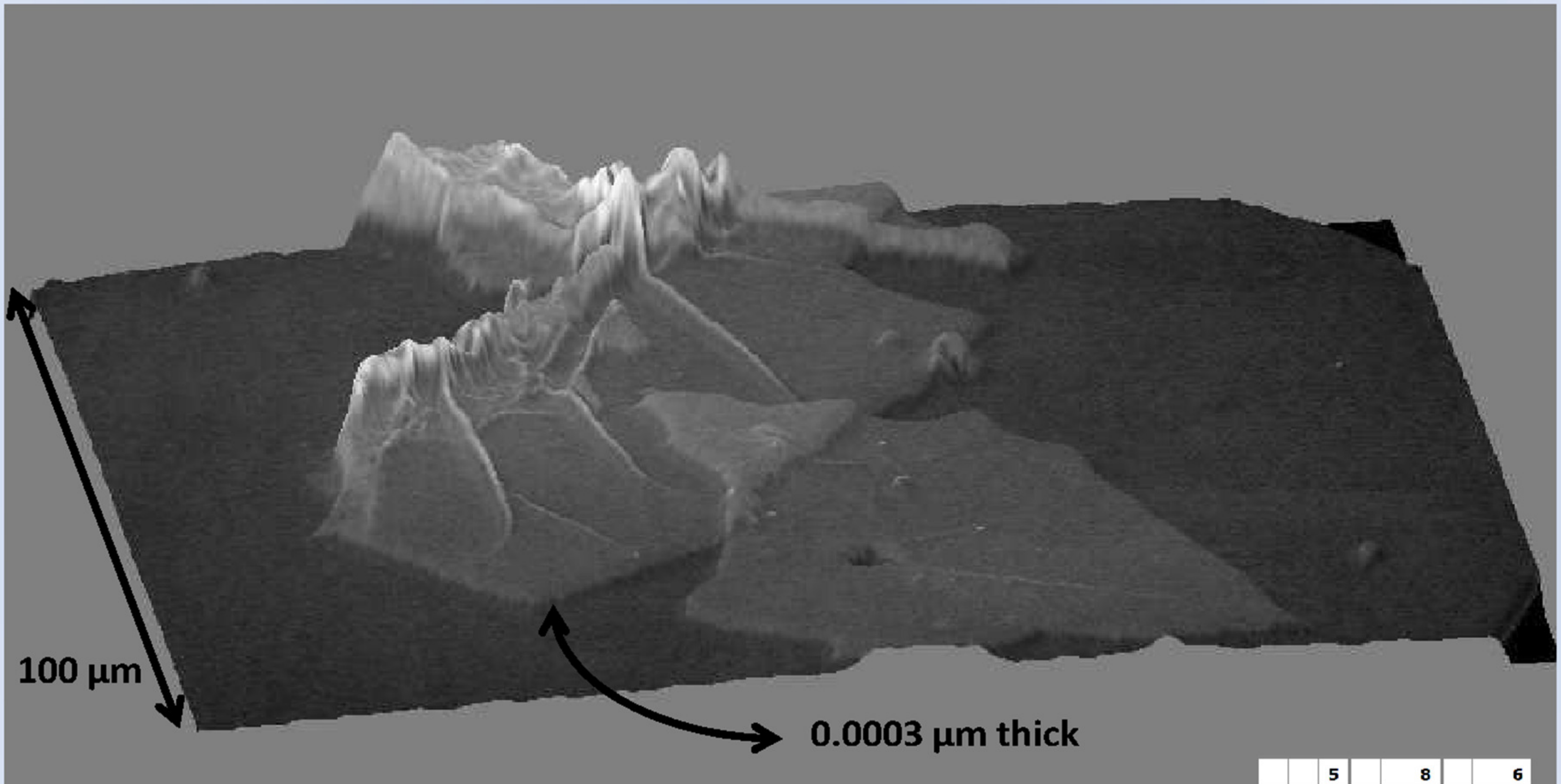
Incident n_0 | $\tilde{n}_1 = n_1 - jk_1$ | Emergent n_3



K1 = 0; n0 and n3 exchangeable | K1 ≠ 0, n0 < n3 | K1 ≠ 0, n0 > n3

New AR surfaces | transparent and conductive ⇨ BALM

Puzzle: which technique was used ?
(graphene oxide monolayers)



(you may also chose sudoku grid)

		5			8			6
6		7			2		1	9
9	1	2		3	6			
	4							5
8	5	6				9	7	3
2							4	
			4	9		1	5	2
1	2		6			4		8
5			2			6		

