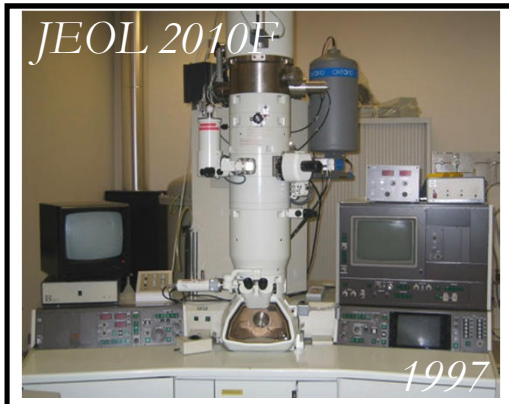
Microscopie à balayage à double faisceaux (FIB/SEM)

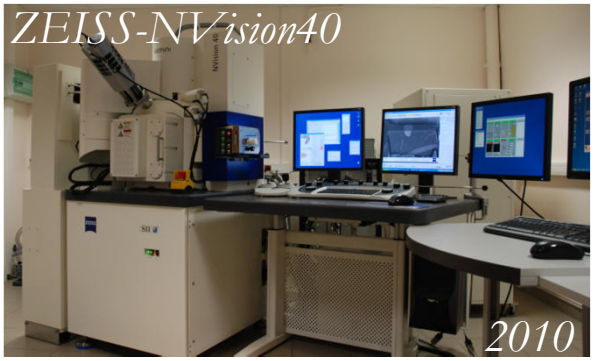
N. Blanchard[1], *A. Descamps*[2], *T. Douillard*[3] *and* *B.Van de Moortèle*[4]

[1]ILM, Uni. C. Bernard Lyon1, Université de Lyon, France
[2]INL, INSA de Lyon, Université de Lyon, France
[3]MATEIS, INSA de lyon, Université de Lyon, France
[4]LGL, ENS de Lyon, Université de Lyon, France

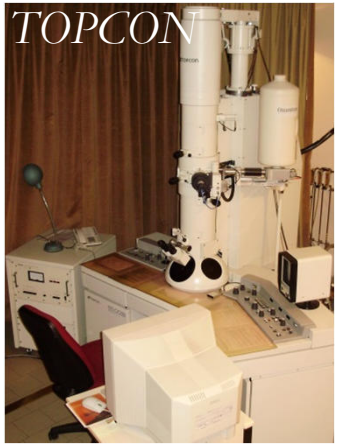
FED 4092, ww.clym.fr

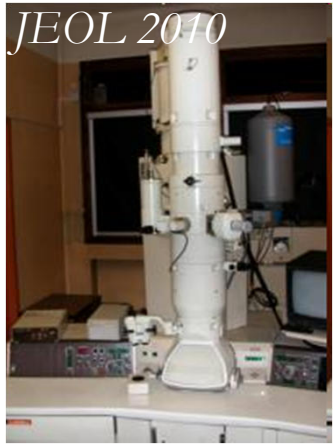
Thierry EPICIER
(MATEIS – INSA)



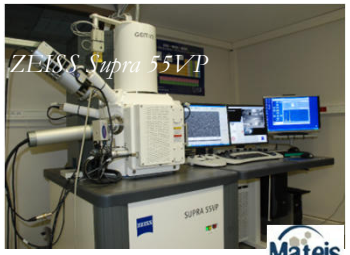


instruments 100% CLYM





instruments partagés labos/CLYM



instruments labos

CaZaC

Carl Zeiss application Community

Le bureau de CaZaC

Bertrand Van de Moortèle - ENS Lyon : Président

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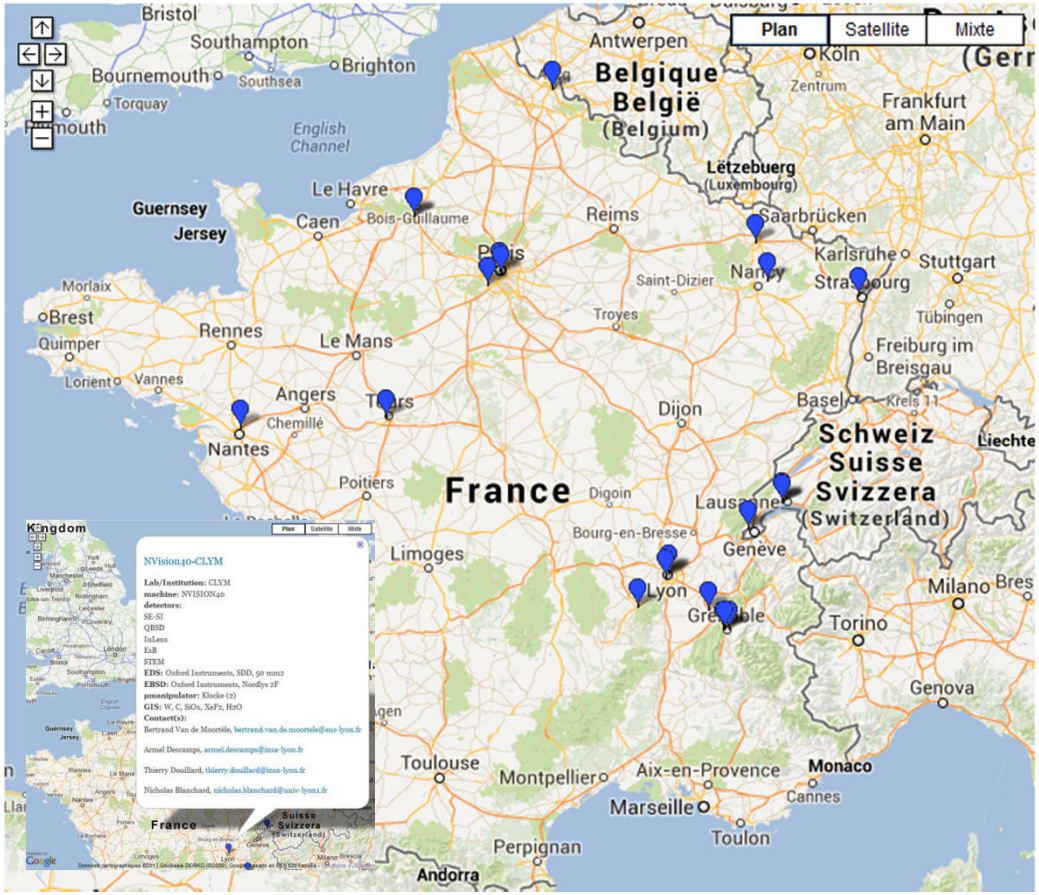
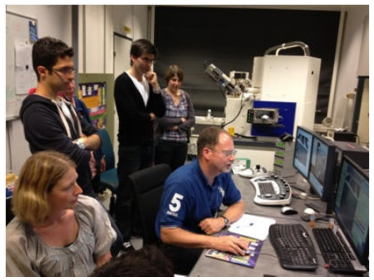
Michel Amez-Droz - HES : Secrétaire-adjoint

		jeudi 23 Mai 2013			vendredi 24 Mai 2013
8h30-10h30	8h30-9h00	**Accueil**	8h30-10h30		
	9h00-9h30	Discours de bienvenue : P.Billardon (ZEISS), L.Lissmyr (ZEISS)		9h00-9h30	**Heiko Stegmann (ZEISS)** : évolution du sie web, quelques développemeents récents en API
	9h30-10h30	**J. Cazaux (Univ. De Reims)** : Le filtrage en énergie des électrons secondaires et rétrodiffusés : Principes, Intérêts, Applications		9h30-10h00	**P. Gnauck (ZEISS)** : Orion Nanofab
				10h00-10h30	**M. Cantoni (CIME-EPFL)** : Merlin
10h30-11h00	pause café		10h30-11h00	pause café	
11h00-12h30	11h00-12h00	**P. Gnauck** (ZEISS) : nouveautés chez Zeiss	11h00-12h30	11h00-11h30	**D. Lethiec (INRA de Nancy)** : Utilisation des techniques du froid et de la pression contrôlée pour l'observation et l'analyse X d'échantillons biologiques
	12h00-12h30	**Anna Sartori-Rupp (Institut Pasteur)** : µ-corrélative		11h30-12h30	Table ronde, questions au constructeur : contrats d'entretien, maintenance, upgrade des machines,
12h30-14h00	REPAS + photographie de groupe		12h30-14h00	REPAS (+ résultat concours photos)	
14h00-15h30	14h00-14h20	**E. Robin** : EDX Bruker 4 cadrans.	14h00-16h00	14h00-14h15	**A.S. Gay (IFPEN)** : apport de la préparation par polissage ionique pour les observations MEB
	14h20-14h40	**PH Jouneau (CEA Grenoble)** : installation des machines : clim, vibrations, etc...		14h15-14h35	**J. Guyon, N. Gey (LEM3, Univ. De Metz)** : prémices de l'EBSD-3D en mode statique
	14h40-15h00	**C. Collet (Thales)** : Structuration et réalisation de nano-objets assistées par FIB		14h35-15h00	Debrieffing Workshop FIBICS
	15h00-15h30	**F. Courtade (CNES)** : Expertise sur matériel Spatial au laboratoire intégré du CNES		15h00-15h30	**présentation libre**
15h30-16h00	pause café			15h30-16h00	**Frank Stietz (Zeiss)** : Trends in Charged Particle
16h00-18h30	16h30-17h00	**C. Boyaval** (IEMN, Univ. de Lille 1): Mesures électriques *in-situ*			fin des journées
	17h00-17h30	**Nils Anspach (DME)** : AFM insitu			
	17h30-18h00	Assemblée générale CAZAC			
	18h00-18h30	Soirée offerte par ZEISS			





Ateliers, CaZaC 2012, Lausanne

CaZaC 2014

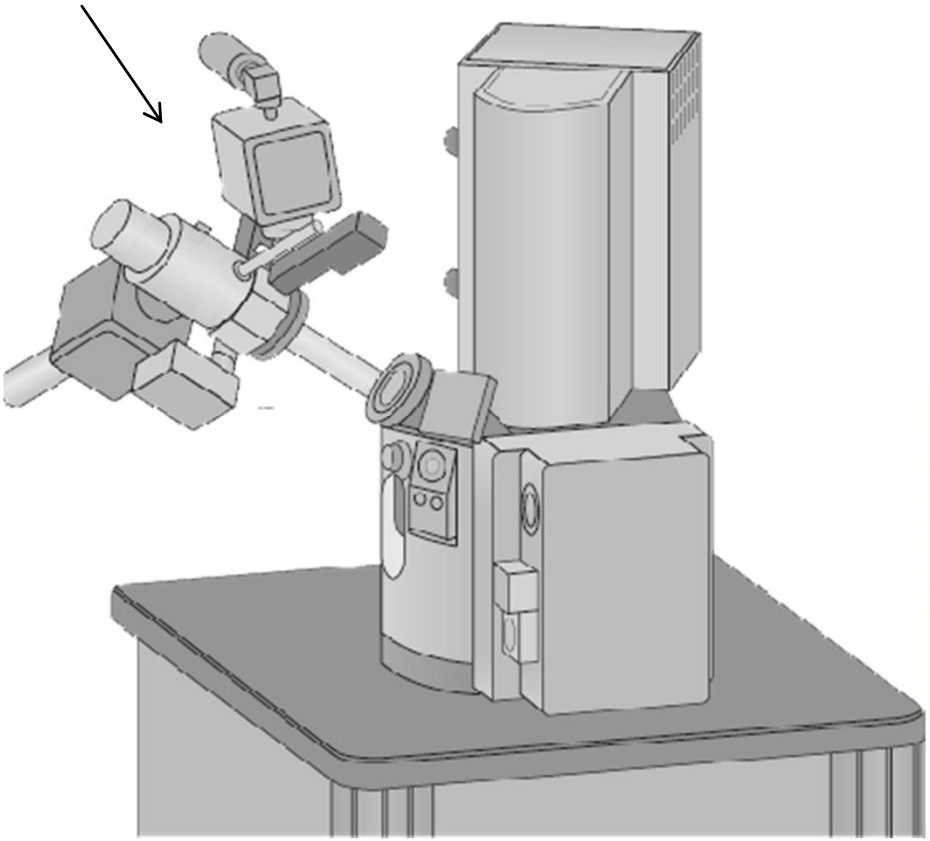
Institut Pasteur

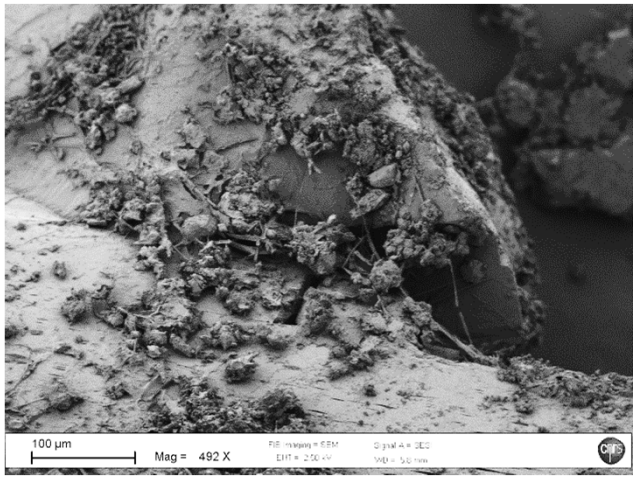
22, 23 et 24 Mai 2014

Qu'est-ce qu'un FIB?

