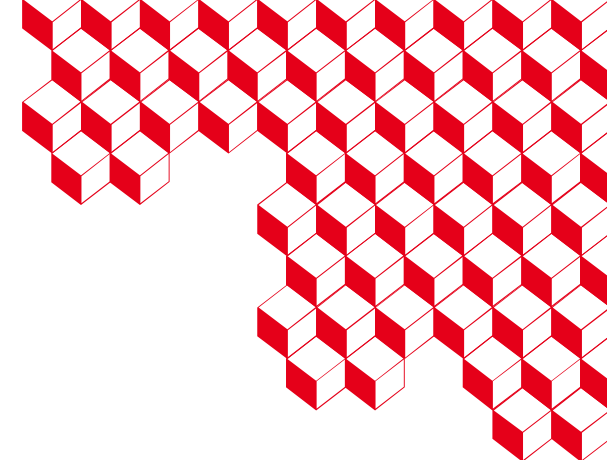




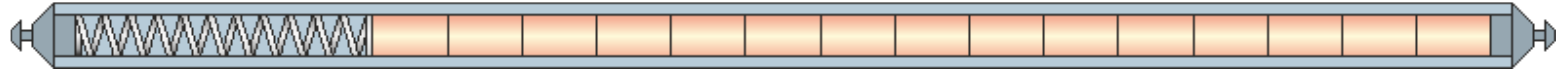
iresne



Réalisation de microéchantillons dans le combustible irradié à l'aide du FIB

Thierry BLAY



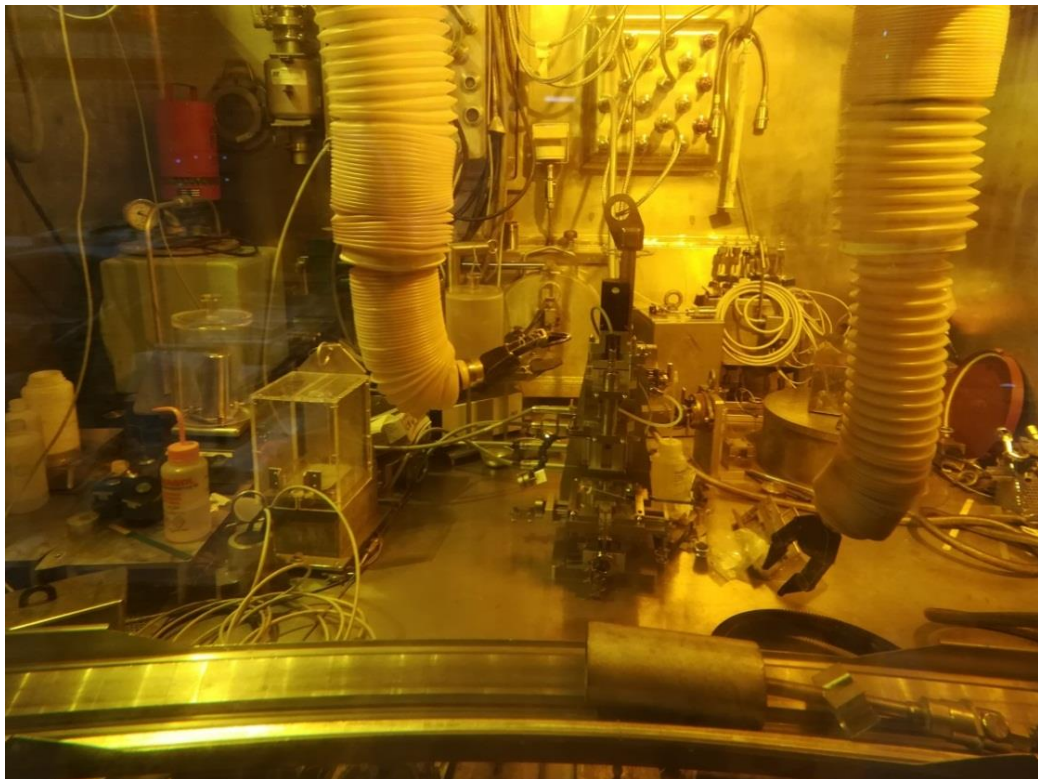


Cellules blindées

LECA
Laboratoire de Haute
activité dédié à
l'examen de
combustible irradié



Examens post irradiatoires



Préparation des échantillons :

- Découpe
- Enrobage
- polissage

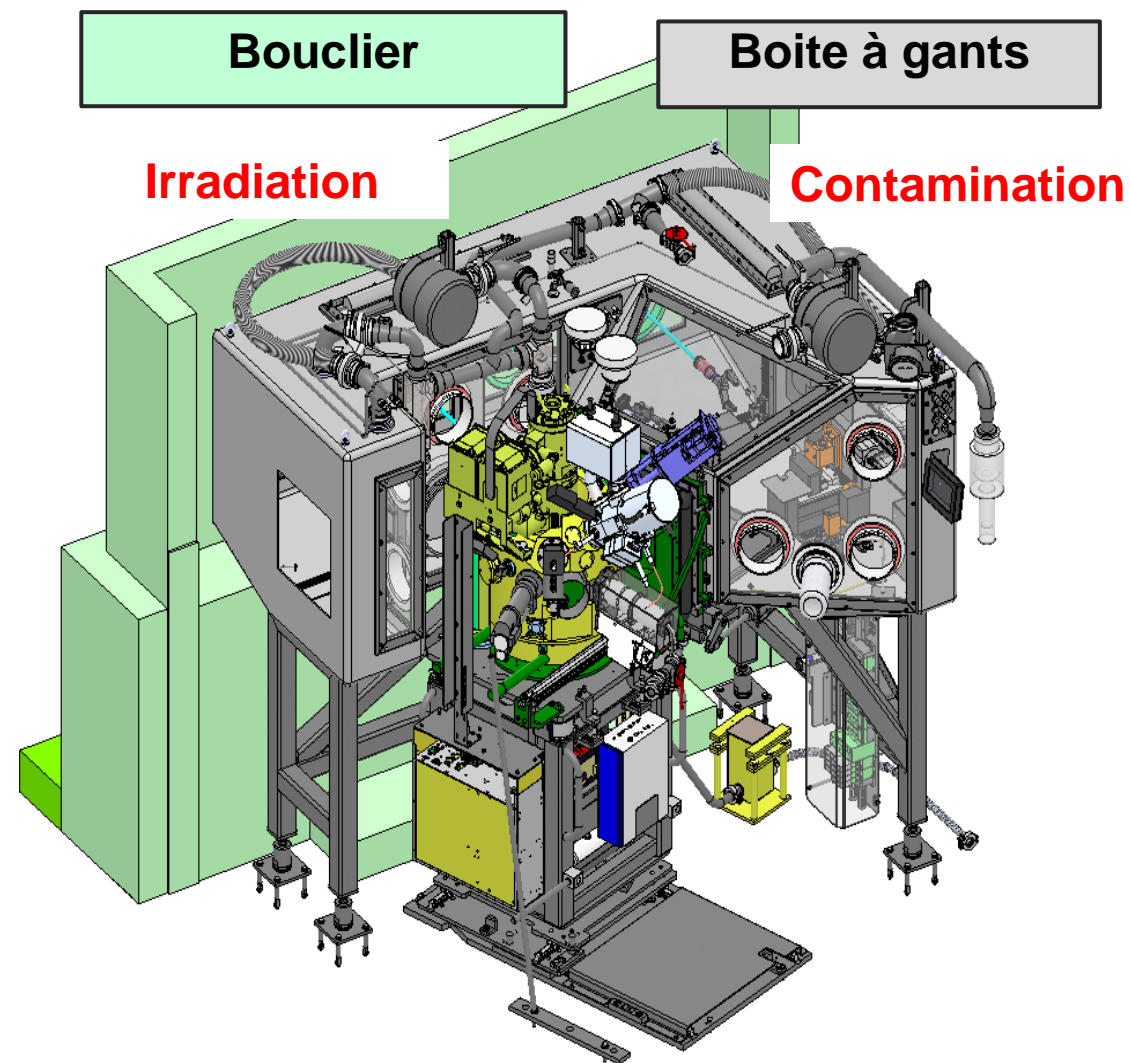
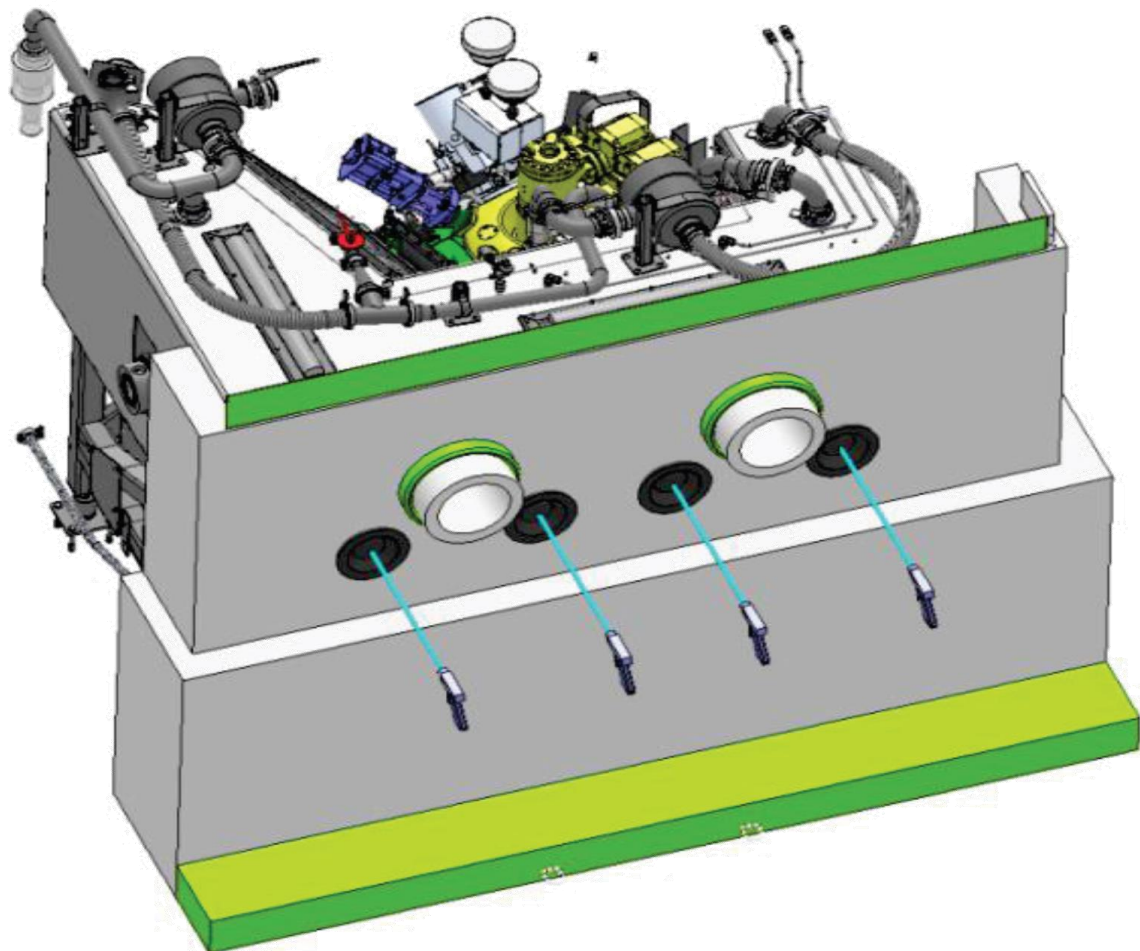
Examen μ scope optique