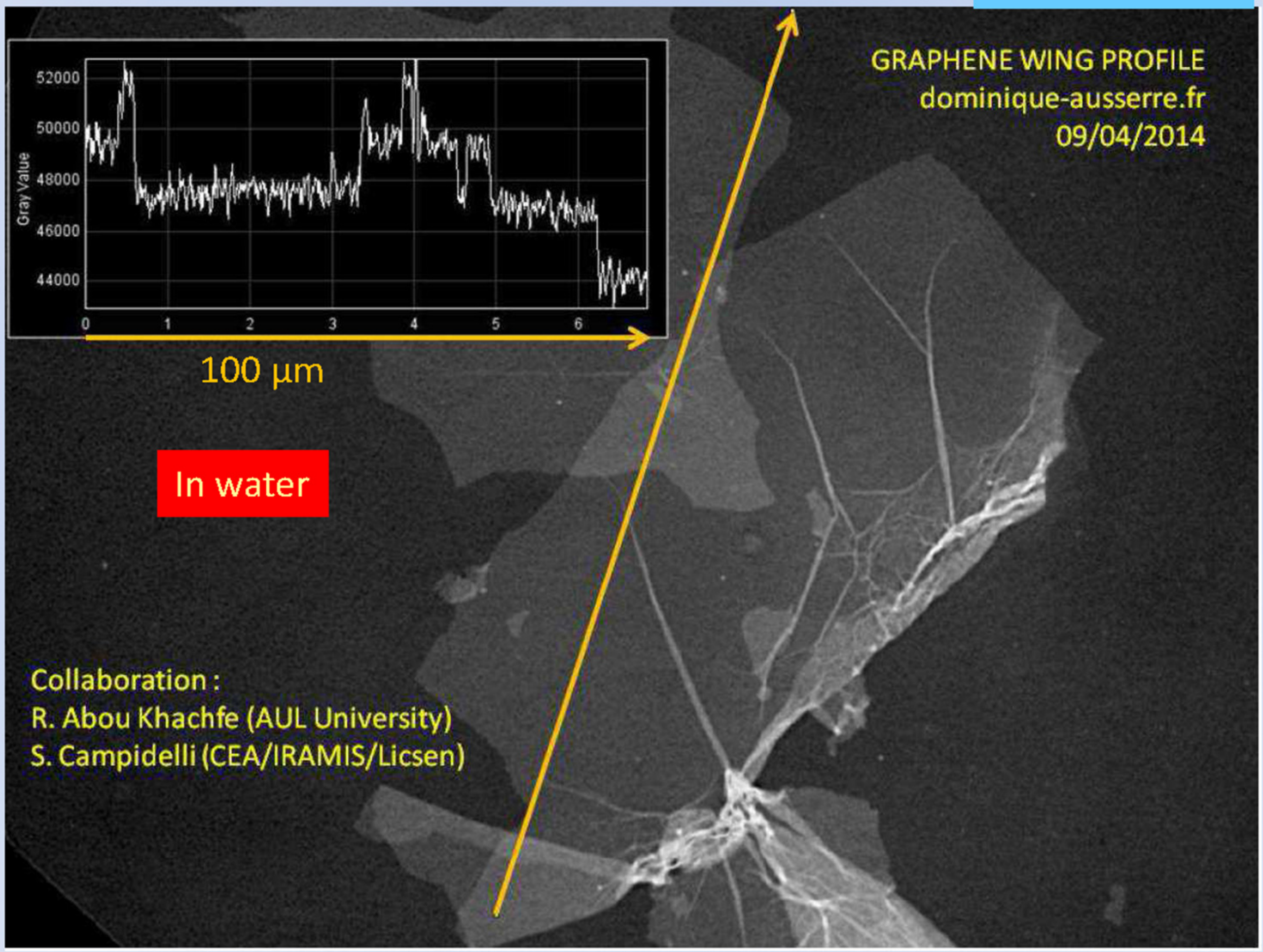
Answer

4	3	5	9	1	8	7	2	6
6	8	7	5	4	2	3	1	9
9	1	2	7	3	6	5	8	4
3	4	1	8	7	9	2	6	5
8	5	6	1	2	4	9	7	3
2	7	9	3	6	5	8	4	1
7	6	8	4	9	3	1	5	2
1	2	3	6	5	7	4	9	8
5	9	4	2	8	1	6	3	7

