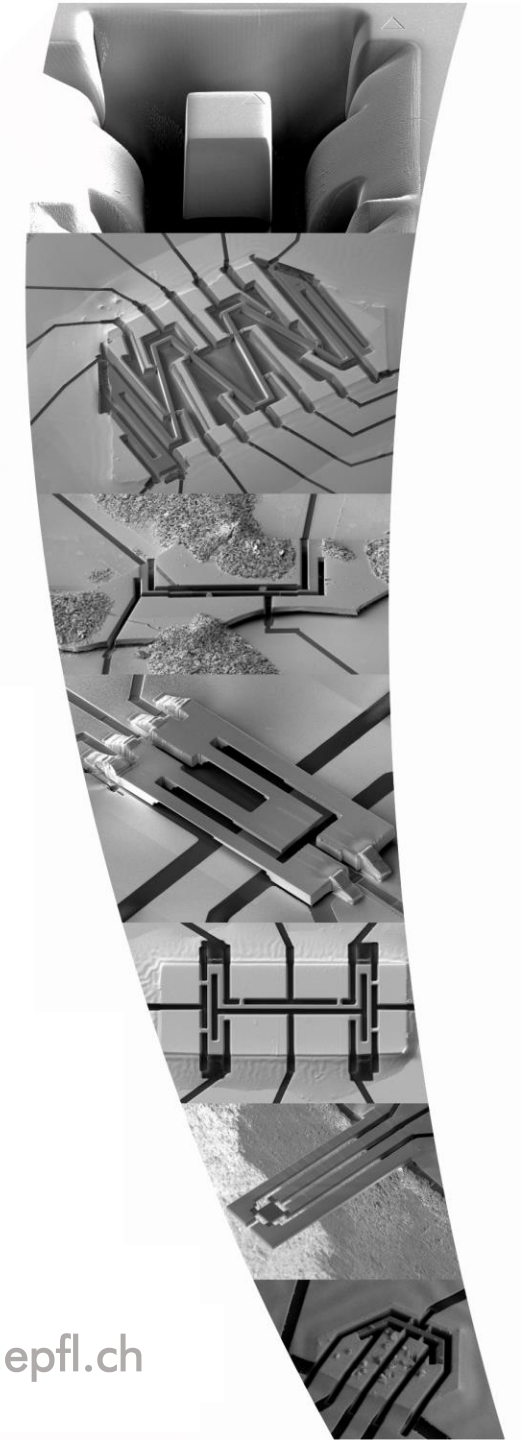


CIME - Plasma FIB

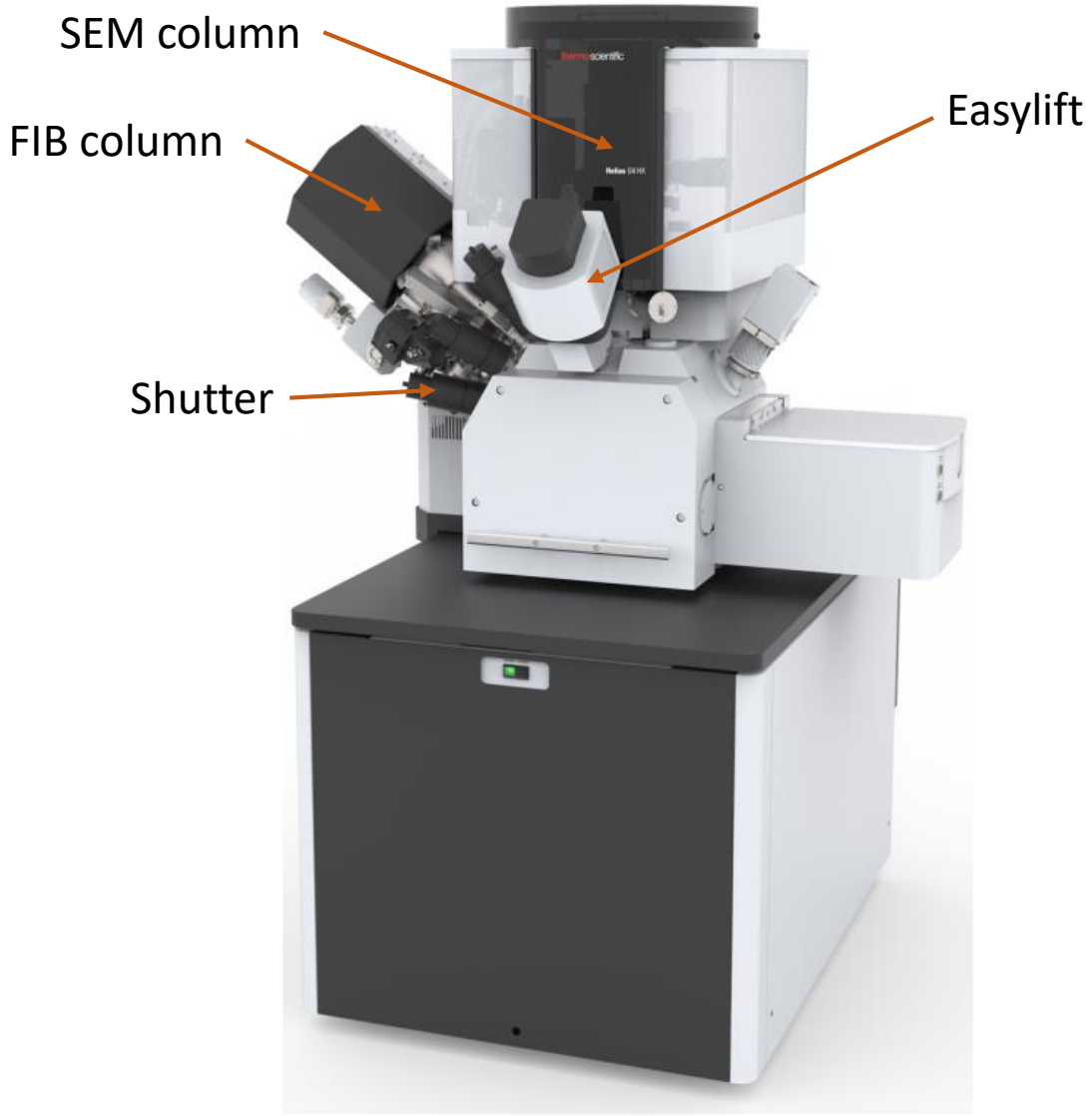
MSE-704

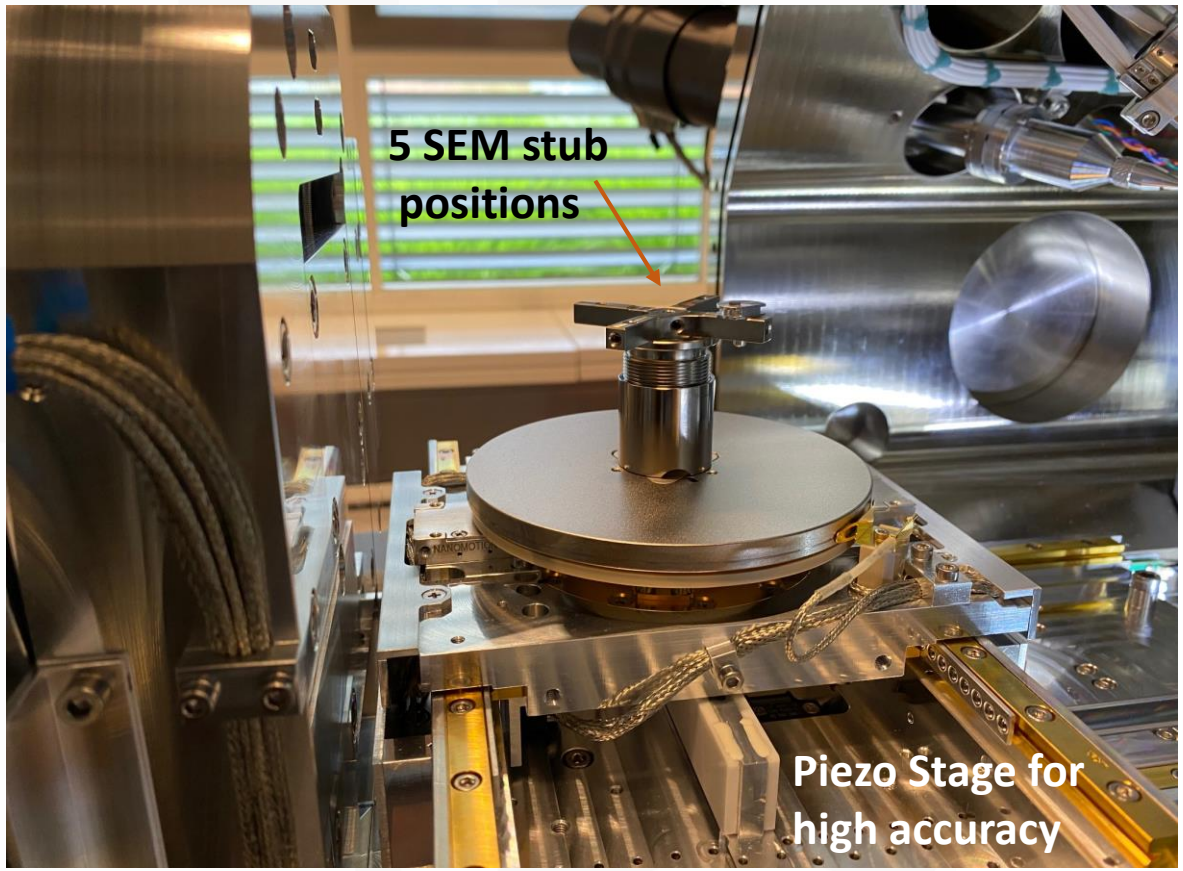
Carsten Putzke

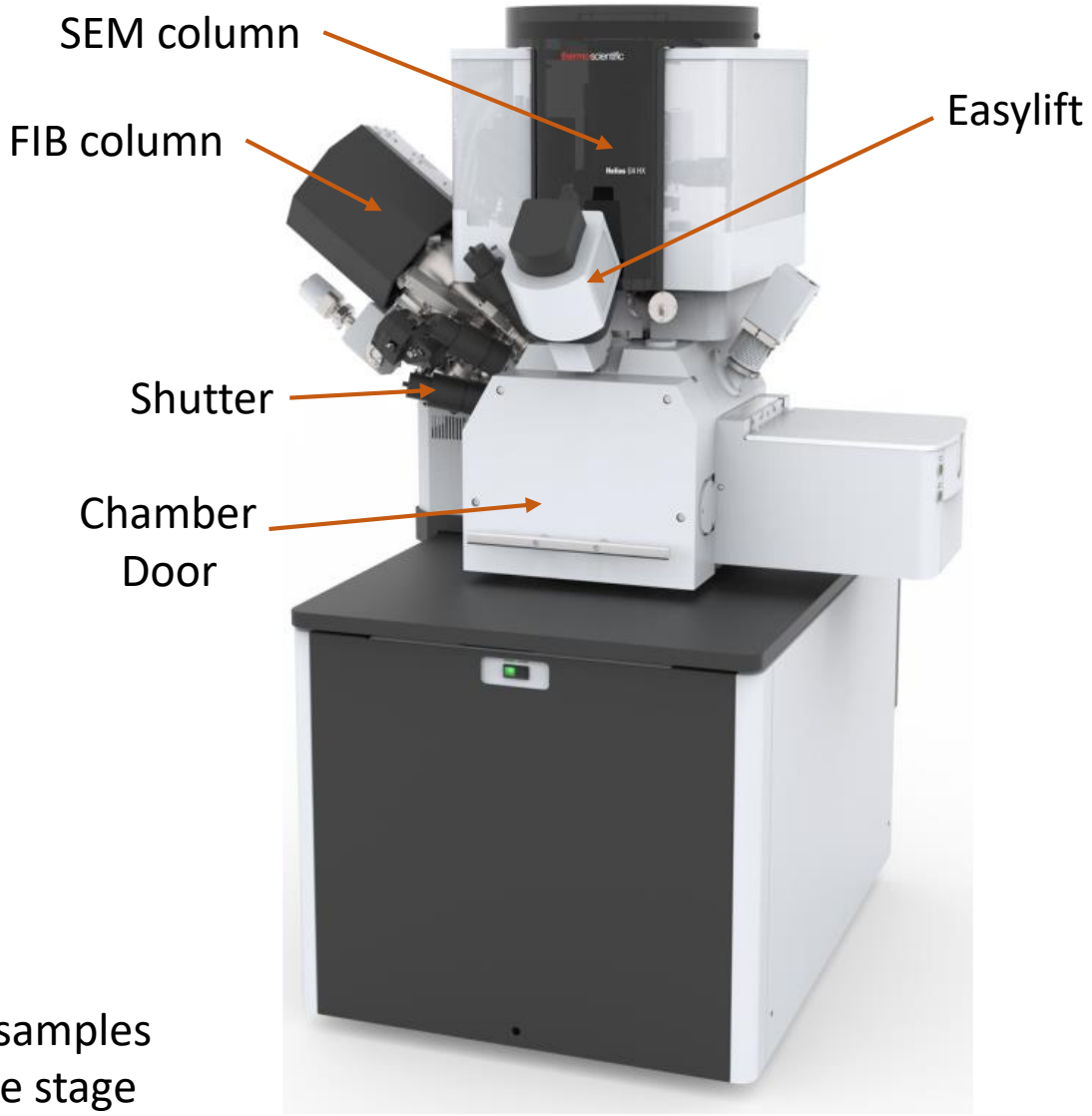
Quantum Materials Laboratory

Helios G4 Plasma FIB

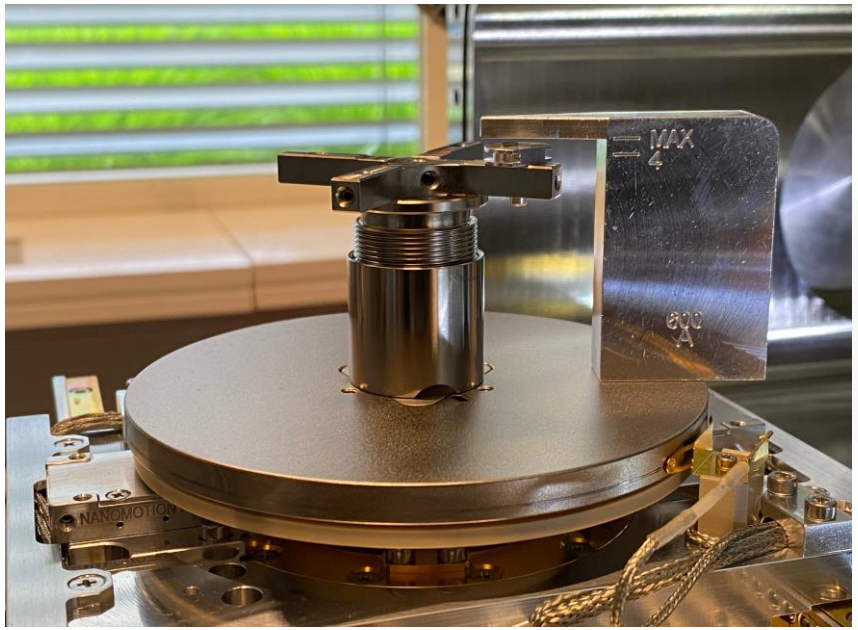
- Dual Beam System
  - SEM
  - Xe-ion beam
- Build In detectors
  - ICE (secondary electrons and ions)
  - ETD (Everhart Thornley detector)
  - TLD (through lense detector)
  - optical camera
- MultiGIS (multi gas injection system)
    - Pt,C,W
- Easylift
- EDX

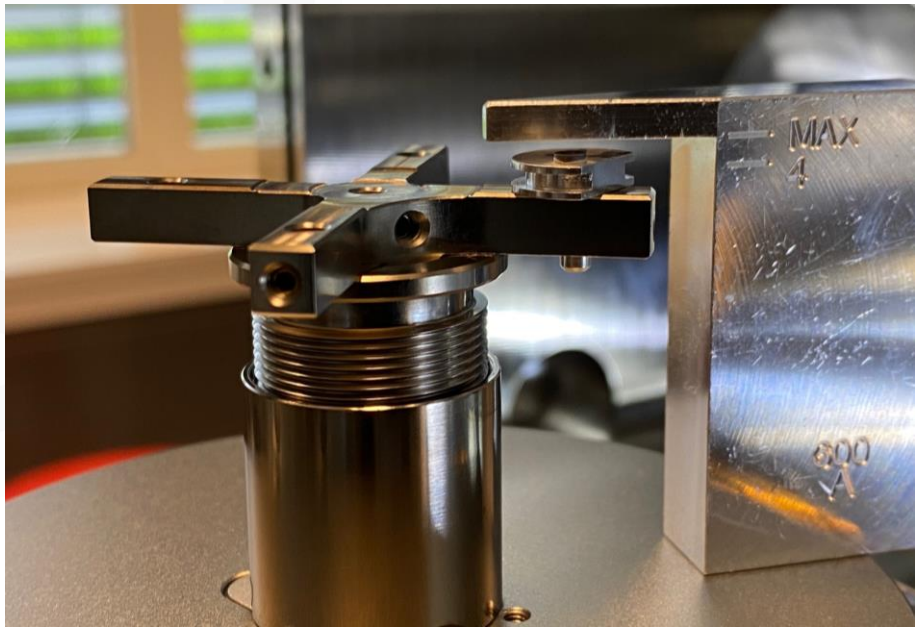

SEM column
FIB column
Shutter
Easylift





The piezo stage is limited to 9mm z-motion. When mounting tall samples the stub holder cross can be adjusted. Due to the sensitivity of the stage one needs to be extra careful.