**Microsonde
MEB FIB
SIMS
 μ scope Confocal
DRX

TEM**

MEB FIB AURIGA 40 nucléarisé



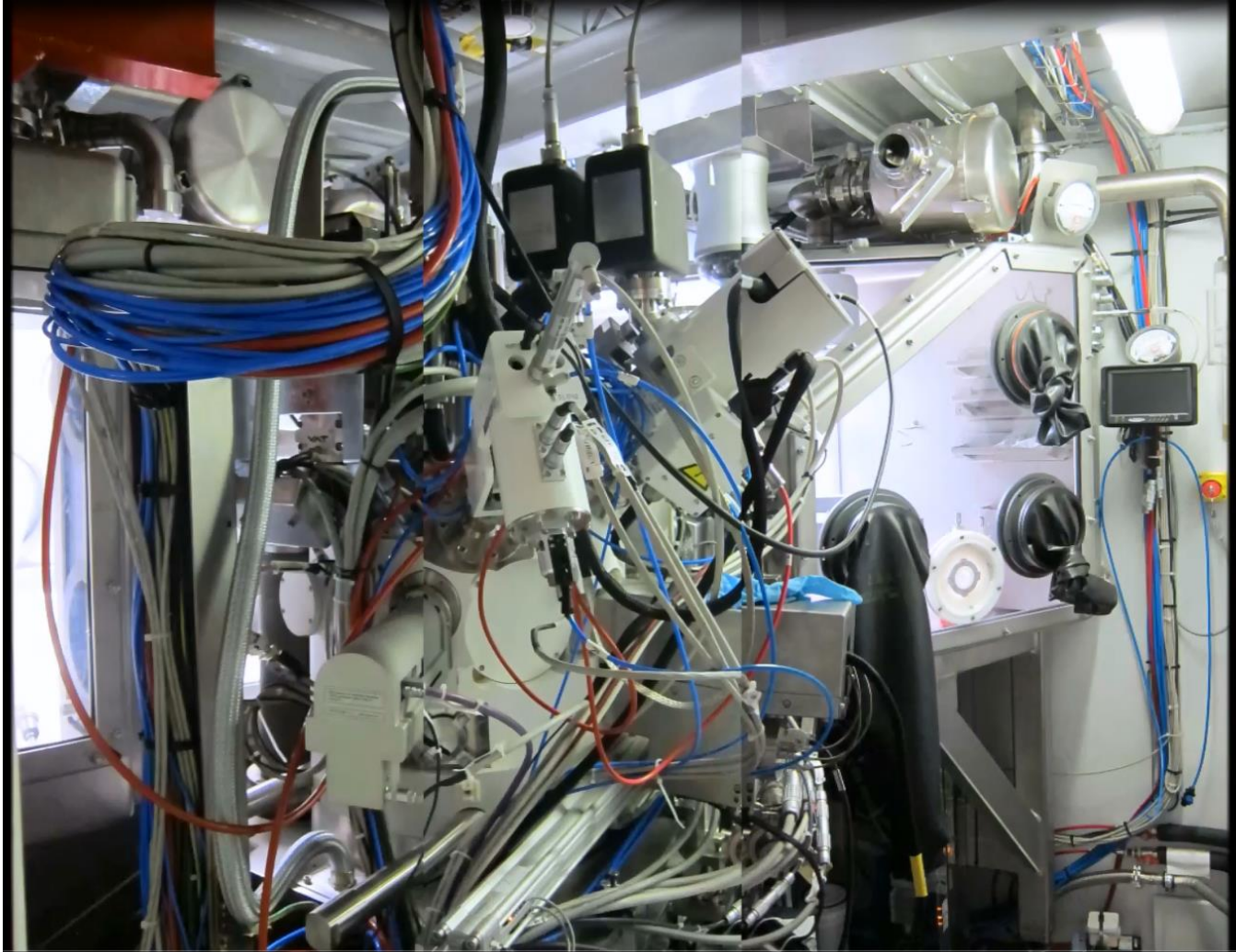
Bouclier de protection



**Socle :
béton 50cm d'épaisseur**

**Partie supérieure :
plomb 13 cm d'épaisseur**

**Hublot :
40 cm d'épaisseur**



MEB :

Détecteurs se : Inlens / SESI
Détecteurs bse : YAG / Inlens Esb

Caméra EBSD
Détecteur EDX

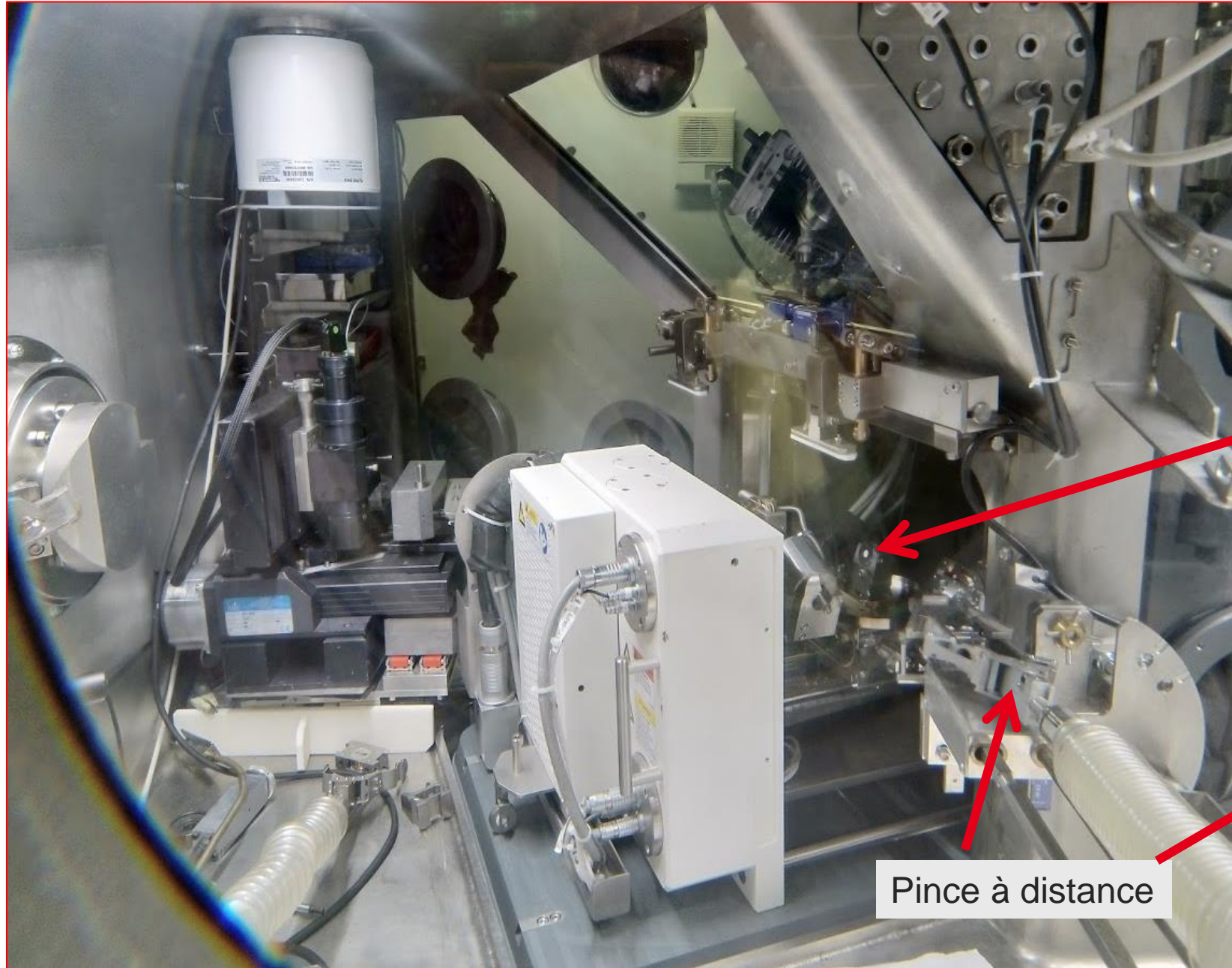
FIB :

colonne COBRA Ga

Micromanipulateur Kleindick
STEM custom

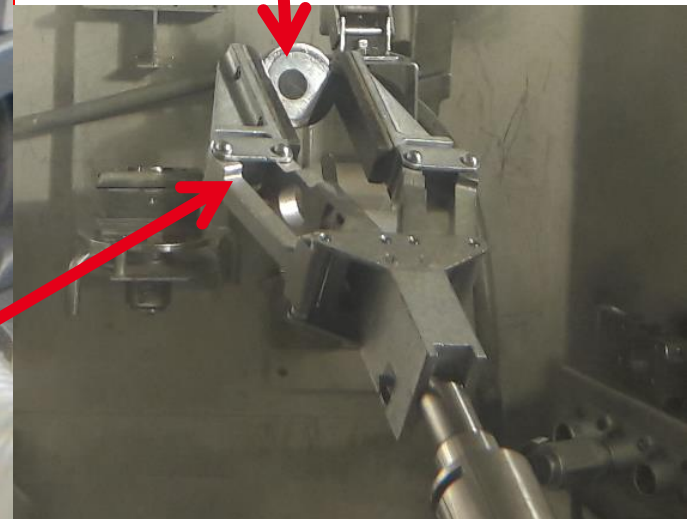
Nano indenteur : V1 :CSM
V2 : ALEMNIS

MEB FIB AURIGA 40

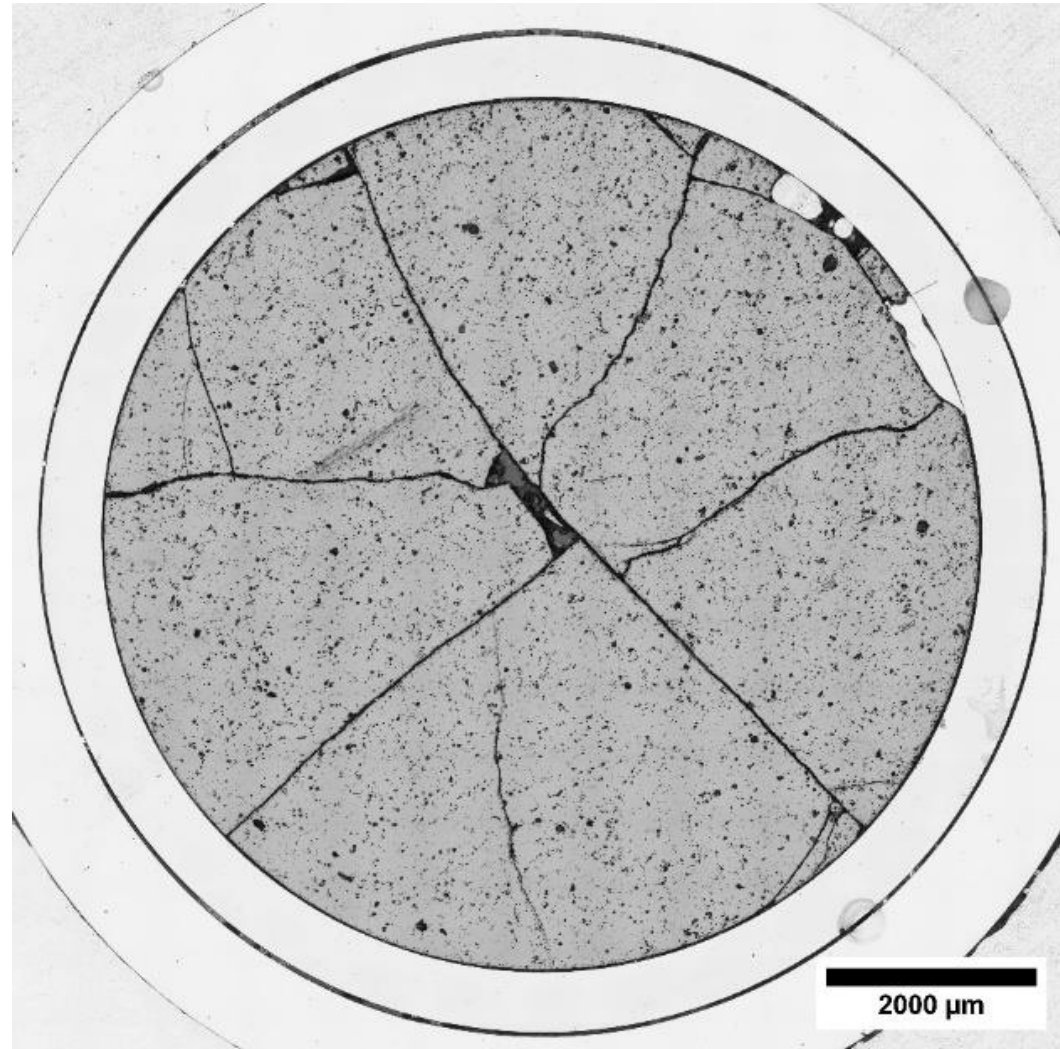
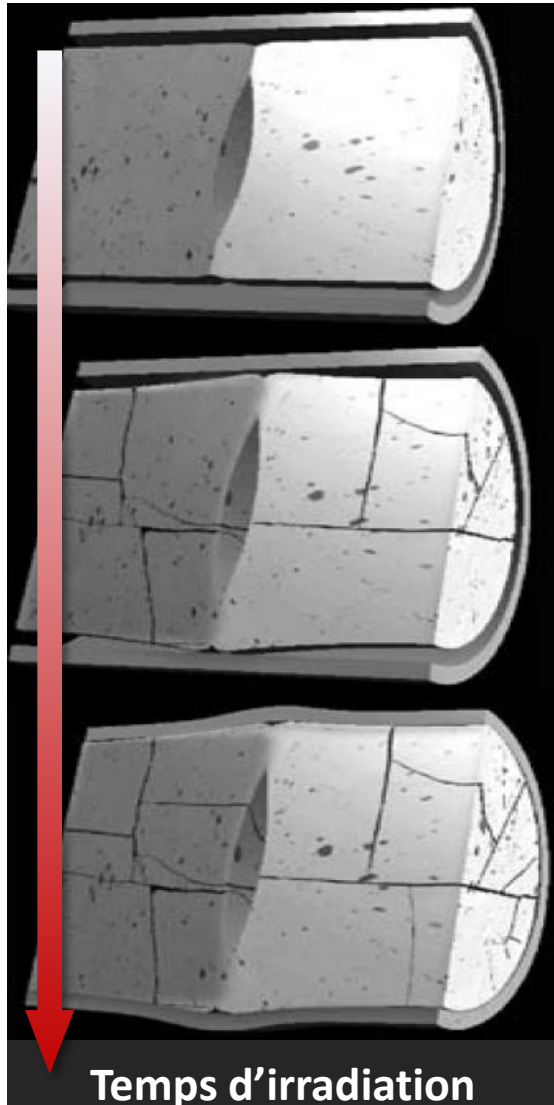
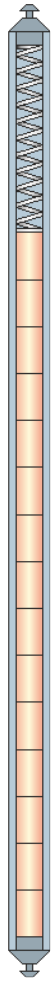