Answer to other Puzzle: The technique was BALM

Backside Aborbing Layer Microscopy

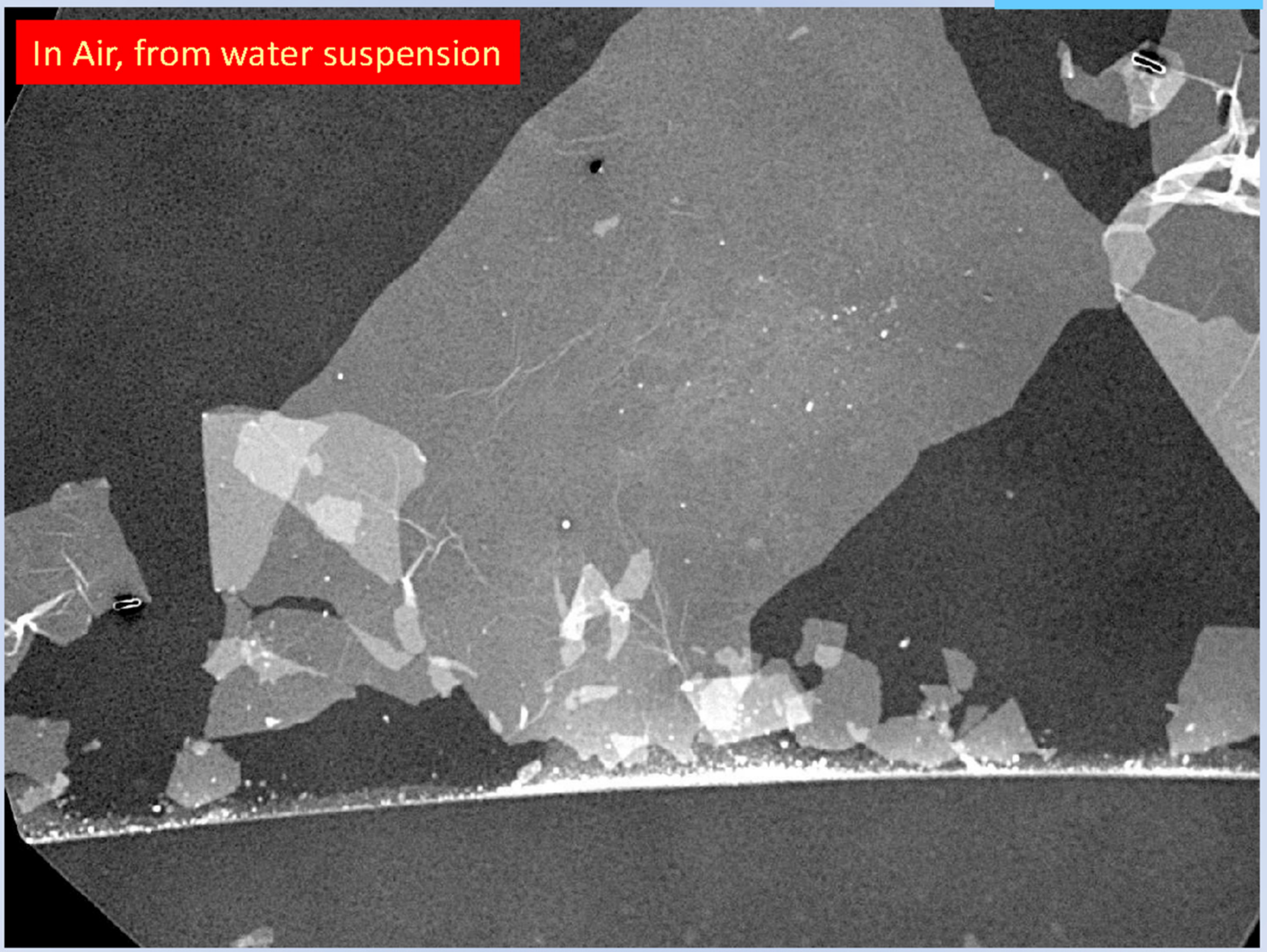
Looks like AFM



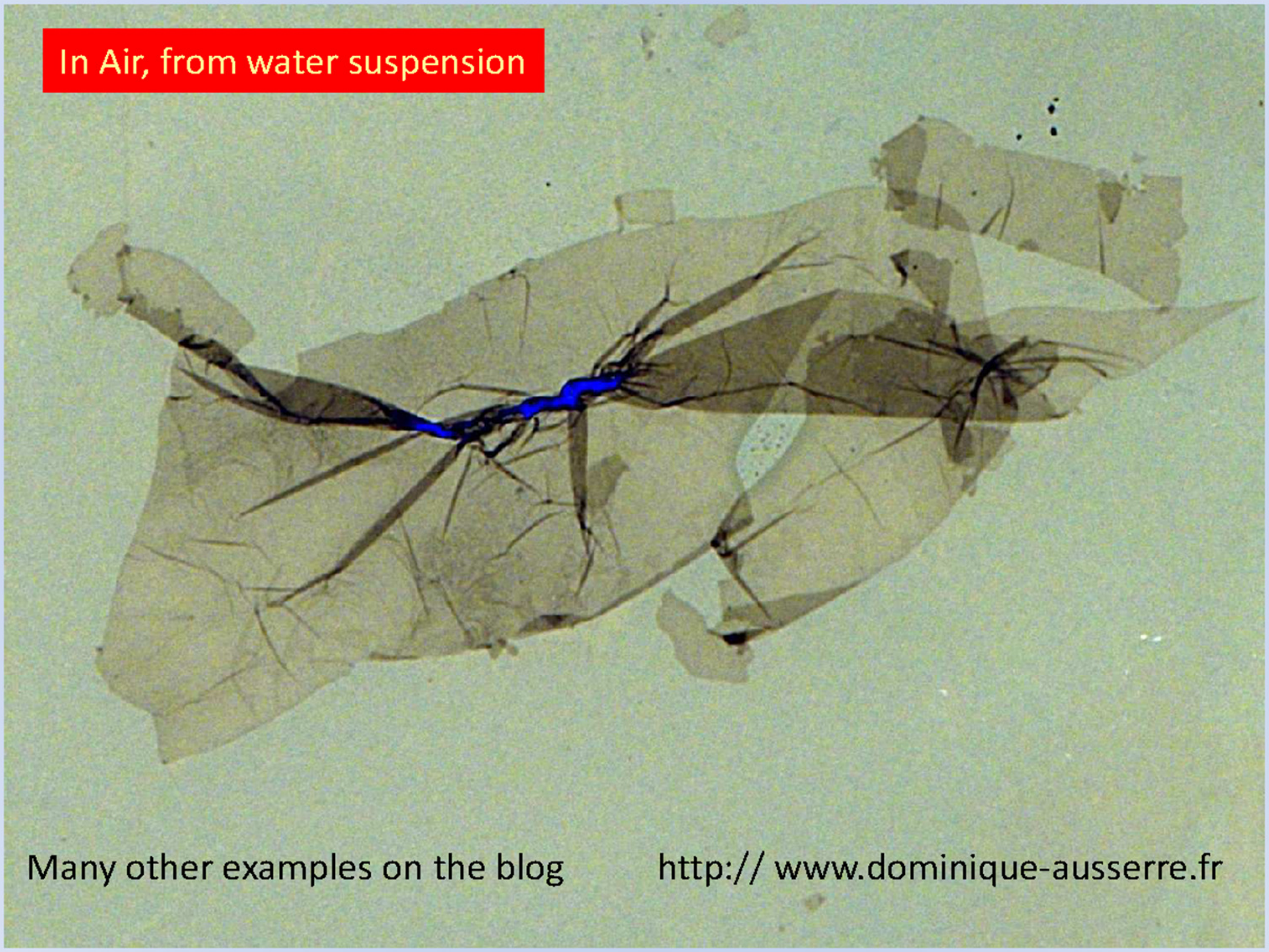
Graphene (GO) sheets

