SEM

2ND CEMM WORKSHOP: **SCANNING ELECTRON MICROSCOPE**

MAJA KOBLAR, SC. ENG. PHYSICS

Scanning electron microscope

General considerations of SEM:

- magnification and resolution
- depth of focus (field,depth) - DOF
- preparation
  - conductive
  - vacuum compatible

SEM components we will discuss:

- vacuum system
- microscope column
- sample chamber
- graphic user interface (JSM-7600F)

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(Images: ammrf)

Vacuum system

rough,

high,

ultra high and

extremely high

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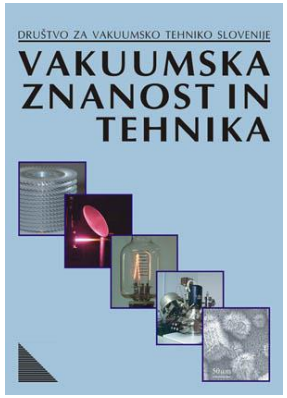
Vacuum

- to produce a mean free path for electrons greater than the lenght of the electron column
- to avoid collisions between electrons of the beam and molecules
- to prevent beam induced chemical reactions
- required for stable emission (arcing and damaging the filament) and for some detectors and electrostatic lenses

The division of areas of low pressure:

	abbreviation	Vacuum area	Pressure [mbar]	numerical density [particles/m^3]
rough	LV (sl: GV)	low vacuum	$1000 - 1$	$10^{19} - 10^{16}$
rough	MV (sl. SV)	medium vacuum	$1 - 10^{-3}$	$10^{16} - 10^{13}$
	HV (sl. VV)	high vacuum	$10^{-3} - 10^{-7}$	$10^{13} – 10^{9}$
	UHV (sl. UVV)	ultra high vacuum	$10^{-7} - 10^{-12}$	$10^{9} - 10^{4}$
	EXV (sl. EVV)	extremely high vacuum	under 10^{-12}	under 10^{4}



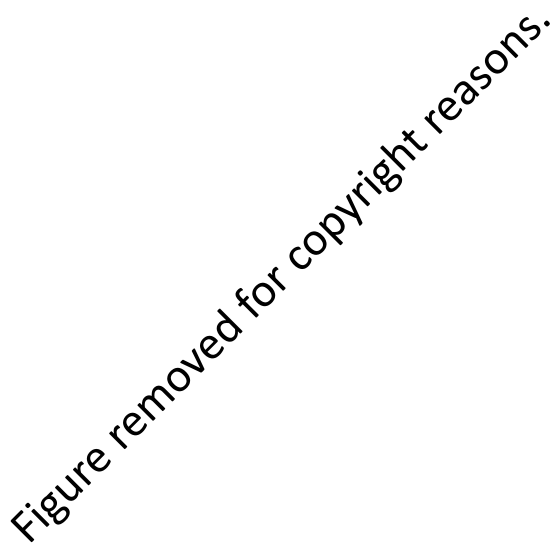
Types of vacuum pumps in SEM

Gas transfer vacuum pumps:

- Rotary pump
- Diffusion pump
- Turbomolecular pump

Entrapment vacuum pumps:

- Ion pump
- Cold trap



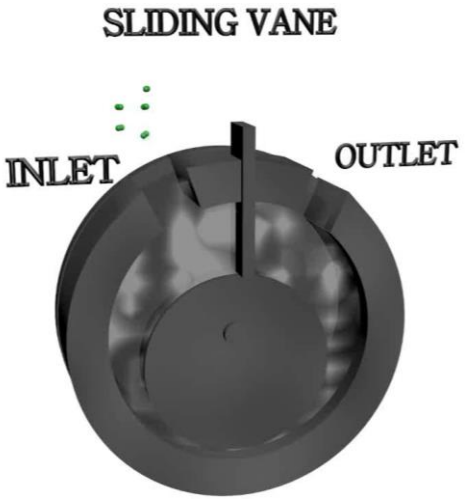
(Image: electronica.ugr.es)

Rotary Pump

Pumps by rotation of an off-center cylinder.

Initial pump (to pump the chamber after sample change, in airlock exchange).

Good efficiency for high pressure – 100 L/min.



(Video: YouTube)

Disadvantages:

- vibrations
- oil vapour
- maintenance

JXA-840A

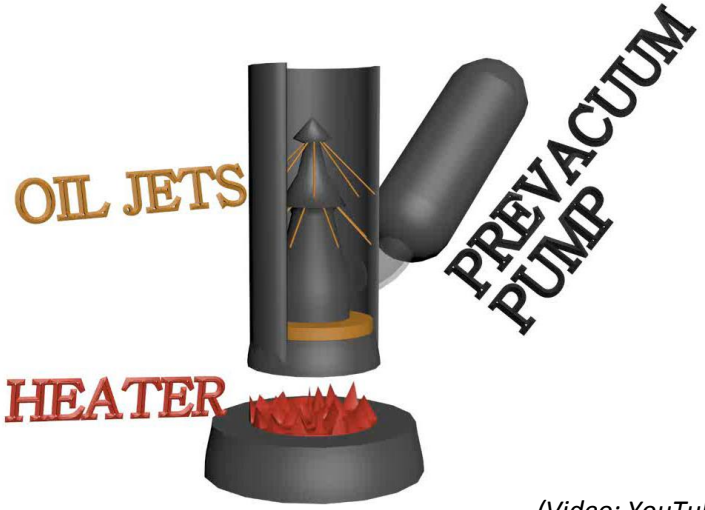
JSM-7600F

Diffusion Pump

Molecules diffuse into the active part of the pump where they are trapped and removed.

Very high pumping speed, pumps also light gases.

Tolerant with particles.



(Video: YouTube)

Disadvantages:

- needs warm up and special oil, which is evaporated
- needs cooling too
- can only work vertically

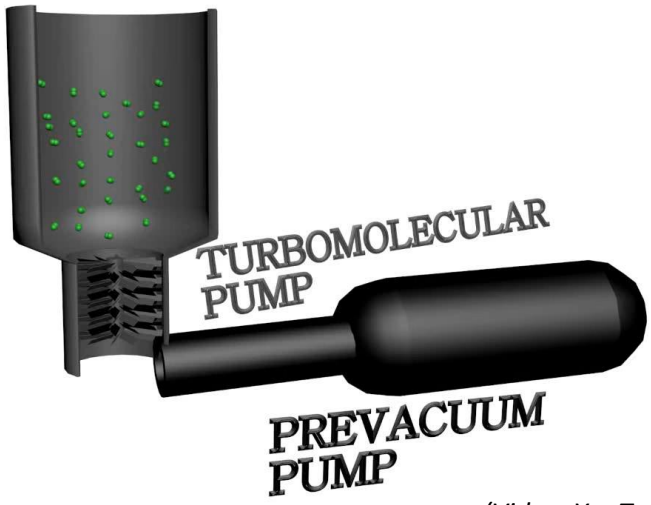
(Image: pchemlabs.com*)*

Turbomolecular Pump

A jet turbine and works by momentum transfer (multiple stages of rotating blades (rotor) spaced between fixed blades (stator).

High pumping speed but not for light gases.

Clean, no warm up, oil free.



(Video: YouTube)

Disadvantages:

- relatively expensive
- not tolerant to particles
- can fail catastrophically
- high vacuum is pure hydrogen

(Image: wikipedia)

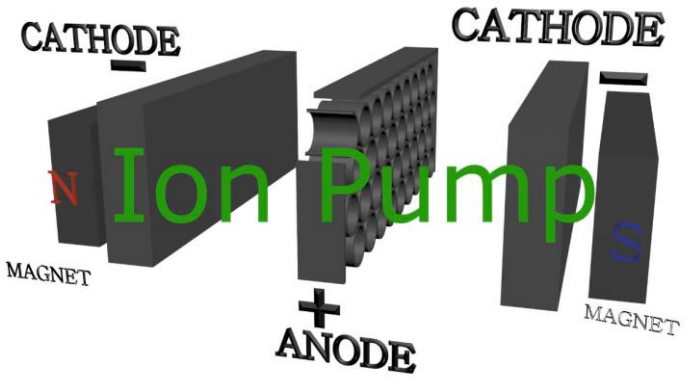
Sputter Ion Pump

Air molecules are removed from the chamber by gettering them onto a surface by ionizing gas within a magnetically confined cold cathode discharge

Can achieve ultrahigh vacuum.

No moving parts.

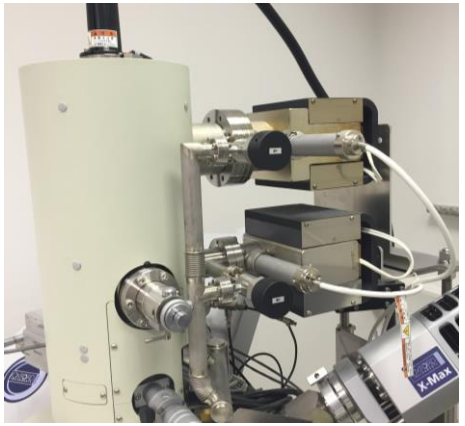
Ions sputter Ti, which reacts with residual gases and buries these under a film.



(Video: YouTube)

Disadvantages:

- not very efficient for water
- gasses not permanently removed



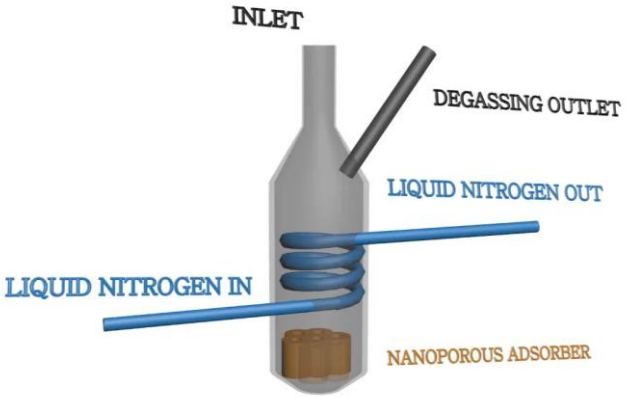
JSM-7600F

Liquid nitrogen trap

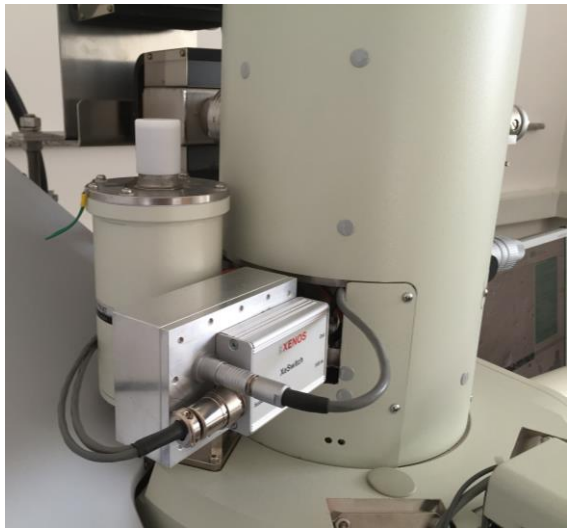
The gettering is accomplished by making the pump wall very cold (cryopump). Molecules are trapped on the surface (sorption).