Echantillon enrobé

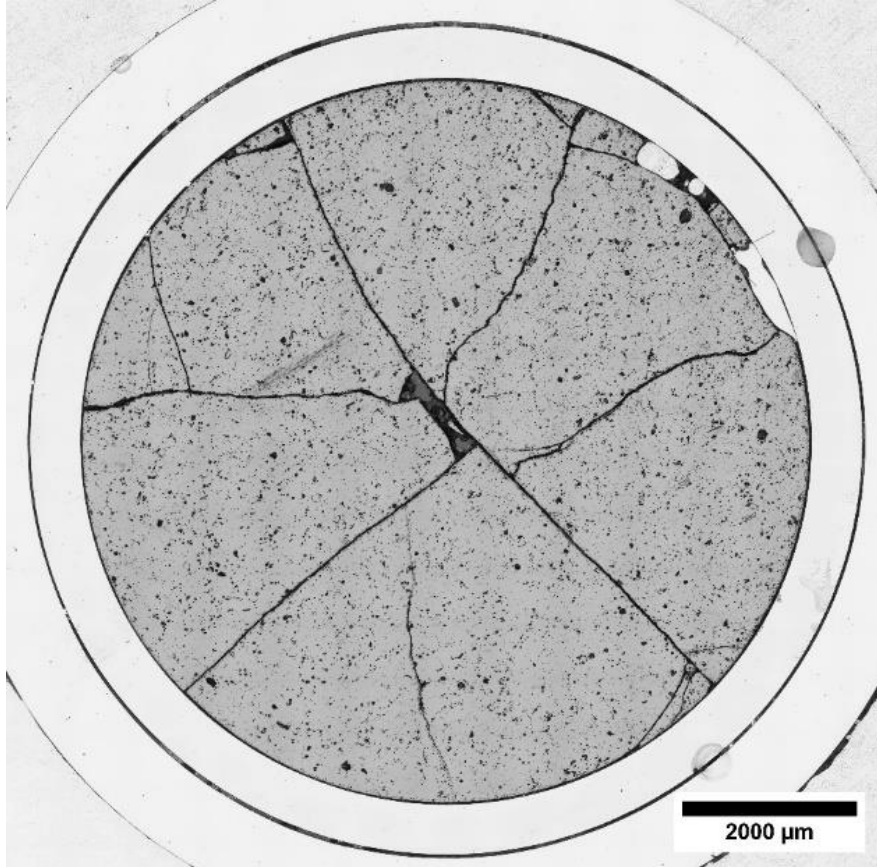
Pince à distance



le combustible irradié



Echantillons massifs vs μ échantillons



Échantillon massif \Leftrightarrow \varnothing 10 mm H = 5mm

- risques : Irradiation + contamination
- Suivi de matière nucléaire
- Installations appropriées
- Nucléarisation \Rightarrow couts + difficultés

μ échantillon \Leftrightarrow qq μm^3

- risques : contamination
- Facilité de transport
- Simplicité

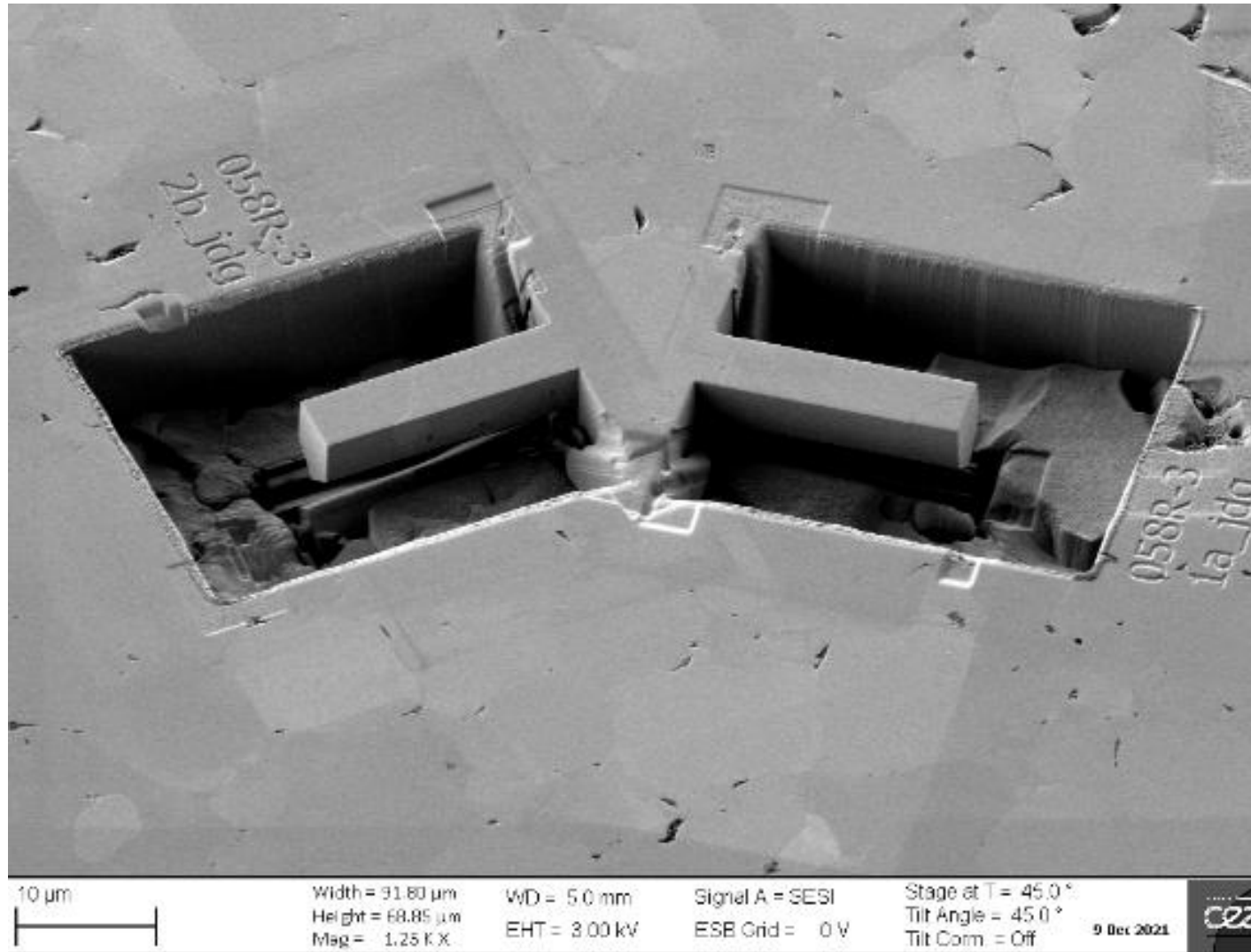
Fabrication de poutres \Rightarrow essais mécaniques in situ

Prélèvement de qq m³ \Rightarrow synchrotron

Fabrication de lames TEM

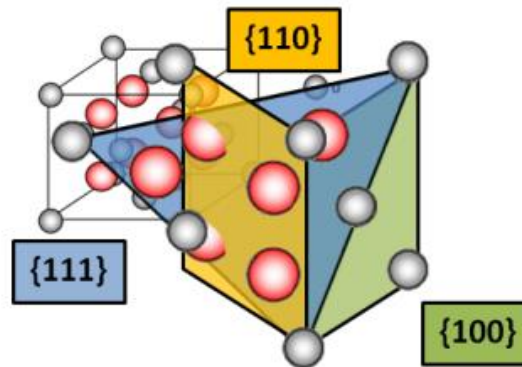
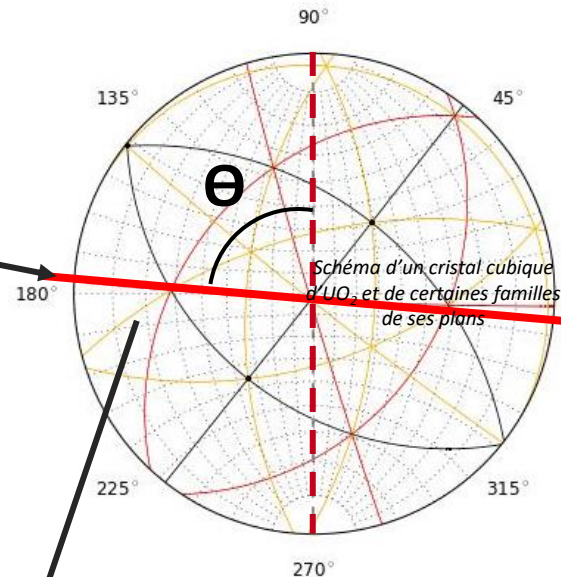
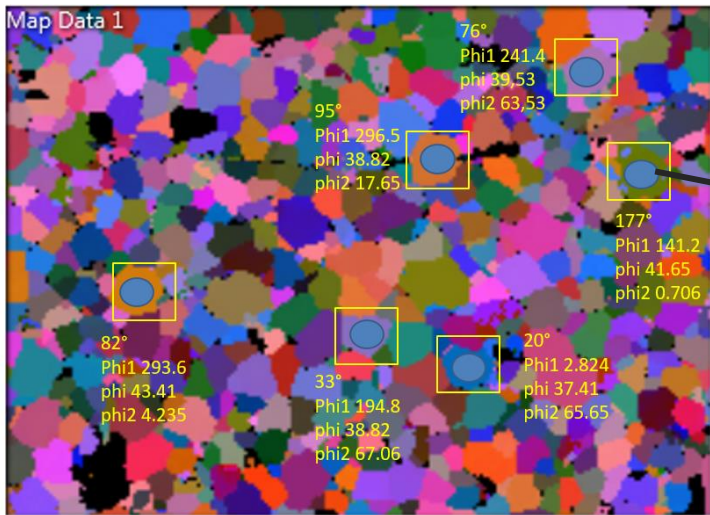
Fabrication de pointes SAT

Fabrication de μ poutres



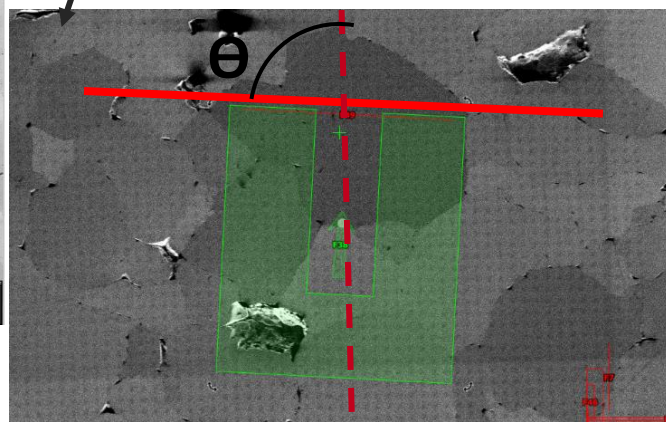
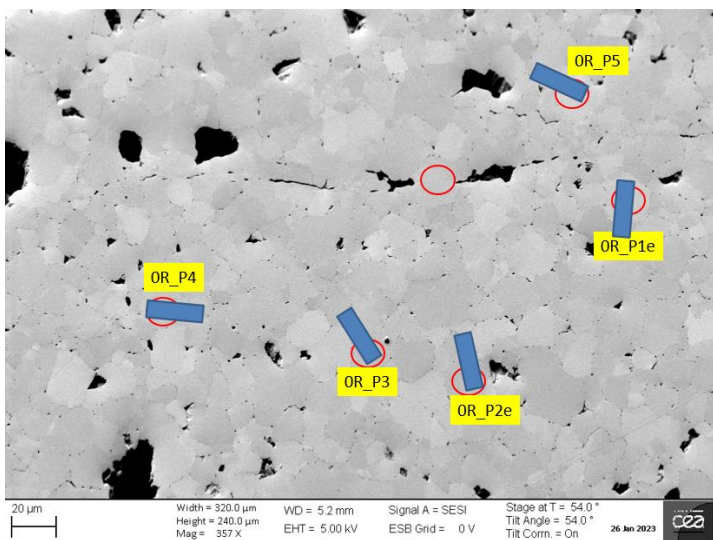
Thèse Ronan HENRY 25/05/2019:

Caractérisation locale des propriétés à la rupture du combustible nucléaire irradié