To prevent the sample from damaging the column while closing the door a reference is provided.

It is important to place the sample between the 4mm mark and the MAX position.

We will discuss the 4mm when looking at the software.

SEM column

FIB column

Easylift

Shutter

52° between columns

company standard

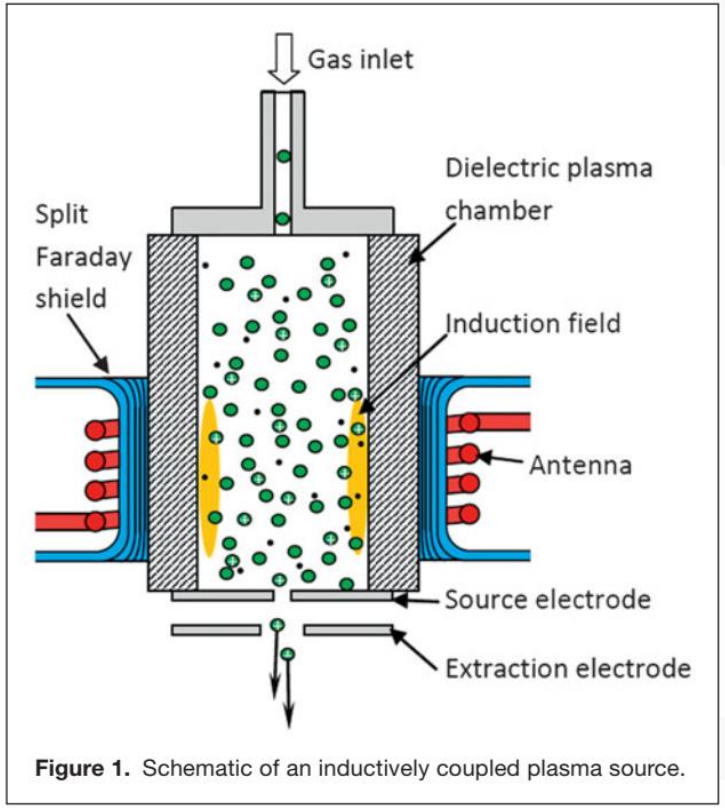


Figure 1. Schematic of an inductively coupled plasma source.

N.S. Smith et al. MSR Bulletin 39, 329

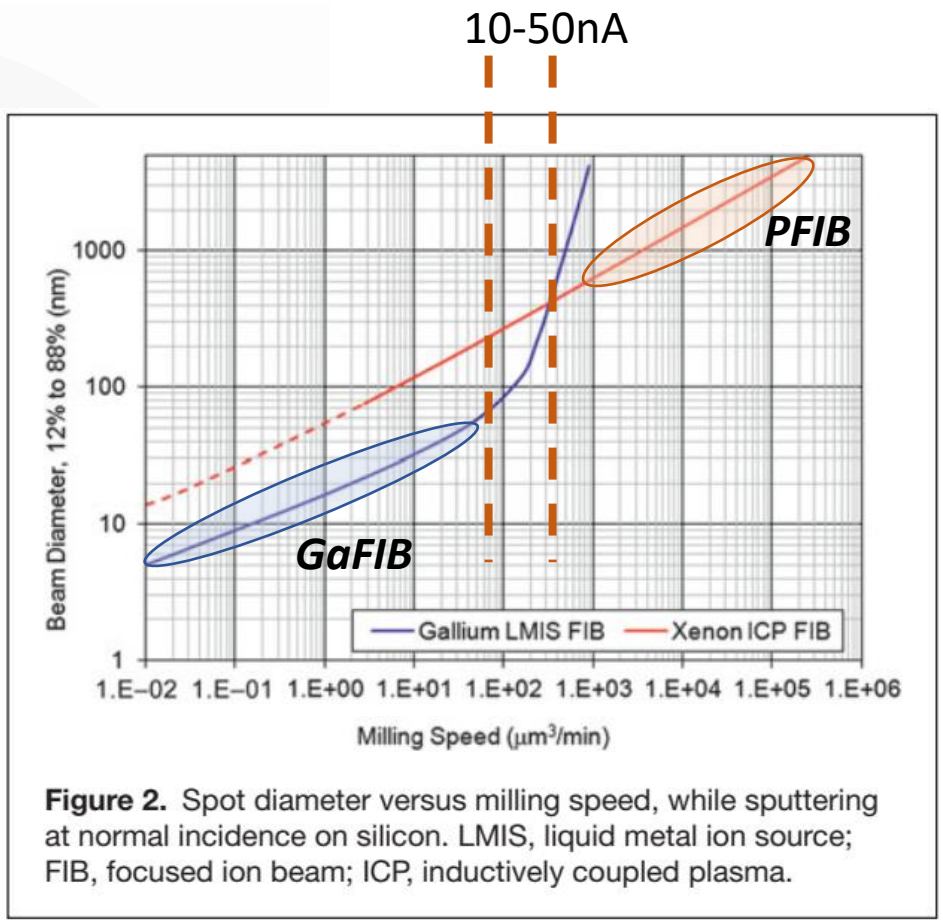


Figure 2. Spot diameter versus milling speed, while sputtering at normal incidence on silicon. LMIS, liquid metal ion source; FIB, focused ion beam; ICP, inductively coupled plasma.

Defines Beam

BAA
Beam
Acceptance
Aperture

Defines Current

BDA
Beam
Defining
Aperture

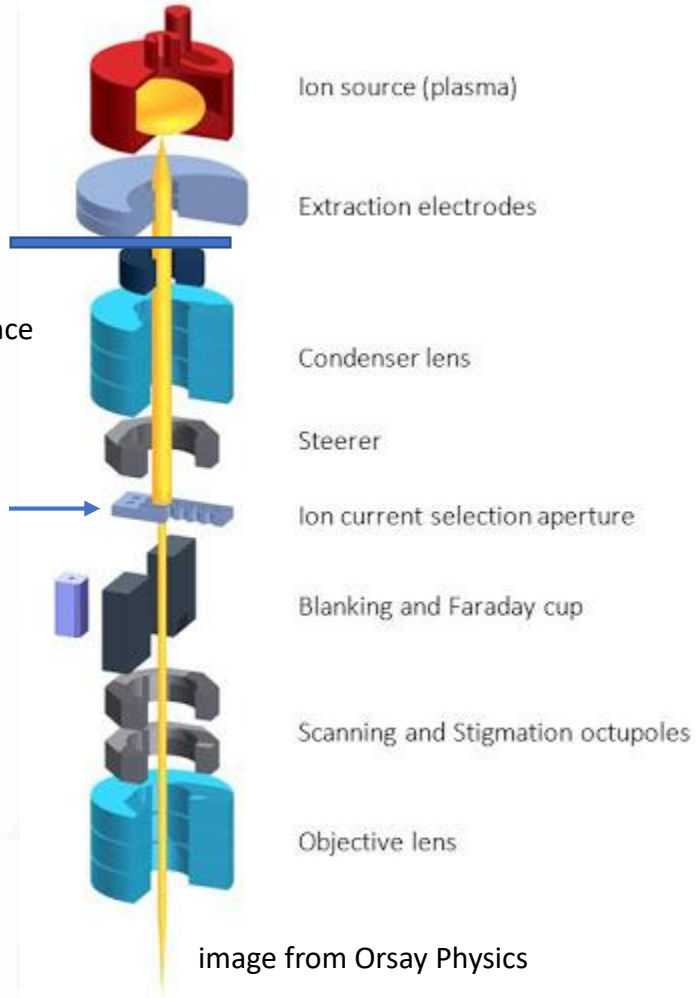
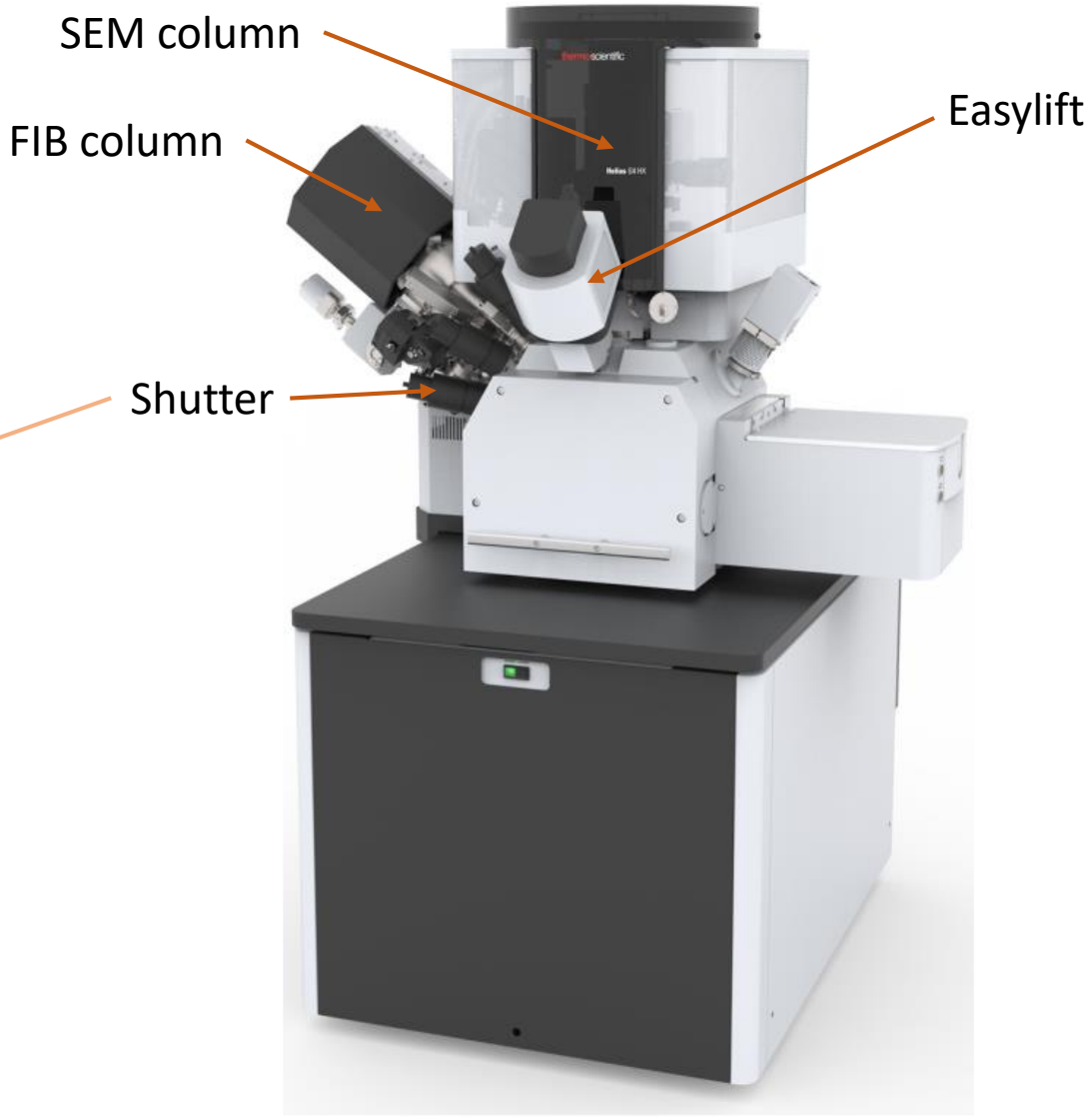
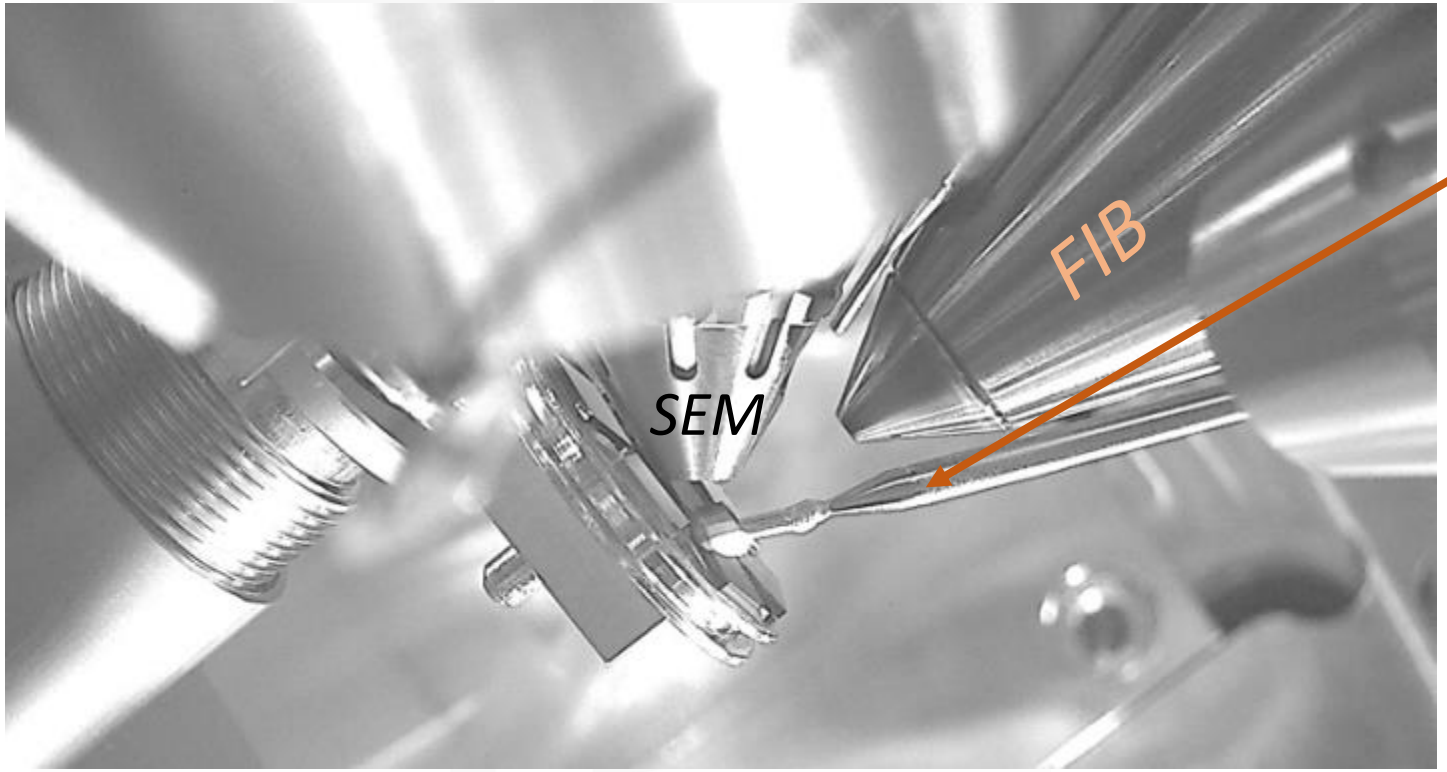
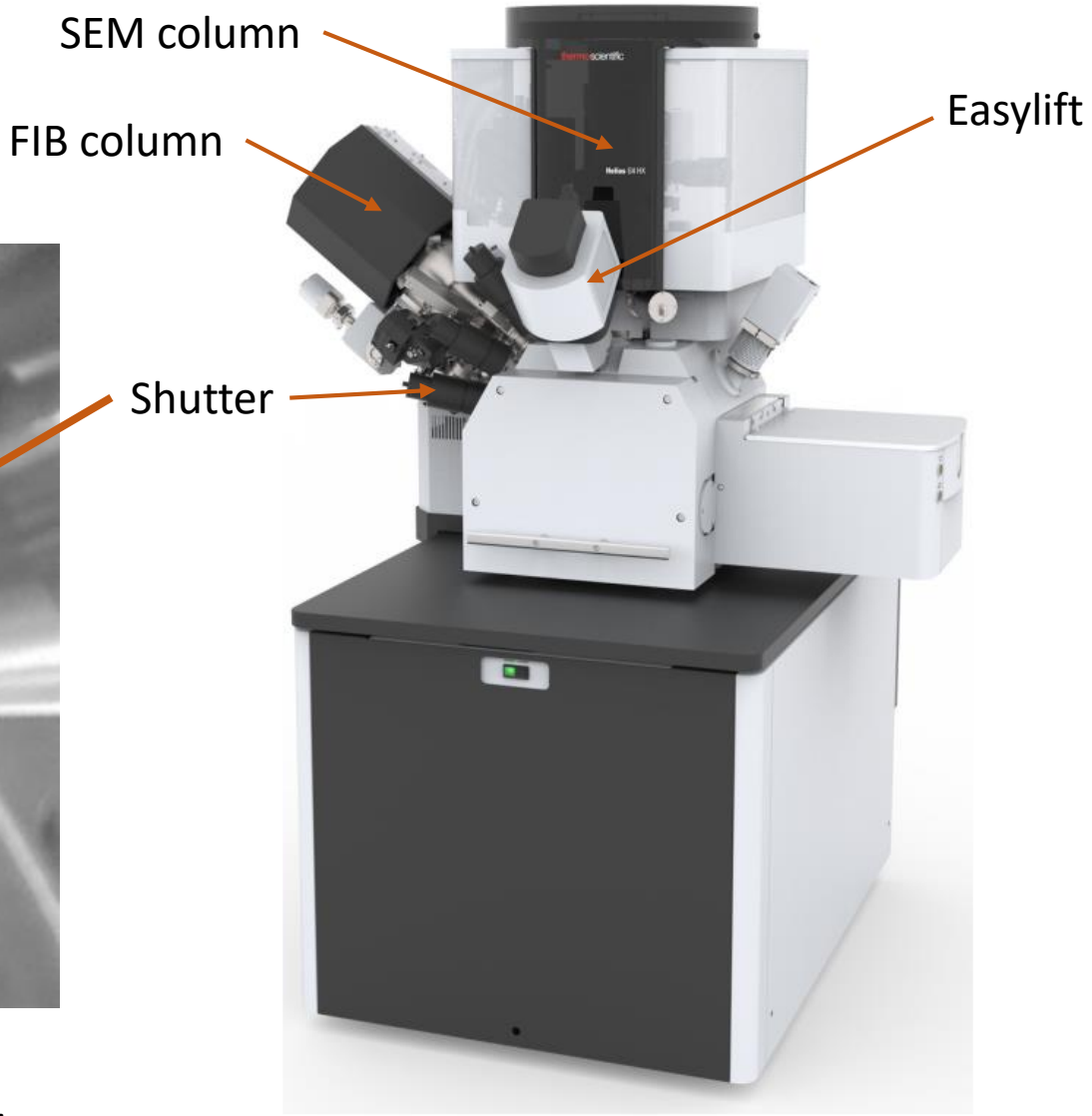