FIB = Focused Ion Beam

ion column



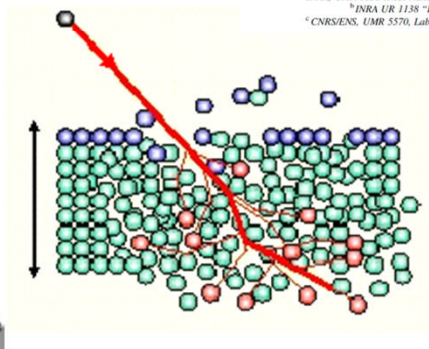


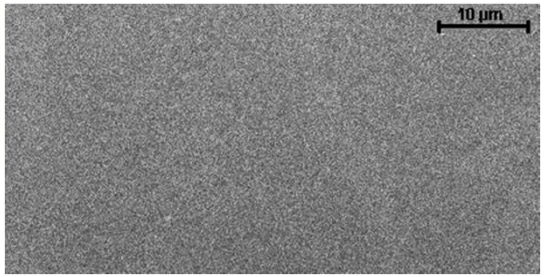
ELSEVIER
INSTITUT PASTEUR
Research in Microbiology 162 (2011) 820–831
www.elsevier.com/locate/resmic

Bacterial weathering and its contribution to nutrient cycling in temperate forest ecosystems

Stéphane Uroz [a,b,*], Phil Oger [c], Cendrella Lepleux [a,b], Christelle Collignon [a,b], Pascale Frey-Klett [a], Marie-Pierre Turpault [b]

[a] INRA, UMR 1136 INRA Nancy Université "Interactions Arbres Micro-organismes", Centre INRA de Nancy, 54280 Champenoux, France
[b] INRA UR 1138 "Biogéochimie des Ecosystèmes Forestiers", Centre INRA de Nancy, 54280 Champenoux, France
[c] CNRS/ENS, UMR 5570, Laboratoire des Sciences de la Terre Ecole Normale Supérieure 46, Allée d'Italie, 69364 Lyon Cedex, France





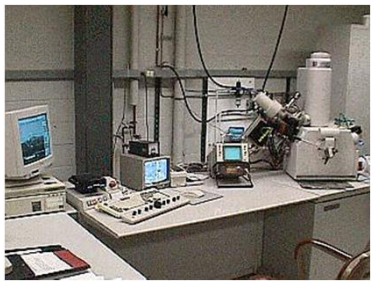
Une histoire pas si récente que cela…

1979: R. Seigler, *Hughes Research Laboratories*, Malibu, California, USA
" High-resolution, ion–beam processes for microstructure fabrication",
Seliger *et al*, *J. Vac. Sci. Technol.* **16** (1979) 1610

1979-1992: Focused Ion beam (single beam)

fault diagnostics, mask repair, TEM lamella, gas deposition, patterning, contrast orientation image, etc…

1993: 1st FIB dual beam, DualBeam 620 (Philips)

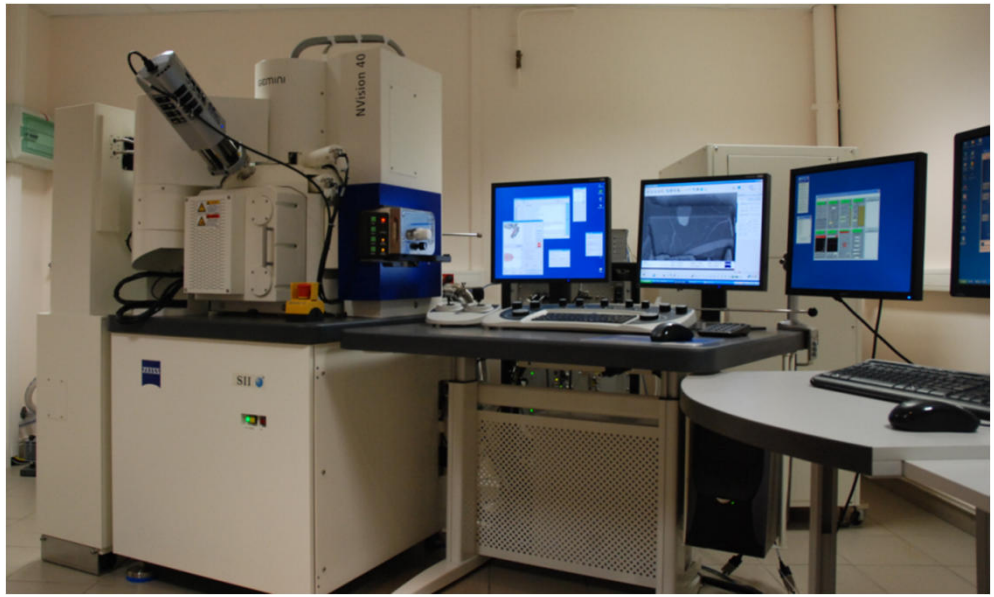


➔ EDX
EBSD

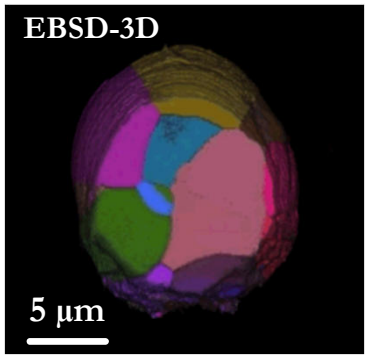
1998: Development of an Ion and Electron Dual Focused Beam Apparatus for Three-Dimensional Microanalysis
T. Sakamoto et al., Jpn. J. Appl. Phys. 37 (1998) pp. 2051-2056

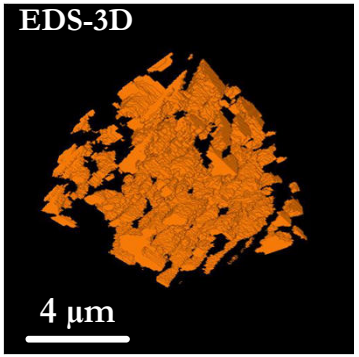
~ 2000: in-situ µmanipulateurs

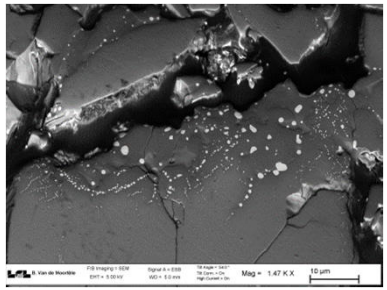
NVision 40, CLYM

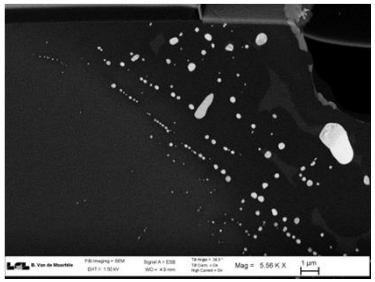


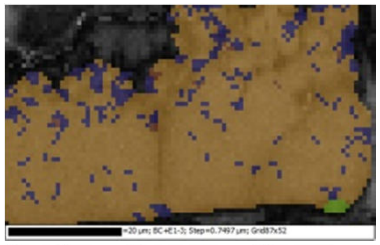
detectors : SESI, BSE, InLens, EsB, STEM
µmanipulators : 2 KlockeNanotechnik
EDX : SDD 50 mm^2, Oxf. Instr.
EBSD : camera Nordlys F^+, Oxf. Instr.
GIS : W, SiO_x, C, H_20, XeF_2
Flood Gun
External Scan generator : FIBICS

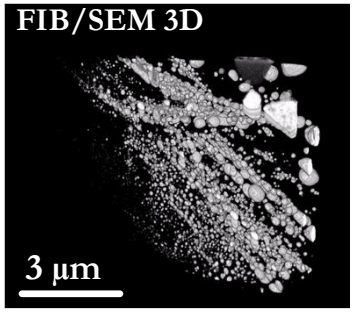


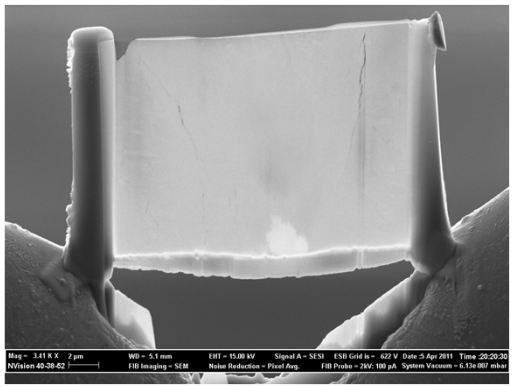




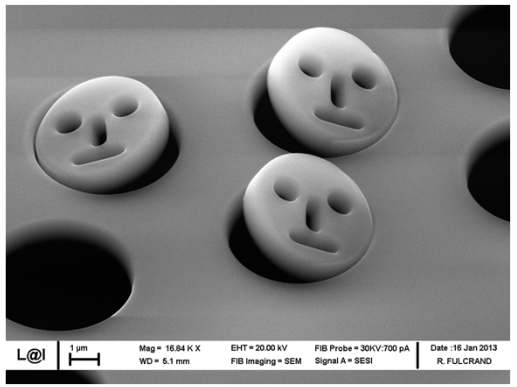








TEM lamella prep.



Nano-patterning

Principal Ion Column and FIB Manufacturers

FEI

ZEISS

JEOL

NANOSOLUTIONS by ORSAYPHYSICS

SII

Raith

TESCAN
PERFORMANCE IN NANOSPACE

nanoDUE'T
NB5000

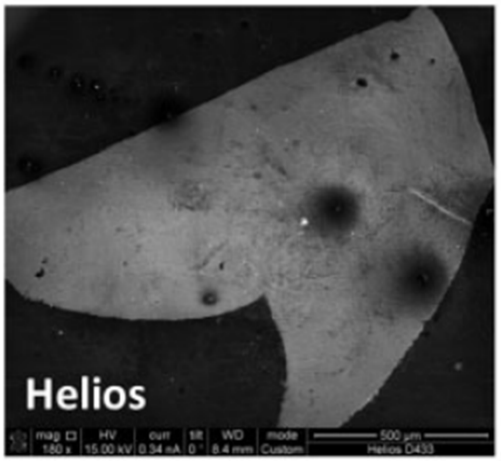
HITACHI
Inspire the Next

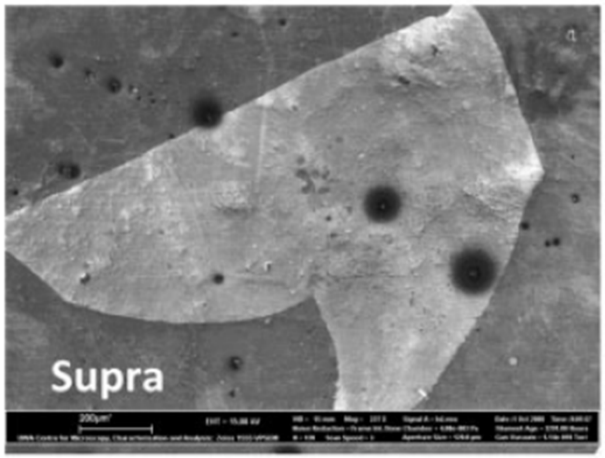
Principal Ion Column and FIB Manufacturers

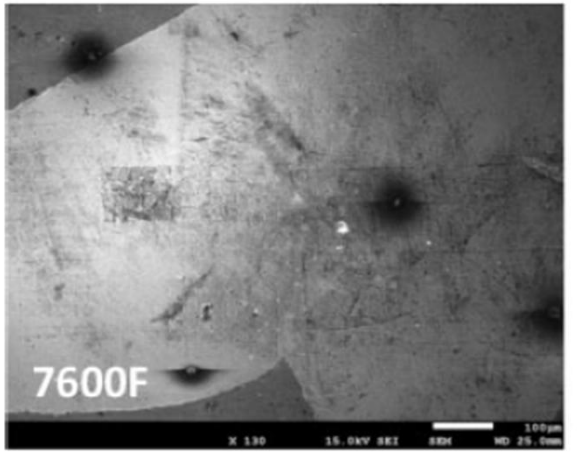
A Comparison of Conventional Everhart-Thornley Style and In-Lens Secondary Electron Detectors—A Further Variable in Scanning Electron Microscopy