Collaboration S. Campidelli, CEA Saclay

Looks like SEM



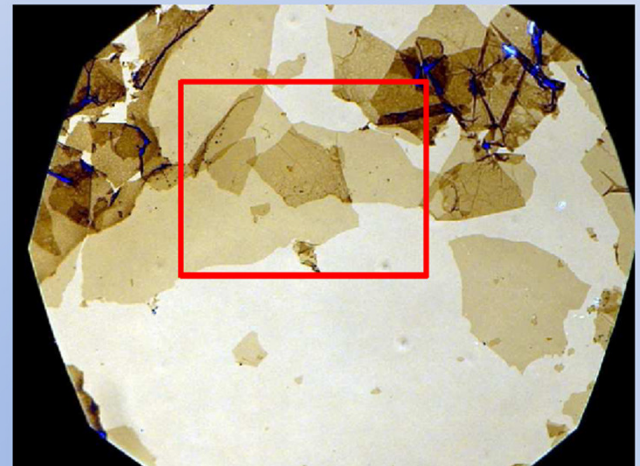
Graphene (GO) sheets observed in white light



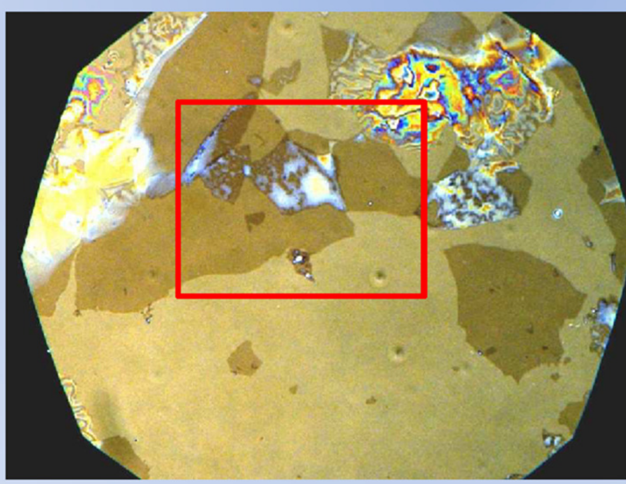
Same graphene sheets in air and in water