image from Orsay Physics

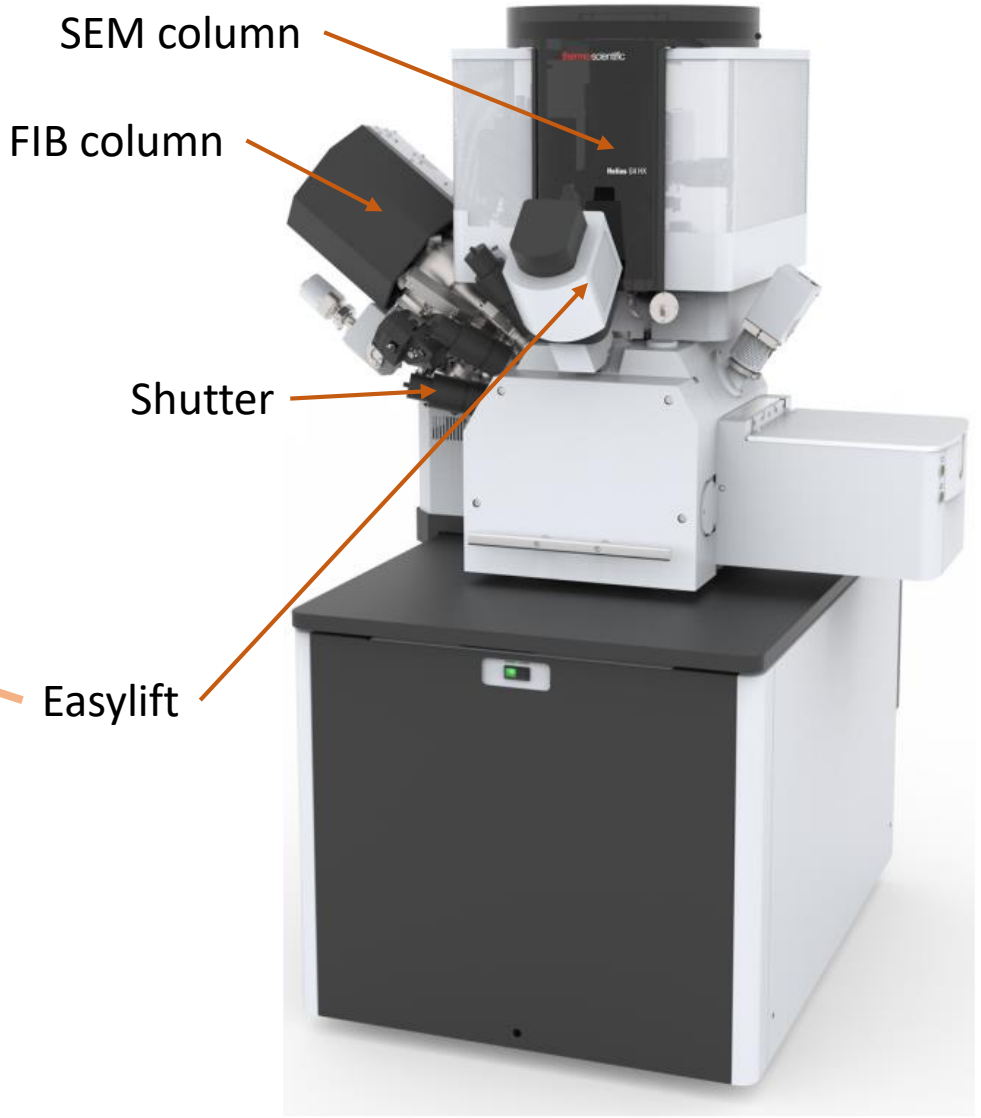
For I>4nA: only a spot burn test can tell beam condition.