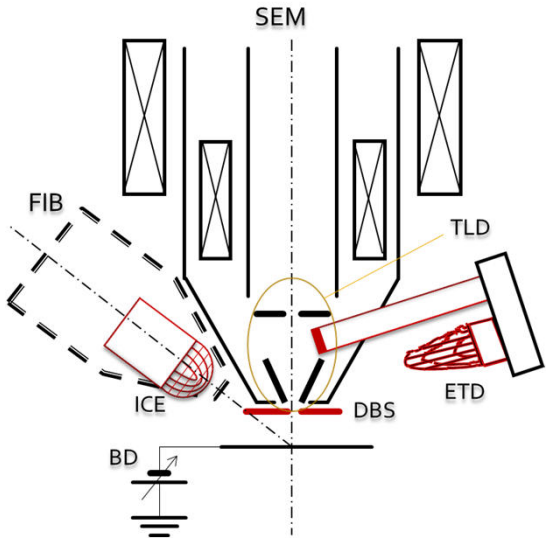
BRENDAN J. GRIFFIN

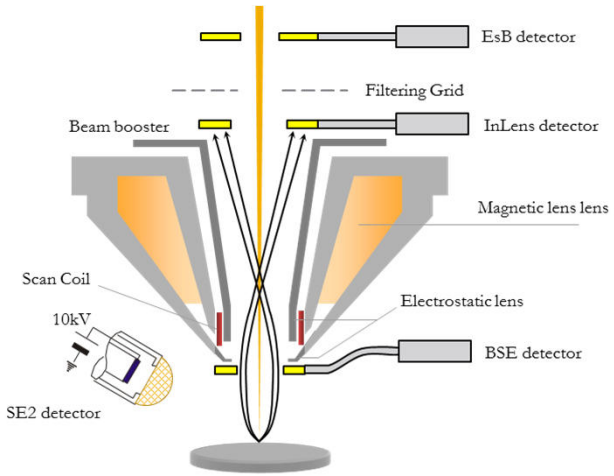
SCANNING VOL. 33, 162–173 (2011)

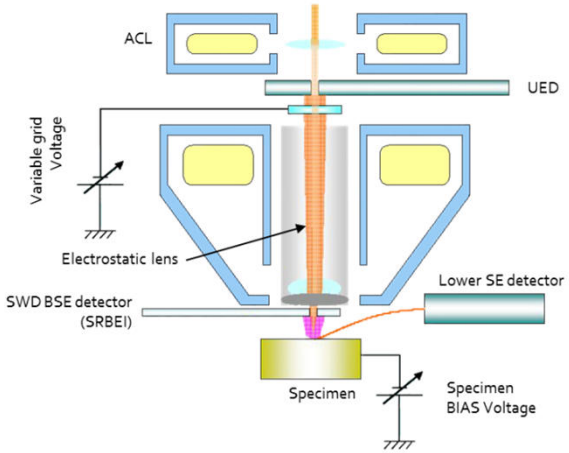




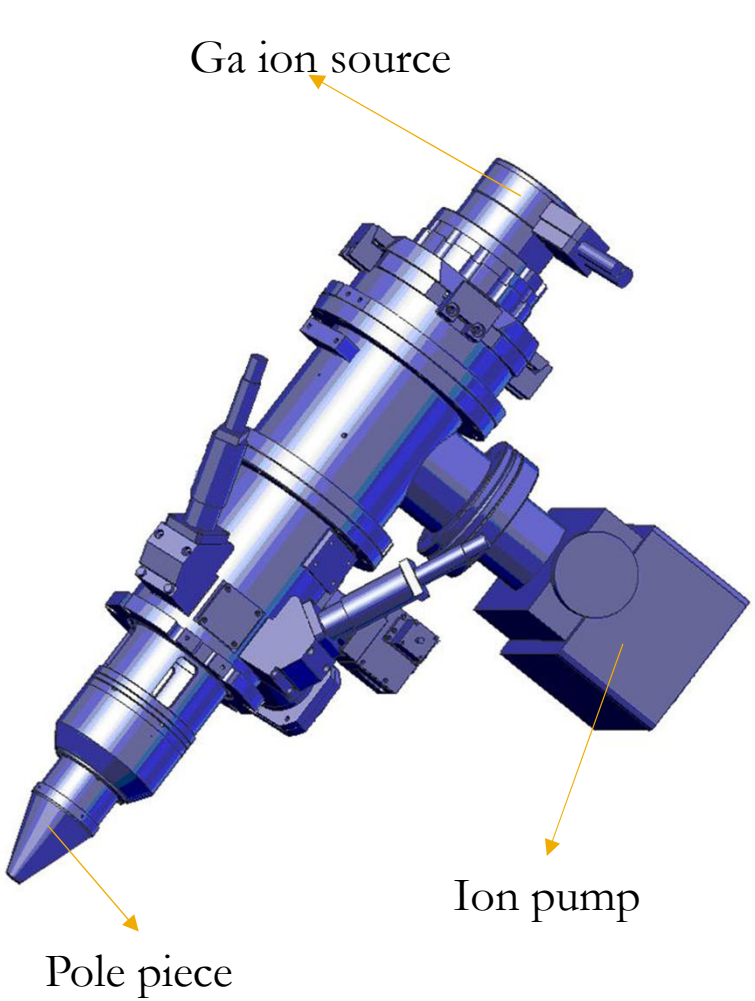


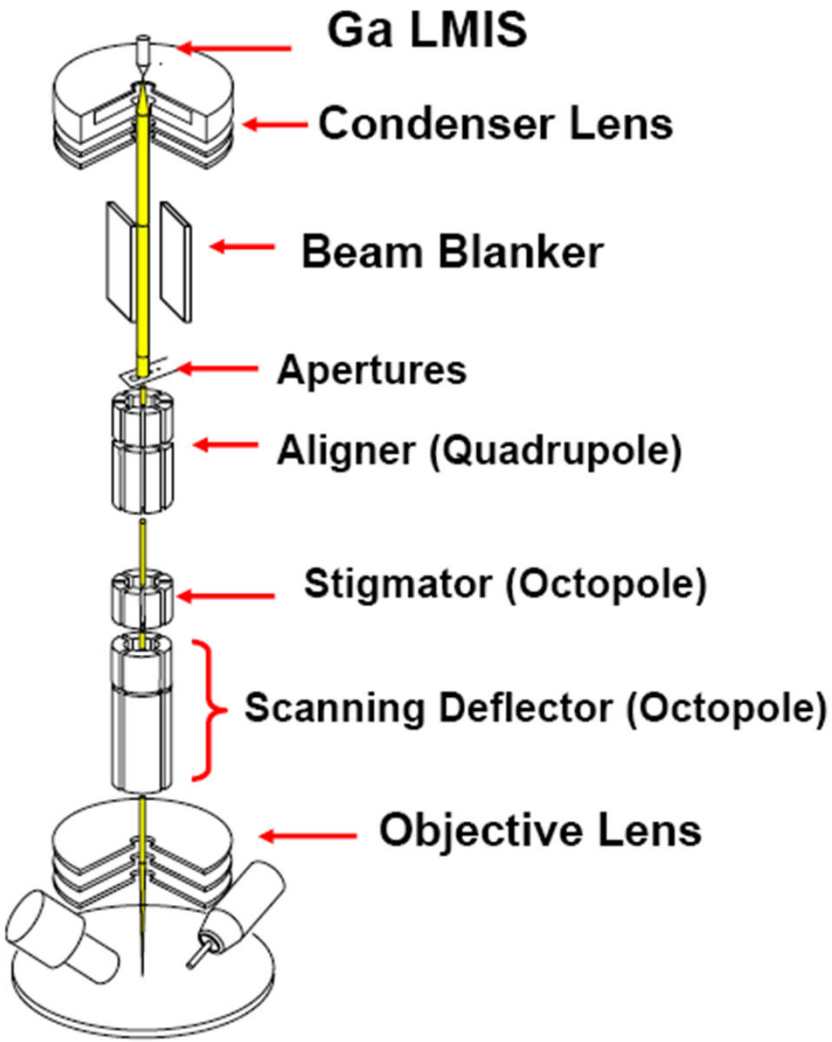






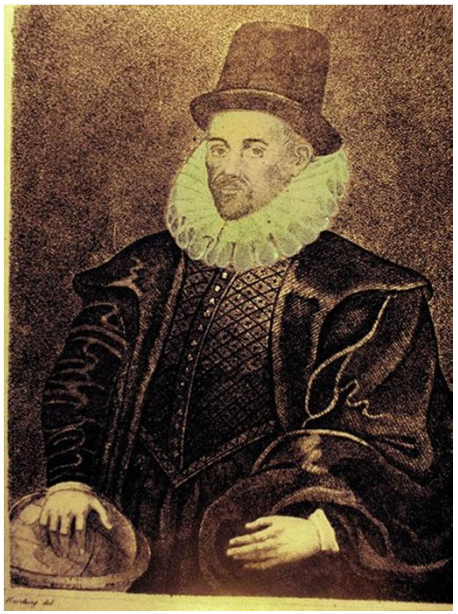
SII Ion Column

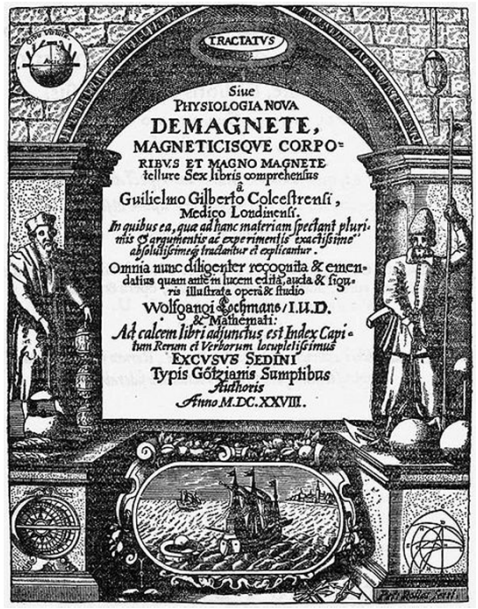




LMIS: history

William GILBERT (1544-1603), English medical doctor and physicist. The first to observe the formation of a cone when a fluid is subjected to a high electrostatic field. This observation was described in his treatise « *De Magnete* » (1600).





"Cambridge Scientific Minds", Edited by P. Harman & S. Mitton, Cambridge University Press, 2002

"... it is probable that amber exhales something peculiar that attracts the bodies themselves, and not air. It plainly attracts the body itself in the case of a spherical drop of water standing on a dry surface; for a piece of amber held at a suitable distance pulls towards itself the nearest particles and ***draws them up into a cone****;..."*

LMIS: history

314 years later…

John ZELENY (1872-1951), American physicist.