No moving parts.

Good for water (water vapor desorbs slowly from the internal surfaces of the chamber).



(Video: YouTube)



JSM-7600F

Disadvantages:

- frequently degassed
- gasses not permanently removed

(Image: JEOL)

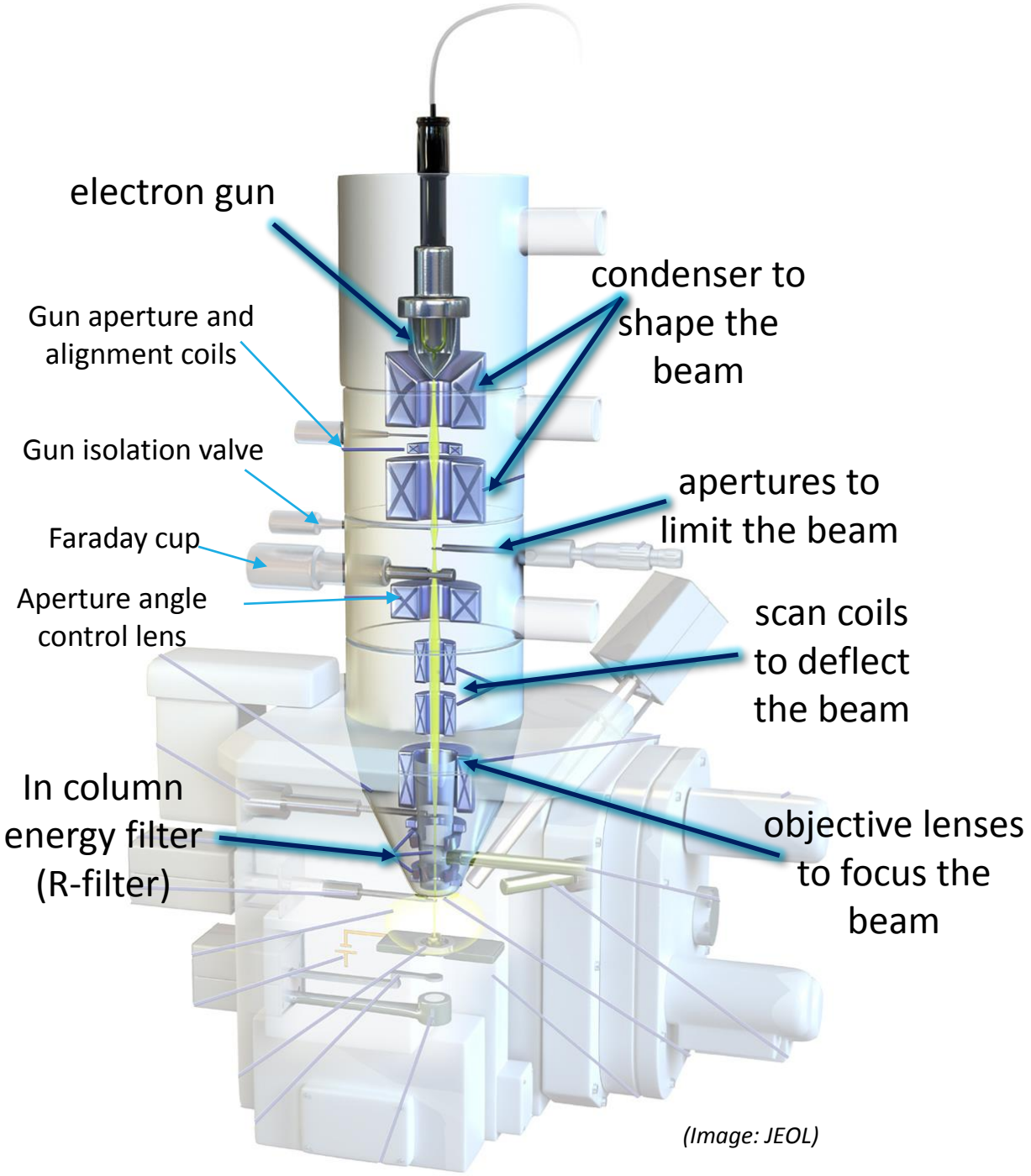
JSM-7600F, JSM-5800 and JXA-840A

Basic principle of SEM operation

(Image: ammrf)

Center for electron microscopy and microanalysis

Microscope column



(Image: JEOL)

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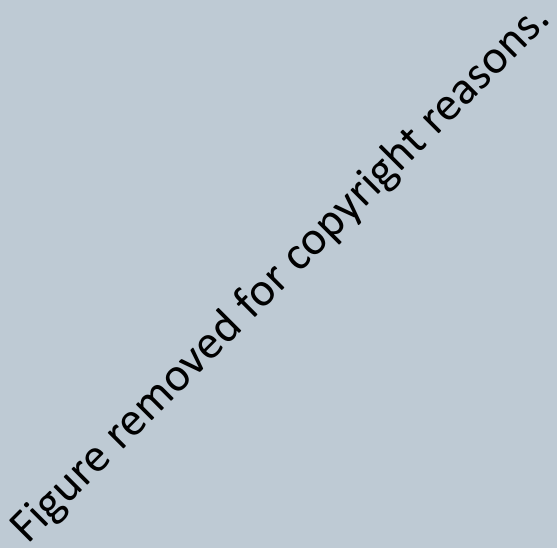


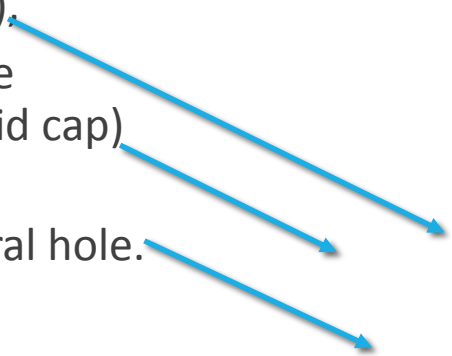
Electron gun

Thermionic emission

To produce an electron beam:

- an **emitter** (electrode),
- a surrounding cathode (**Wehnelt** cylinder/ grid cap) and
- an **anode** with a central hole.

(Image: ammrf)



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(Image: nau.edu)

$$E = E_w + E_F$$

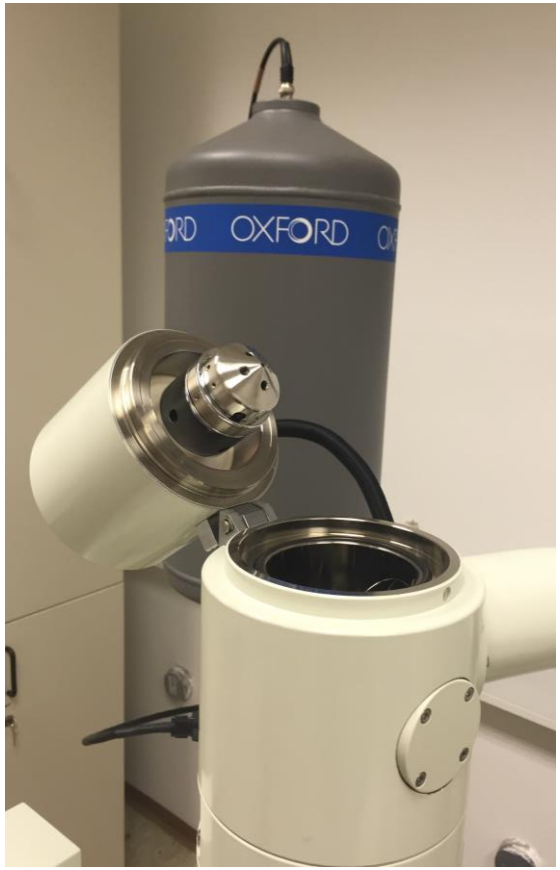
Richardson- Dushman equation: $J_{th} = -AT^2 exp\left[{}^{-e\,E_w}/_{kT}\right]$

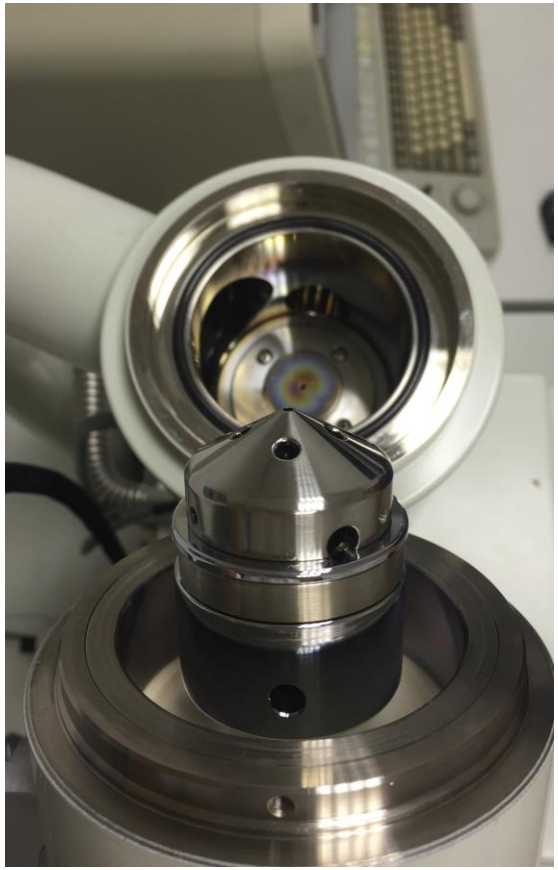
Tungsten: $T = 2700$ K, $E_w = 4{,}5$ eV → J_{th} =3,4 A/cm²

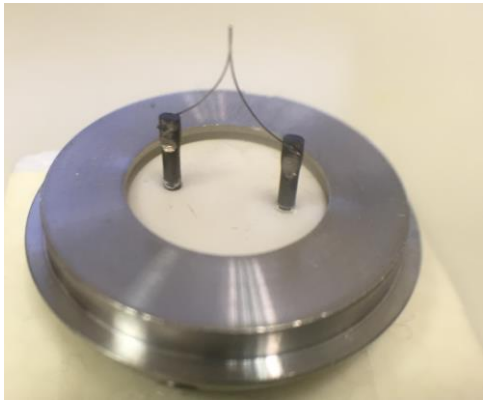
LaB_6: $T = 1800$ K, $E_w = 2{,}5$ eV → J_{th} =40 A/cm²

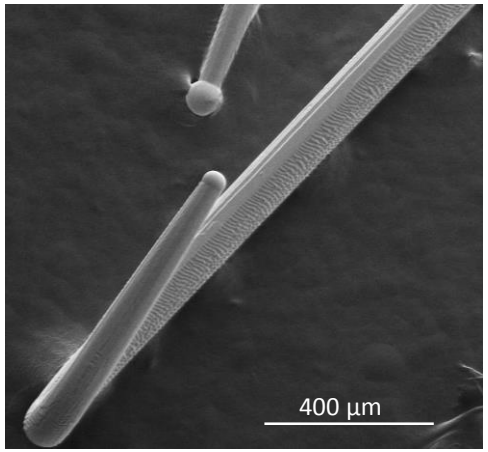
J_{th} ... Thermionic current density (A/m2)
A ... constant for thermionic emitters (120 A/cm²K²)
T... metal temperature (K)
e ... electron charge (C)
Ew ... metal work function (eV)
k ... Boltzmann's constant (J/kg)

W gun (JSM-5800, JXA-840A)









JSM-5800

Field emission

The cathode is a tungsten rod, very sharp point (<100nm).