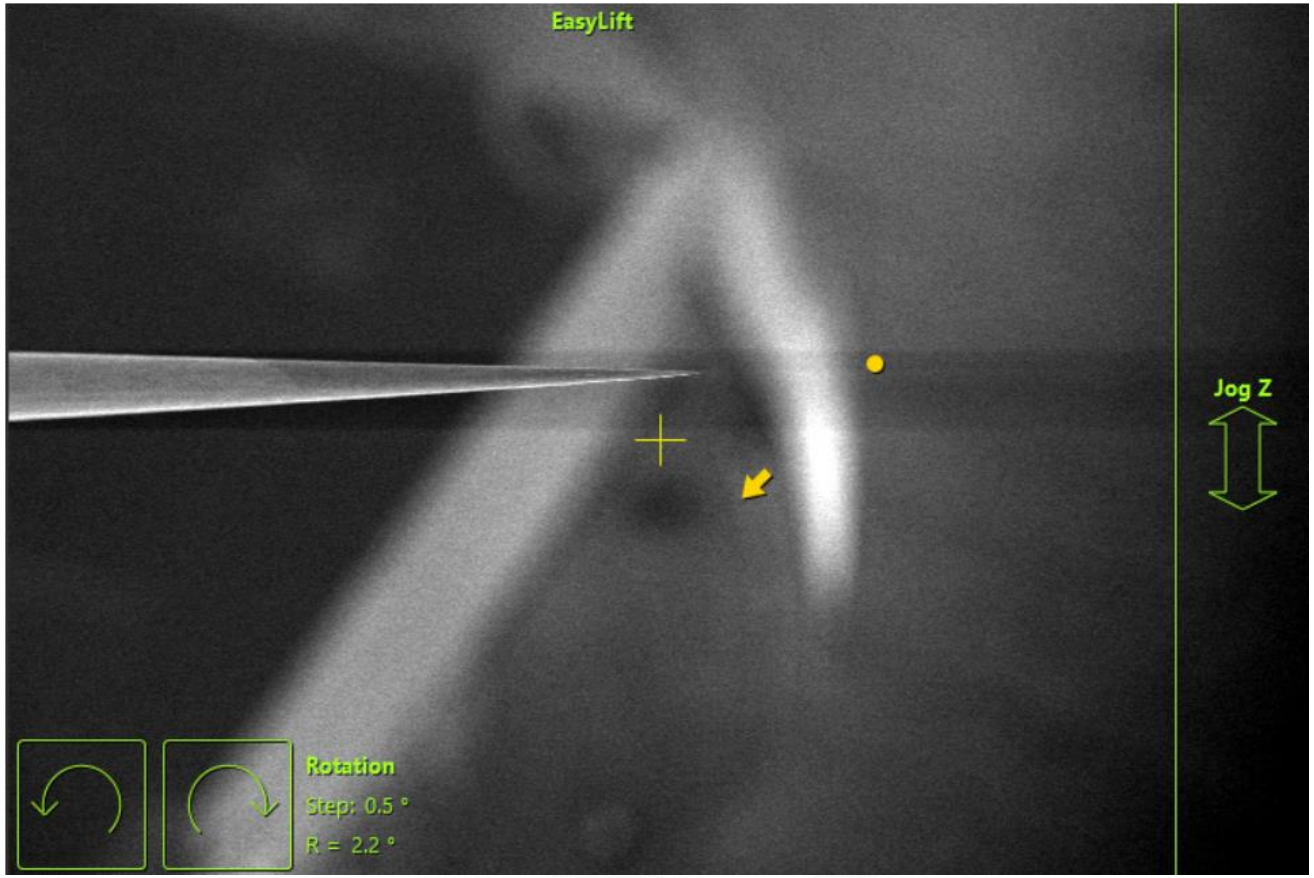

SEM column
FIB column
Easylift
Shutter

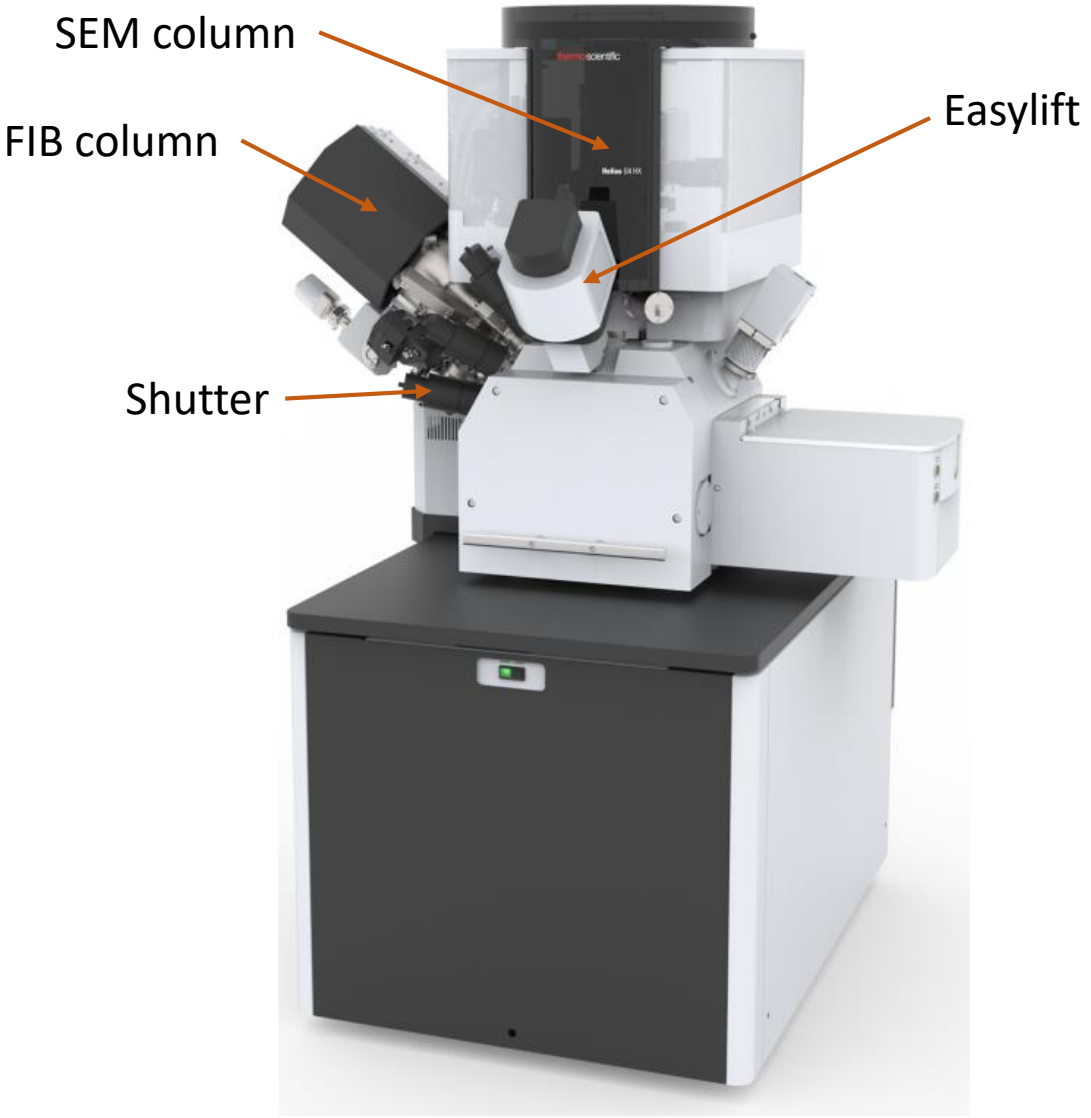




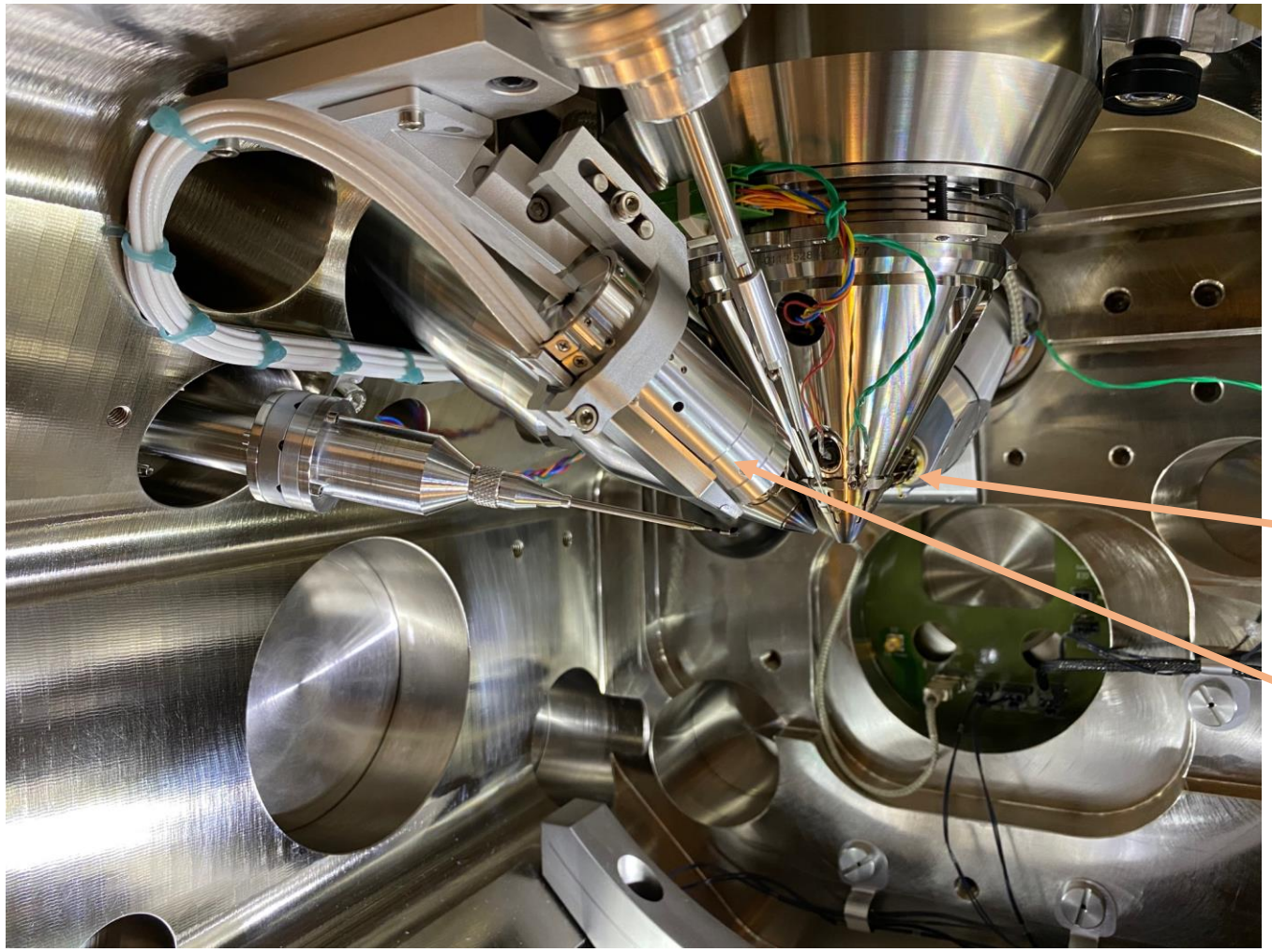
- Automatically inserted at currents >0.2uA.
- Prevents contamination of the SEM column at large volume milling.
- Inserted with reference to the coincidence point!


SEM column
FIB column
Shutter
Easylift





- 3 axis control + rotation
- X,Y-axis are relative to beam used for image
- Z-axis always parallel to SEM
- Movement controlled by dragging the mouse on the screen.
- Speed control by mouse movement.



ETD

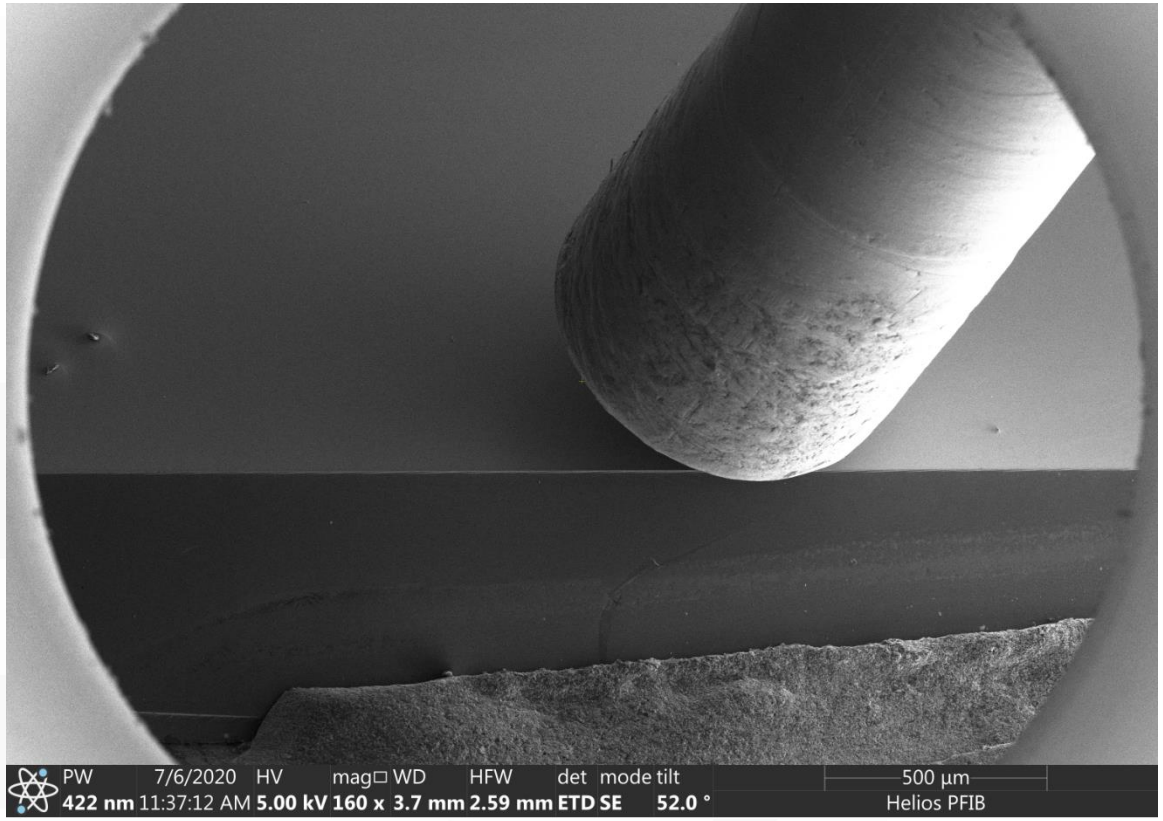
ICE

SEM column

FIB column

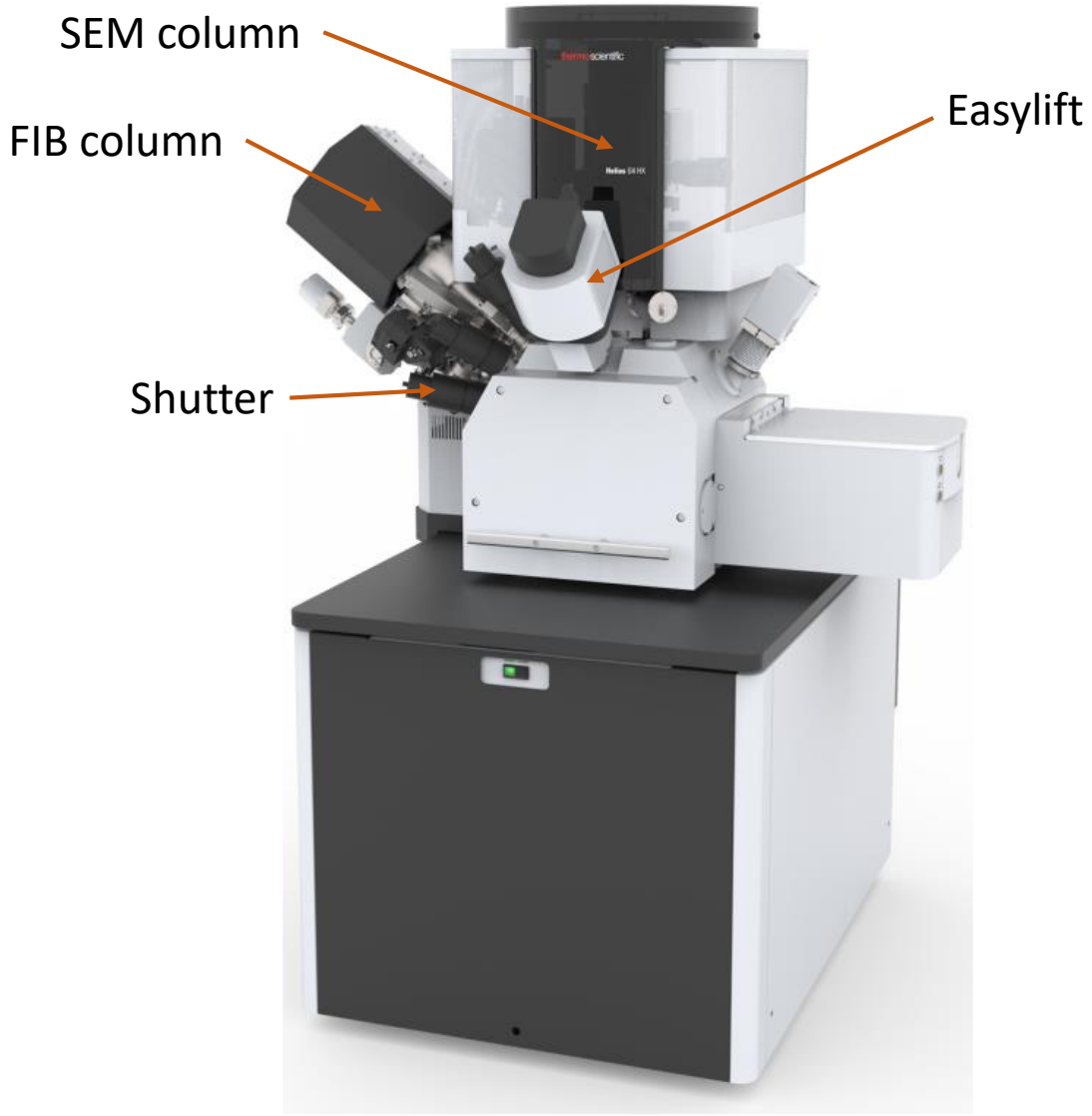
Shutter

Easylift

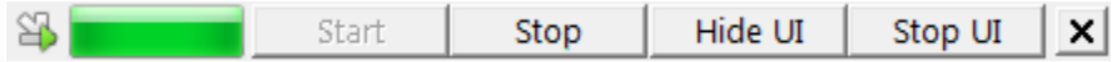


MultiGIS (Gas Injection System)
Allows deposition of Pt, C, W and mixtures of those.

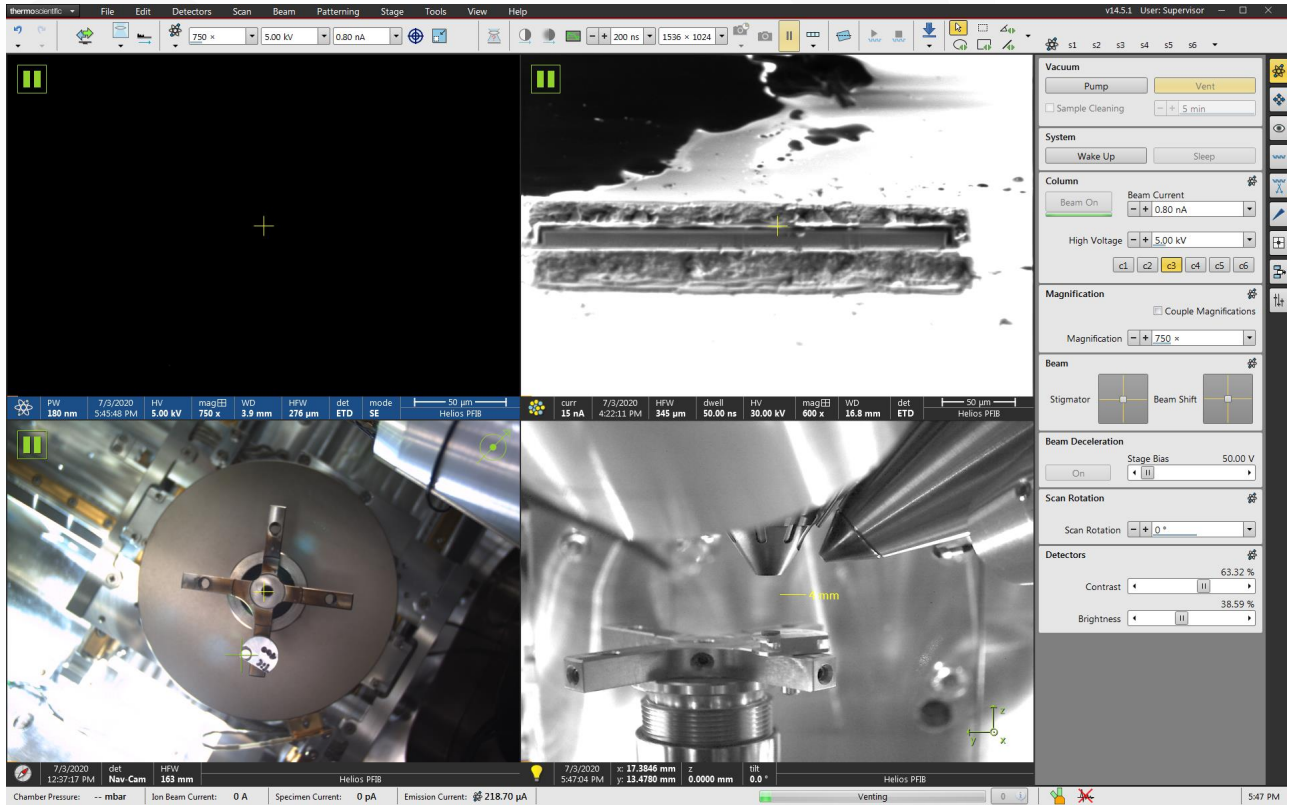
Lets close the door and switch to the computer.