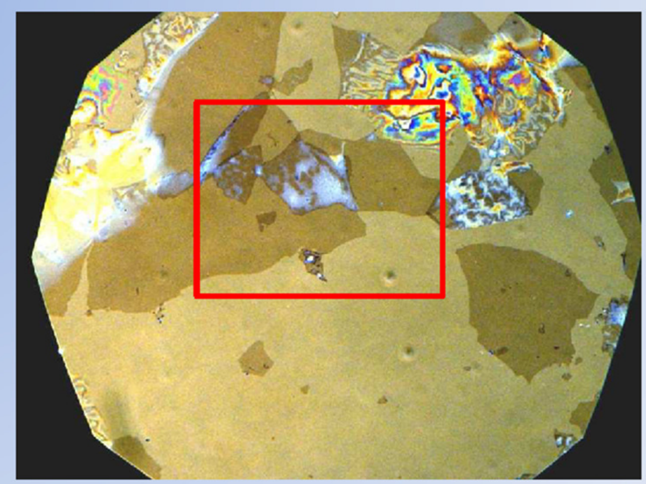
100 µm

In air



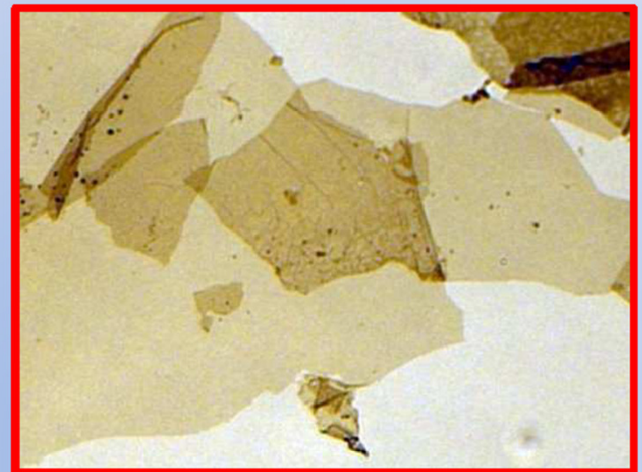
in water



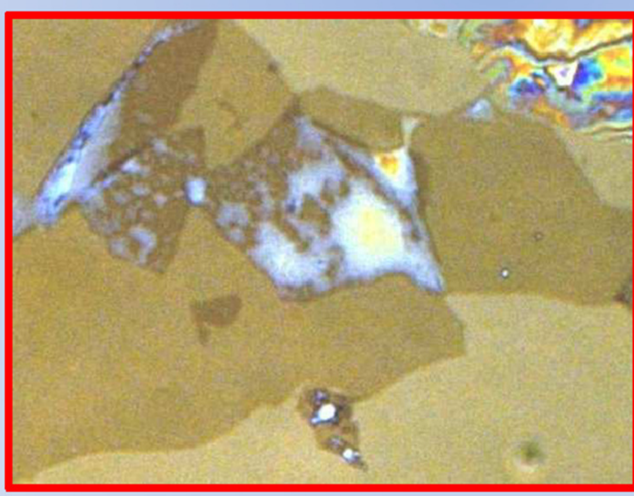


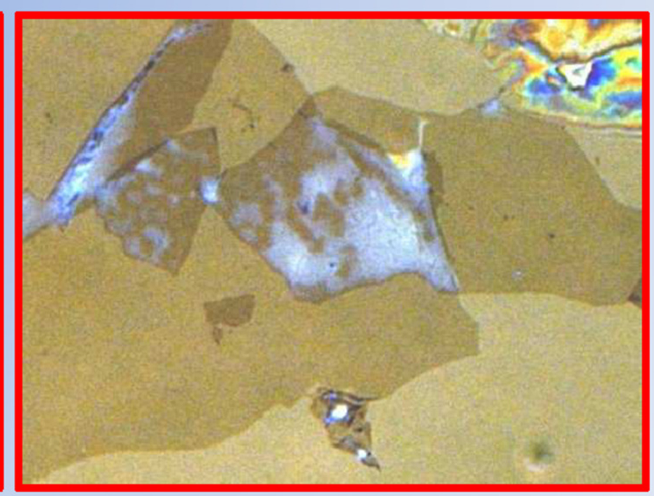
Same graphene sheets in air and in water: zoom x 2.5