Make a very strong field at the tip (>10^7 V/cm), by applying potential to the first anode (3-5kV).

Electrons can escape cathode without applying any thermal energy.

Very high vacuum (<10^{-10} torr)

Use a second anode for accelerating electrons.

Fowler – Nordheim tunneling

Schottky FEG

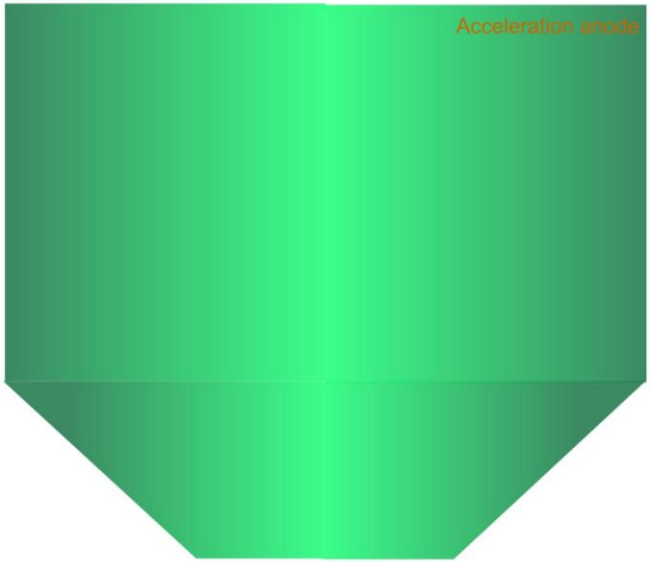
The thermal or Schottky field emission gun consists of:

- accelerating anode
- extraction anode
- suppresser anode
- emitter

The tip is W covered with Zirconium oxide. It lowers the work function so that large emission current can be obtained.

The suppresser cuts the thermionic electrons emitted from a large surface of emitter.

The surface is not covered by air molecules so that a stable emission current can be obtained.



(Image: JEOL)

Electron gun - FEG

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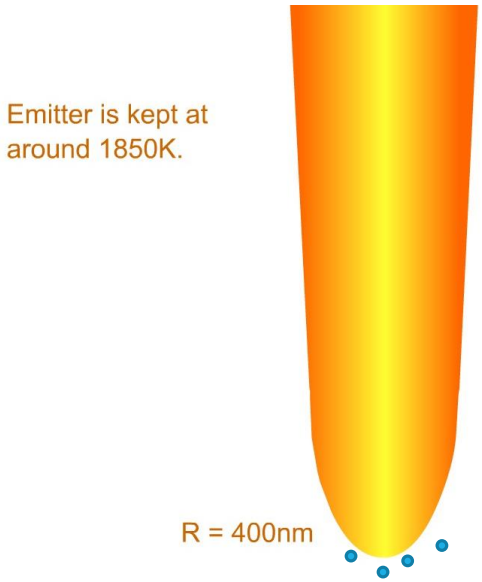
(Image: tnw.tudelft)

The thermal (SE) FEG works at the pressure of 10^{-9} Torr or 10^{-7} Pa.

(Image: JEOL)



Some of the electrons emitted from the tip ionizes molecules of air.

The ionized oxygen and nitrogen are pulled towards the tip by the strong potential and sputter zirconium oxide off.

Comparison of electron guns

Emitter Type Cathode material	Thermionic W	Thermionic LaB_6	Schottky FEG ZrO/W (100)	cold FEG W(310)
Operating temperature [K]	2,800	1,900	1,800	300
Cathode radius [nm]	60,000	10,000	< 1,000	< 100
Effective source radius [nm]	15,000	5,000	15	2.5
Emission current density [A/cm^2]	**3**	30	**5,300**	17,000
Total emission current [µA]	200	80	200	5
Normalized brightness [A/cm^2.sr.kV]	**1 x 10^4**	1 x 10^5	**1 x 10^7**	2 x 10^7
Maximum probe current [nA]	1000	1000	10 - 100	0.2
Energy spread @ cathode [eV]	0.59	0.40	0.31	0.26
Energy spread @ gun exit [eV]	**1.5 - 2.5**	1.3 - 2.5	**0.35 - 0.7**	0.3 - 0.7
Beam noise [%]	1	1	1	5 - 10
Emission current drift [%/h]	**0.1**	0.2	**< 0.5**	5
Operating vacuum hPa/mbar[1]	**< 1 x 10^{-5}**	< 1 x 10^{-6}	**< 1 x 10^{-9}**	< 1 x 10^{-10}
Typical Cathode life [h]	**100**	> 1000	**> 5000**	> 2000
Cathode regeneration	not required	not required	not required	every 6 to 8 hours
Sensitivity to external influence	minimal	minimal	low	high

(Table: tedpella)

Condenser to shape the beam

Condenser lens

Similar to glass lenses in optical microscopes.

Main role of EM lenses is to demagnify the source of electrons to form a much smaller diameter probe.

Two main lenses used in SEM:

- Condenser lenses
- Objective lenses

Figure removed for copyright reasons.

(Images: ammrf)

The main role of the condenser lens is to control the size of the beam and determines the number of electrons in the beam which hit the sample.

Figure removed for copyright reasons.

Apertures to limit the beam

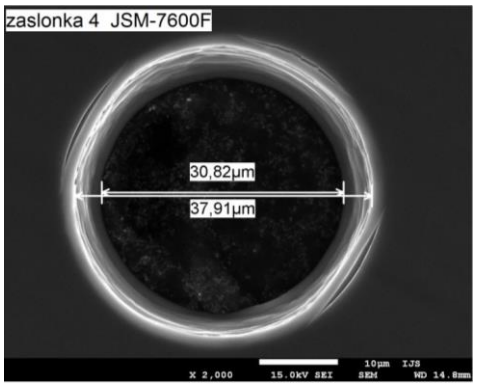
Apertures

Three (JSM-5800: 100 µm, 30 µm and 20 µm)

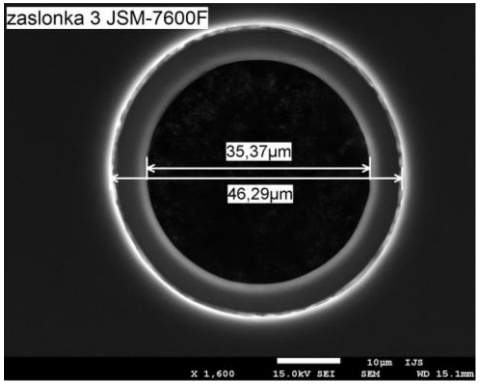
Four (JSM-7600F: 110 µm, 70 µm, 50 µm and 30 µm)

Reduces the beam current.

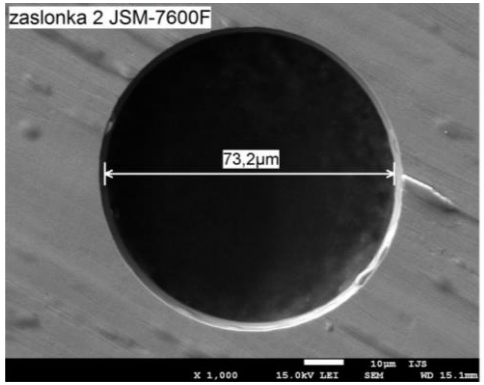
Lowers the angular spread and spherical aberration.



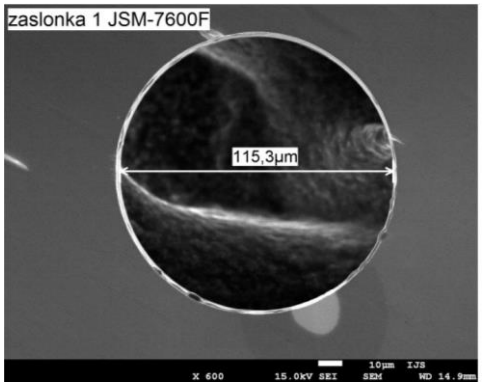
30 µm



50 µm



70 µm



110 µm

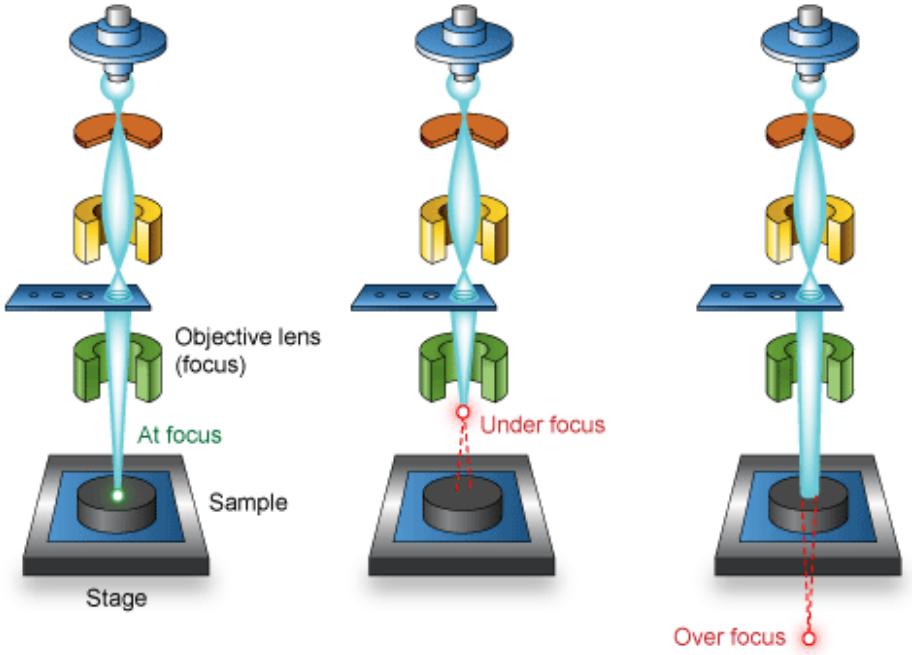
Electromagnetic lenses to focus the beam

Objective lens

Focuses electrons on the sample at the working distance.