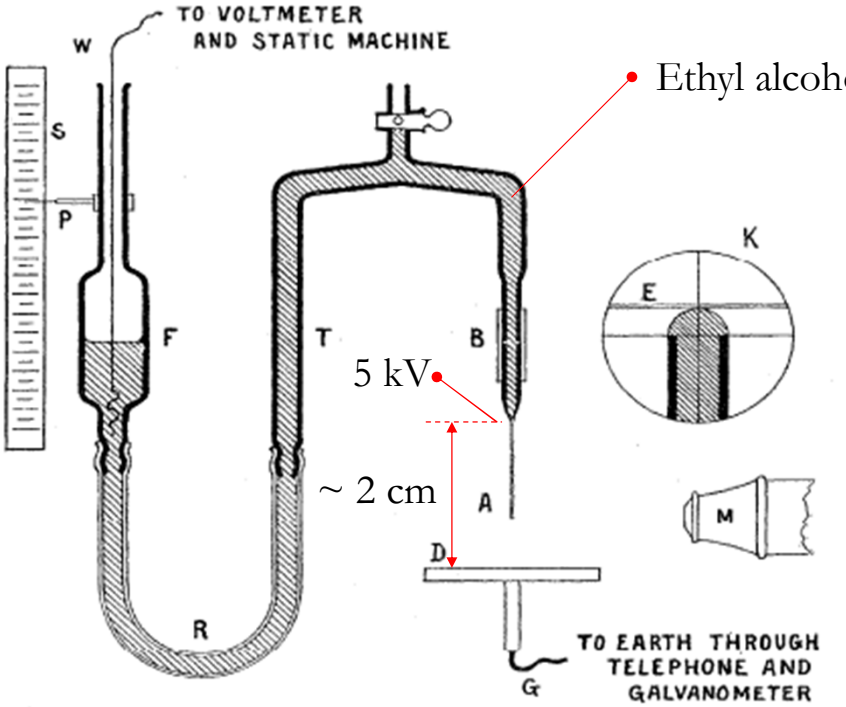
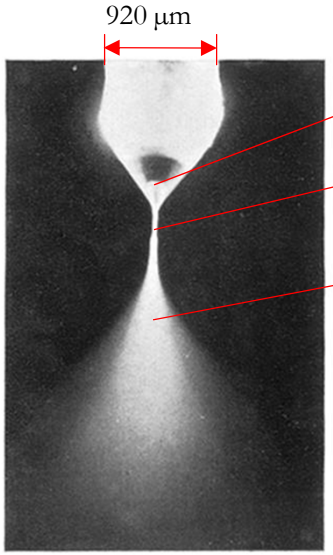
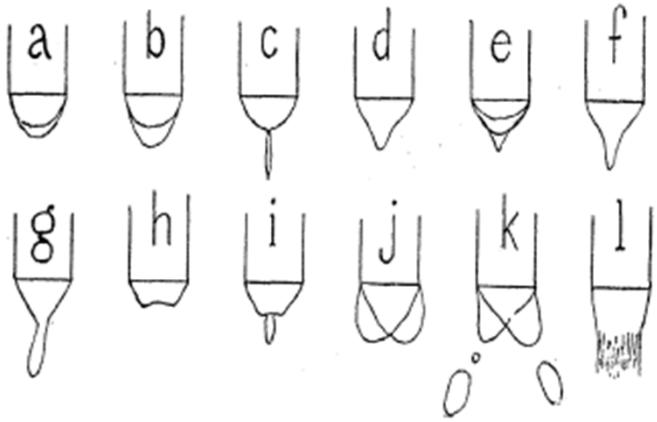


Fig. 1.
Diagram of apparatus.



- Liquid forms a cone
- Thread dia. ~ 4 μm
- Thread breaks up into droplets

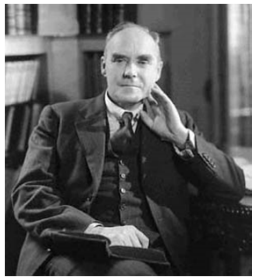
Photograph taken with an exposure time = 30 s



Oscillations of meniscus during intermittent discharge.

J. Zeleny, *Physical Review* , **3** (1914) 69–91
J. Zeleny, *Physical Review* , **10** (1917) 1–6

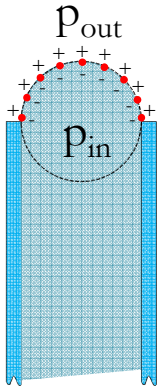
Taylor Cone



Sir Geoffrey Ingram TAYLOR (1886-1975),
British physicist/mathematician,
specialised in the field of fluid mechanics.

Taylor was interested by the behaviour of water droplets in the presence of strong electrostatic fields such as storm clouds. With this problematic in mind he found an analytic solution to the equations of electro-hydrodynamics.

Surface Pressure Jump



$$\Delta p = p_{in} - p_{out} = \gamma c - \frac{1}{2}\varepsilon_0 F^2$$

Where:

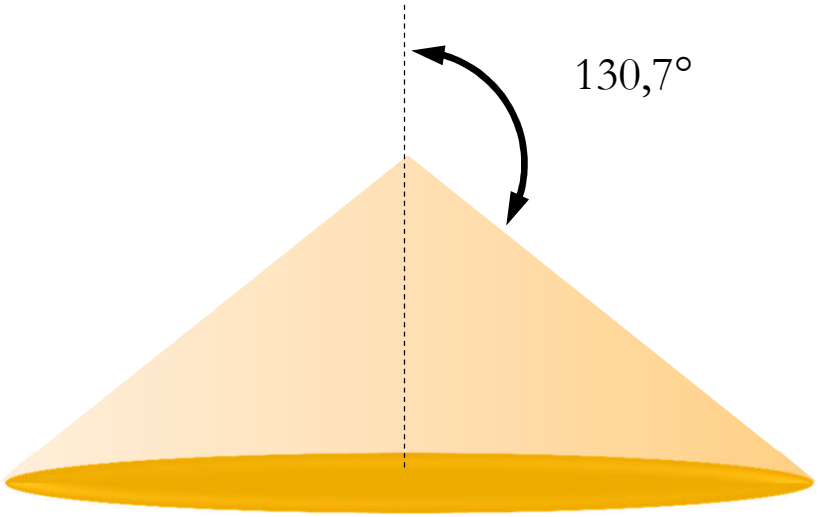
γ = surface tension

c = surface curvature

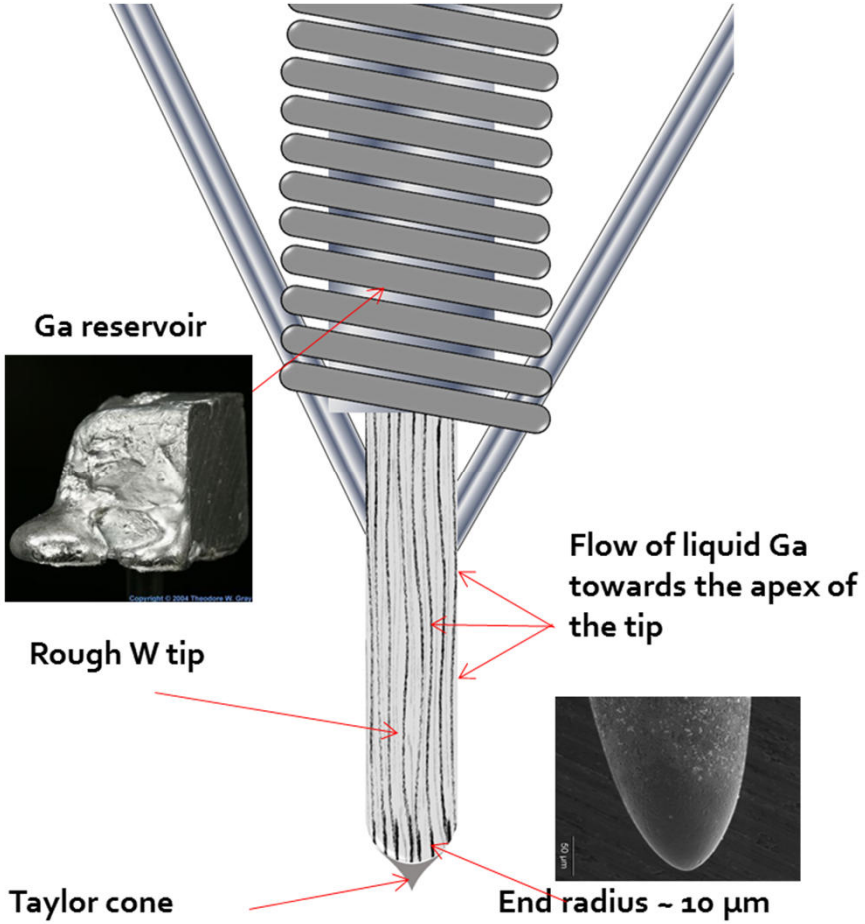
F = electric field

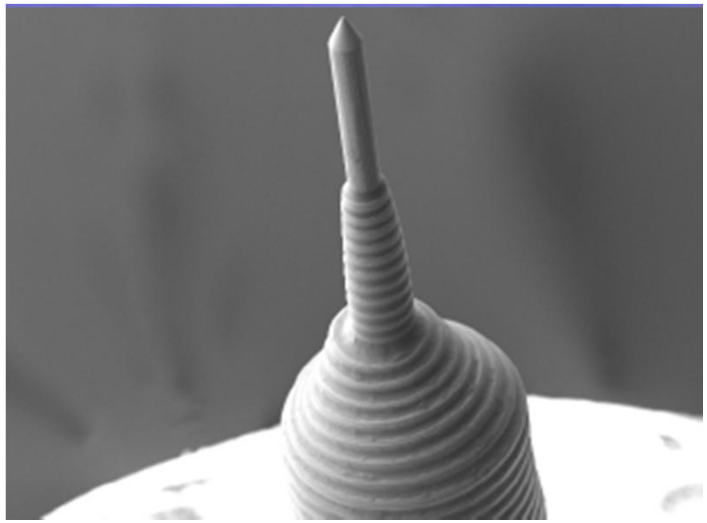
The Taylor cone is the only conical shape which satisfies the condition

$$\tfrac{1}{2}\varepsilon_0 E^2 = 2\gamma/r$$

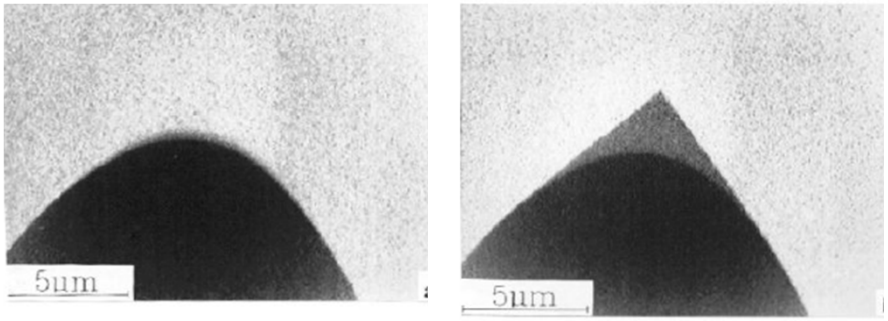


Liquid Metal Ion Source (LMIS)



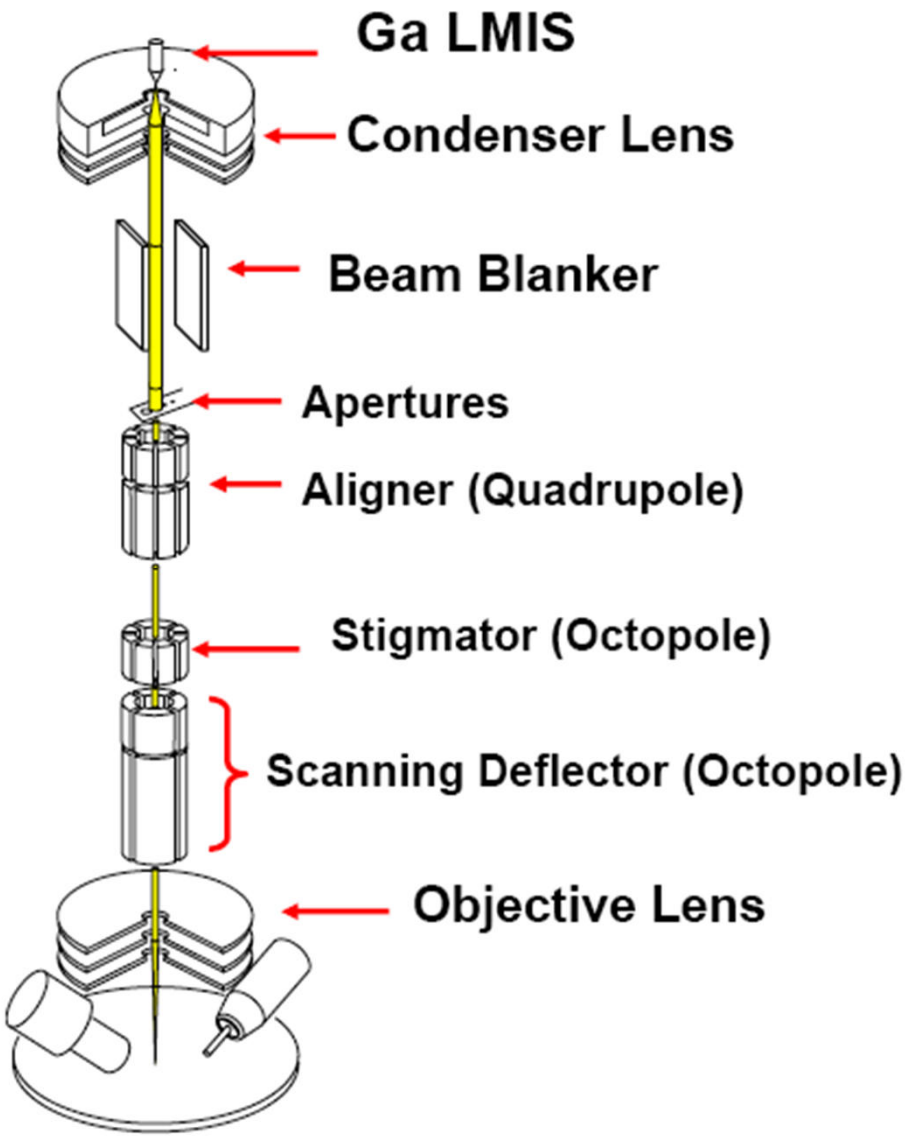


Orsay Physics Ga-LMIS



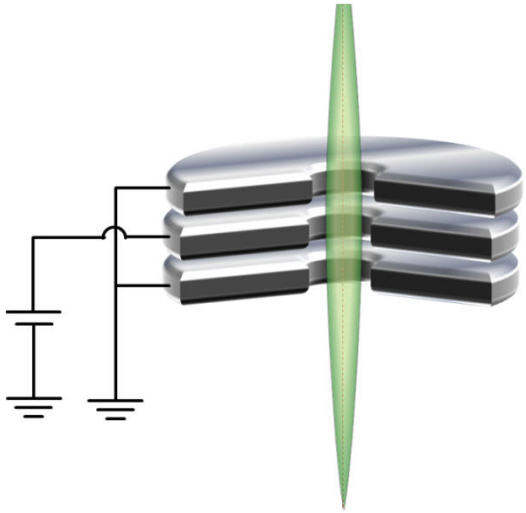
Driesel et al. – MPI Halle 1MeV TEM (1996)