In air



in water



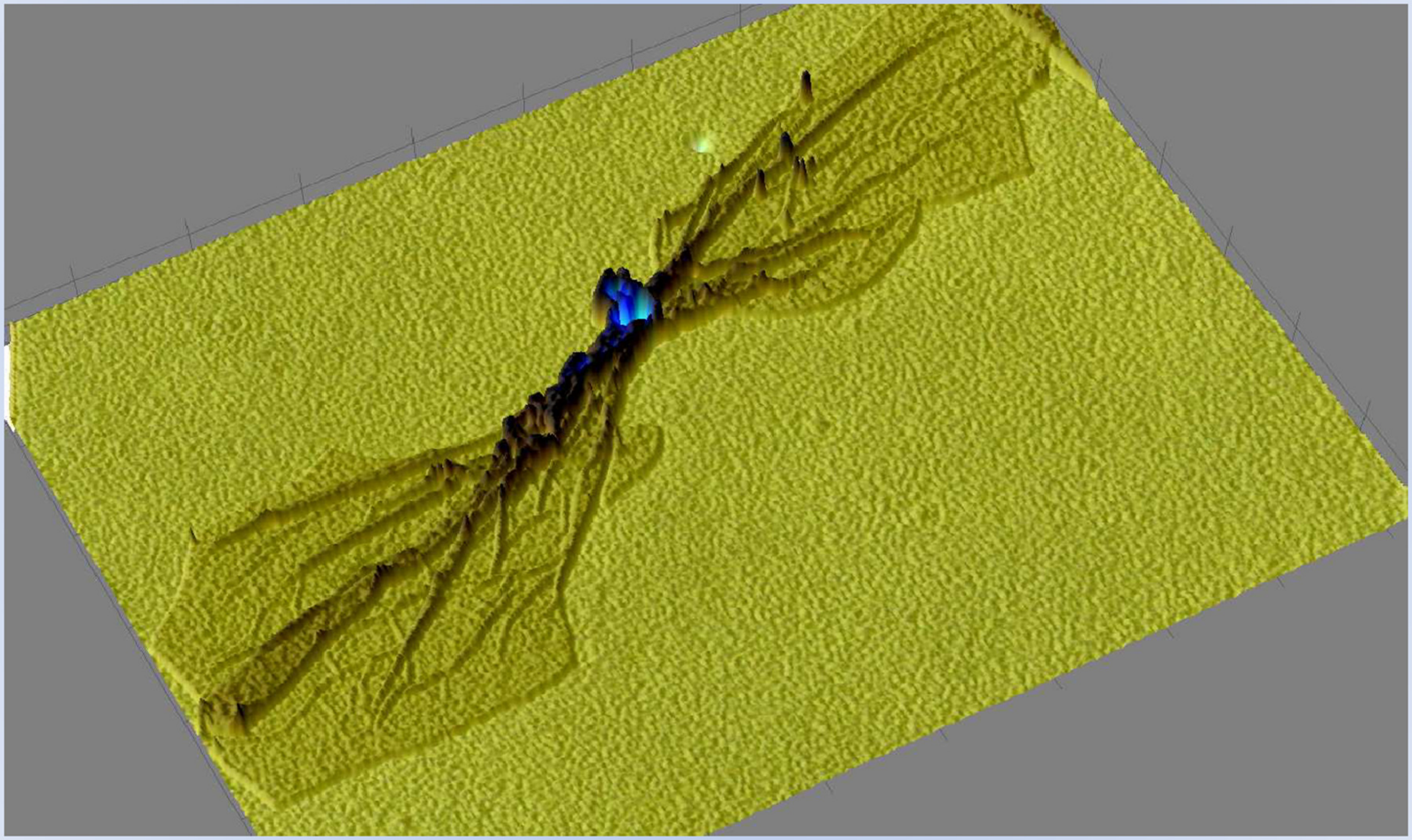


BALM answer to current needs in graphene imaging

- ✔ Qualify/monitor in situ graphene production
- ✔ Control/monitor graphene sheets deposition/organization - Switch from air to water
- ✔ Count local number of superimposed graphene sheets
- ✔ Probe/monitor in situ graphene chemistry
- ✔ Visualize impurity intercalation
- ✔ Probe local conductivity

- ✔ Do all these things at the same time on a same sample without destroying it
- ✔ Do all these things fast and at a low cost

Thanks for your attention !



***Dominique Ausserré**, Institut des Molécules et Matériaux du Mans, CNRS UMR 6382*
ausserre@univ-lemans.fr
blog http:// www.dominique-ausserre.fr

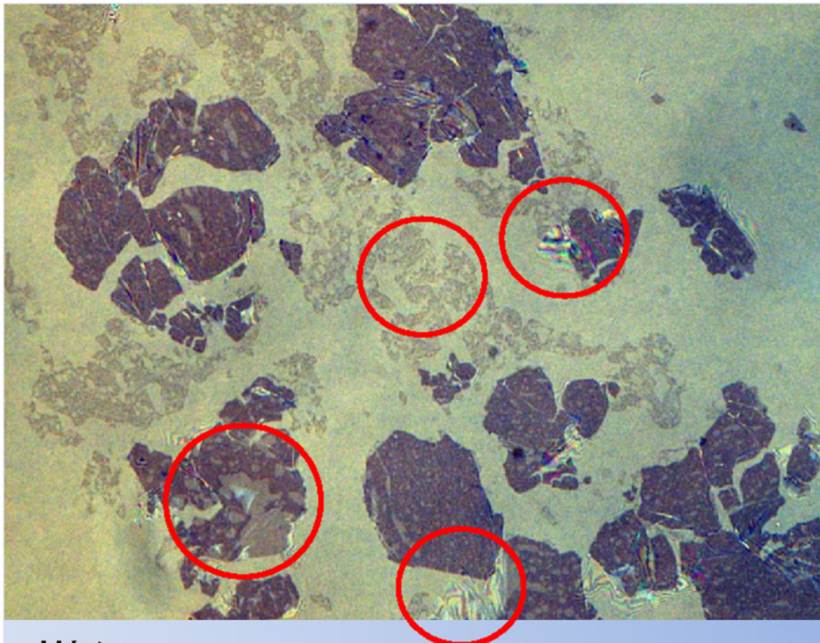
***Collaboration with**:*

Refahi Abou Khachfe, AUL University, Beyrouth, Liban *numerical calculations*
Stephane Campidelli, CEA/DSM/IRAMIS, Saclay, France *graphene*

***Granted by ANR**:* *PNANO-07-050*

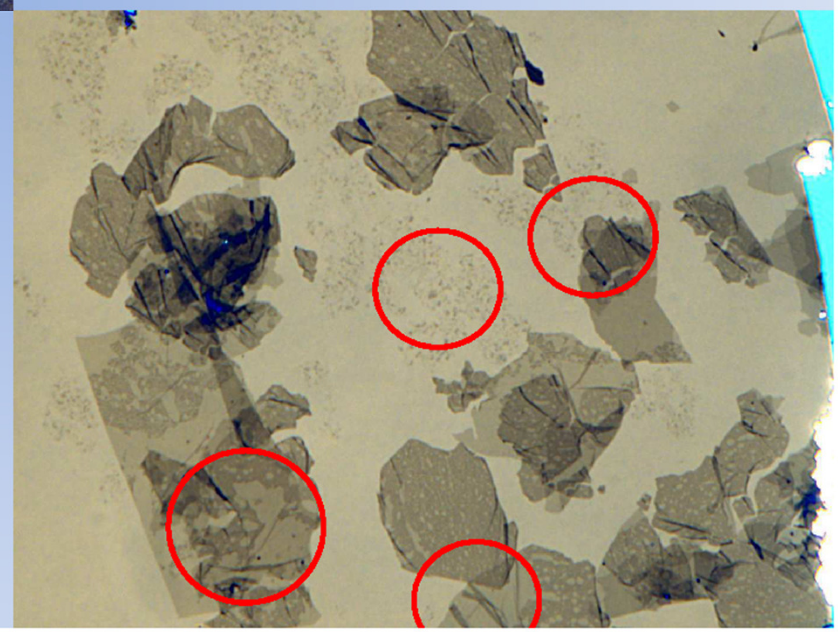
***BALM commercialized by the Startup**:* ***Watch Live S.A.S.** (created today)*
Informations *ausserre@gmail.com*