Properties:

- large demagnification
- two sets of deflection coils are included – scan coils
- stigmator is built in it
- includes the beam shift coils
- the visible light microscope optics (EMPA)

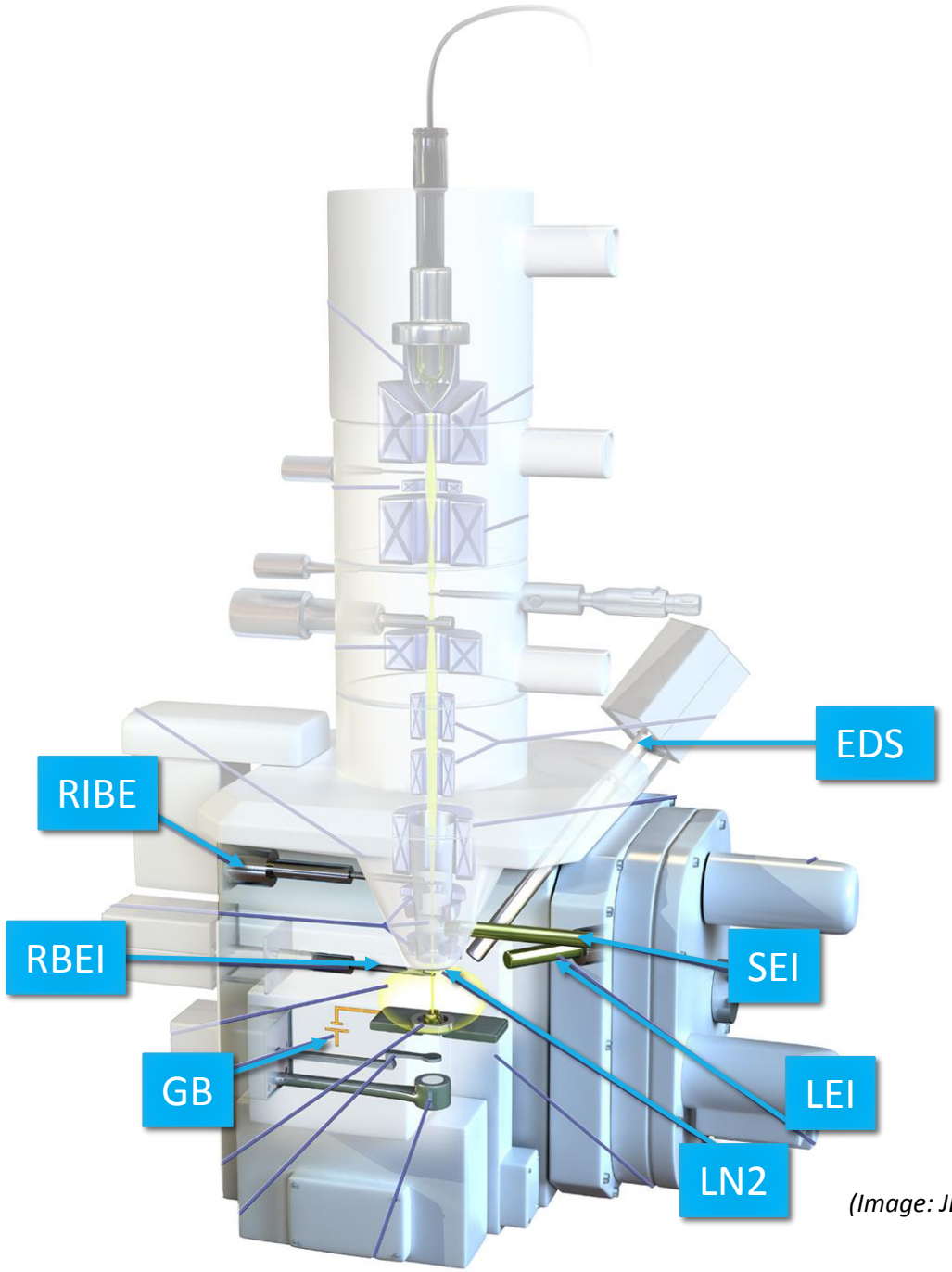


(Images: ammrf)

Sample chamber

motorized stage (x,y,z,t,r)

detectors



(Image: JEOL)

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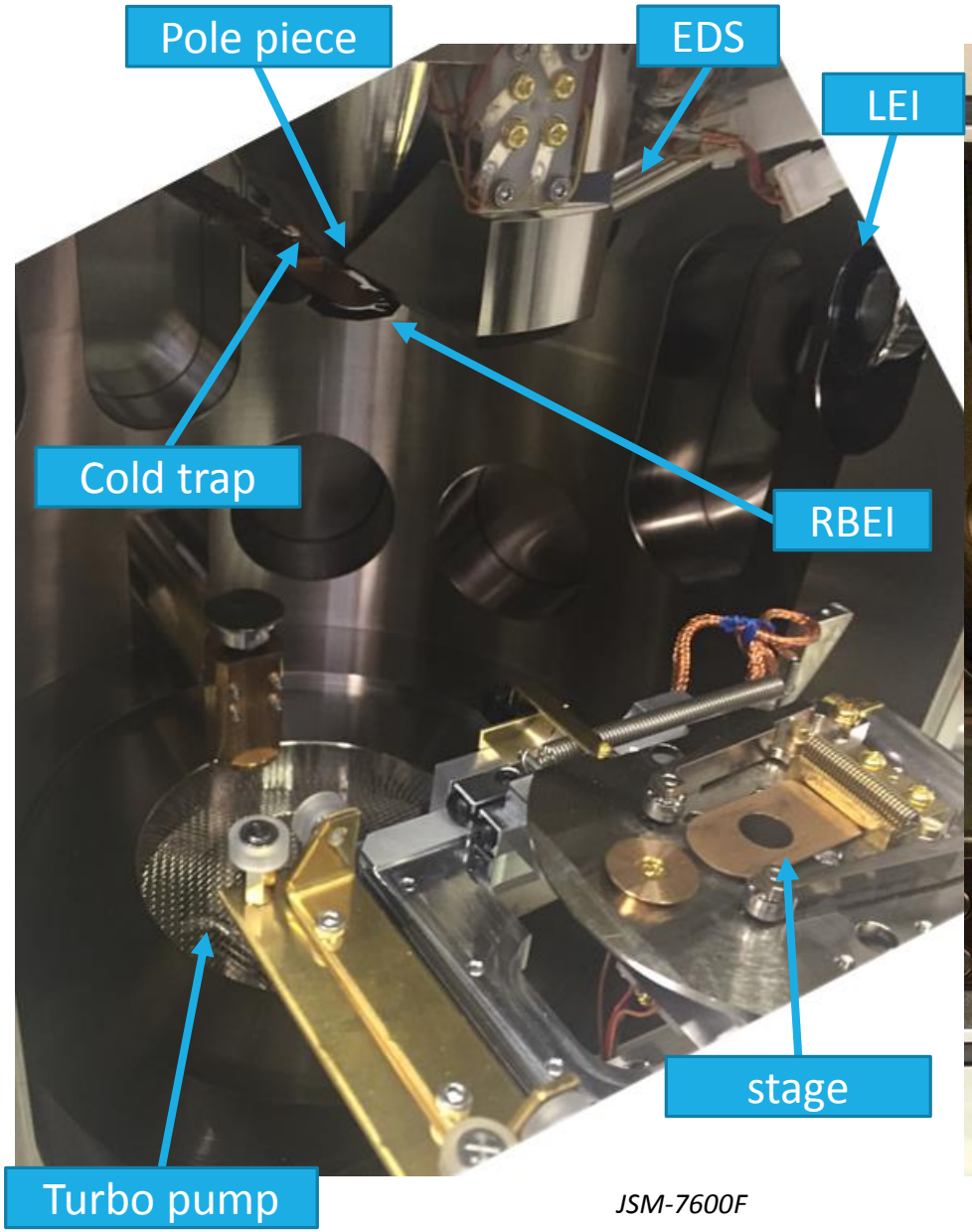
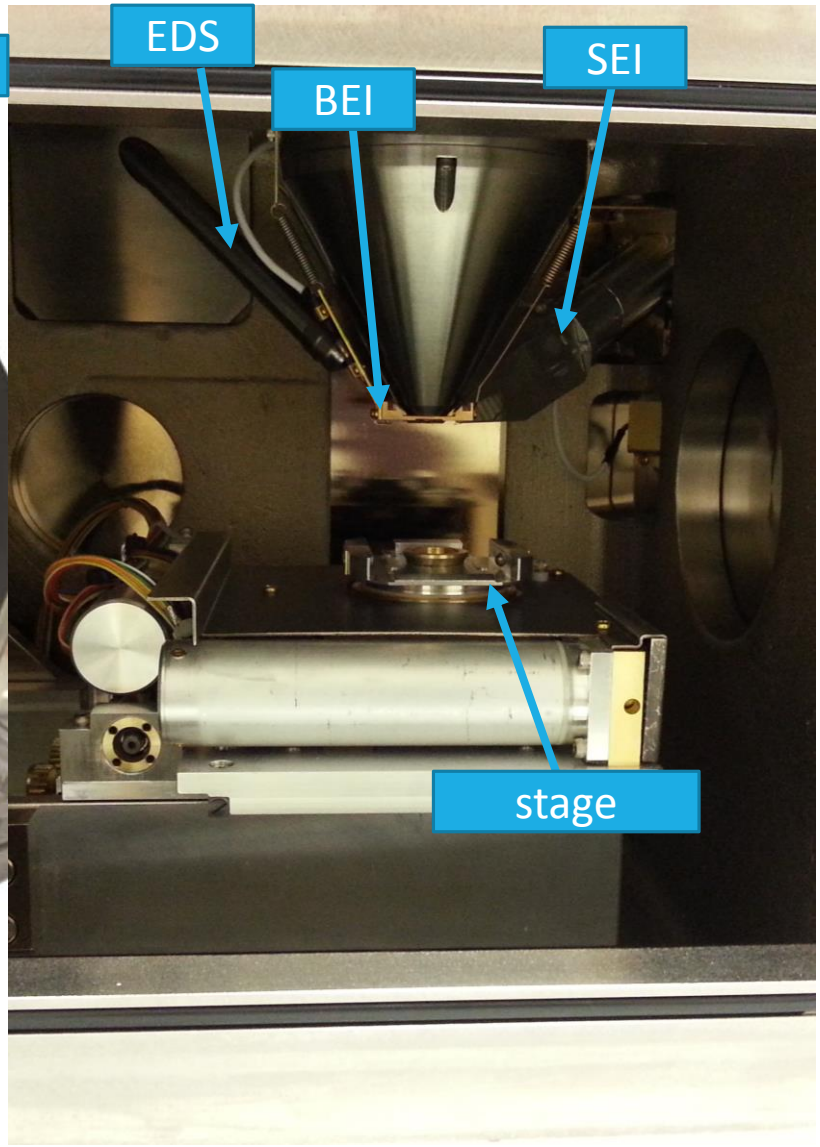
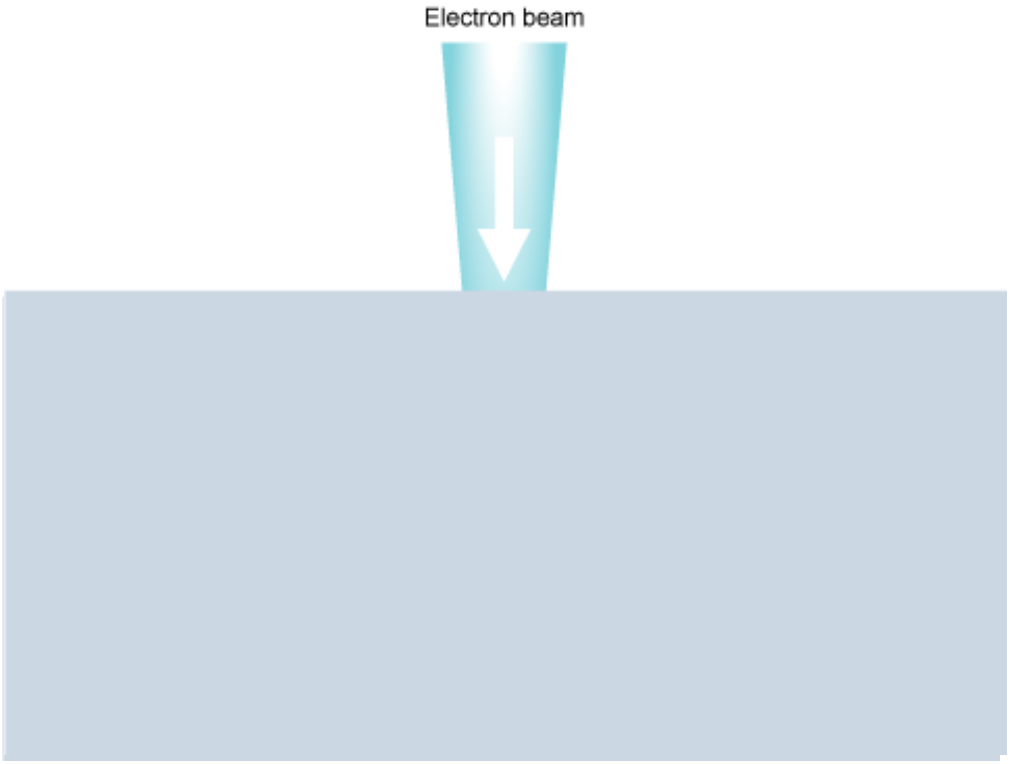