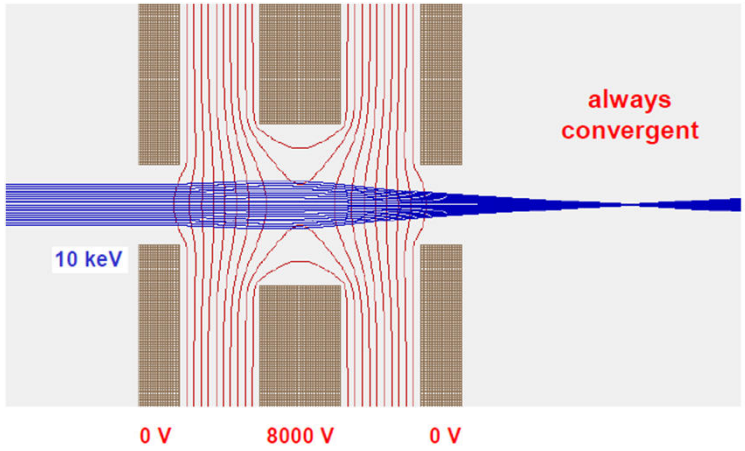
SII Ion Column



Principle of an electrostatic lens

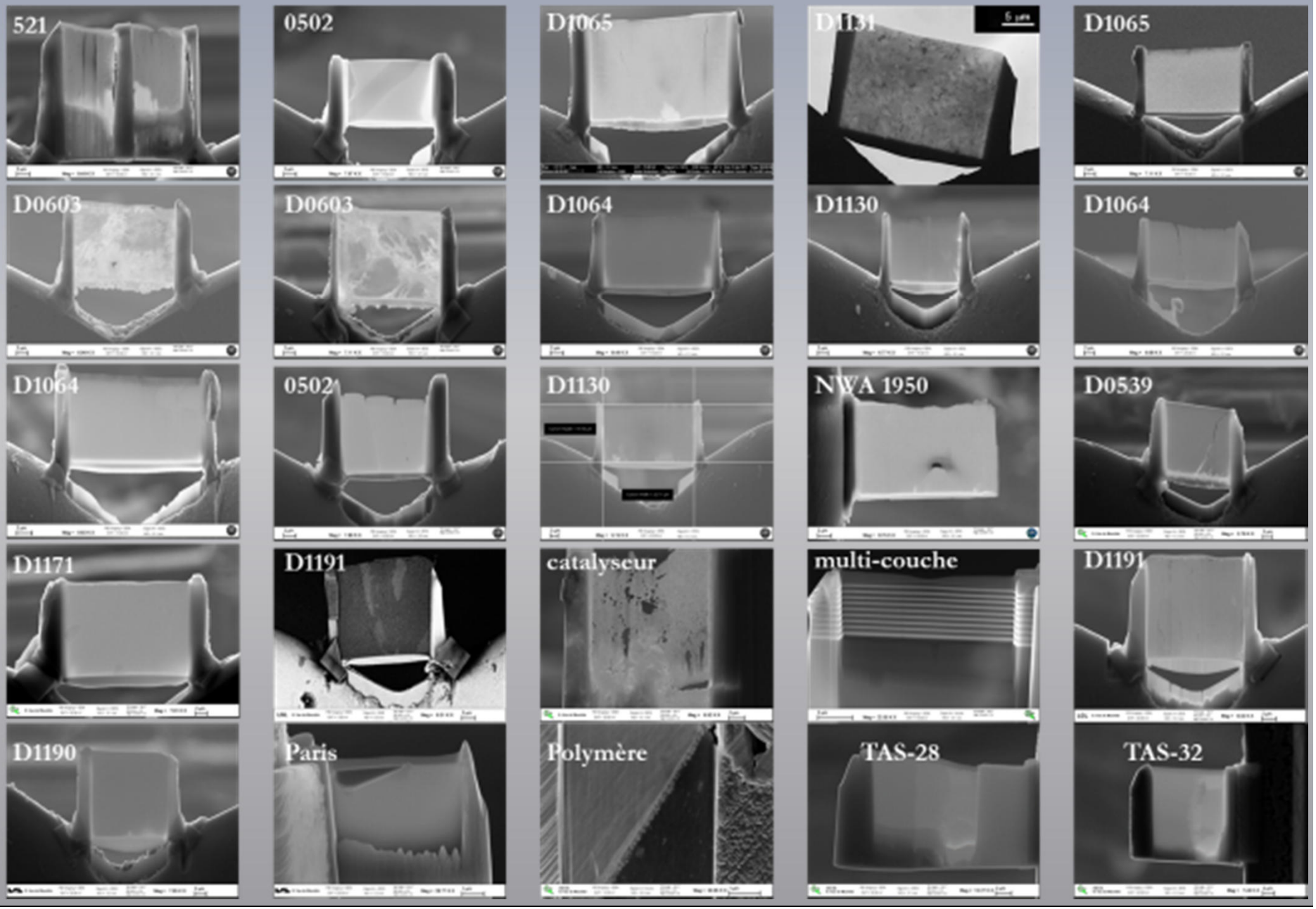
Unipotential or *Einzel* lens



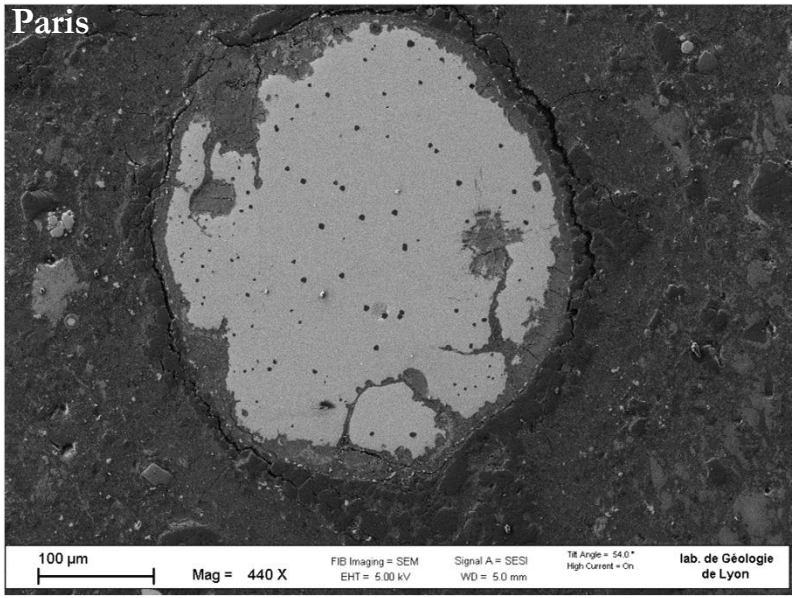


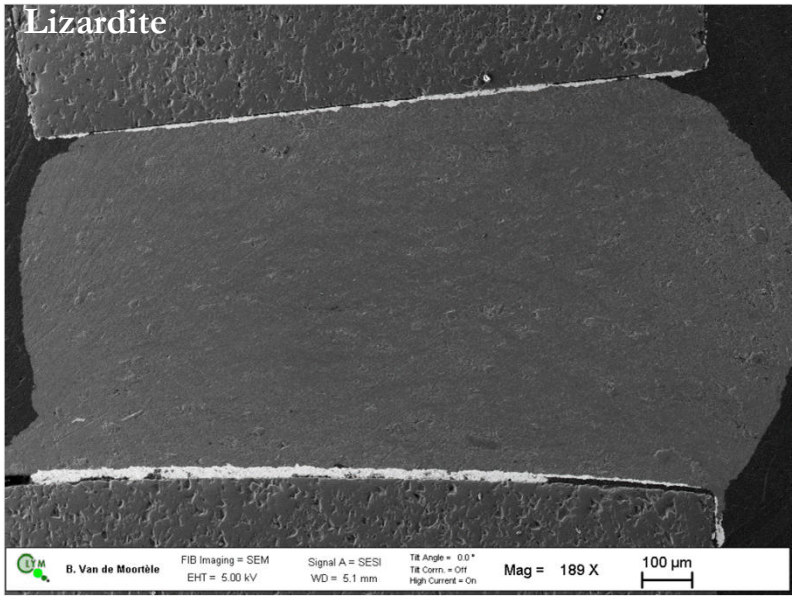
From Rasser, CNRS formation entreprises, Lyon, mars 2013

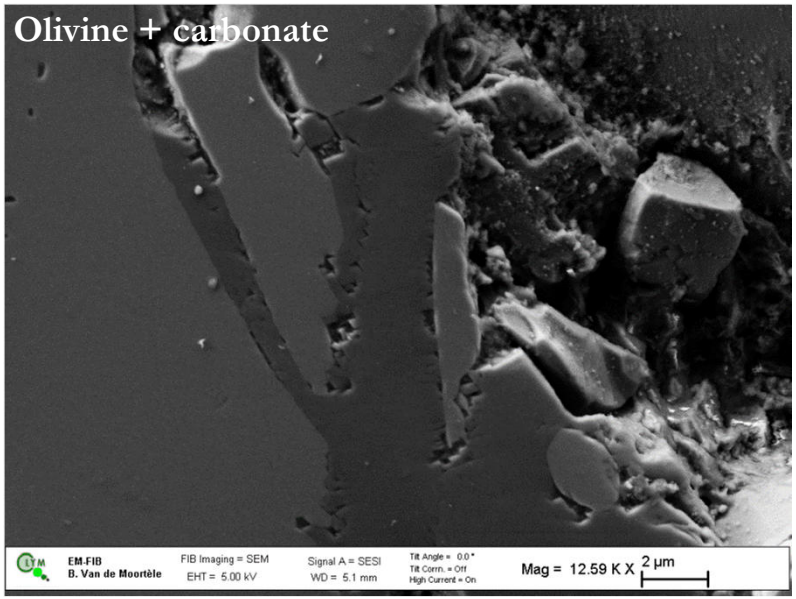
TEM Lamella Preparation

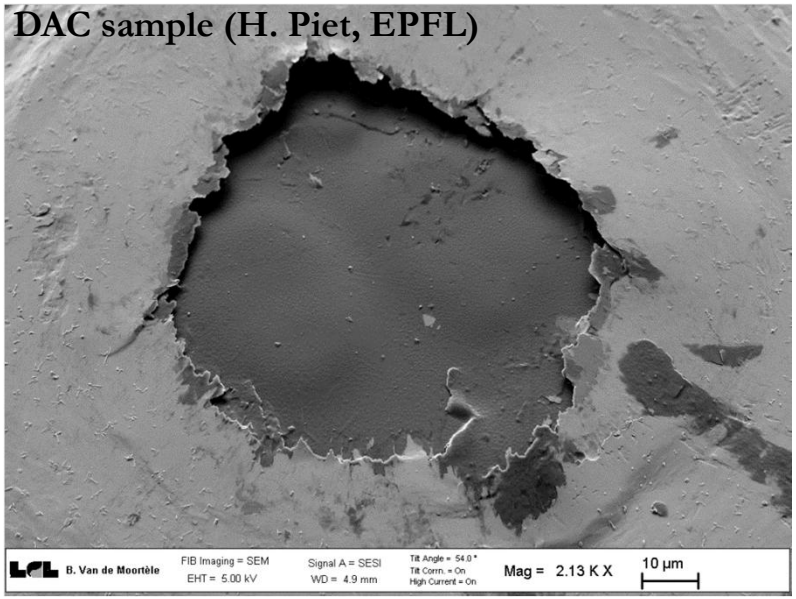


Why using FIB for preparing TEM lamellae?