Surface Chemistry



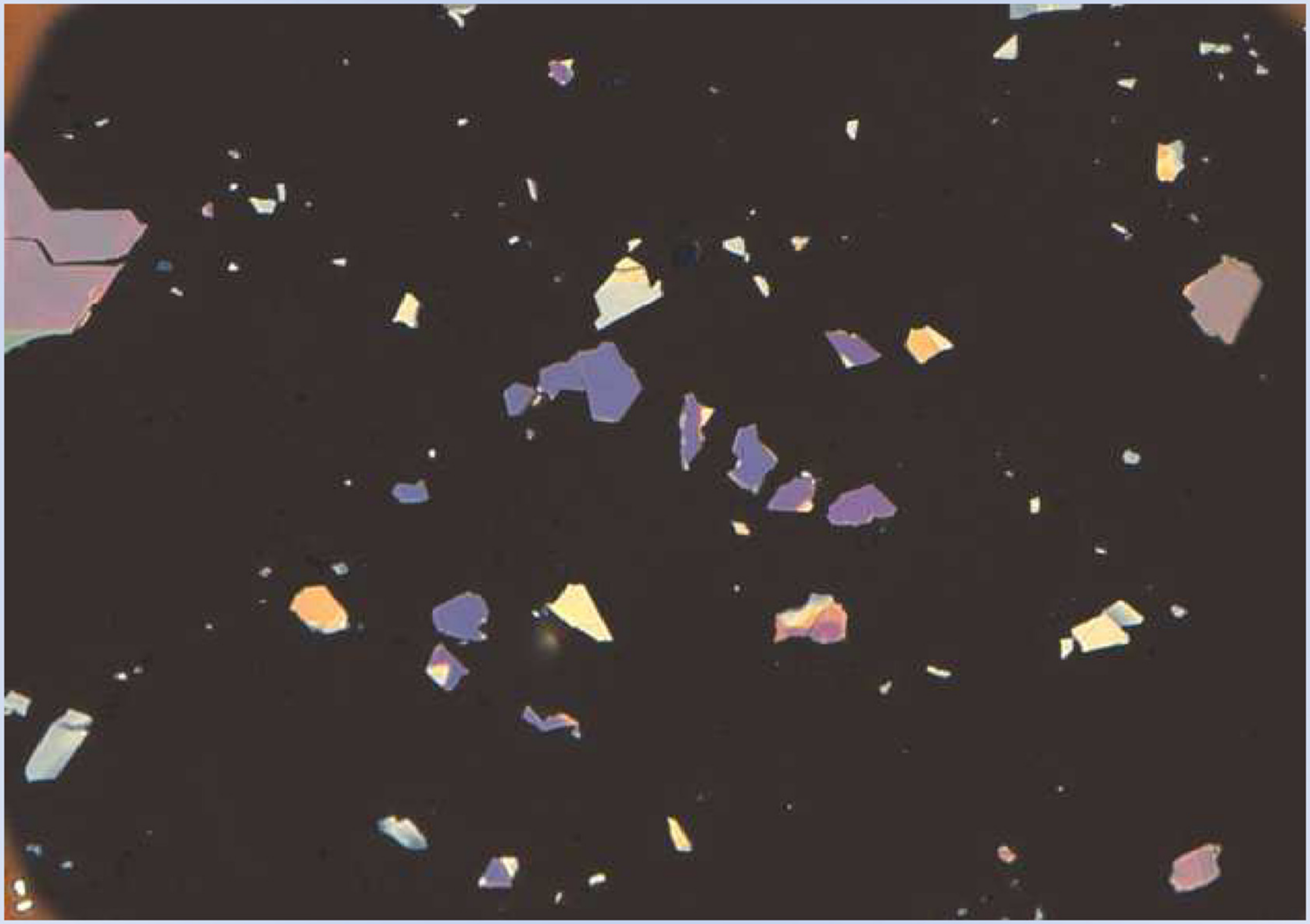
Air

Water



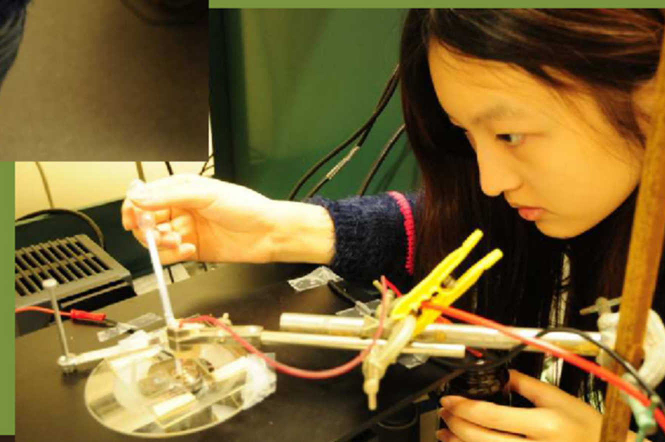
Dominique Ausserré – Nanotek 2014 - San Francisco 141203