JSM-7600F



JSM-5800

Signals and interactions



(Image: ammrf)

Signals and interactions

(Image: ualberta)

(Image: Low Voltage Electron Microscopy: Principles and Applications)

SE vs BSE

Secondary electrons

- High resolution
- Strongly topography sensitive
- Little element sensitive
- Sensitive to charging

Figure removed for copyright reasons.

(Video: YouTube)

Backscattered electrons

- Lower resolution
- Atomic number contrast in particular strong signal to heavy atoms
- Less sensitive to charging

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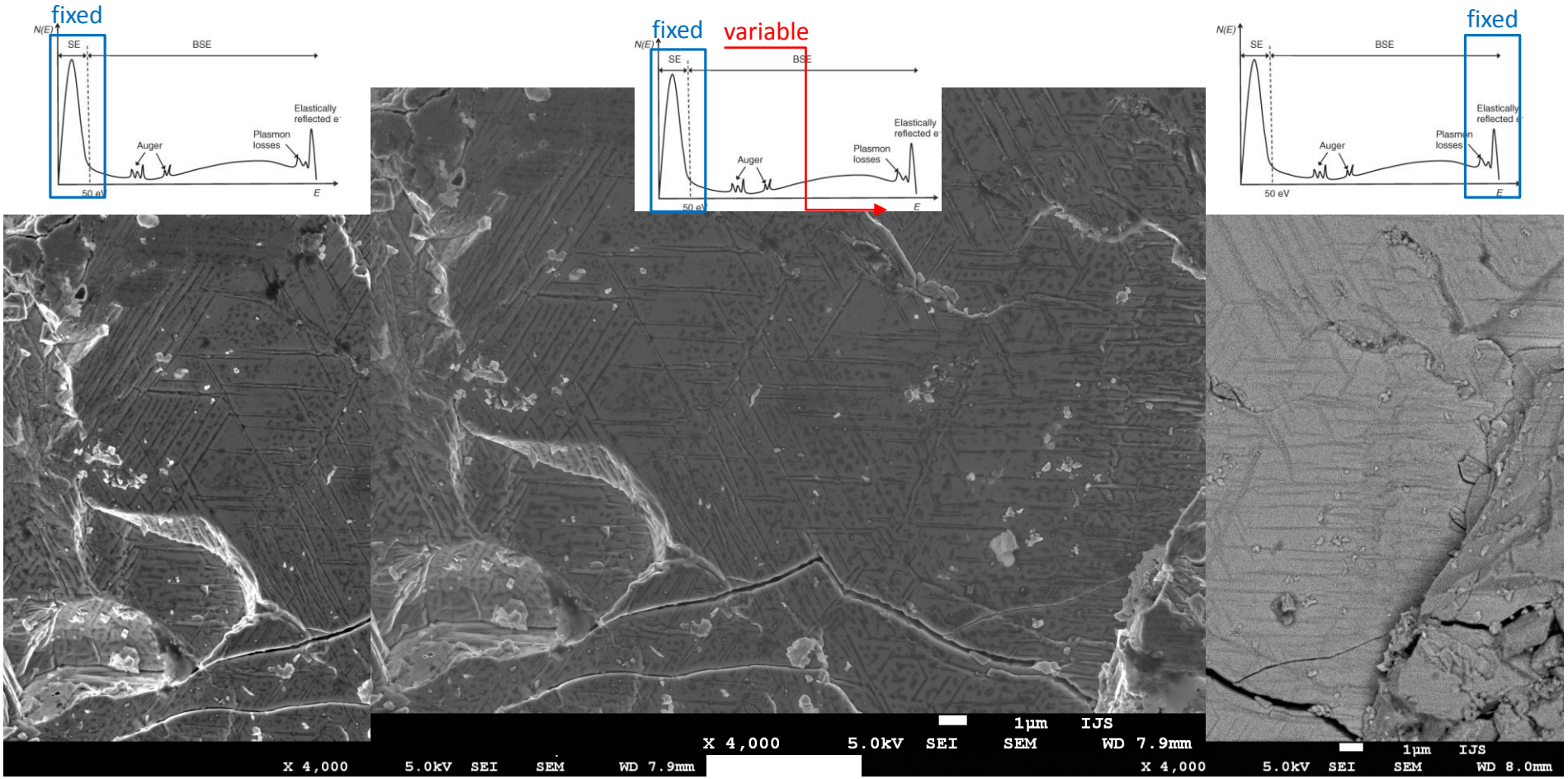
(Video: YouTube)