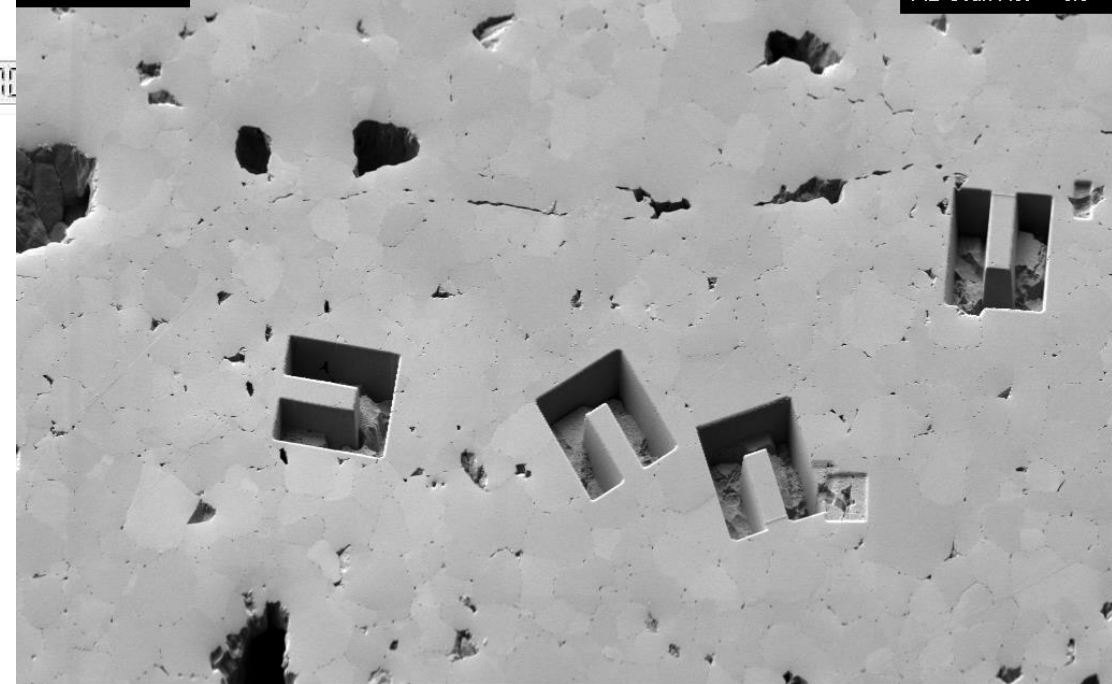


Euler Angle

Phi 1 141.2 PHI 41.65 Phi 2 0.706

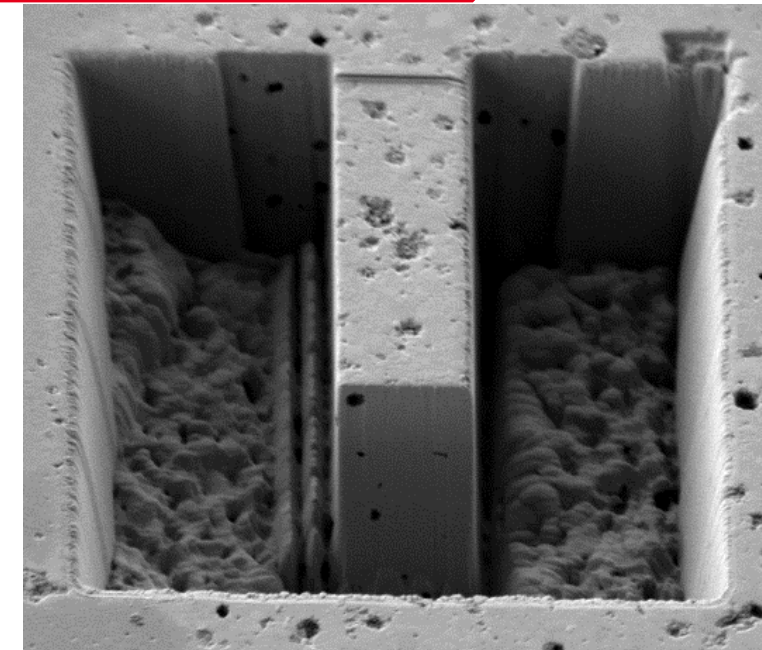
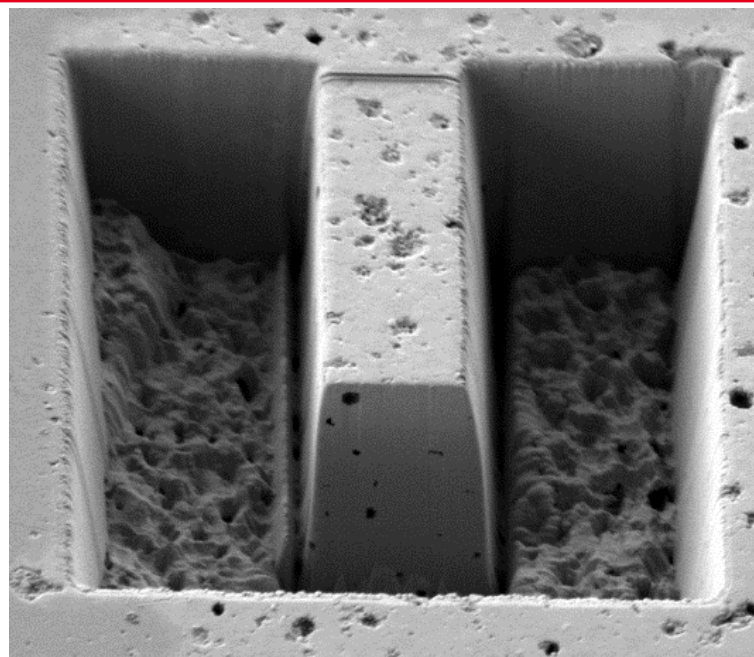
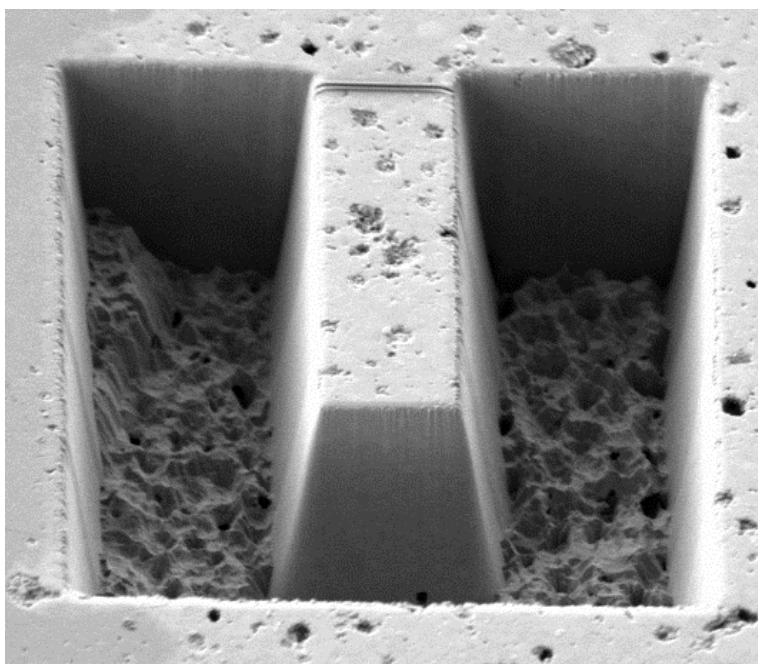


FIB Suppressor = -743 V FIB Milling Probe = 30kV 8nA FIB Image Probe = 30kV 8nA Stage at T = 54.0°
FIB Focus = 0.0 FIB Scan Rot = 0.0°



Tilt 54°

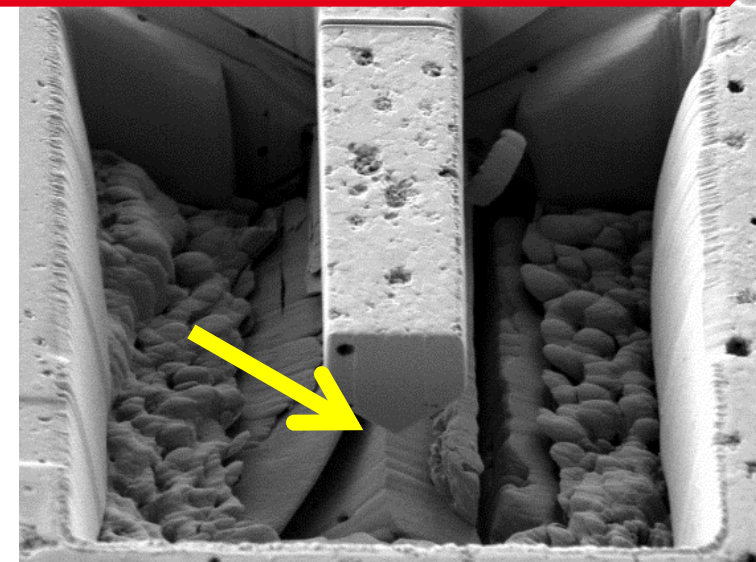
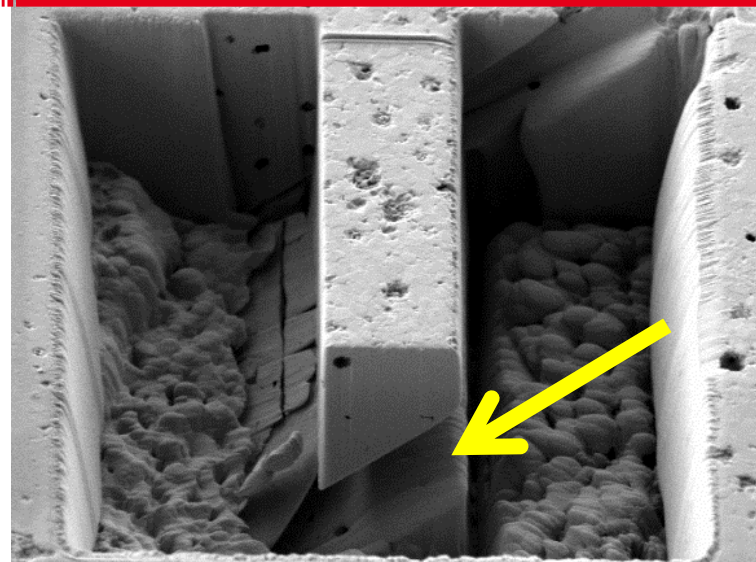
Rectification des faces