Graphene analogs: example of MoS2



Dominique Ausserré – Nanotek 2014 - San Francisco 141203

Implementation



Xia Yin

Advantages

Simple

Low cost

Non destructive

In situ

Real time

Extreme sensitivity

D. AUSSERRE, R. ABOU KHACHFE, C. AMRA, and M. ZERRAD
Absorbing Anti-Reflecting Layers
arXiv:1405.7672v1 [physics.optics] 2014

D. AUSSERRE, R. ABOU KHACHFE, L. ROUSSILLE, G. BROTONS, L. VONNA, F. LEMARCHAND, M. ZERRAD, and C. AMRA
J Nanomed Nanotechnol, **5**:4 (2014); doi: 10.4172/2157-7439.1000214

Contact

ausserre@univ-lemans.fr
(+33) 6 08 28 48 00

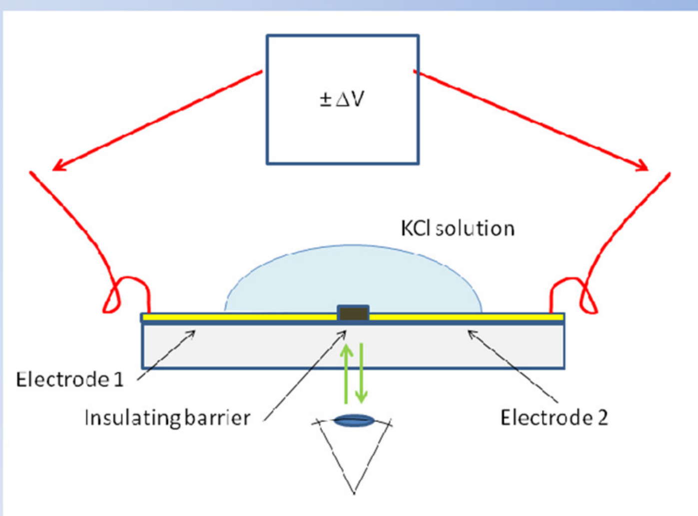
blog: www.dominique-ausserre.fr

Première Observation Visuelle de la Double Couche Electrochimique par une Technique d'Imagerie

Pre-conference workshop

4th International Conference on Nanotek & Expo
Nanotek-2014
December 01-03, 2014 - San Francisco, USA

Dominique Ausserré, Institut des Molécules et Matériaux du Mans, CNRS UMR 6282.
Mathieu Lazerges, UTCBS- ENSCP CNRS UMR 8258 - INSERM U1022
Refahi Abou Khachfe, AUL University, Beyrouth, Liban



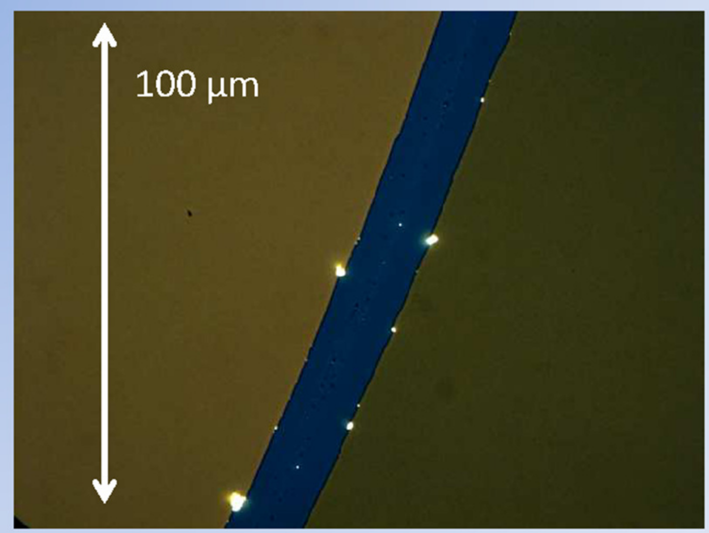


Fig. 2 Common microscopy techniques for imaging GBS. Optical microscopy images of graphene based on (a) interference (scale bar = 20 μm) (adapted from[1], with permission, American Association for the Advancement of Science) and (b) ellipsometry (adapted from[34], with permission, ACS Publication), respectively. Both methods rely on dielectric coated silicon with proper thickness and optimal illuminating wavelength. (c) Atomic force microscopy (AFM, scale bar = 1 μm) imaging of graphene sheet on SiO_2 surface (adapted from[1], with permission, American Association for the Advancement of Science). AFM can give accurate height measurement on smooth surfaces but it is rather low-throughput. (d) Scanning tunneling microscopy (STM, scale bar = 0.1 nm, adapted from[35], with permission, National Academy of Sciences, U.S.A.) can produce high-resolution, atomic-scale images. But it is too low-throughput for routine imaging. Electron microscopy, such as (e) scanning electron microscopy (SEM, scale bar = 20 μm) and (f) transmission electron microscopy (TEM, scale bar = 500 nm, adapted from[28], with permission, Nature Publishing Group) also needs to use special substrates for imaging GBS. (g) Raman imaging (scale bar = 3 μm, adapted from[38], with permission, Elsevier) is particularly useful for identifying the number of layers for graphene samples. But substrates that have low intrinsic fluorescence and can efficiently dissipate laser heating are required. (h) No techniques are available yet for high-throughput imaging of GBS on plastic surfaces or even in solution (inset).