R filter – electrostatic lens

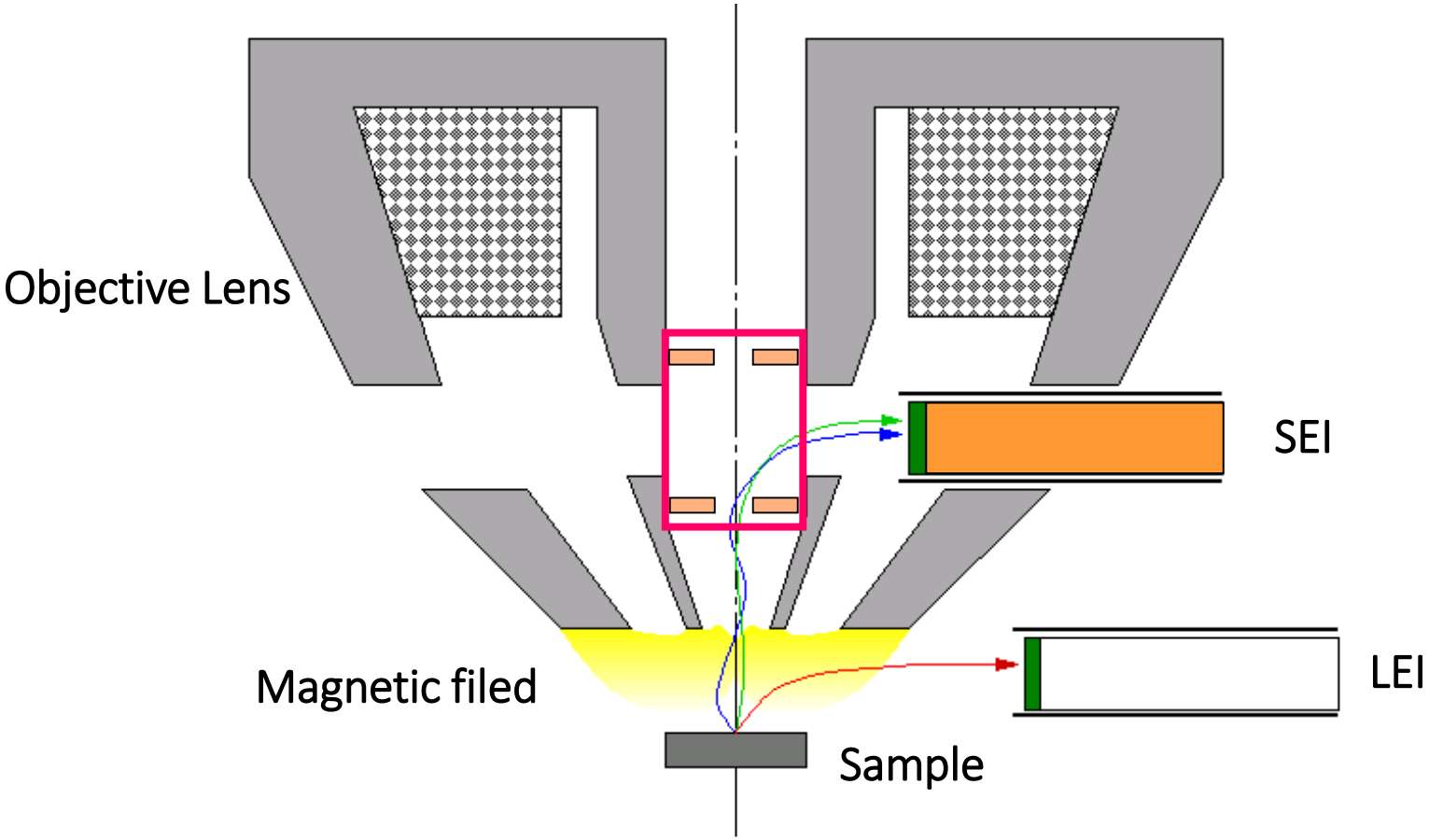


SE mode

SB mode

BE mode

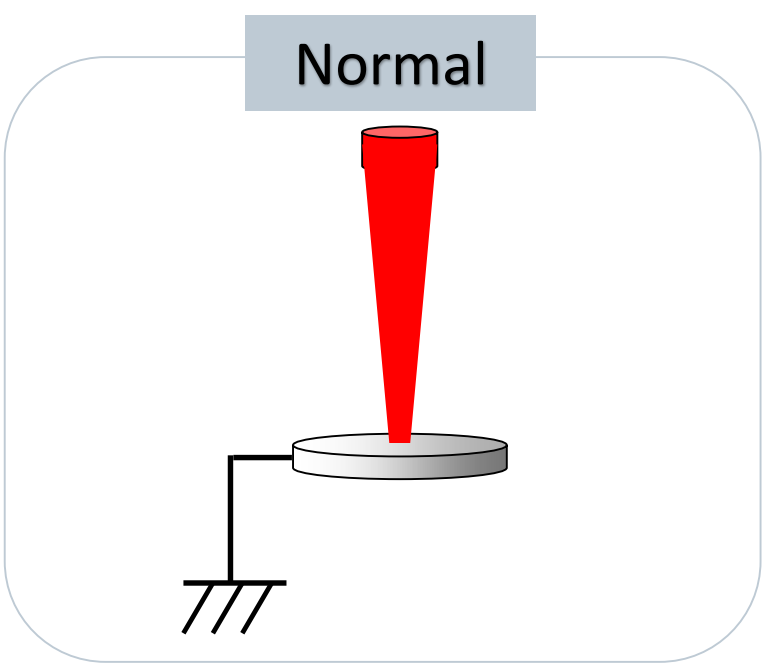
Electrostatic lense



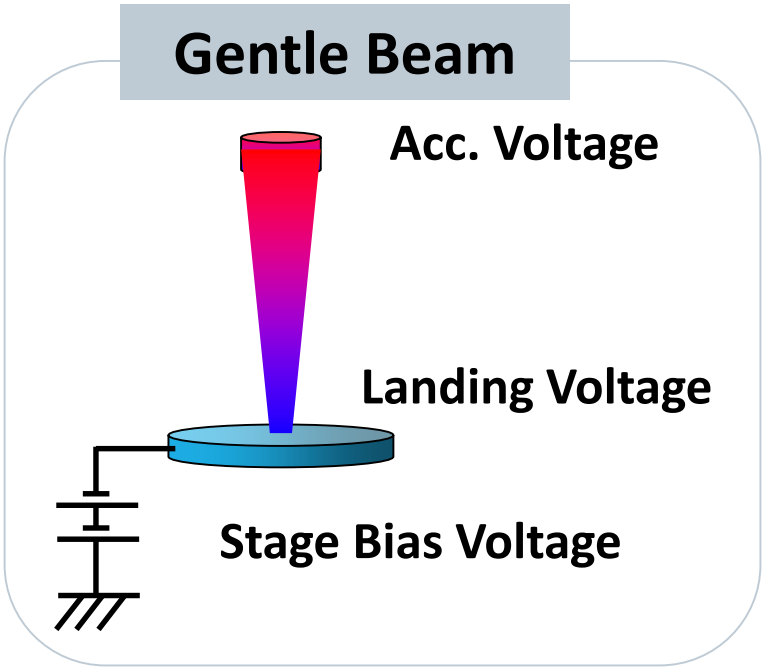
(Image: JEOL)

GENTLE BEAM

Obtain higher image resolution by decelerating primary electron beam just before landing at the specimen



Landing Voltage = Accelerating Voltage



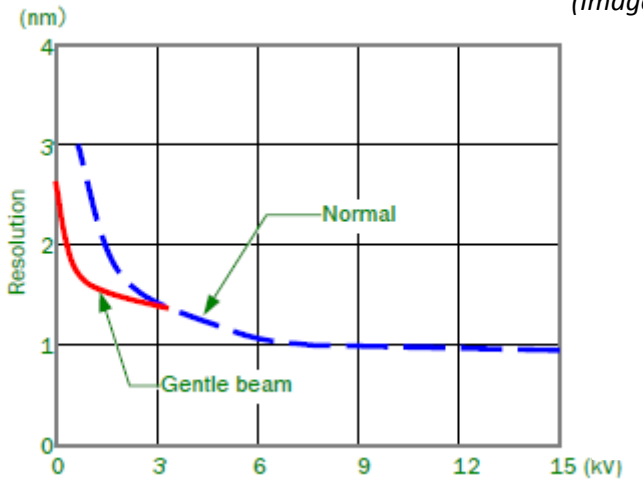
Landing Voltage =Acc. Voltage - Bias Voltage

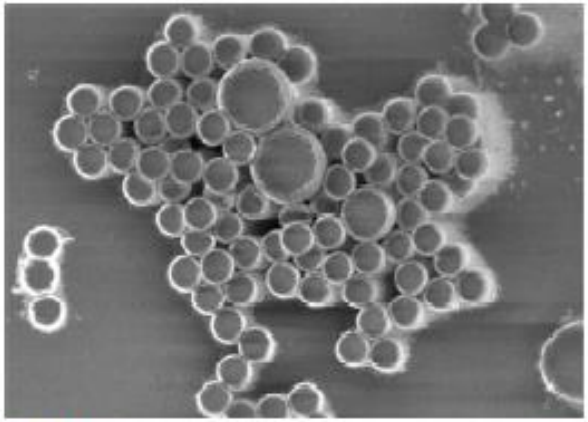
(Images: JEOL)

SEM vs GB mode

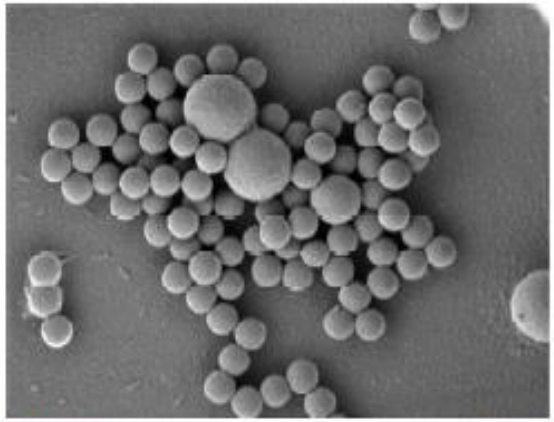
- Improves image resolution
- Reduces charging and beam damage
- Shows pure surface topographic information

(Images: JEOL)