xT Microscope Server

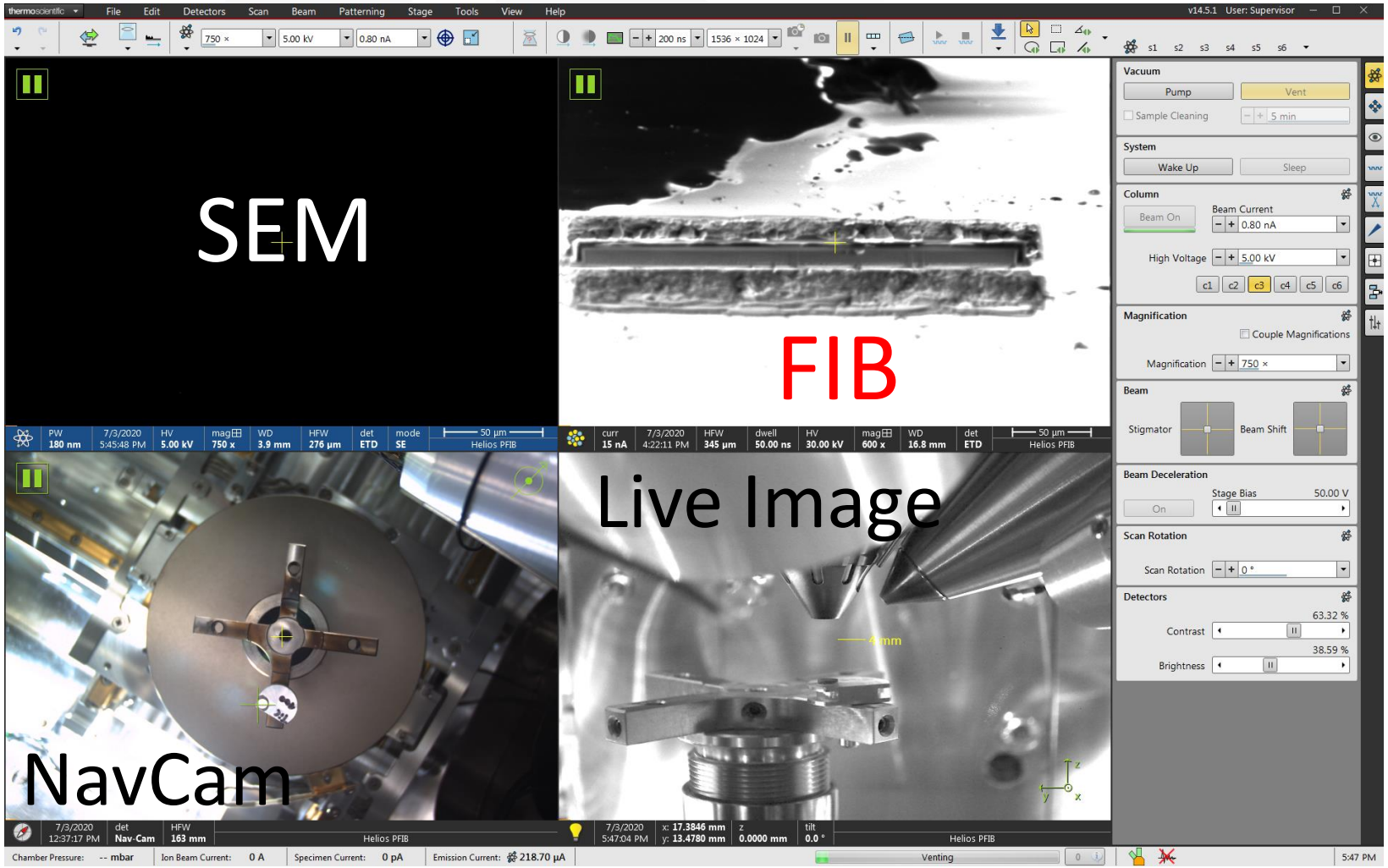


Microscope Control Software



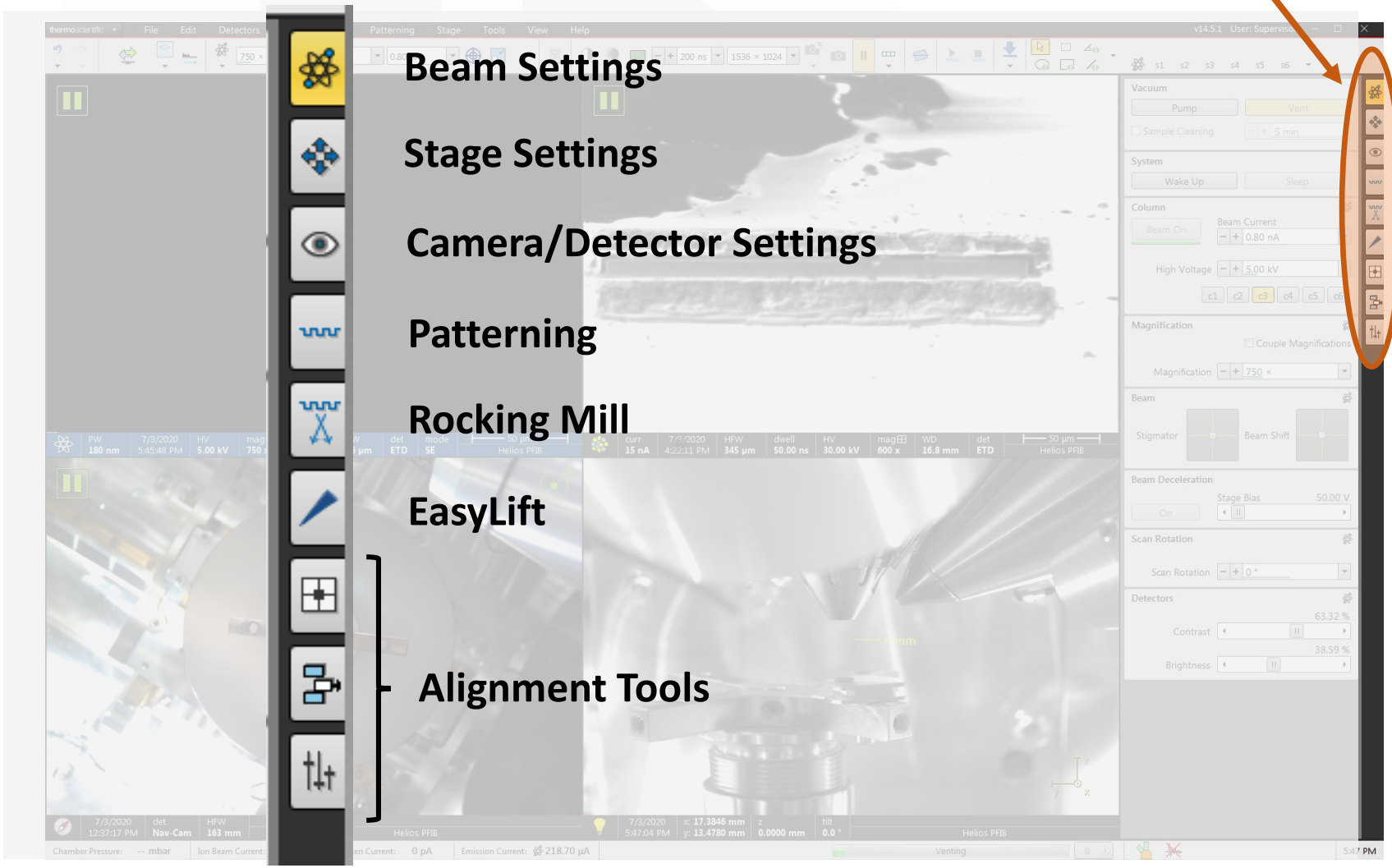
Carsten.Putzke@epfl.ch

Microscope Control Software



Carsten.Putzke@epfl.ch

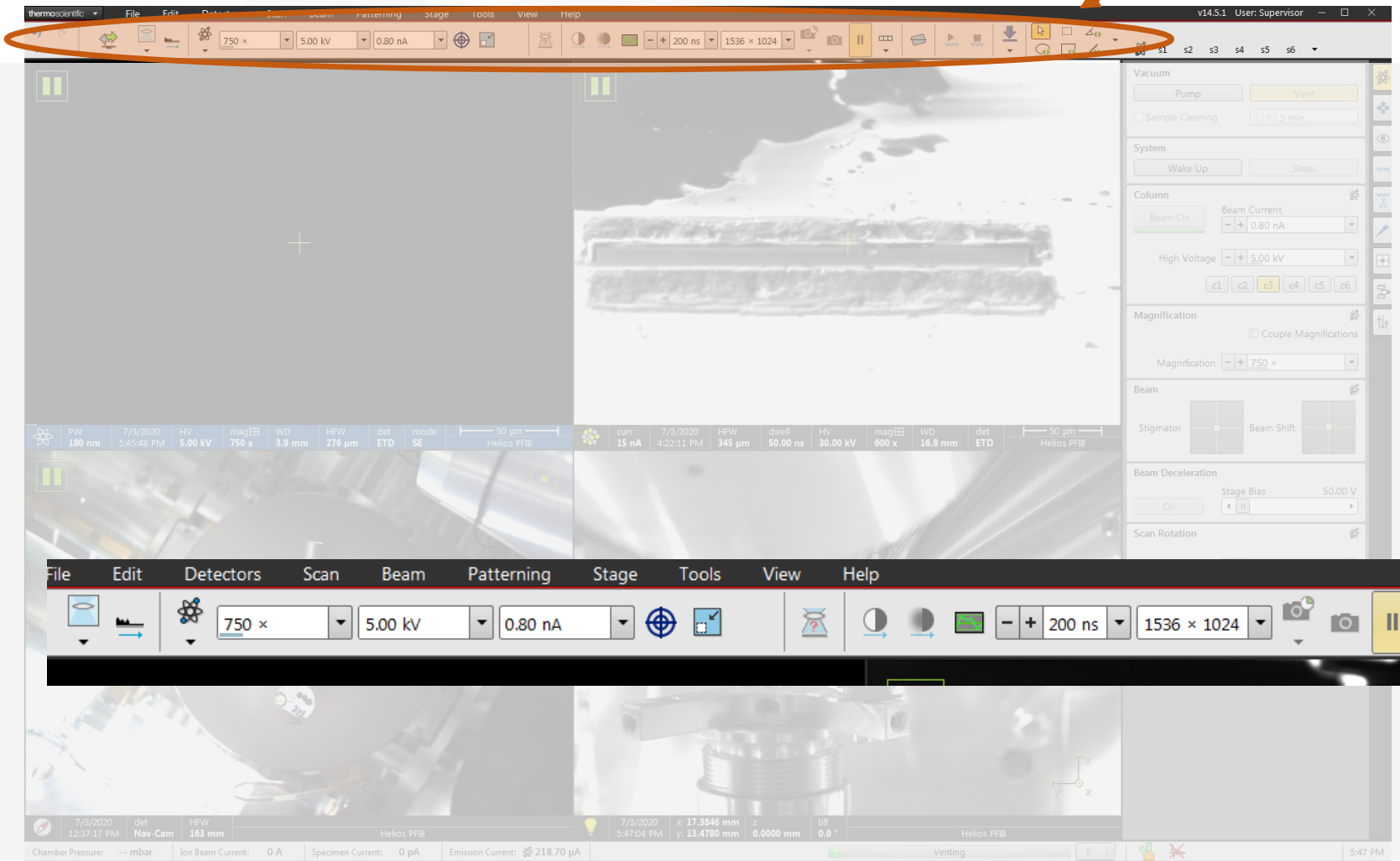
Microscope Control Software



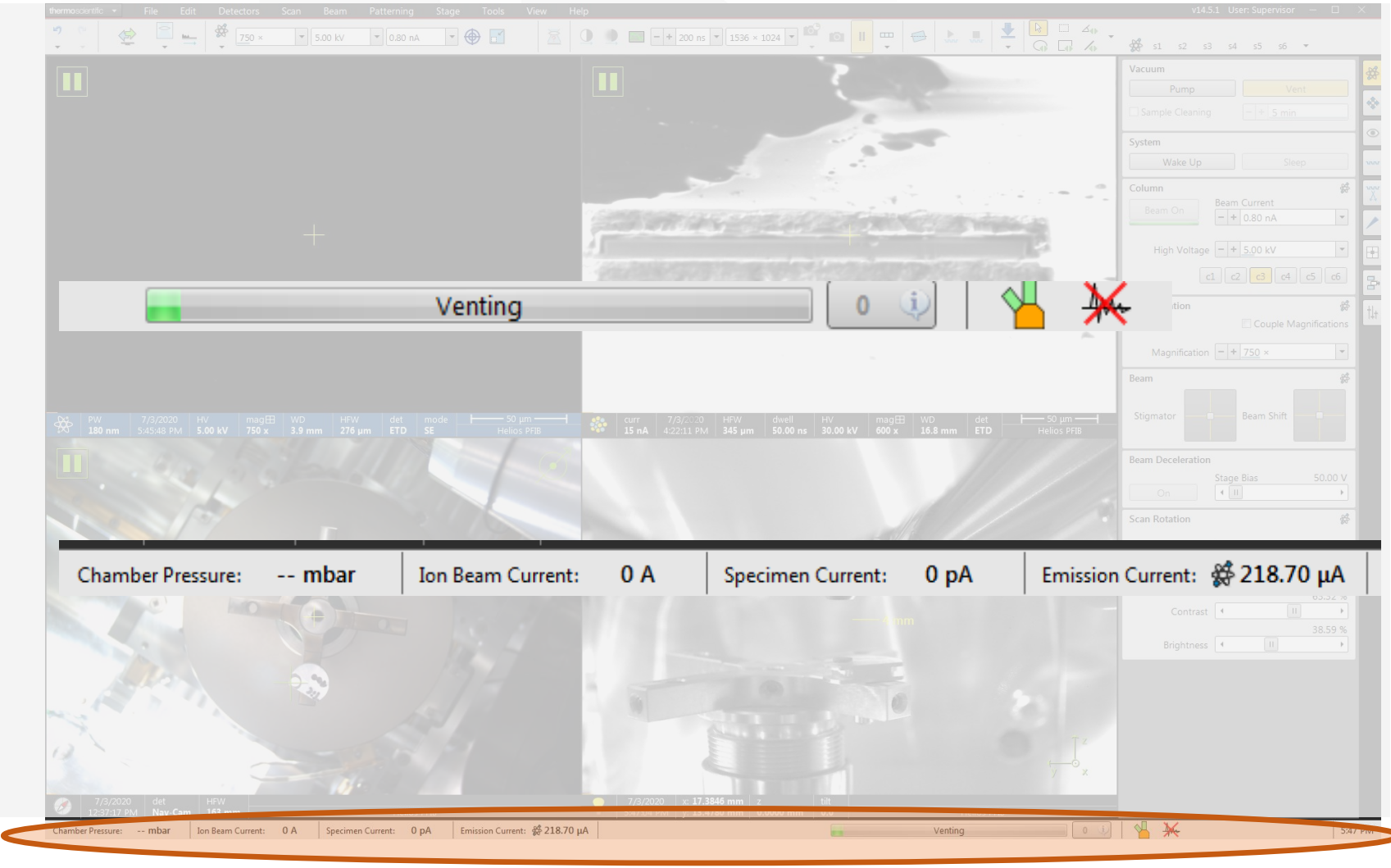
Carsten.Putzke@epfl.ch

Microscope Control Software

Parameter



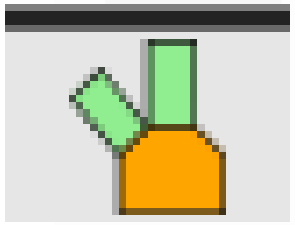
Microscope Control Software

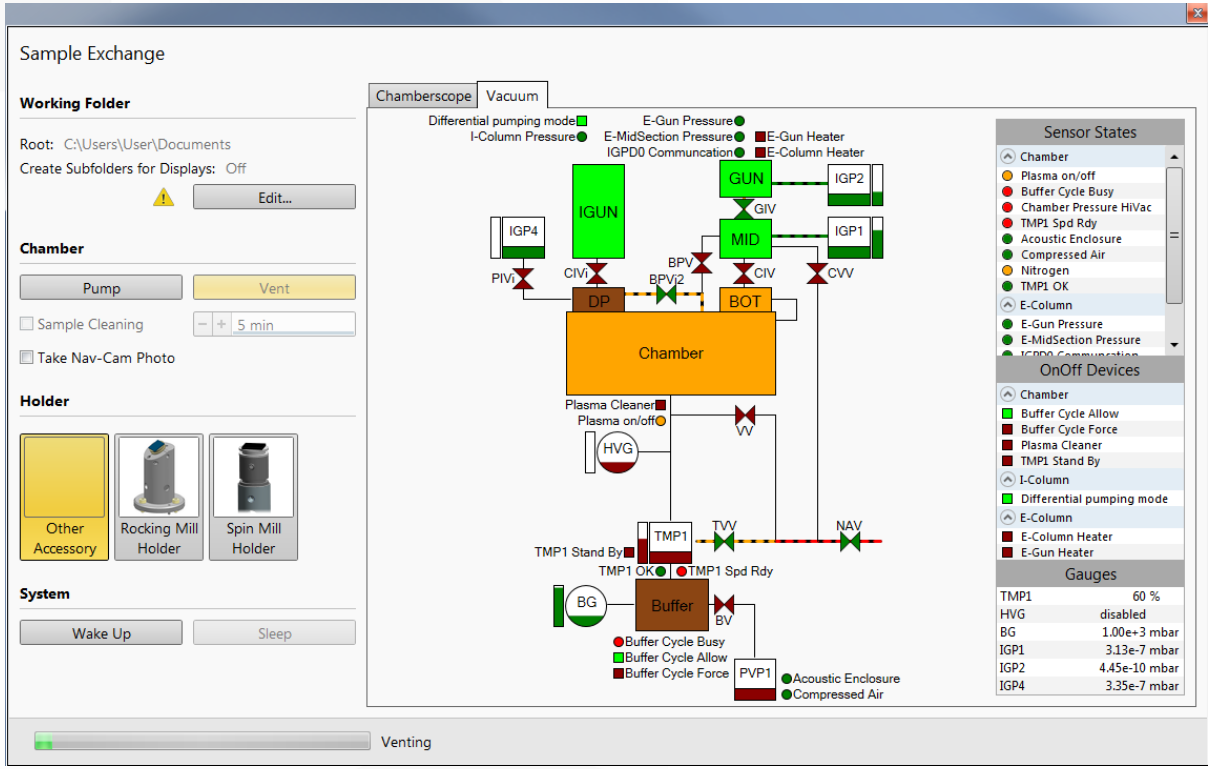


Status bar

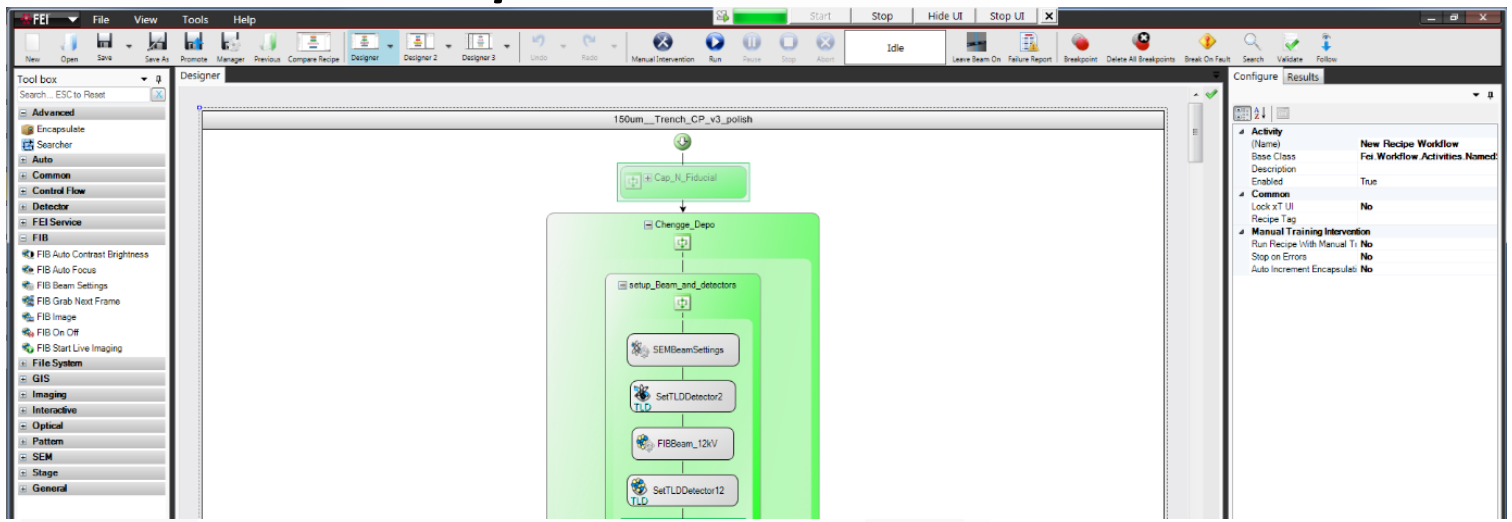
Carsten.Putzke@epfl.ch

Microscope Control Software

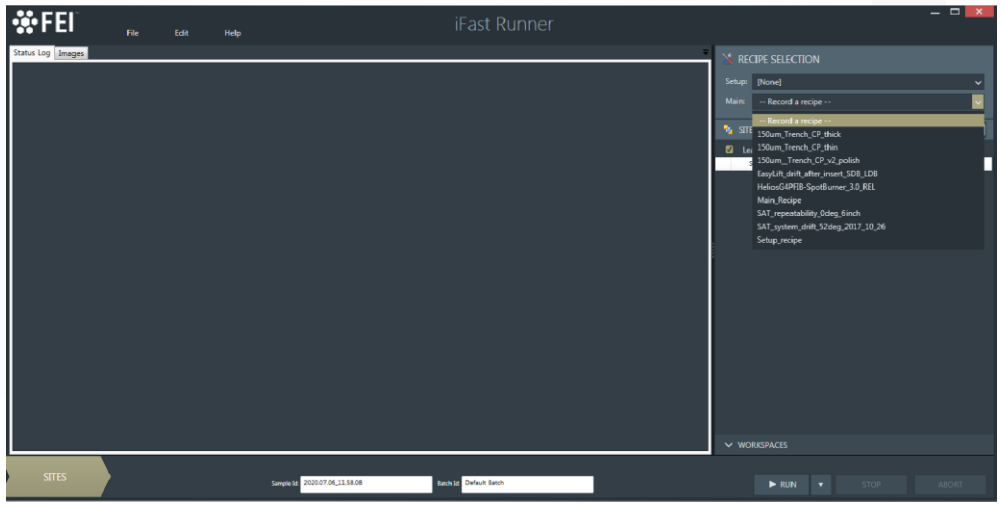




iFast Developer



iFast Runner



Allows easy execution at multiple sites.

Python Autoscript

Tests - [C:\Users\User\PycharmProjects\Carsten\Tests] - ...\settingparameter.py - PyCharm Community Edition 2017.2.2

File Edit View Navigate Code Refactor Run Tools VCS Window Help

Tests > settingparameter.py

Project

Tests C:\Users\User\PycharmProjects\
- drill_holes_constants current.py
- drill_holes_diffCurrentsLoop.py
- drill_holes_diffCurrentsLoop_andcr
- example.py
- example.pz
- Michal_Array_Pattern.py
- settingparameter.py
- testmove.py

External Libraries

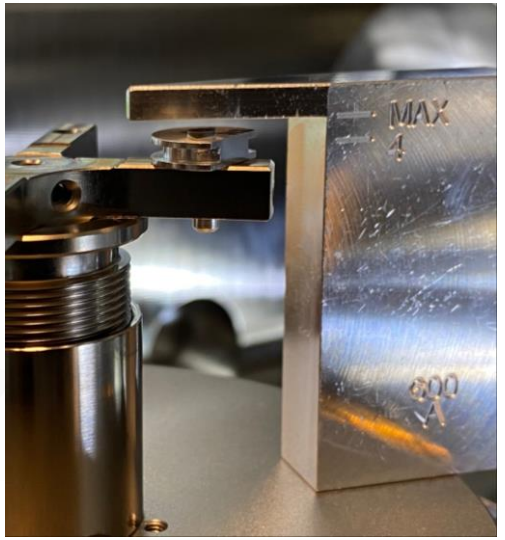
settingparameter.py

```
1  from autoscript_sdb_microscope_client import SdbMicroscopeClient
2  from autoscript_sdb_microscope_client.enumerations import *
3  from autoscript_sdb_microscope_client.structures import *
4
5  microscope = SdbMicroscopeClient()
6  microscope.connect()
7
8
9  lx = 1e-6
10 ly = 1e-6
11
12 patt_dwell_time = 10e-6
13