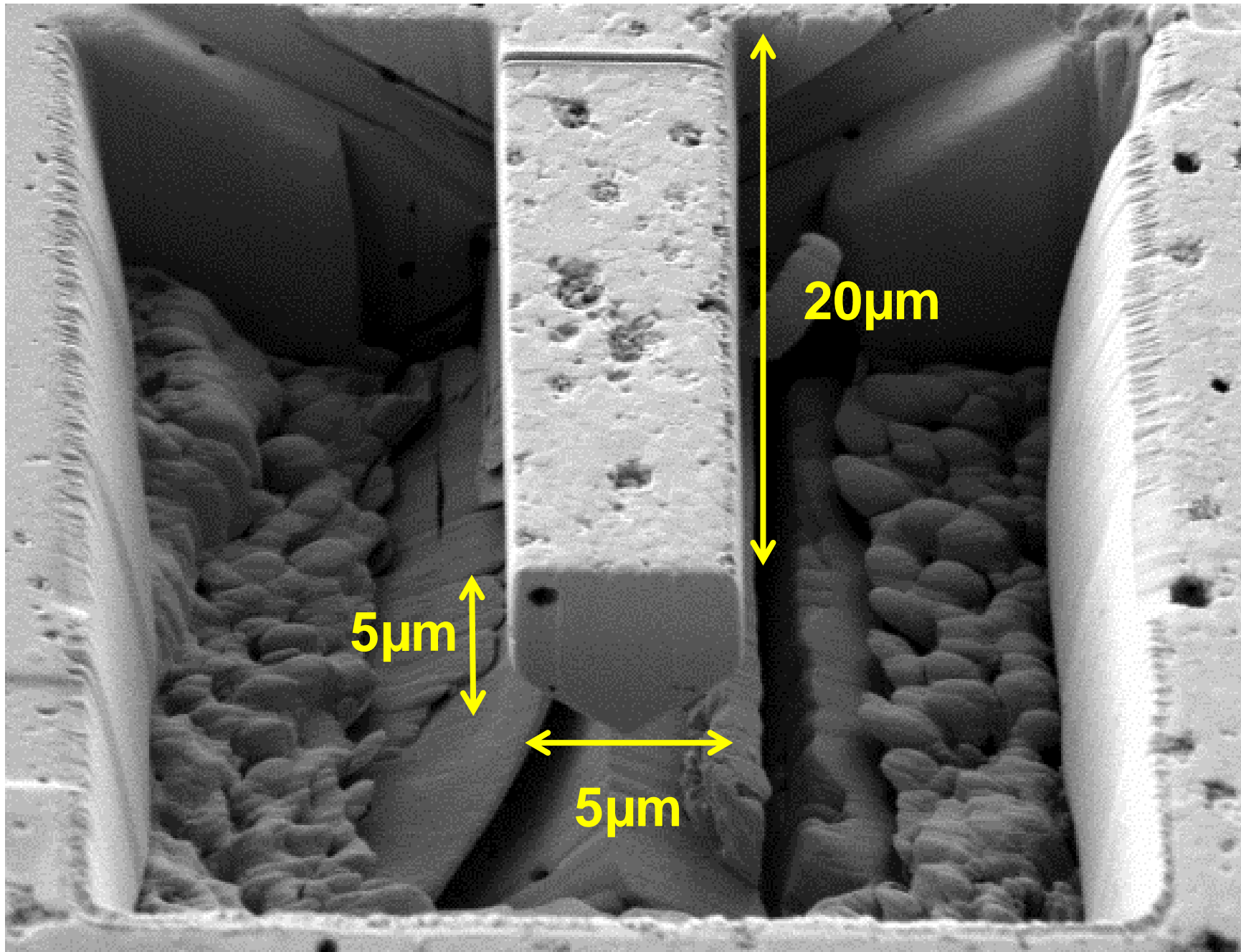
Tilt 0°

Découpe => libération de la poutre

Les étapes de fabrication



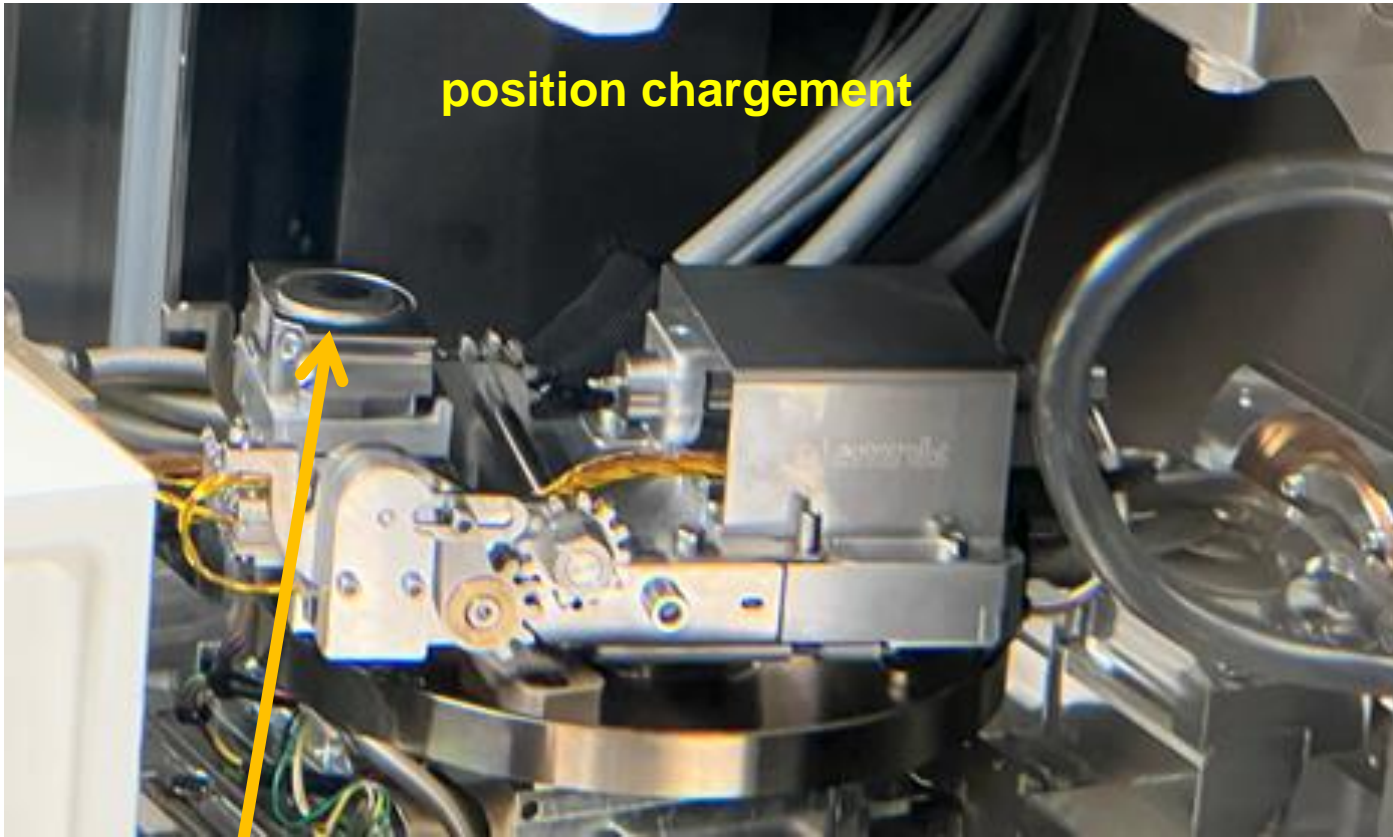
Poutre terminée





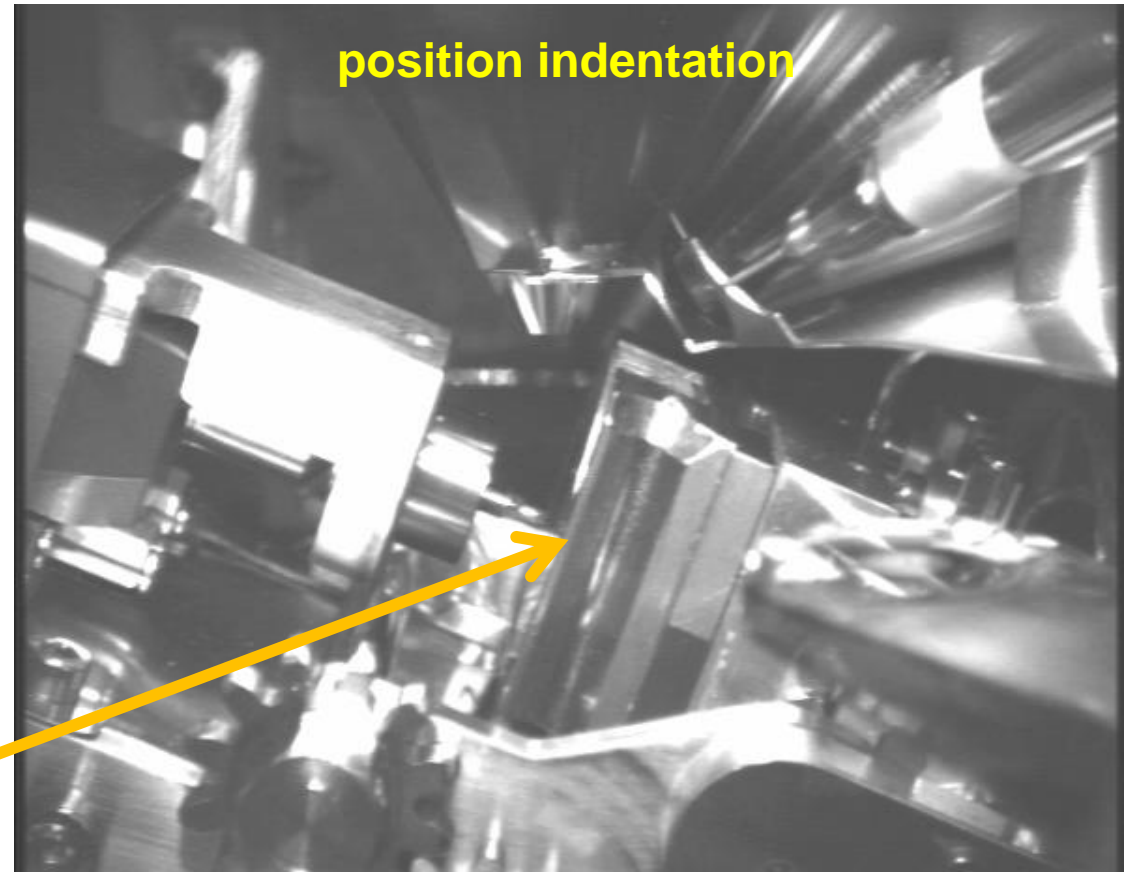
V2 : Nano Indenteur ALEMNIS

position chargement

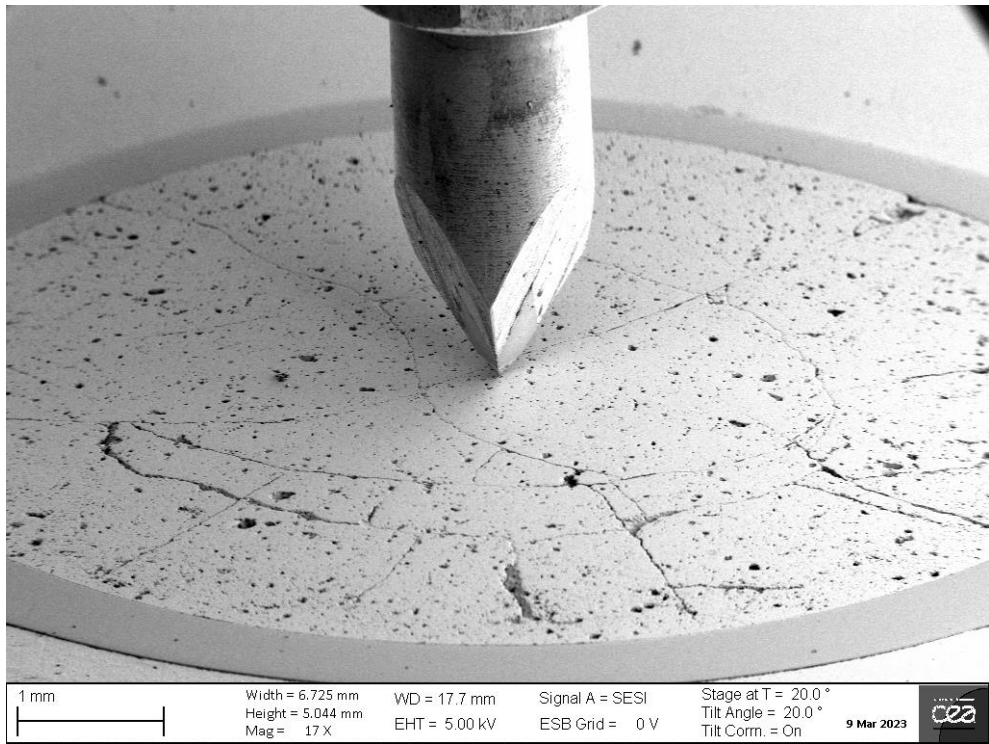


Echantillon dans son
porte échantillon télémanipulable

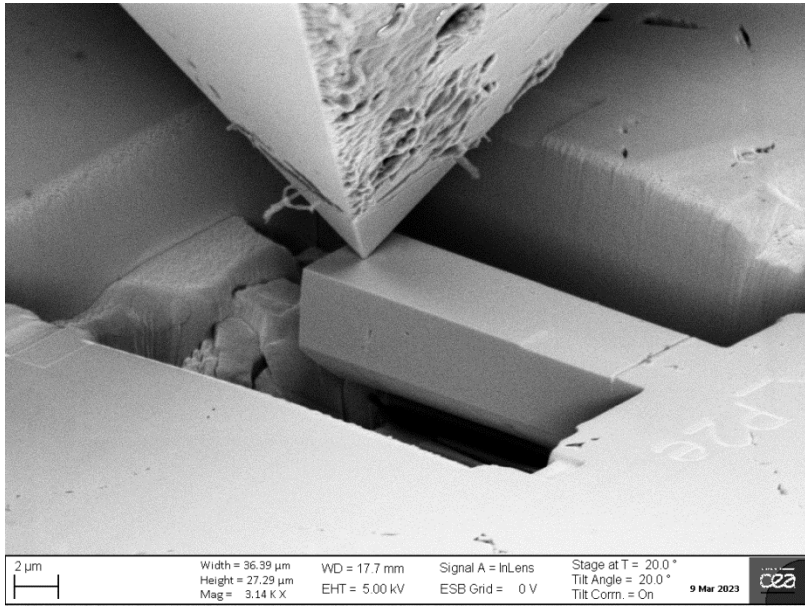
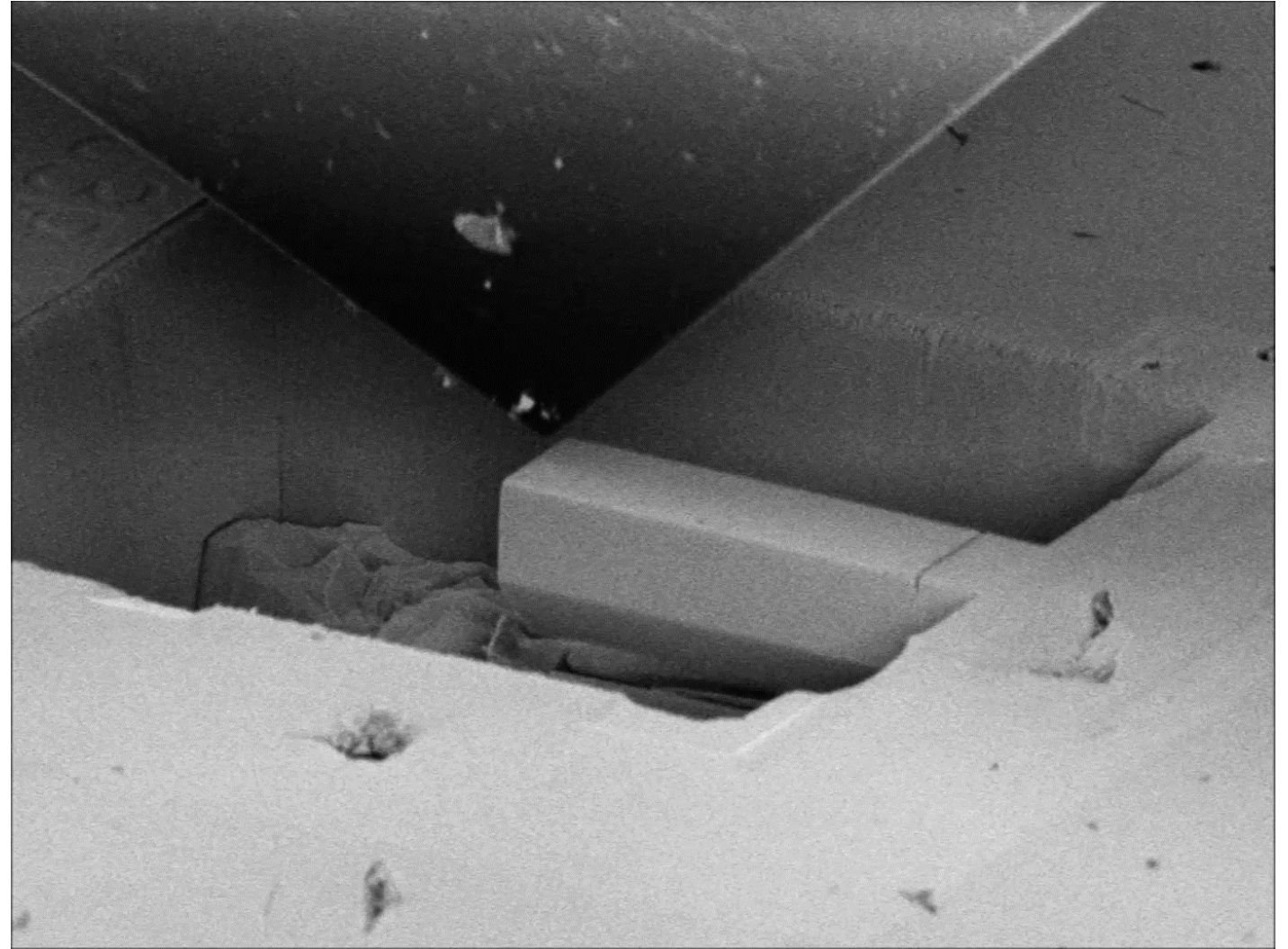
position indentation