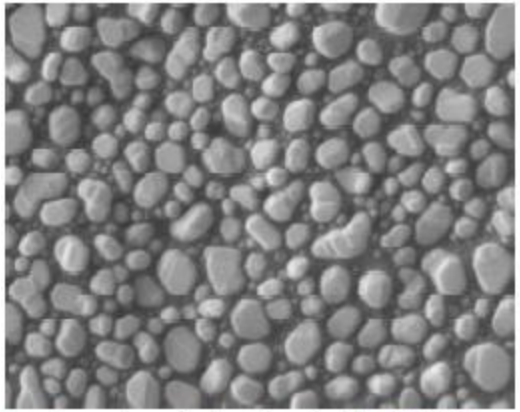




SEM 500V SiO_2



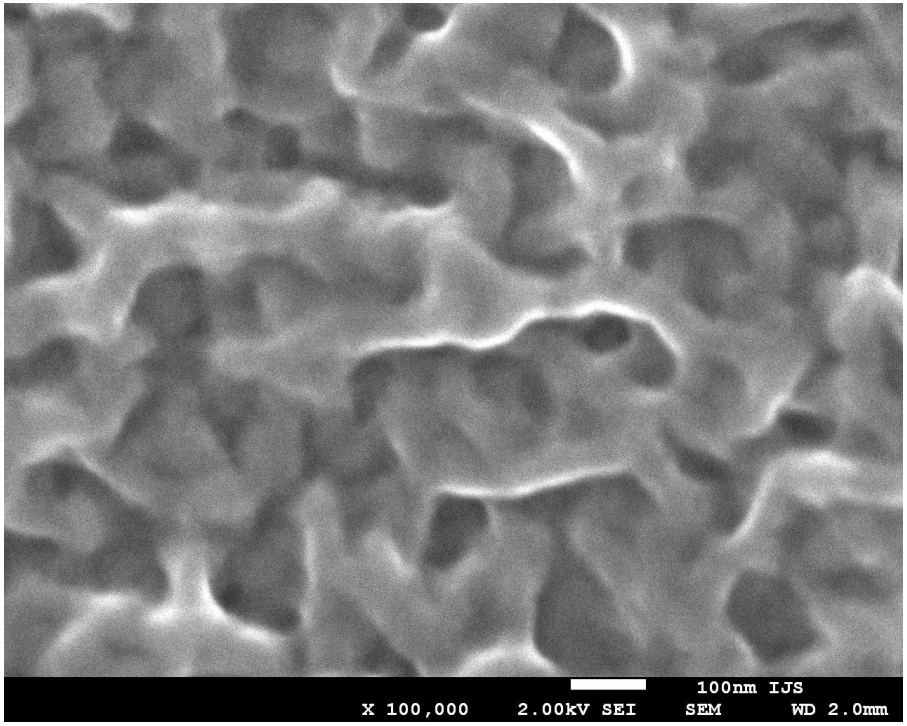
GB 500V SiO_2



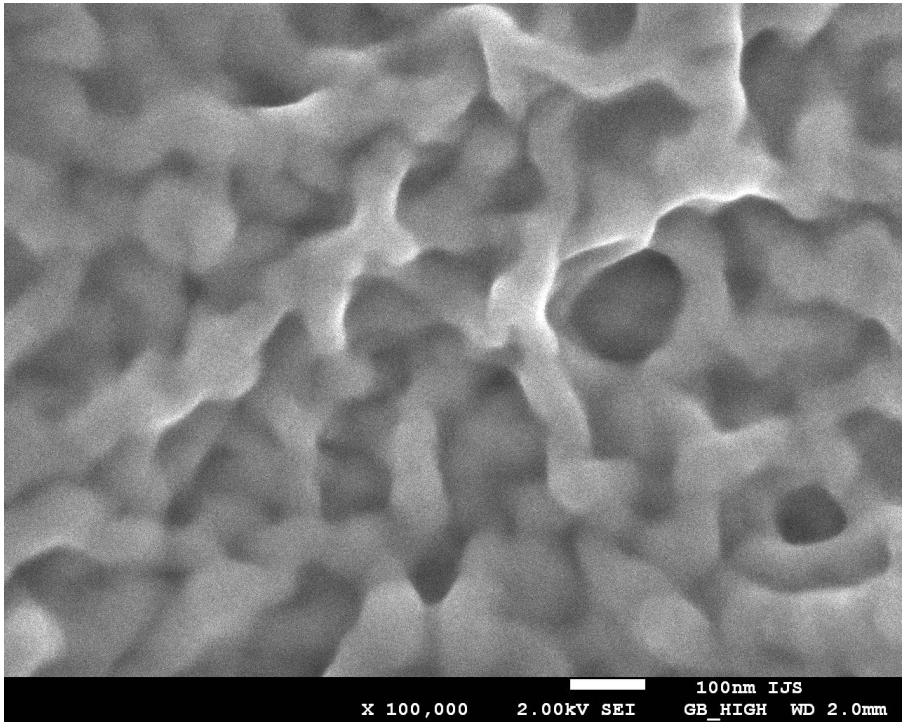
Vapor-deposited grains of gold GB 100 V

SEM vs GB mode

SEM



GB mode



SEM

3RD CEMM WORKSHOP: **GRAPHIC USER INTERFACE ON JSM-7600F**

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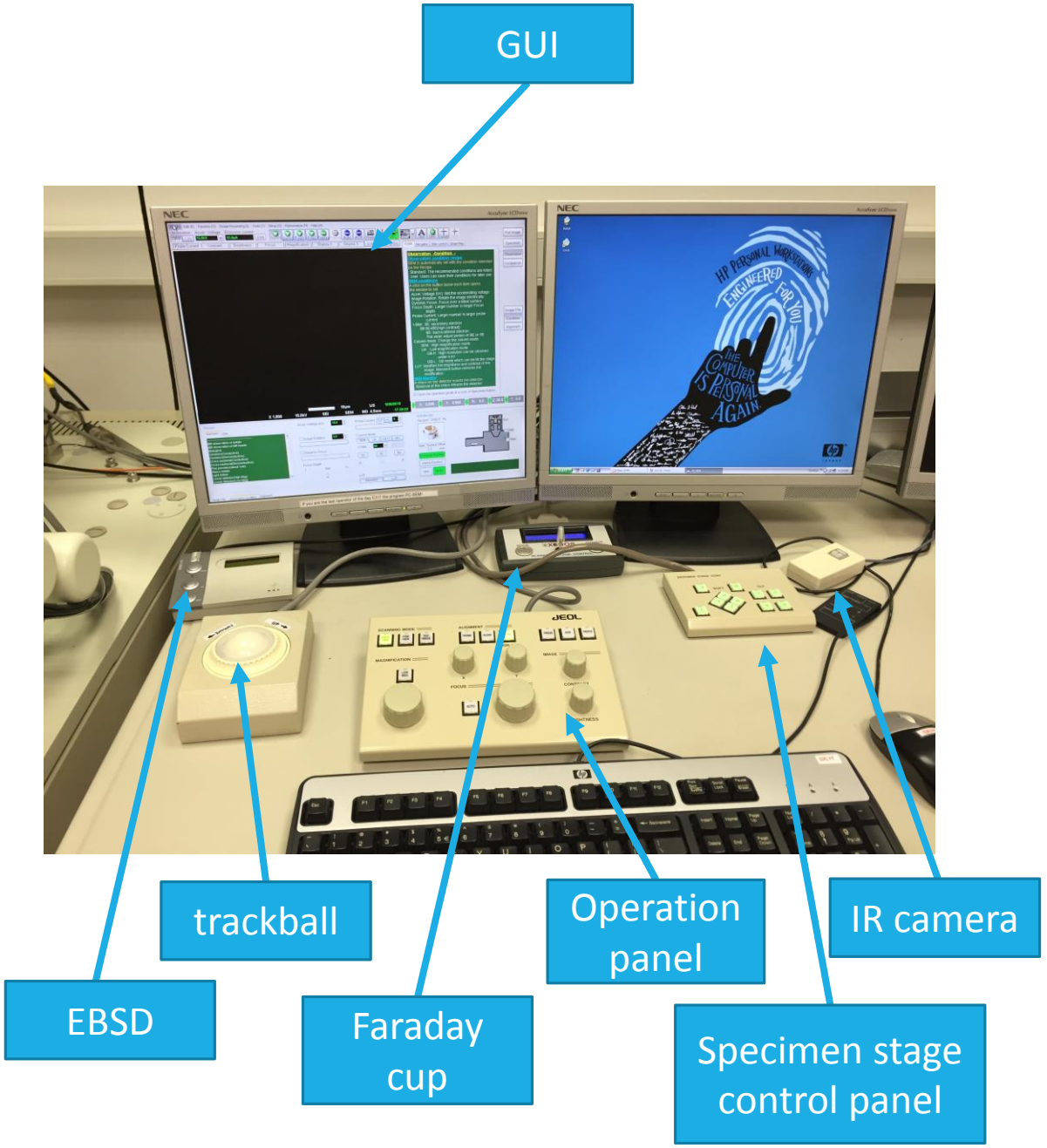
CEMM

Center for electron microscopy and microanalysis

GRAFIC USER INTERFACE



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Electron gun - basic

Voltage (electrical potential)

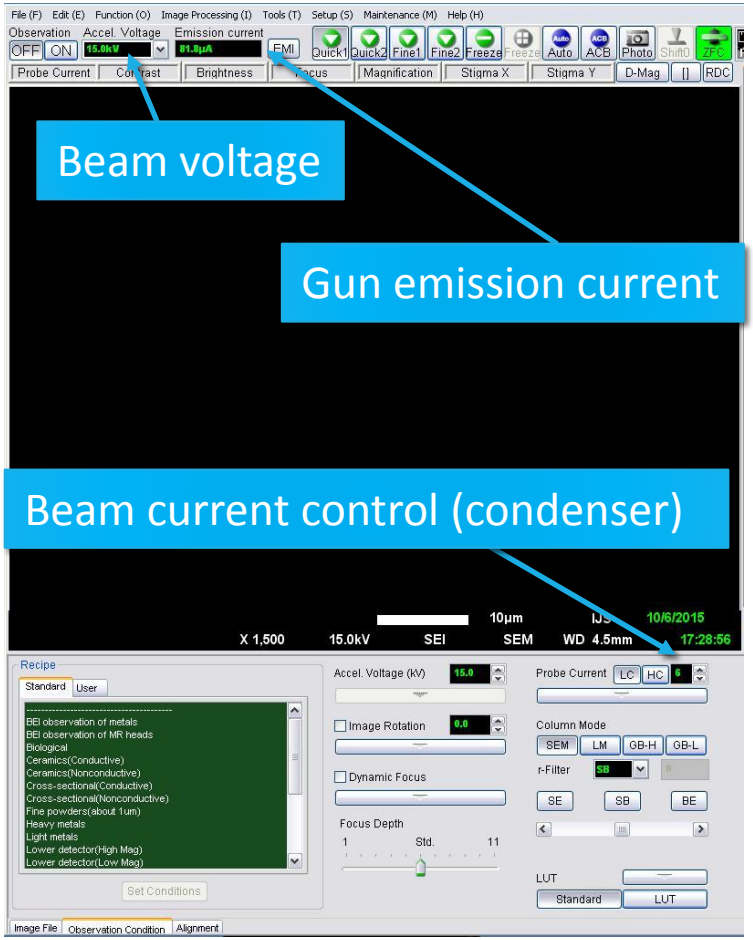
- Consider as the spread or energy of electrons
- Typically 1-30 kV or keV

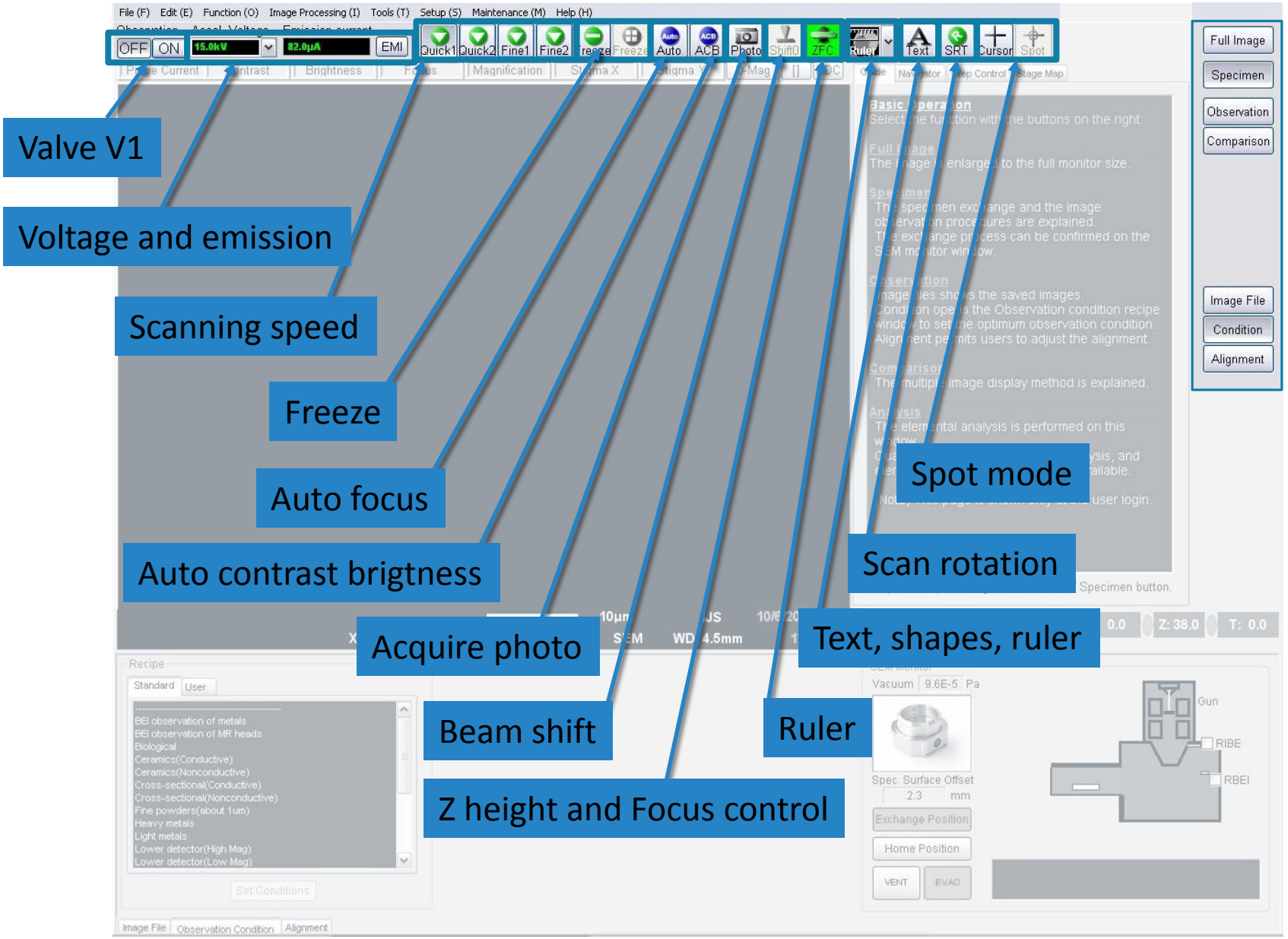
Current (number of electrons/unit time (amps))