14 rp = microscope.patterning.create_rectangle(0, 0, lx, ly, 1e-6)
15
16 rp.dwell_time = patt_dwell_time
17
18 no_px = lx/rp.pitch_x*ly/rp.pitch_y
19
20 patt_time = no_px*patt_dwell_time
21
22 rp.time = patt_time
```

Enables combination of microscope control, image recognition and numerical calculations.

4mm Marker


15 nA
7/3/2020
4:22:11 PM
345 µm
50.00 ns
30.00 kV
600 x
16.8 mm
ETD
Helios PFIB
4 mm
7/3/2020
5:47:04 PM
x: 17.3846 mm
y: 13.4780 mm
z
0.0000 mm
tilt
0.0 °
Helios PFIB
70 µA
Venting


MAX
4
600
µA

4mm Marker

Link the stage after focusing.

- indicates the WD=4mm.
- after focusing the stage needs to be linked
- z(absolute) → z(Full Working Distance)

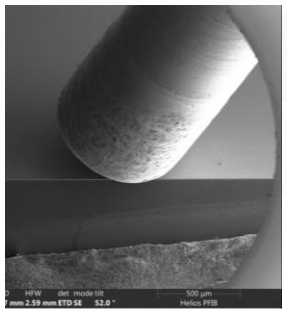
4mm Marker

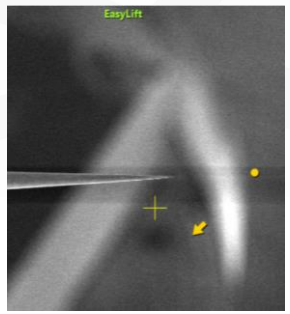
if the sample is too low

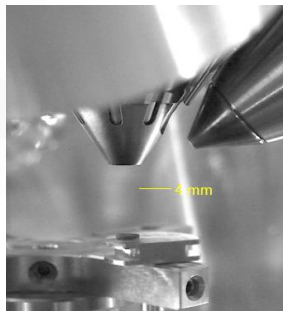
- it is not possible to bring sample into coincidence
- GIS system will be too far from sample for good deposition

if the sample is too high

- ***risk of damaging the system***
  - ***Shutter***
  - ***EasyLift***
  - ***GIS***
  - ***SEM***
- ***your sample will be damaged***





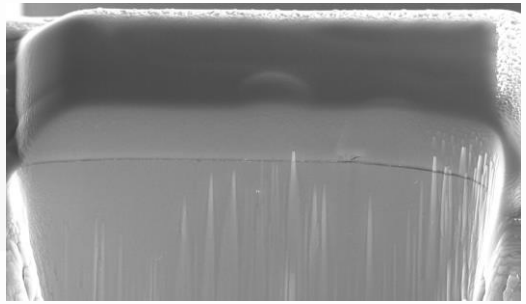


Applications and Examples

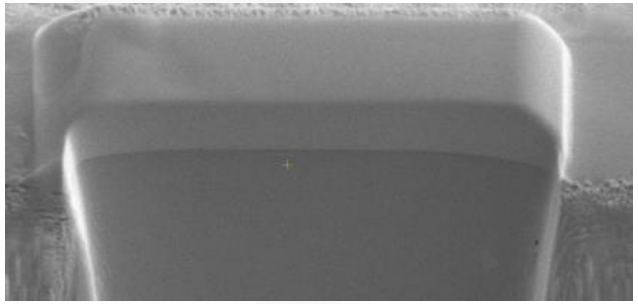
MultiGIS

Combing Pt and C allows for variation in hardness and growth speed.

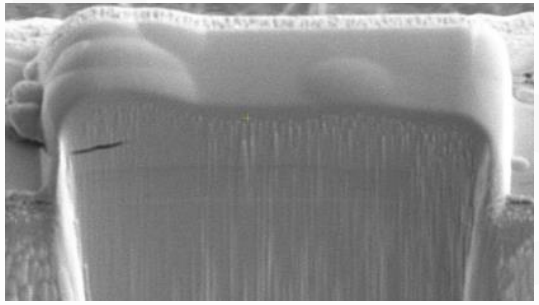
1%C:100%Pt



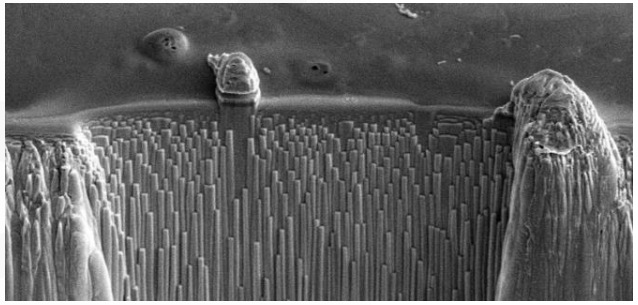
2%C:100%Pt



4%C:100%Pt



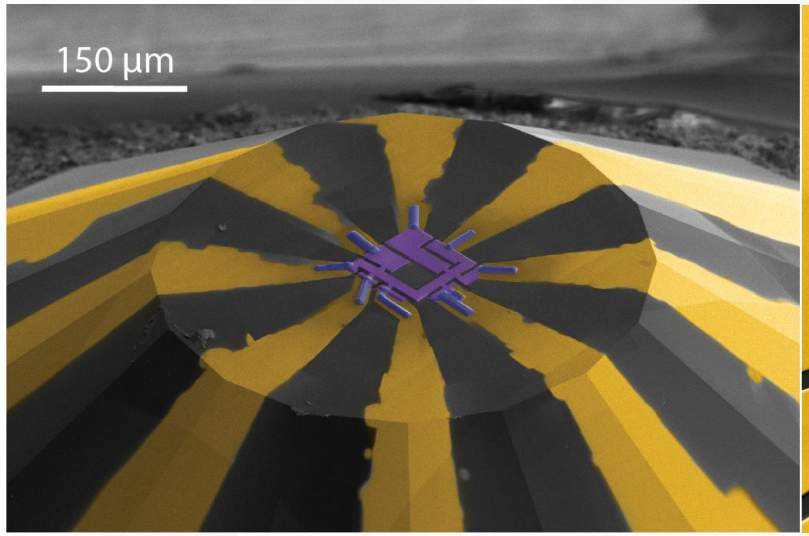
without protection layer

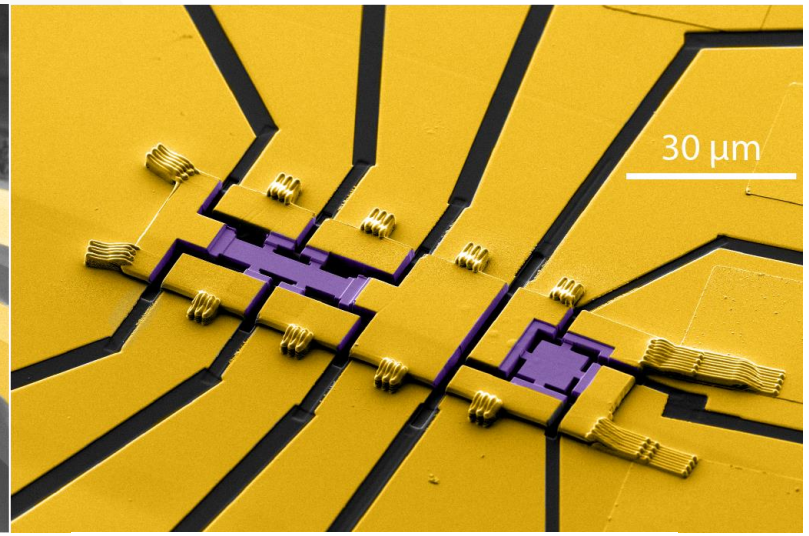


Carsten.Putzke@epfl.ch

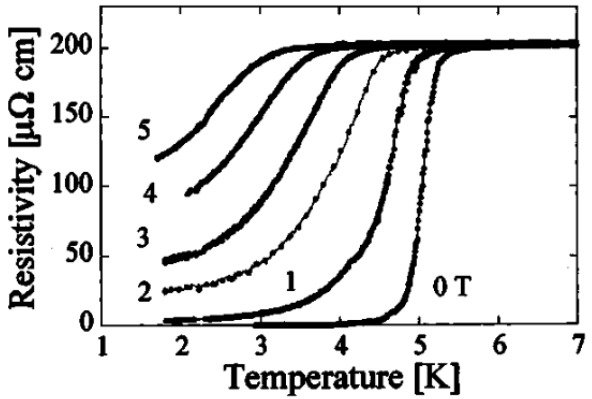
MultiGIS

Pt as electrical contact.