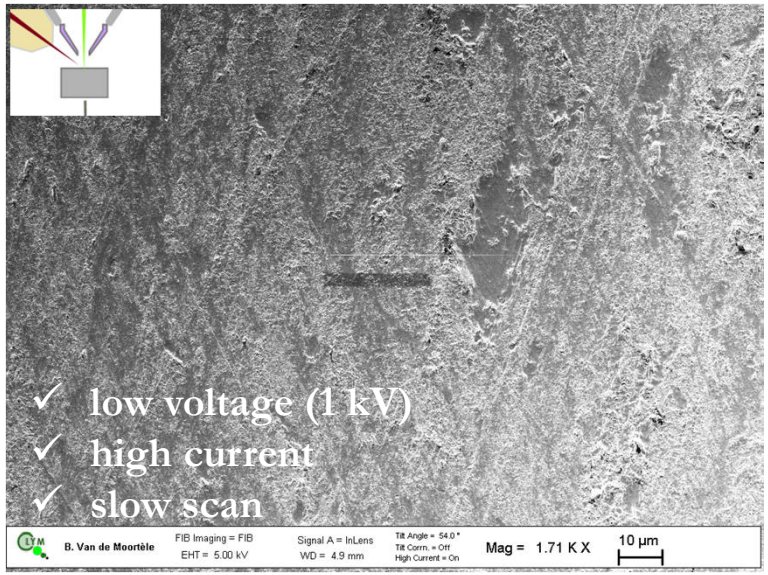


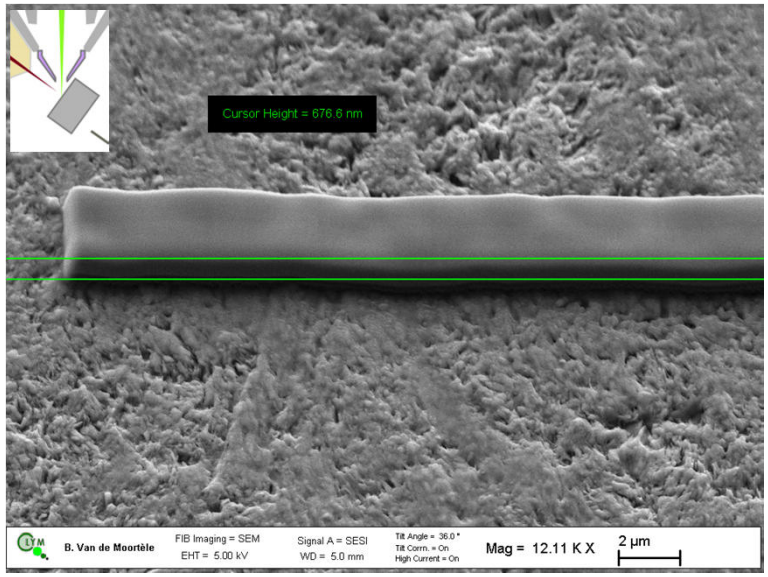


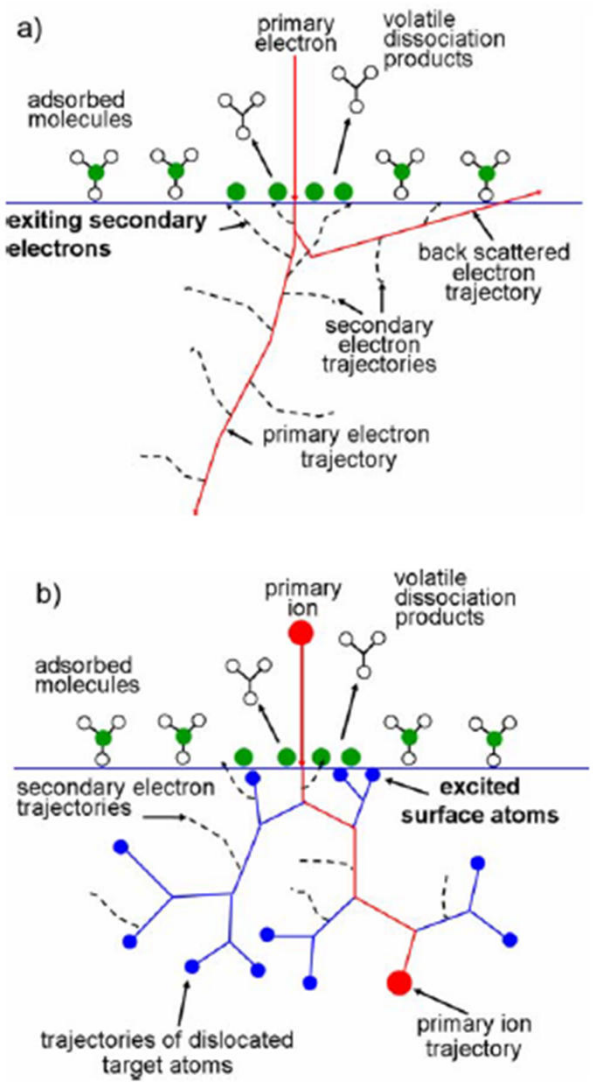




Electron and Ion beam induced deposition

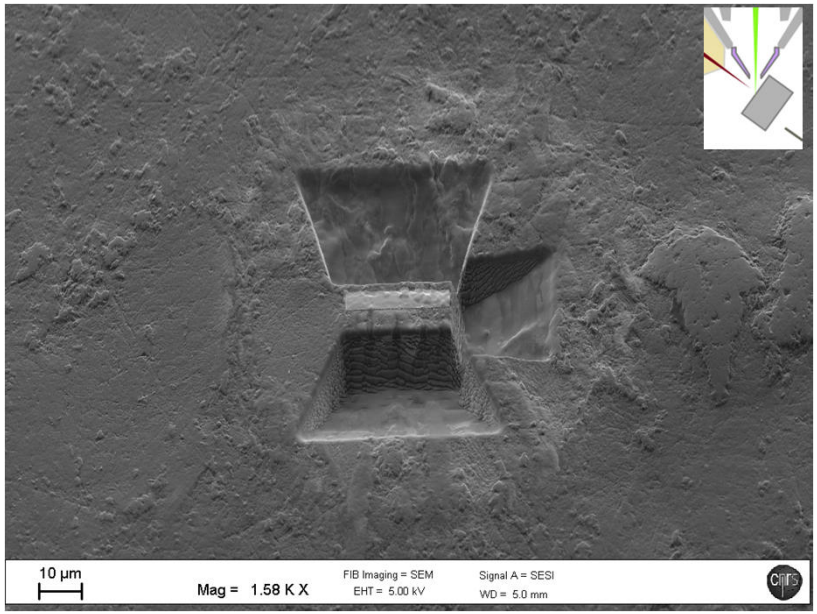


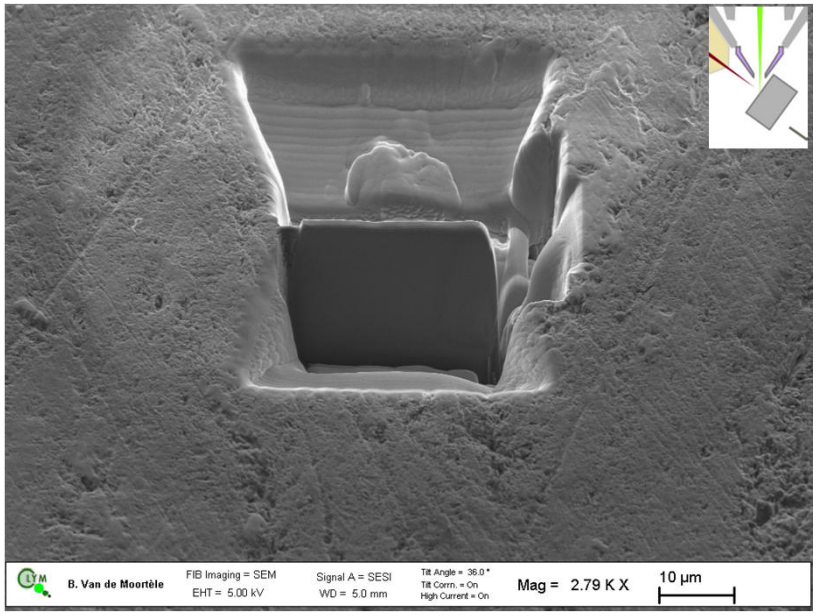


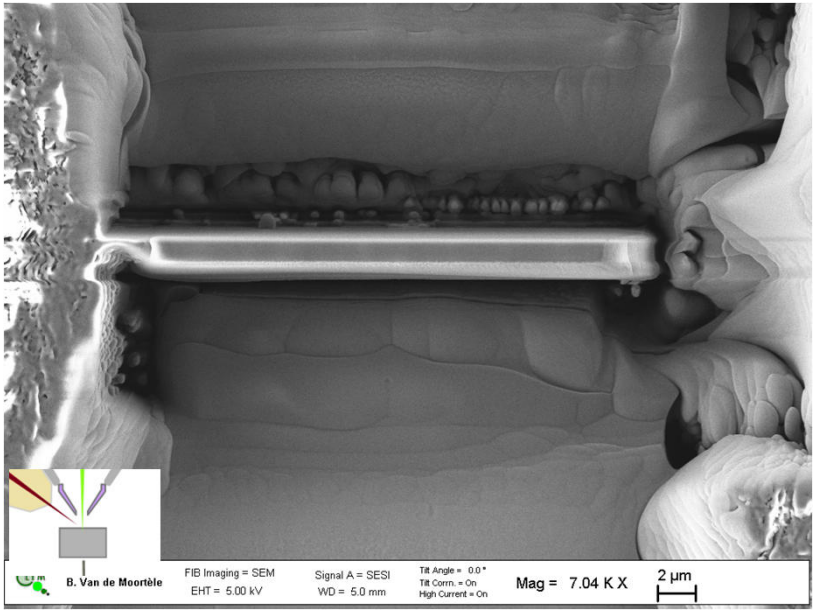


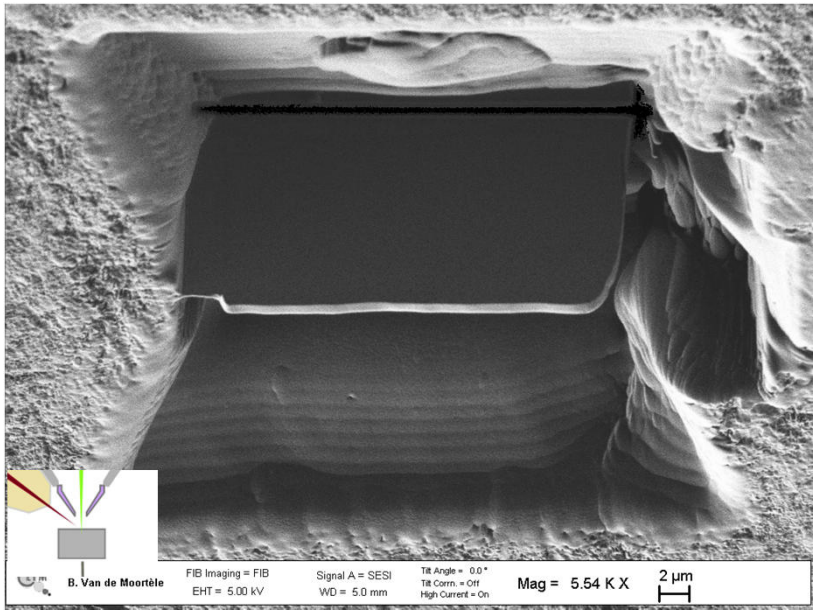
Gas-assisted focused electron beam and ion beam processing and fabrication
I. Utke
Journal of Vacuum Science & Technology B, Vol.26 No 4, Jul/Aug 2008