Echantillon
basculé de 90°



1 mm Width = 6.725 mm WD = 17.7 mm Signal A = SE(S) Stage at T = 20.0 °
Height = 5.044 mm EHT = 5.00 kV ESB Grid = 0 V Tilt Angle = 20.0 °
Mag = 17 X Tilt Corr. = On 9 Mar 2023 cea

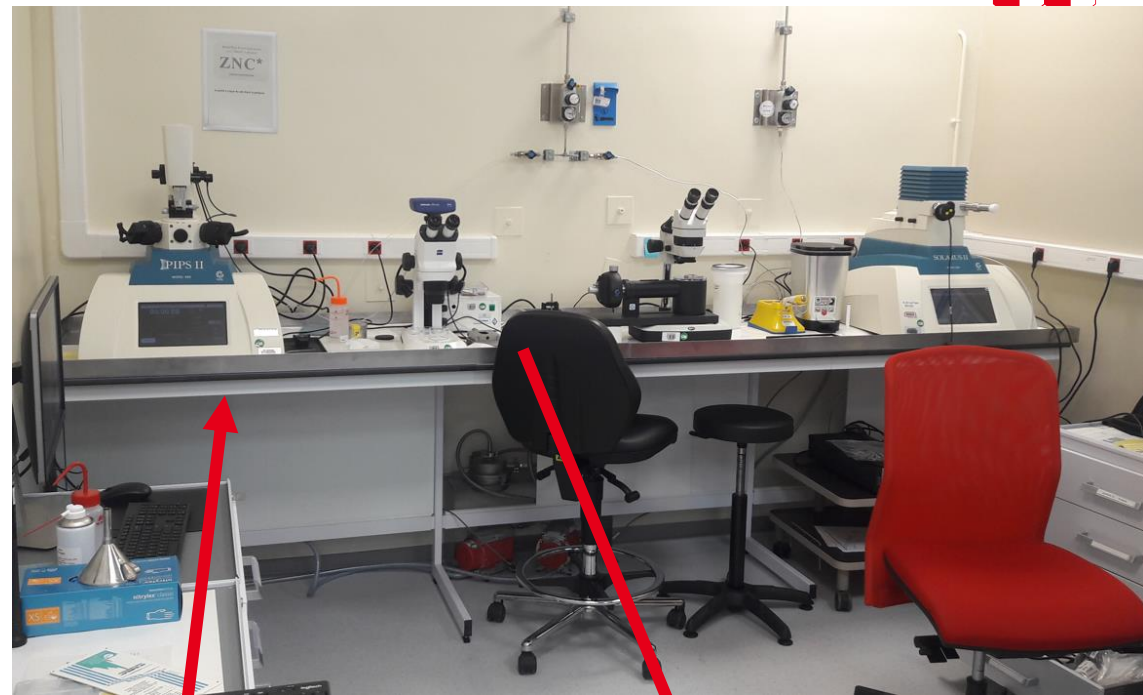
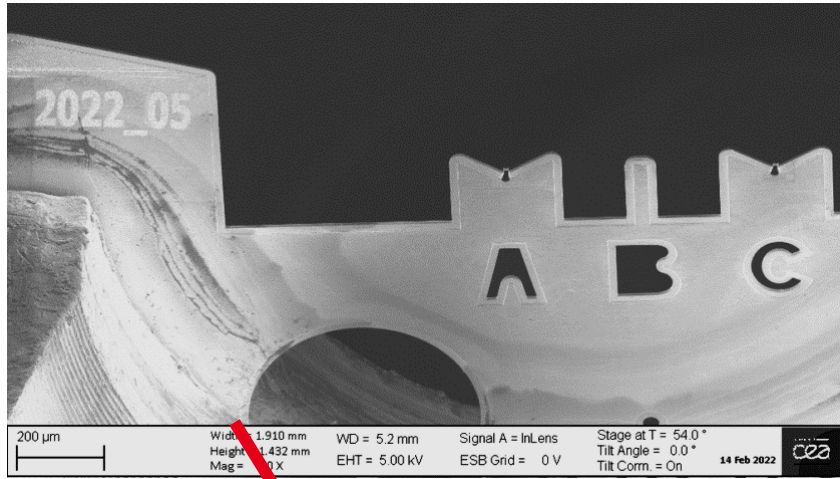


2 μm Width = 36.99 μm WD = 17.7 mm Signal A = InLens Stage at T = 20.0 °
Height = 27.29 μm EHT = 5.00 kV ESB Grid = 0 V Tilt Angle = 20.0 °
Mag = 3.14 K X Tilt Corr. = On 9 Mar 2023 cea

Fabrication d'une lame TEM





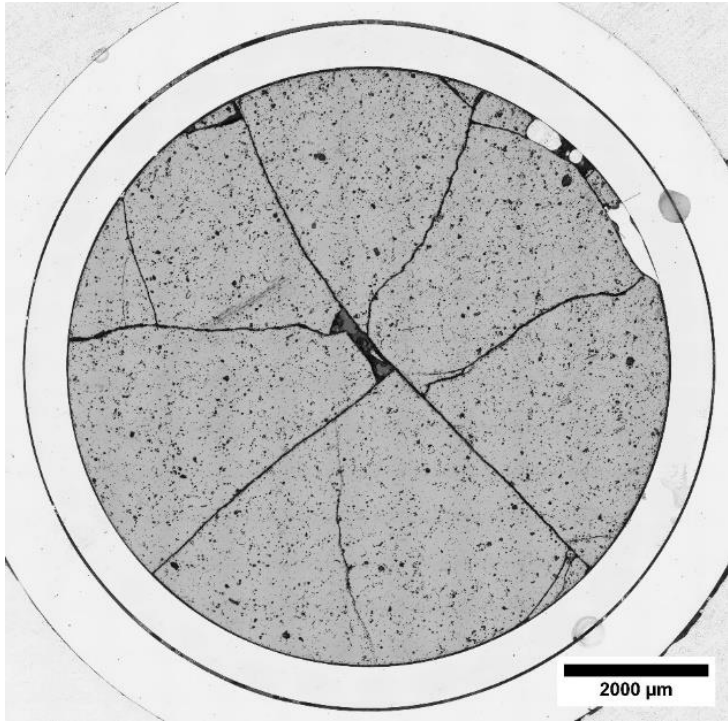


Fabrication d'une lame synchrotron



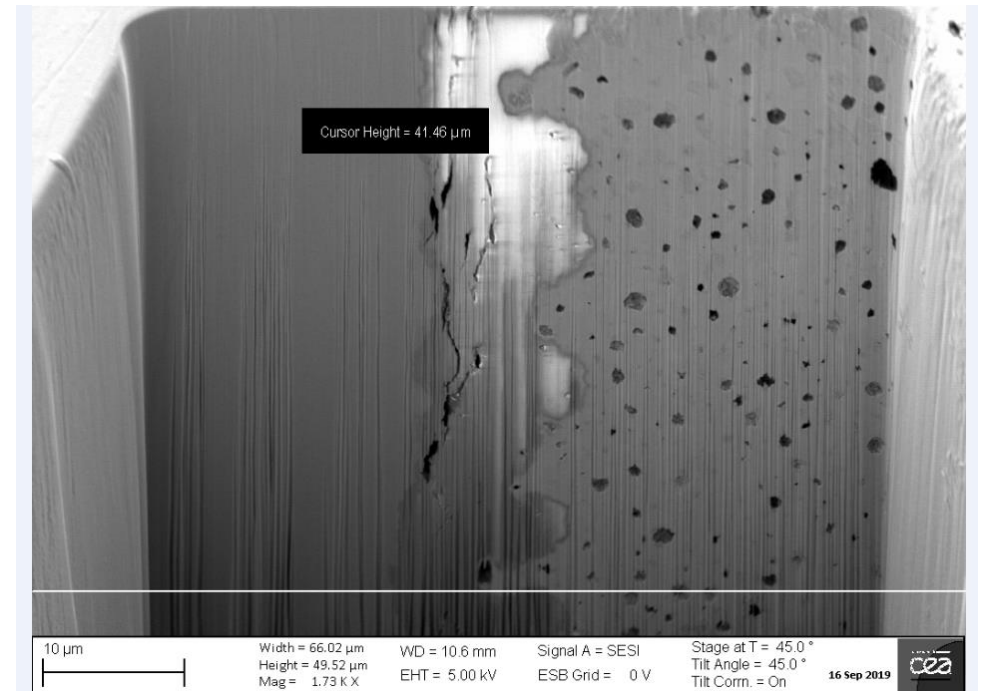
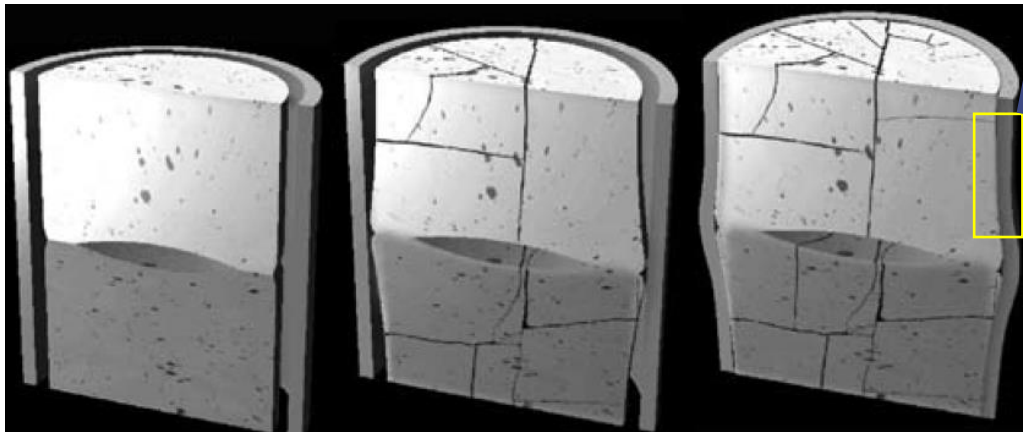
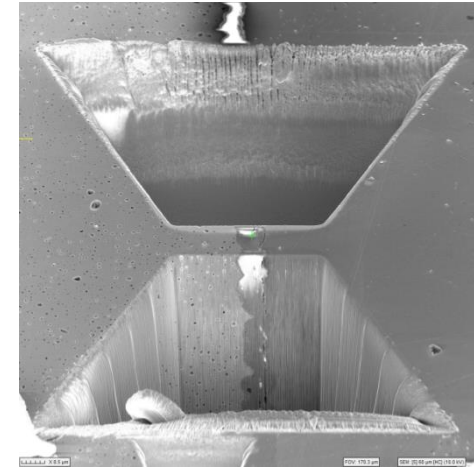
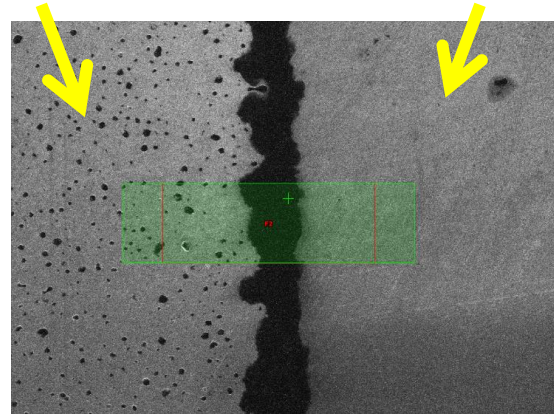
Thèse Cloé SCHNEIDER 4/02/2022:

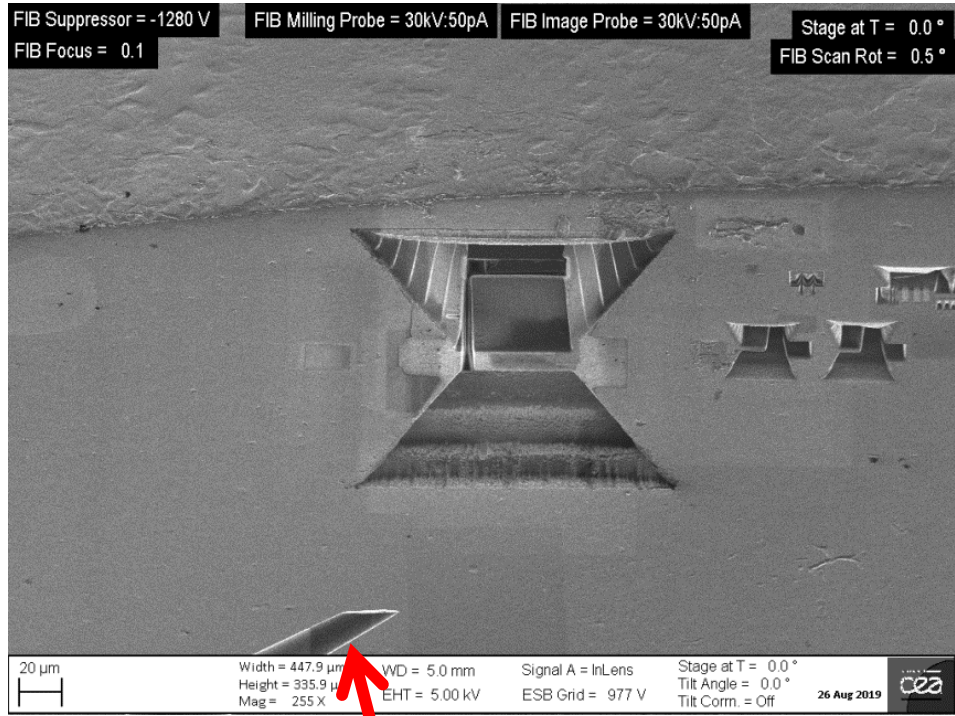
Evolution physico-chimique et mécanique de l'interface pastille-gaine des crayons combustibles des réacteurs à eau pressurisée



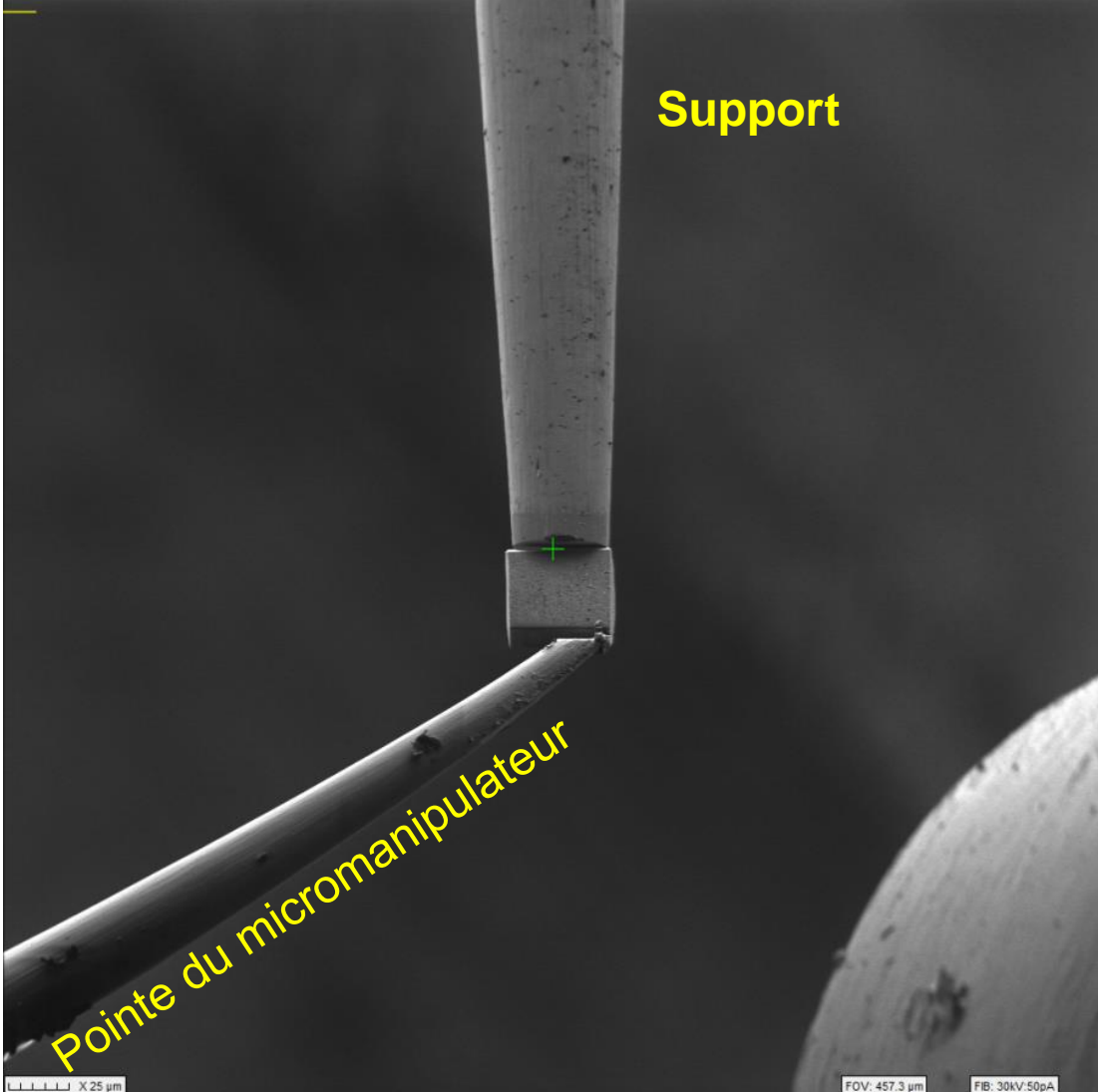
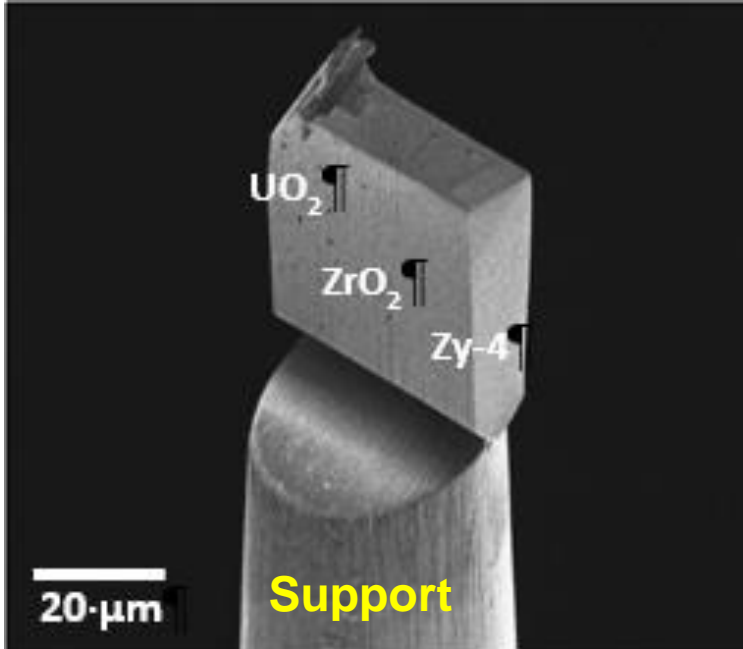
Combustible

Gaine

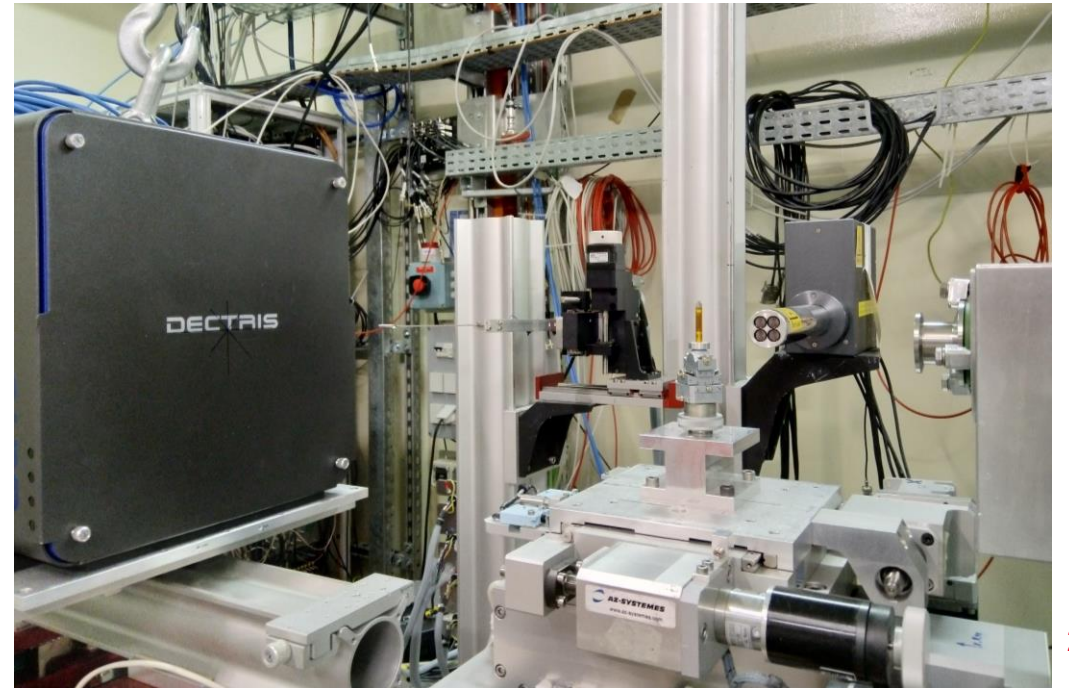
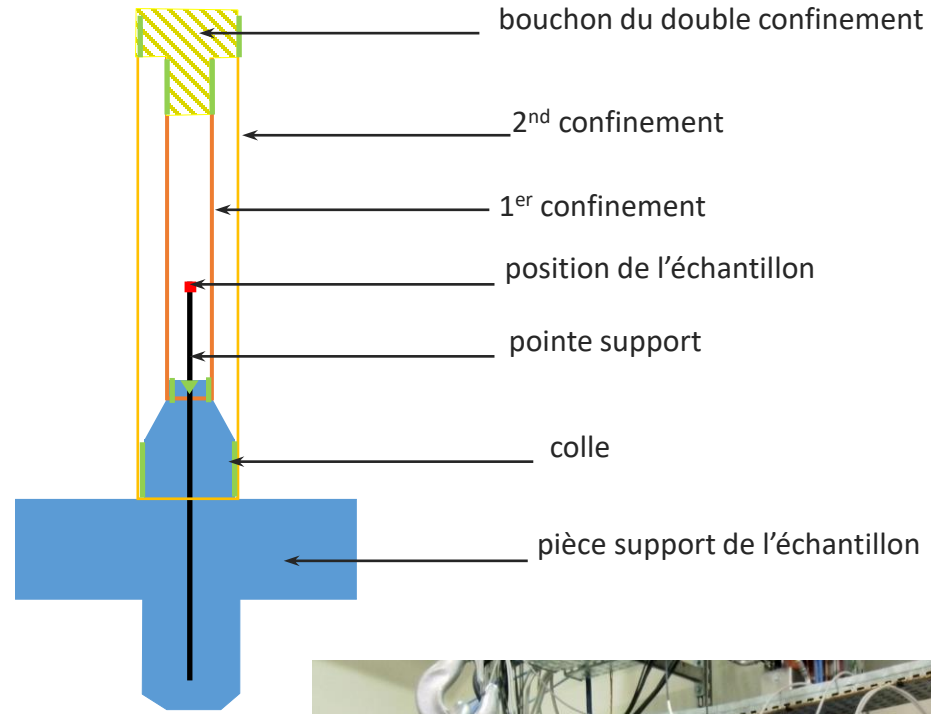