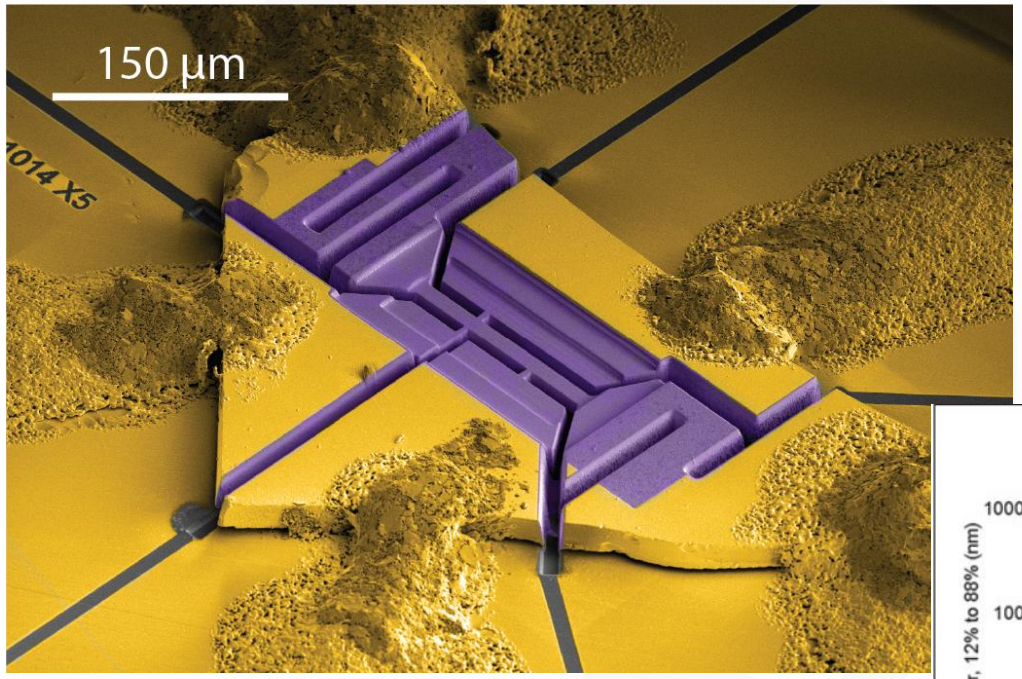


W as superconducting contacts
and reduced cross contamination.



Appl. Phys. Lett. **85**, 6206 (2004)

Studying Electrical Properties



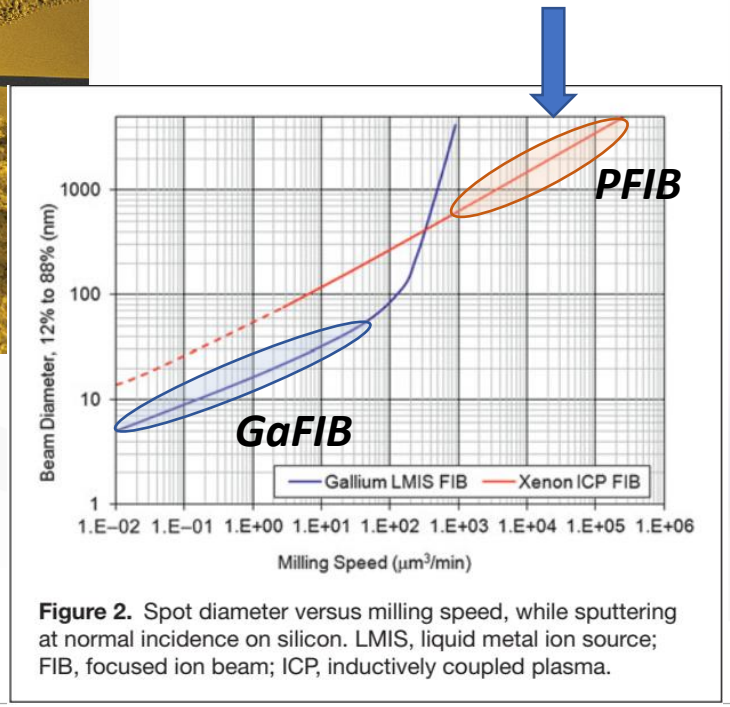


Figure 2. Spot diameter versus milling speed, while sputtering at normal incidence on silicon. LMIS, liquid metal ion source; FIB, focused ion beam; ICP, inductively coupled plasma.

Studying Electrical Properties

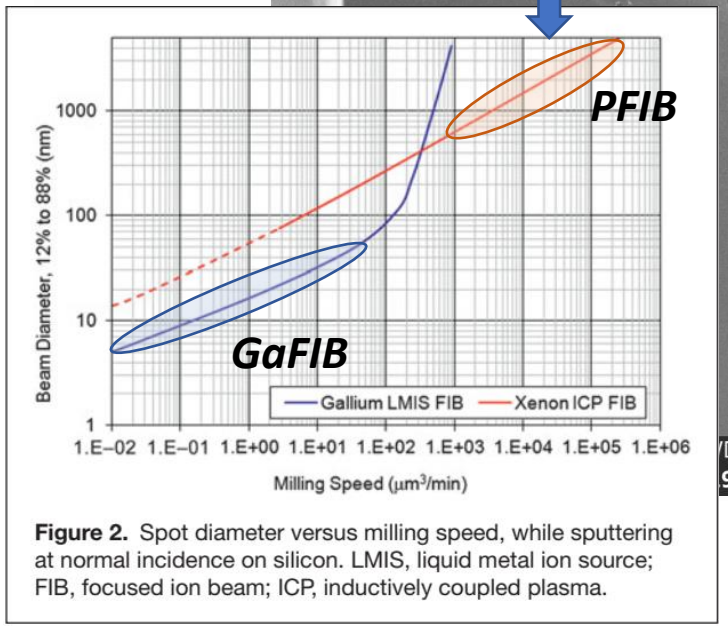


Figure 2. Spot diameter versus milling speed, while sputtering at normal incidence on silicon. LMIS, liquid metal ion source; FIB, focused ion beam; ICP, inductively coupled plasma.

iFast Automation
~1h per lamella

Carsten.Putzke@epfl.ch

Studying Electrical Properties

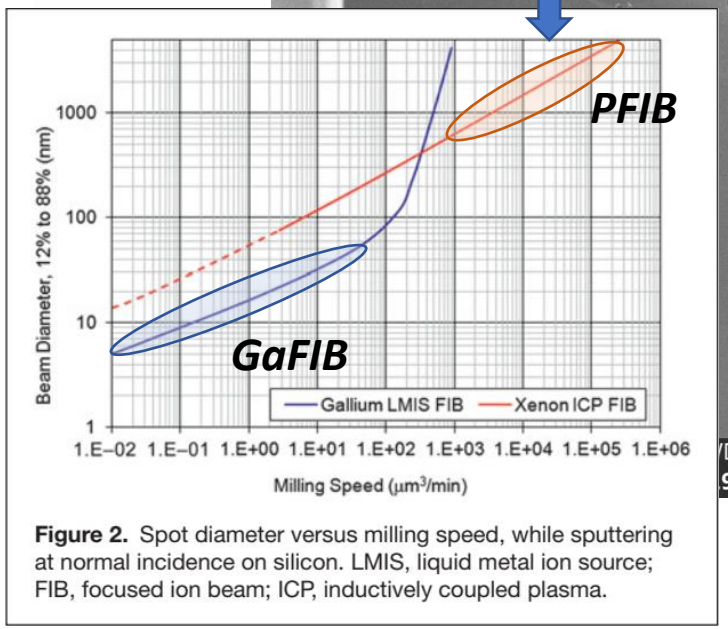
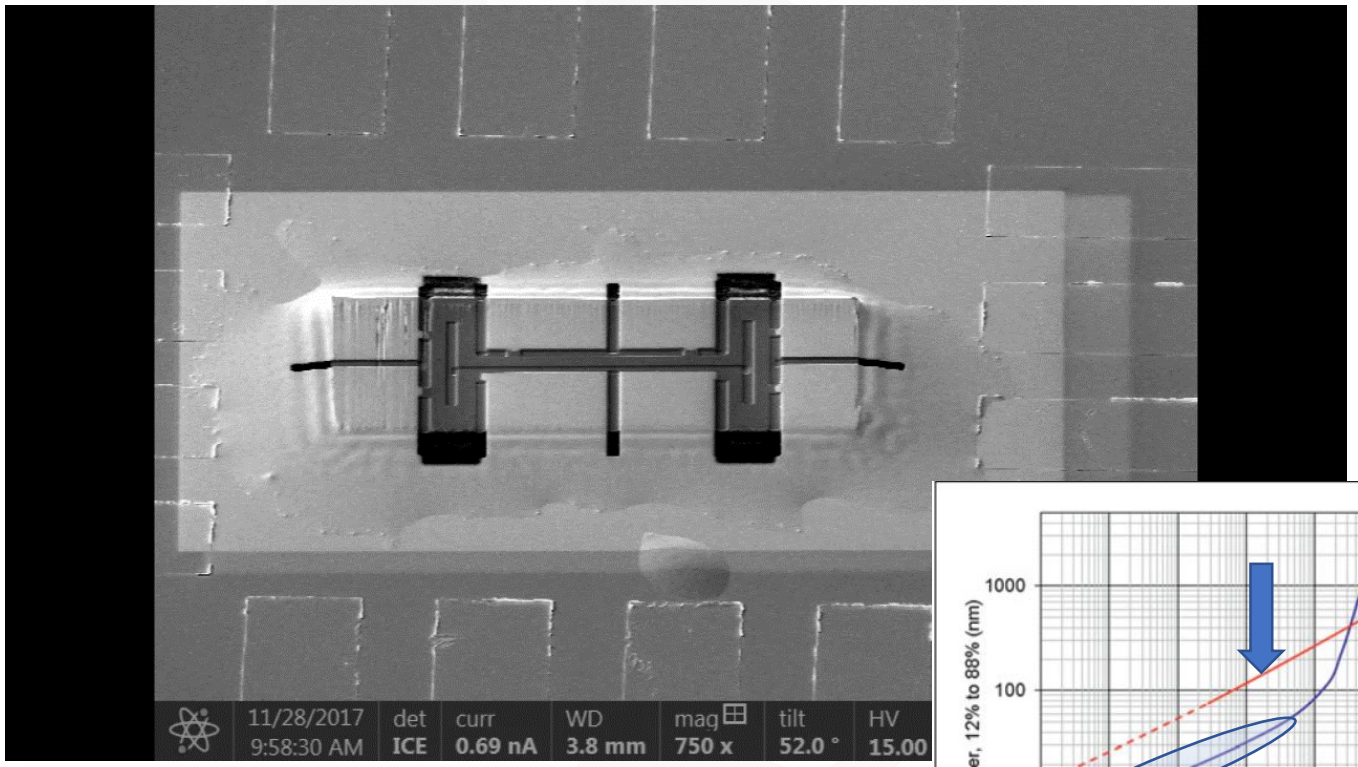


Figure 2. Spot diameter versus milling speed, while sputtering at normal incidence on silicon. LMIS, liquid metal ion source; FIB, focused ion beam; ICP, inductively coupled plasma.

iFast Automation
~1h per lamella

Carsten.Putzke@epfl.ch

Studying Electrical Properties



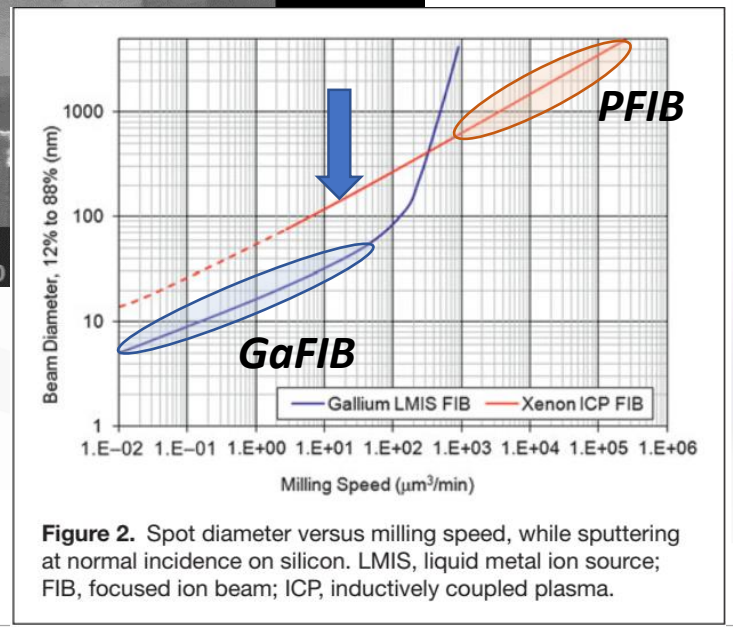
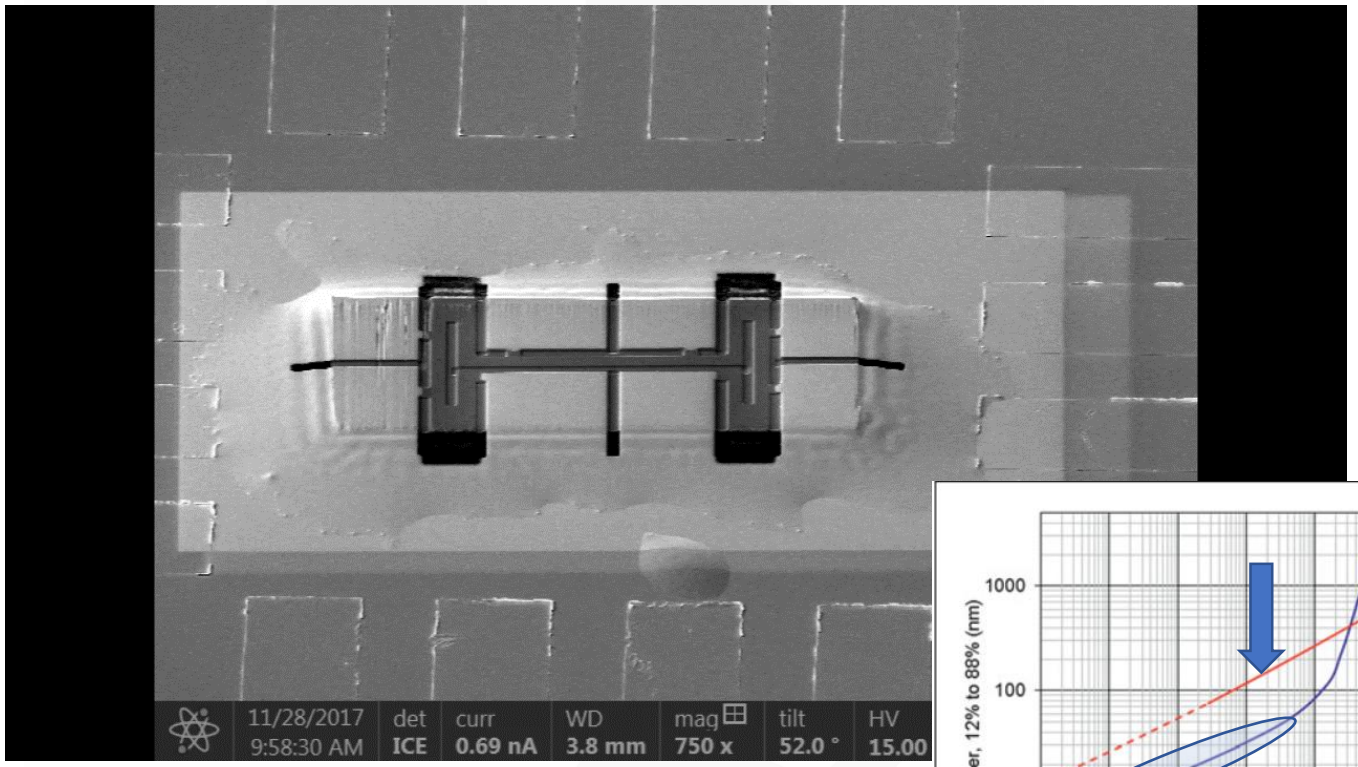