Main steps

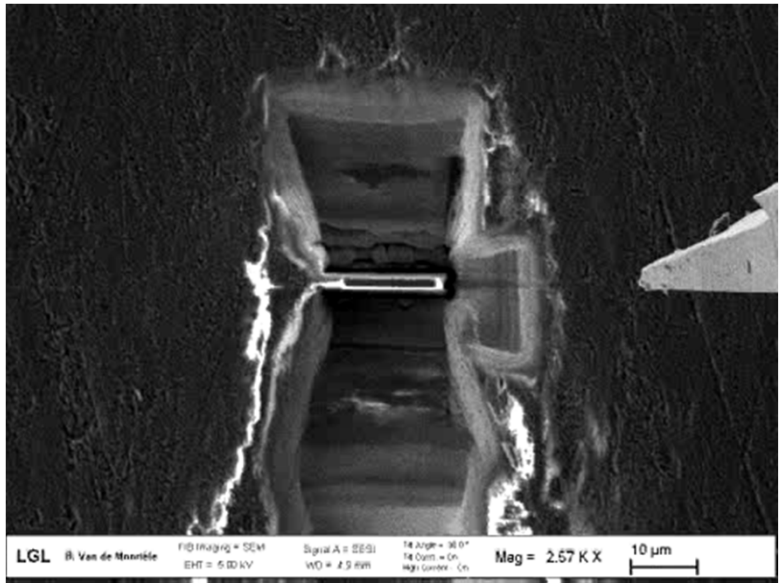

10 µm
Mag = 1.58 K X
FIB Imaging = SEM
EHT = 5.00 kV
Signal A = SESI
WD = 5.0 mm


B. Van de Moortèle
FIB Imaging = SEM
EHT = 5.00 kV
Signal A = SESI
WD = 5.0 mm
Tilt Angle = 36.0 °
Tilt Corrn. = On
High Current = On
Mag = 2.79 K X
10 µm

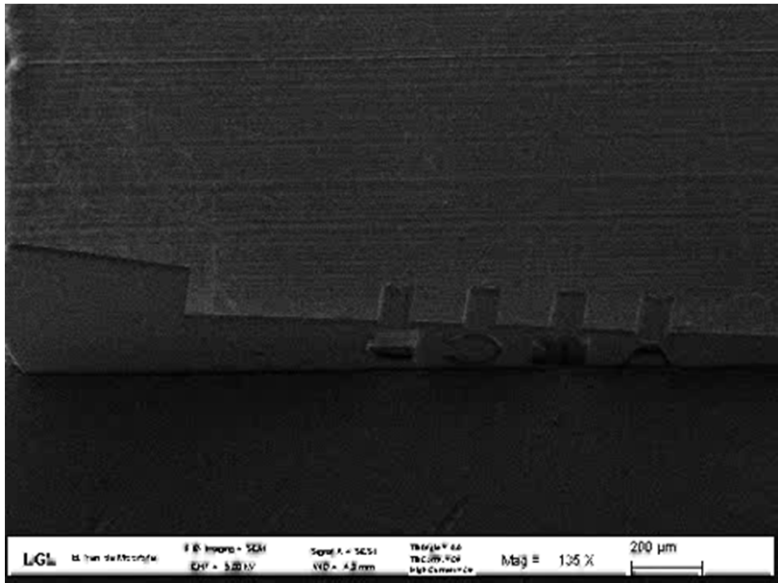

B. Van de Moortèle
FIB Imaging = SEM
EHT = 5.00 kV
Signal A = SESI
WD = 5.0 mm
Tilt Angle = 0.0 °
Tilt Corrn. = On
High Current = On
Mag = 7.04 K X
2 µm


B. Van de Moortèle
FIB Imaging = FIB
EHT = 5.00 kV
Signal A = SESI
WD = 5.0 mm
Tilt Angle = 0.0 °
Tilt Corrn. = Off
High Current = On
Mag = 5.54 K X
2 µm