Pointe du micromanipulateur

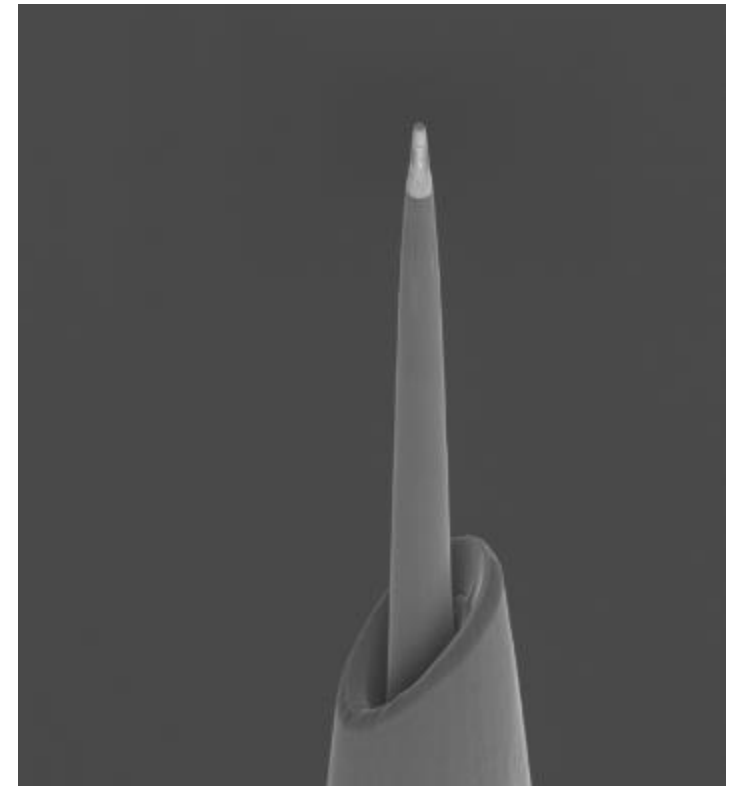


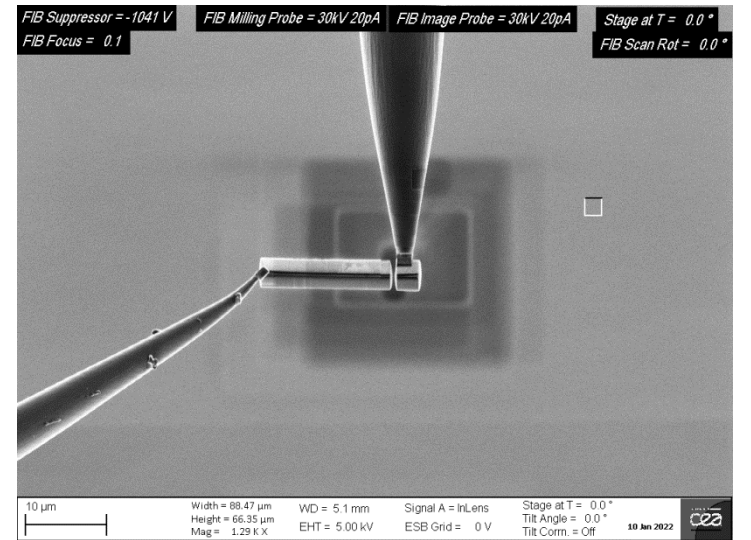
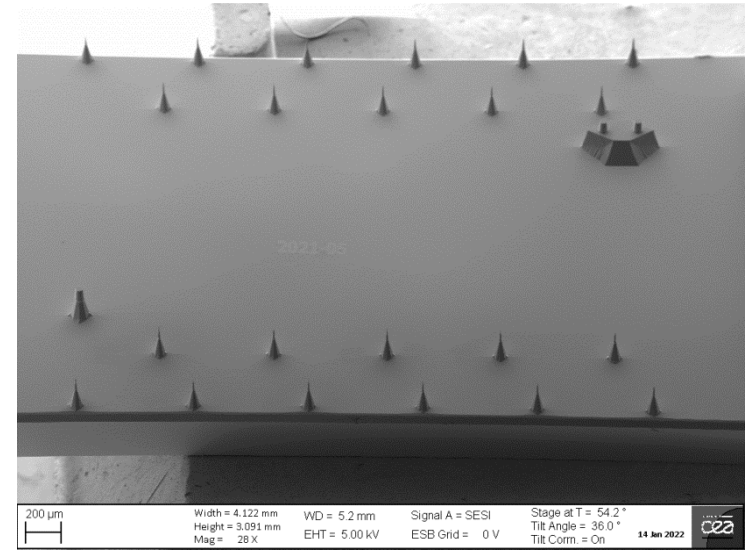
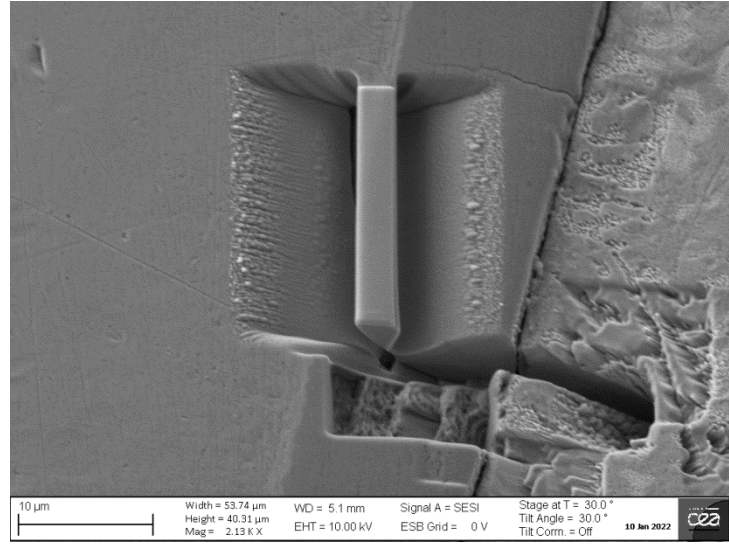
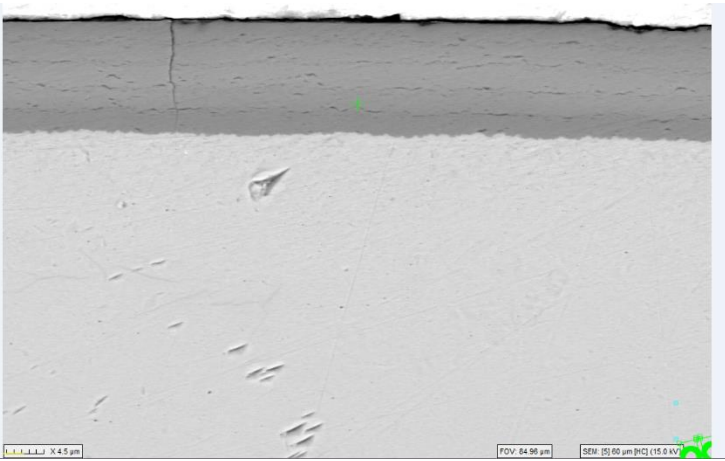
Transfert micromanipulateur => Support





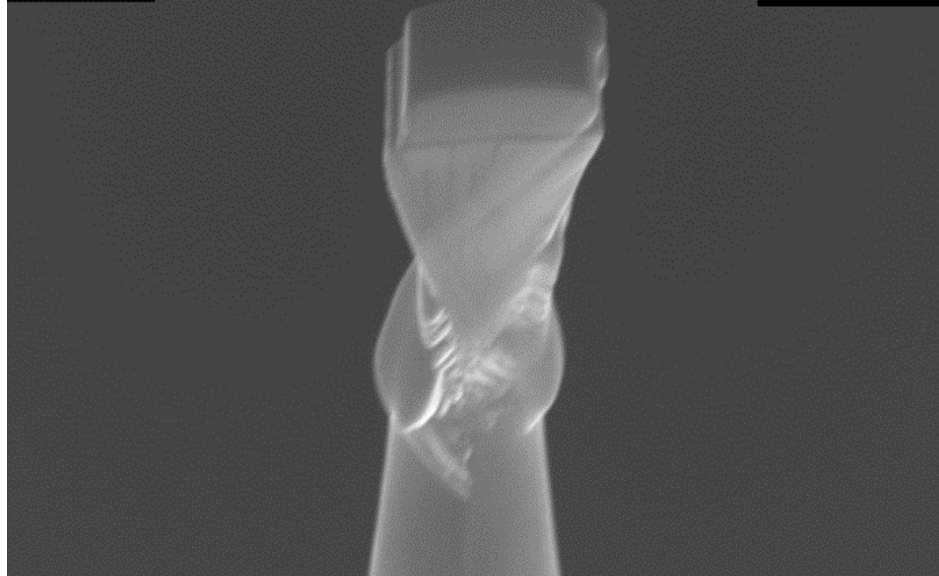
Fabrication de pointes SAT



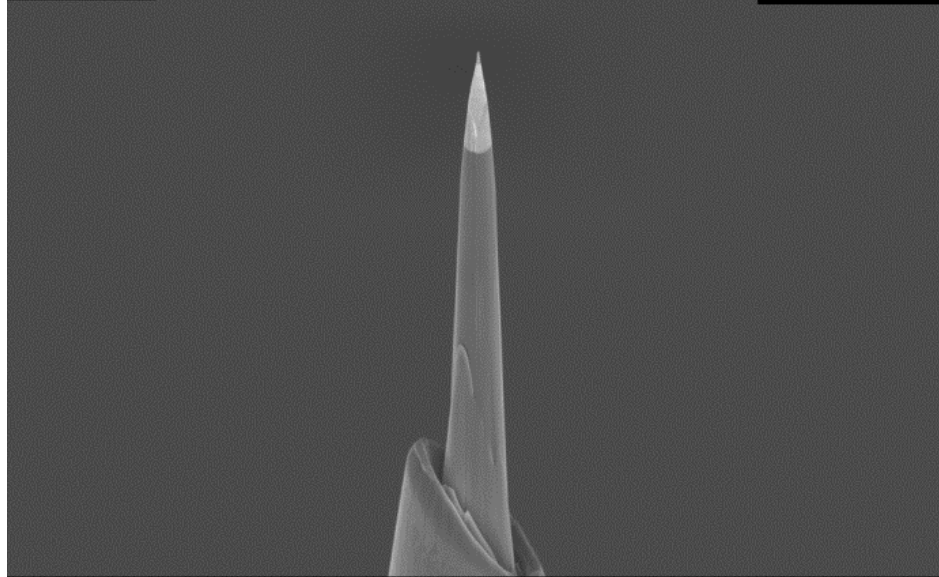




FIB Suppressor = -1361 V FIB Milling Probe = 30kV:50pA FIB Image Probe = 30kV:50pA Stage at T = 54.0 °
 FIB Focus = 0.0 FIB Scan Rot = 0.0 °



FIB Suppressor = -1408 V FIB Milling Probe = 30kV:50pA FIB Image Probe = 30kV:50pA Stage at T = 54.0 °
 FIB Focus = -0.0 FIB Scan Rot = 0.0 °

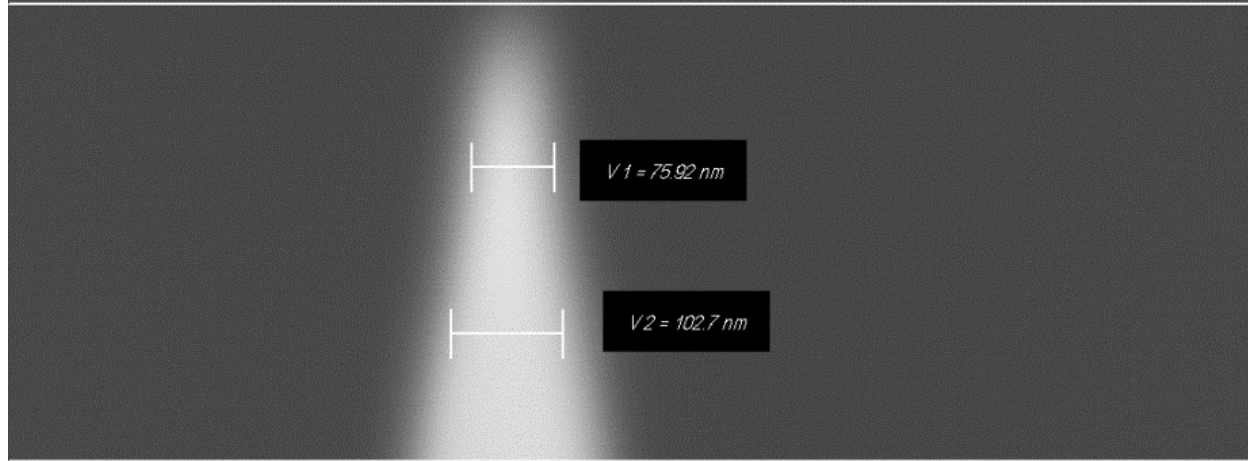


2 μm Width = 44.54 μm WD = 5.1 mm Signal A = InLens Stage at T = 54.0 °
 Height = 33.41 μm EHT = 5.00 kV ESB Grid = 0 V Tilt Angle = 36.0 °
 Mag = 2.57 K X Tilt Corr. = On 13 Jan 2022 cea

FIB Suppressor = -1036 V FIB Milling Probe = 10kV 50pA FIB Image Probe = 10kV 50pA Stage at T = 54.0 °
 FIB Focus = 0.0 FIB Scan Rot = 0.0 °



Cursor Height = 419.8 nm



V1 = 75.92 nm

V2 = 102.7 nm

100 nm Width = 1.143 μm WD = 5.1 mm Signal A = InLens Stage at T = 54.0 °
 Height = 857.5 nm EHT = 5.00 kV ESB Grid = 0 V Tilt Angle = 36.0 °
 Mag = 100.00 K X Tilt Corr. = On 13 Jan 2022 cea



**Merci
pour
votre
attention**