Figure 2. Spot diameter versus milling speed, while sputtering at normal incidence on silicon. LMIS, liquid metal ion source; FIB, focused ion beam; ICP, inductively coupled plasma.

Studying Electrical Properties



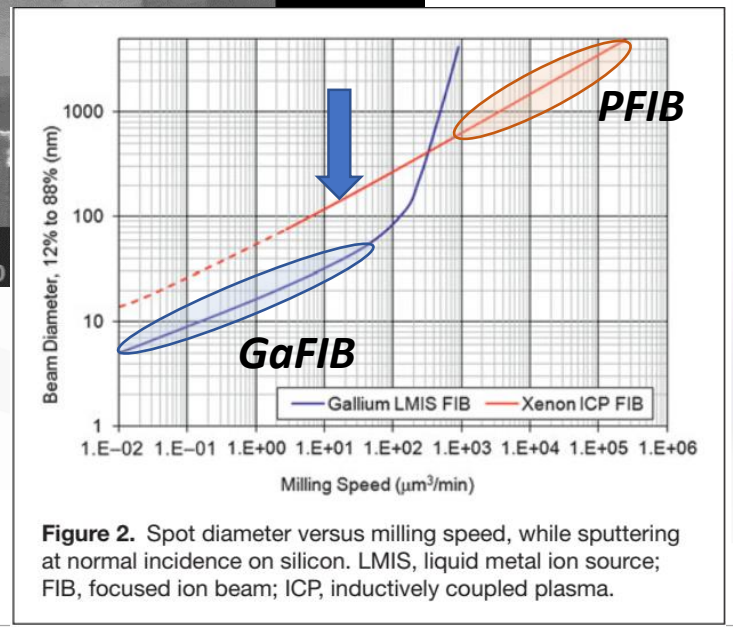
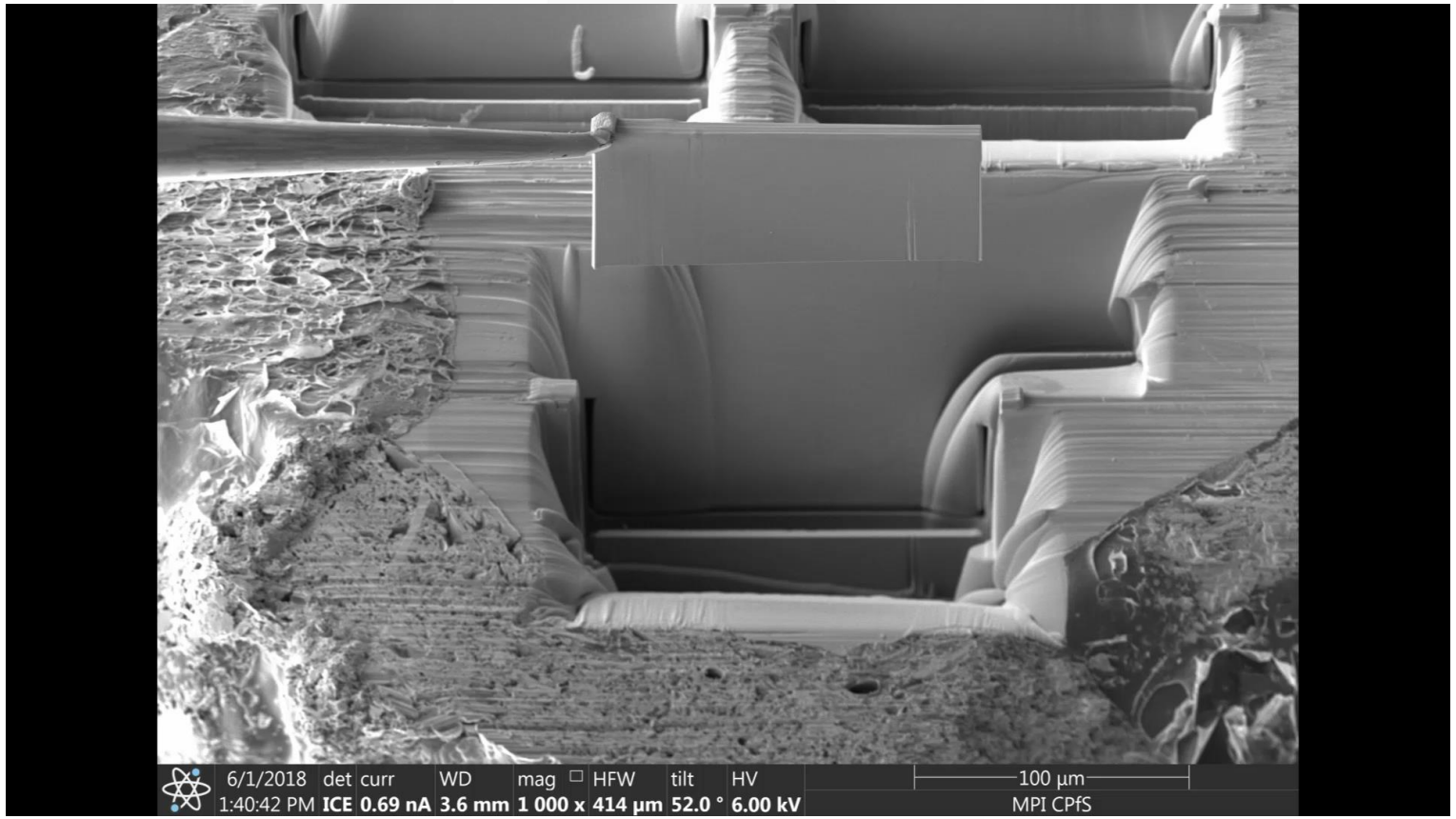
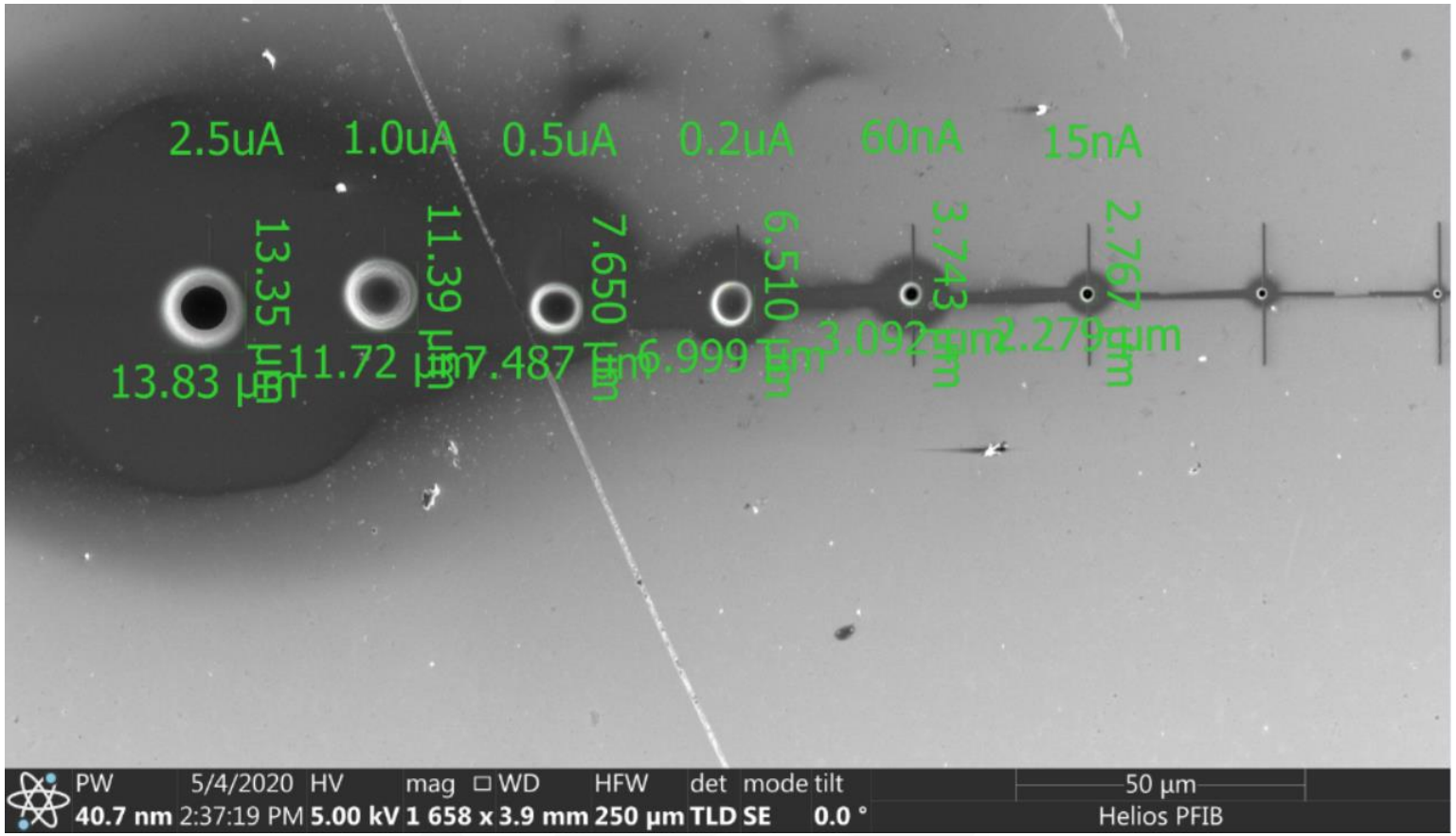


Figure 2. Spot diameter versus milling speed, while sputtering at normal incidence on silicon. LMIS, liquid metal ion source; FIB, focused ion beam; ICP, inductively coupled plasma.

Microelectronic Strain

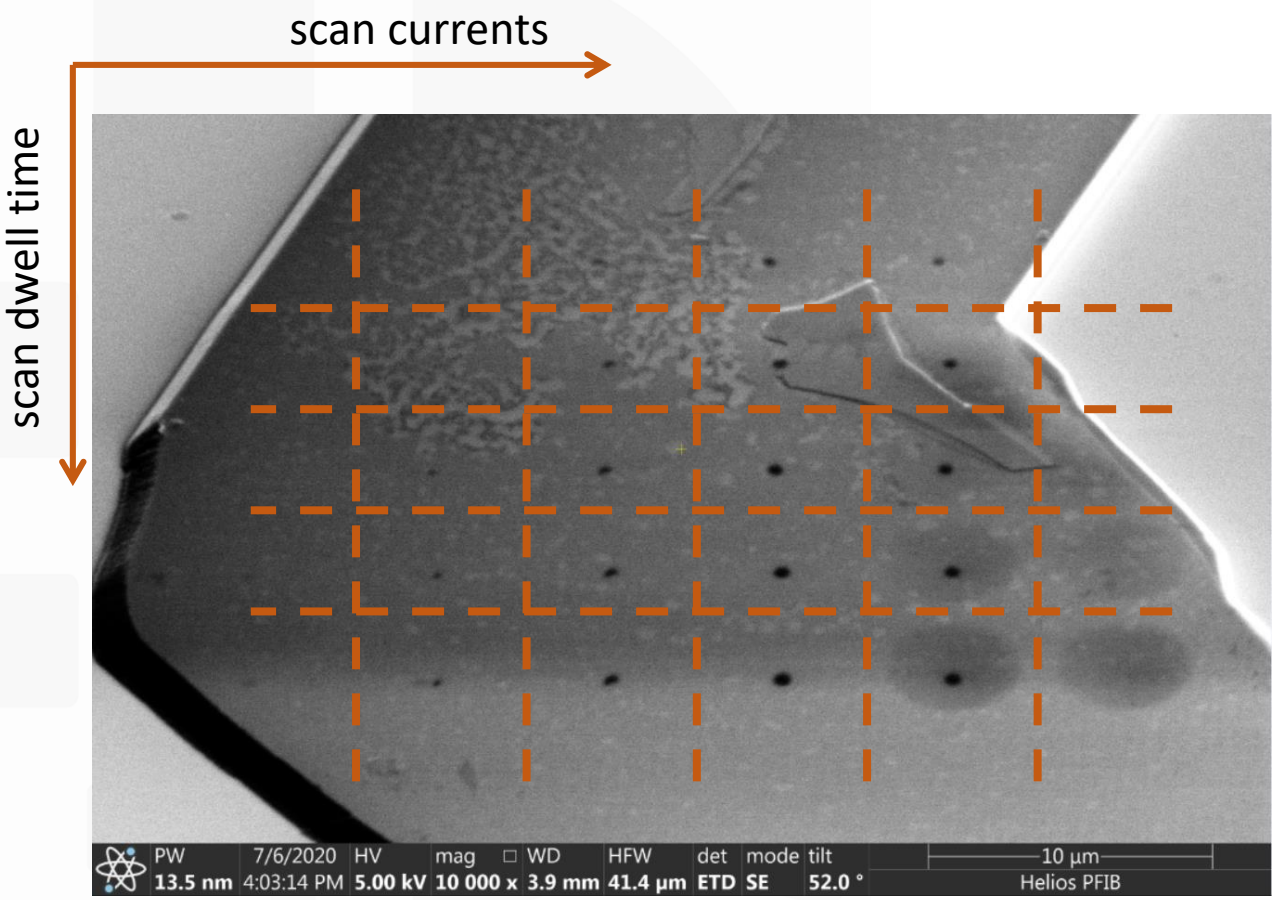


Automated System Check



Python Script lets you automatically check the system for spot size and alignment.

Automated Irradiation Study



Automated parameter scan. Picture taken by Michal Macha.