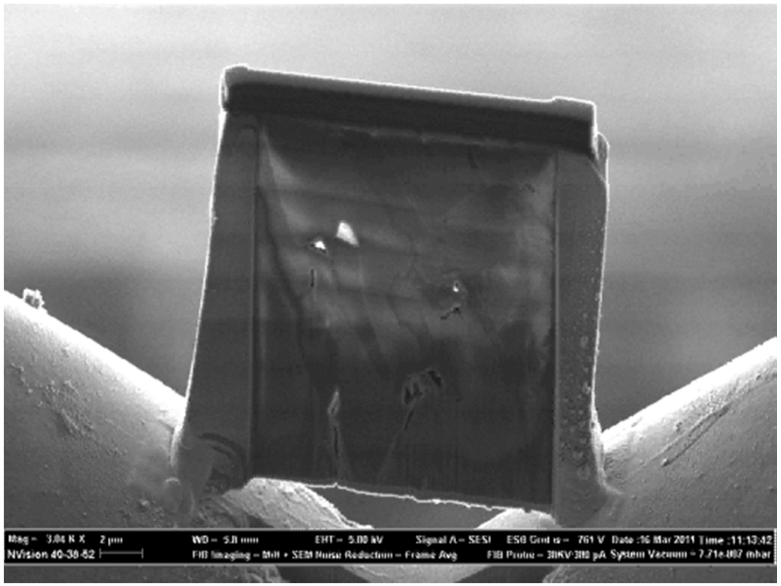
Lift-out



Lift-out

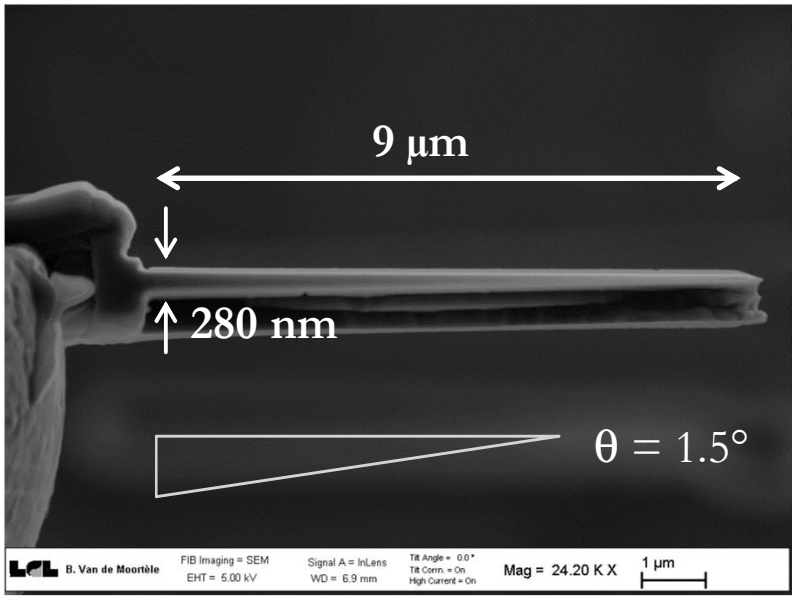


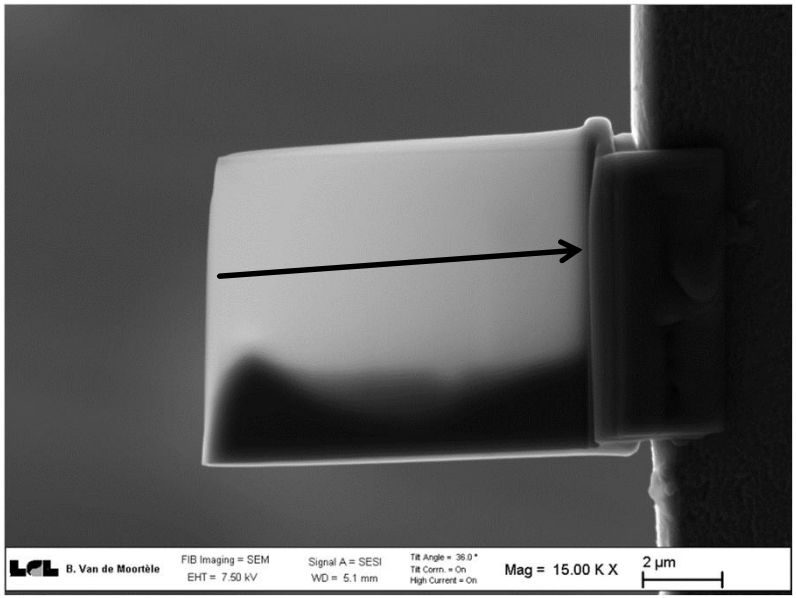
Gluing on copper grid

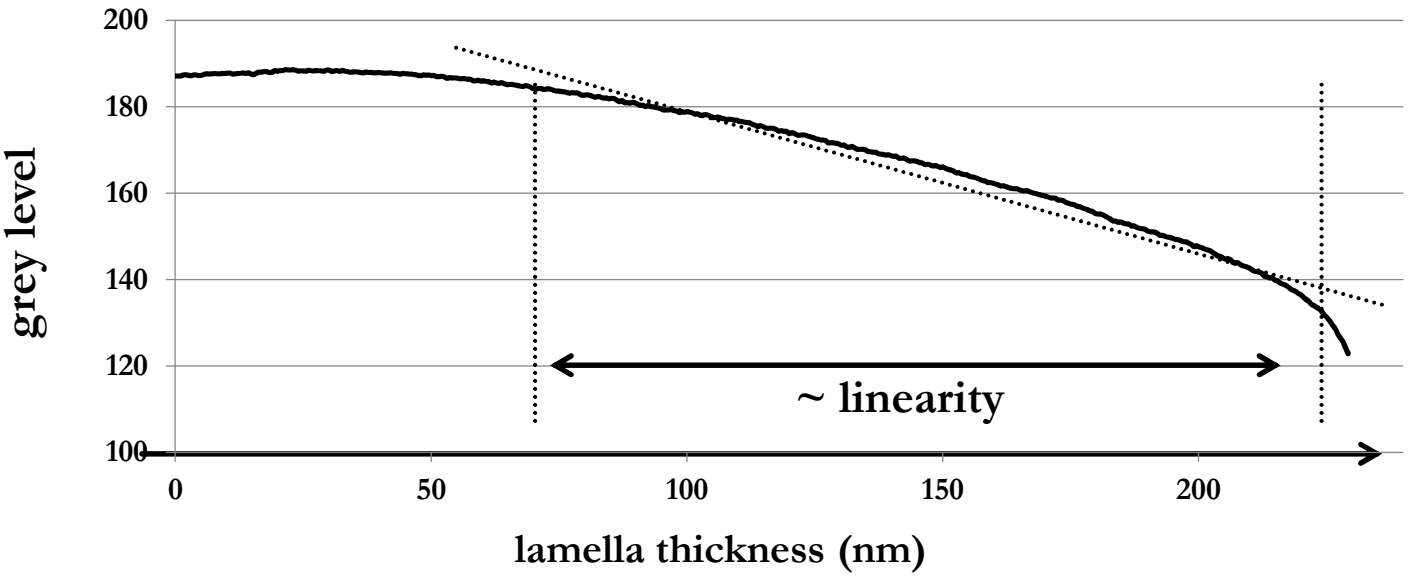


Milling

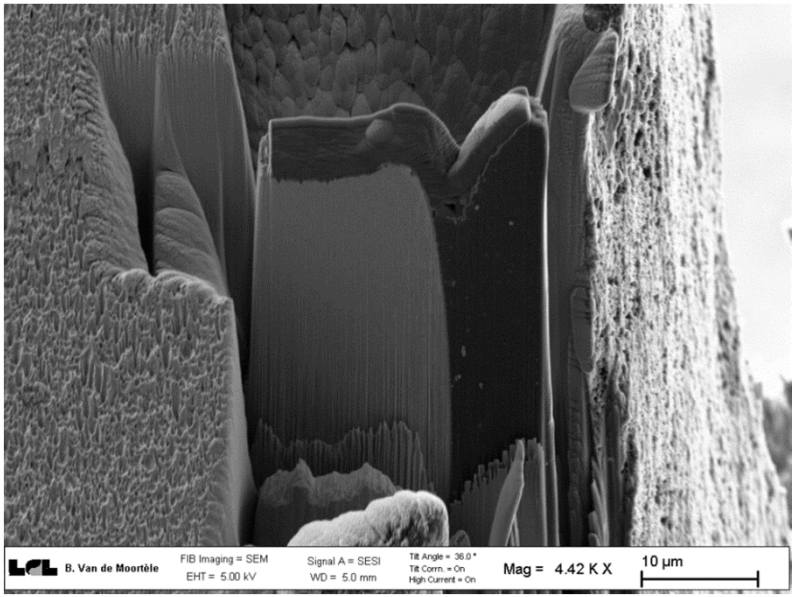
Electron transparency

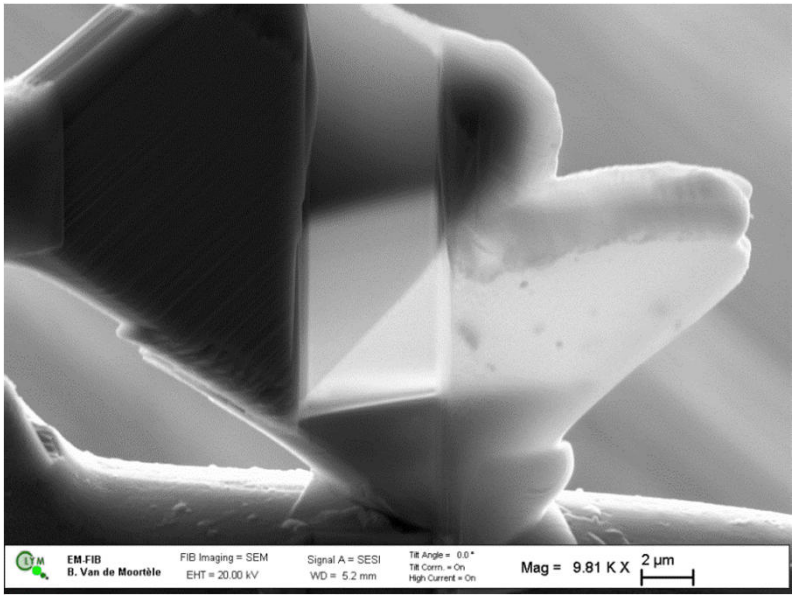


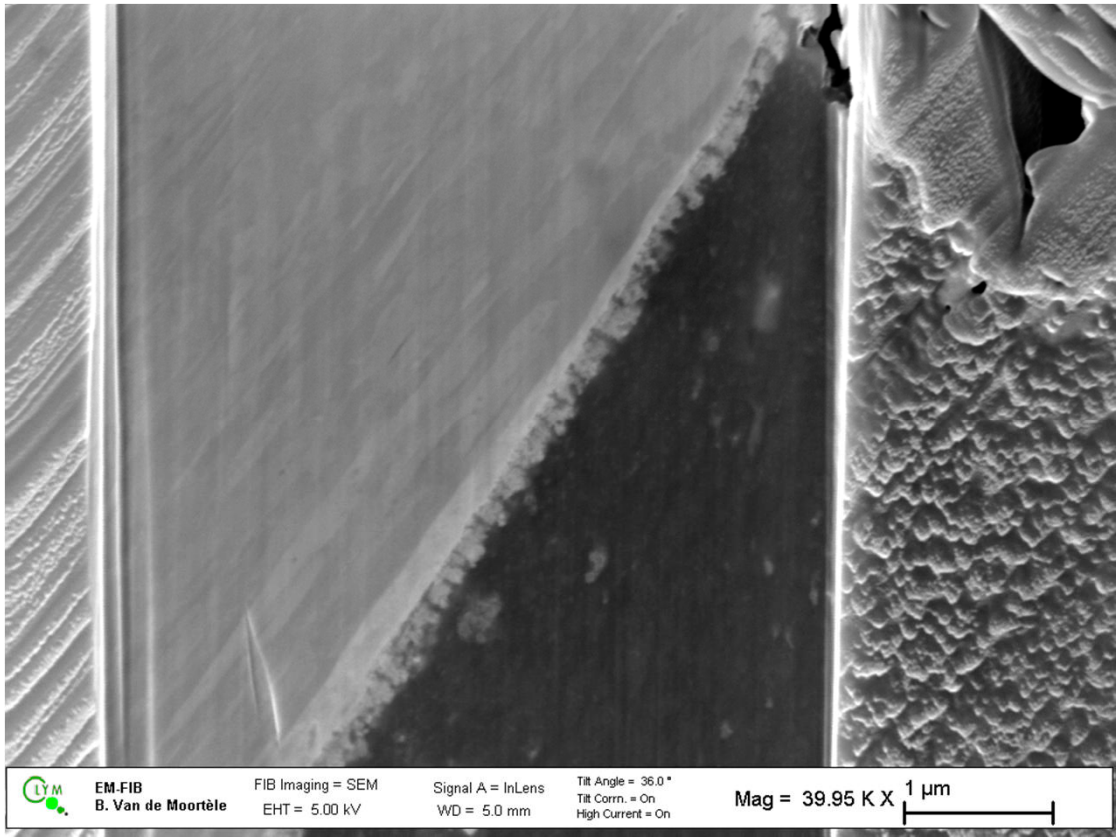


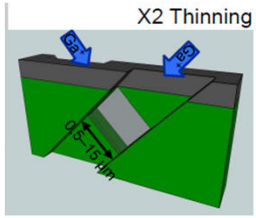


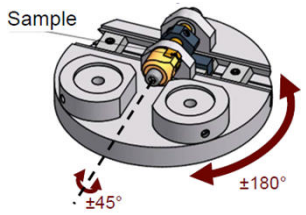
Soft Material





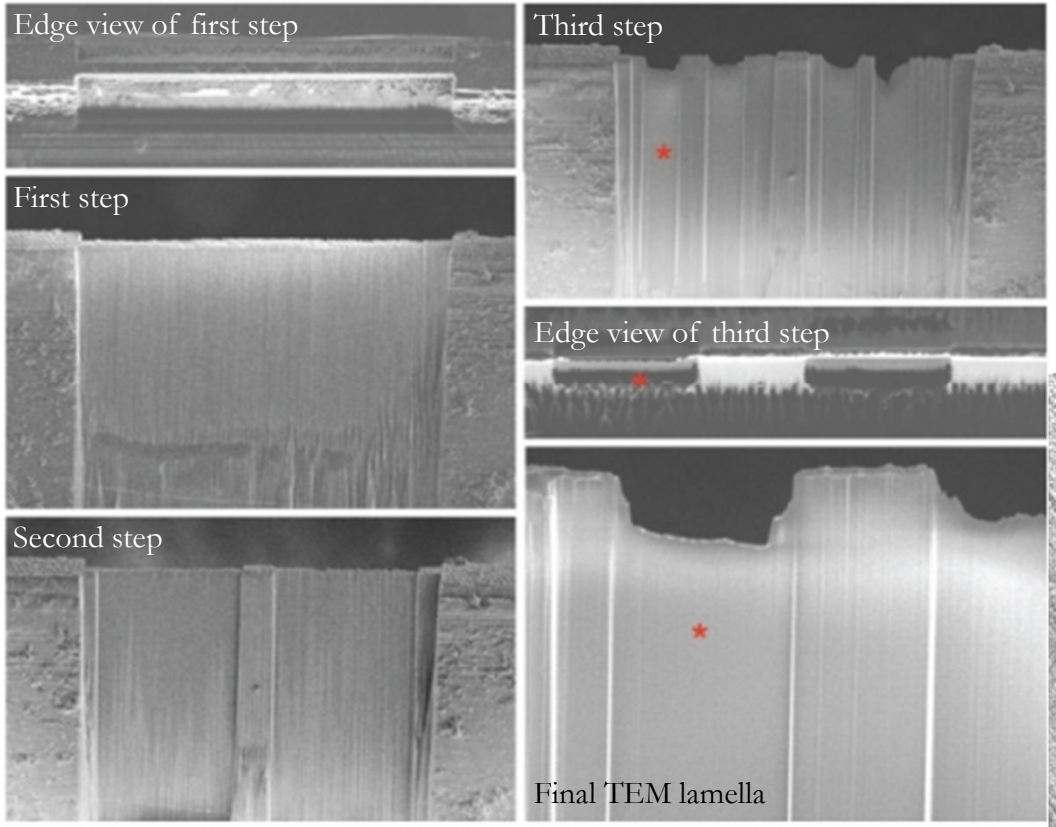


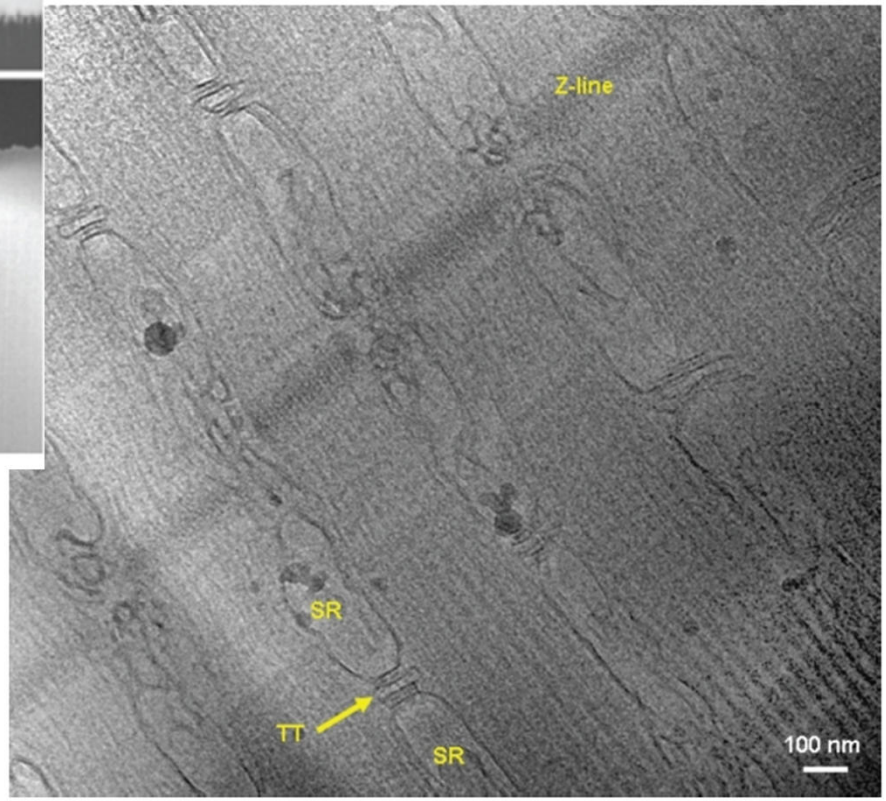




S. Chalal, Zeiss France, is thanked for giving us the opportunity to use the X2 sample holder

Biological sample





Cryo-focused-ion-beam (FIB) preparation of vitreous specimens for cryo-TEM

Mike Marko

Wadsworth Center, New York State Department of Health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The 16th European
MICROSCOPY CONGRESS
Convention Center - 28th August - 2nd September
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FIB/SEM french training

	jour 1		jour 2		jour 3		jour 4		jour 5	
	GR1	GR2	GR1	GR2	GR1	GR2	GR1	GR2	GR1	GR2
8h00-8h30			FIB-TP3			FIB-TP3				
8h30-9h00							fin manipe-3D			
9h00-9h30			IF-TP1+TP3	FIB-TP1+TP2	IF-TP4	FIB-TP4	cours lame TEM		IF-TP2	FIB-TP5
9h30-10h00	accueil				pause		FIB-TP6		questions ouvertes	
10h00-10h30	Rappels sur le MEB				visite du CLYM	IF-TP4			EDS-3D ou EBSD-3D	
10h30-11h00										
11h00-11h30					pause déjeuner		pause déjeuner		pause déjeuner	
11h30-12h00			pause déjeuner							
12h00-12h30					Principes de la 3D, applications en biologie, M. Cantoni		FIB-TP6		EDS-3D ou EBSD-3D	
12h30-13h00	pause déjeuner		Principes généraux du FIB, B. Rasser						bilan des journées	
13h00-13h30					pause		pause			
13h30-14h00	Intéractions ions-matière (+SRIM/TRIM?)						cours pointe			
14h00-14h30			pause		TP-3D-commun					
14h30-15h00			FIB-TP4	visite du CLYM			FIB-TP5	IF-TP2		
15h00-15h30	FIB-TP1+TP2	IF-TP1+TP3								
15h30-16h00										
16h00-16h30										
16h30-17h00										
17h00-17h30										
17h30-18h00										
18h00-18h30										

Direction de l'innovation et des relations avec les entreprises

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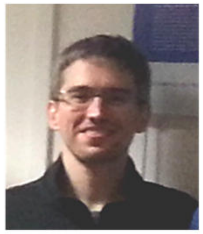
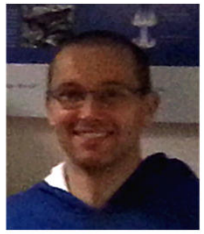
07/04/14 au 11/04/14

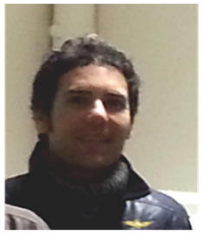
	TP-FIB	TP-IF
TP1	usinage (1.5h)	Fiji (2h)
TP2	dépôt (1.5h)	Fiji (2h)
TP3	µmanipulators (1h)	SRIM/TRIM; 1 h
TP4	ionique (1.5h)	ionique (1.5)
TP 5	pointe (2h)	
TP6	lame (2 ou 4h)	



N. Blanchard
ILM
UCBL



A. Descamps
LPEM
ESPCI



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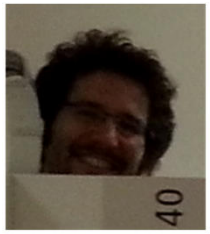

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