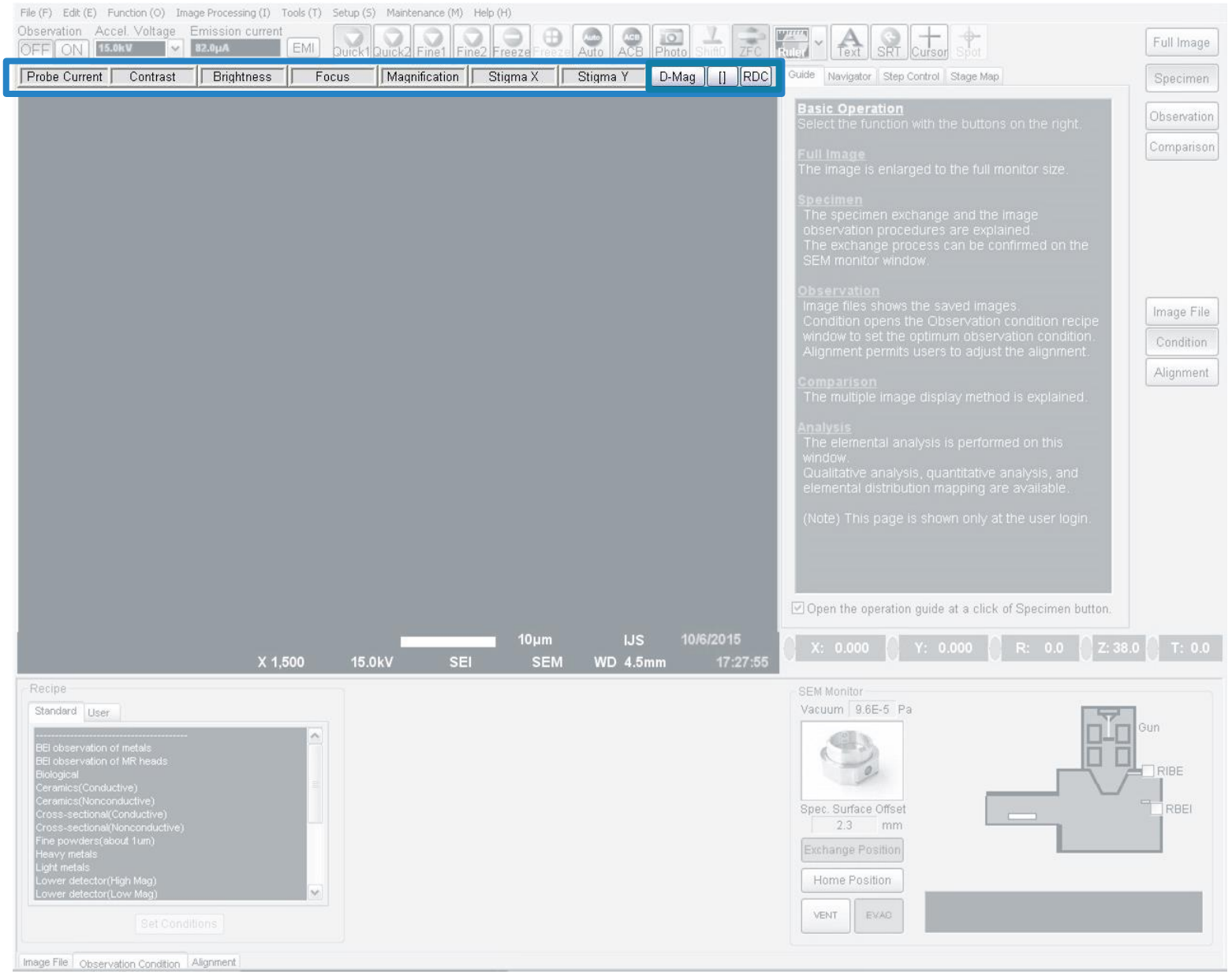
- 1 coulomb ~ 6 x 10^{18} electrons

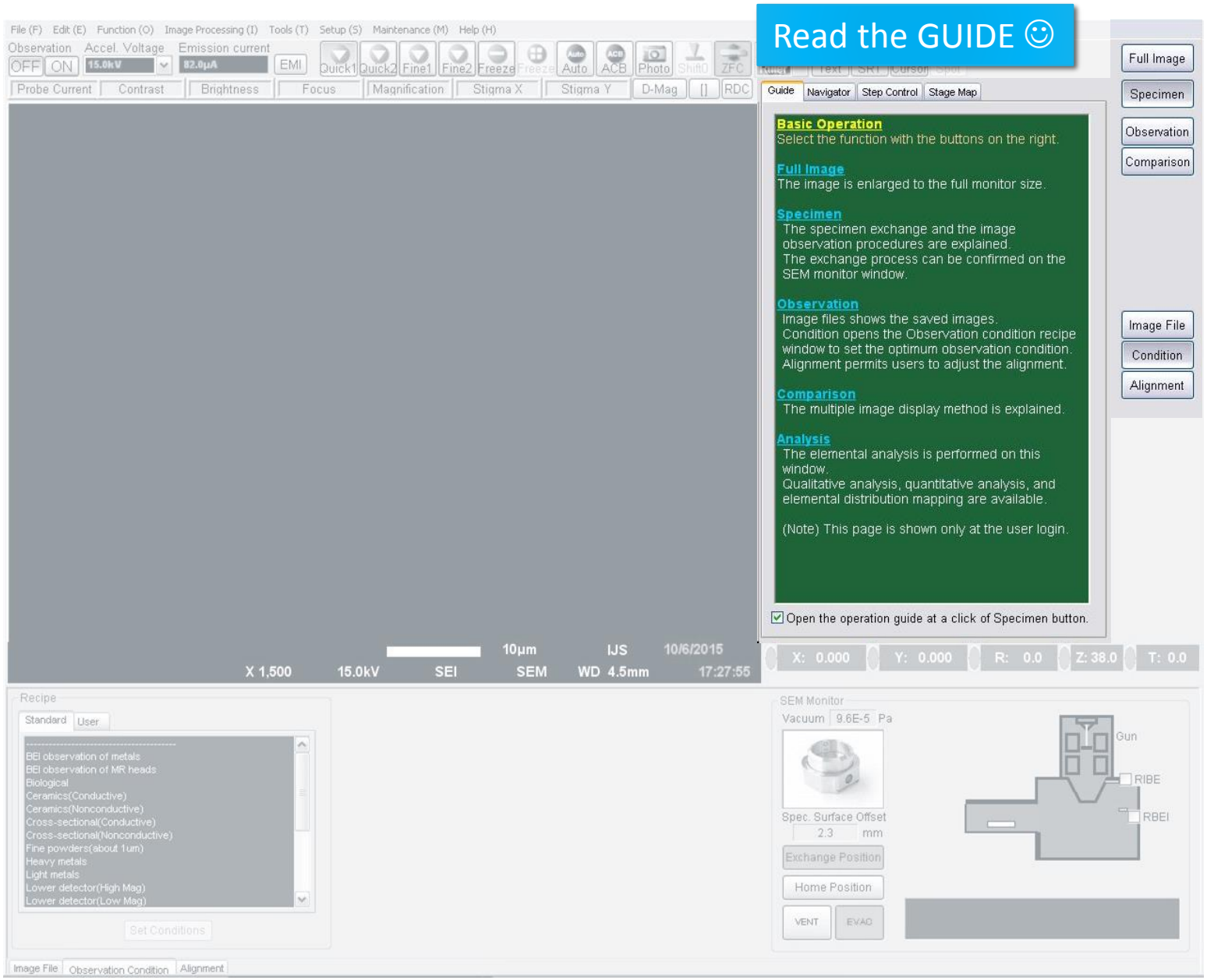
$$1C = 1A \cdot 1s$$

- Typically from 10^{-12} A to 10^{-9} A
- So 1 nA~ 6 x 10^{9} electrons/sec




Valve V1
Voltage and emission
Scanning speed
Freeze
Auto focus
Auto contrast brigtness
Acquire photo
Beam shift
Z height and Focus control
Ruler
Text, shapes, ruler
Scan rotation
Spot mode


File (F) Edit (E) Function (O) Image Processing (I) Tools (T) Setup (S) Maintenance (M) Help (H)
Observation Accel. Voltage Emission current
OFF ON 15.0kV 82.0μA EMI
Quick1 Quick2 Fine1 Fine2 Freeze Auto ACB Photo Shift0 ZFC Ruler Text SRT Cursor Spot
Probe Current Contrast Brightness Focus Magnification Stigma X Stigma Y D-Mag [] RDC
Guide Navigator Step Control Stage Map
Basic Operation
Select the function with the buttons on the right.
Full Image
The image is enlarged to the full monitor size.
Specimen
The specimen exchange and the image observation procedures are explained.
The exchange process can be confirmed on the SEM monitor window.
Observation
Image files shows the saved images.
Condition opens the Observation condition recipe window to set the optimum observation condition.
Alignment permits users to adjust the alignment.
Comparison
The multiple image display method is explained.
Analysis
The elemental analysis is performed on this window.
Qualitative analysis, quantitative analysis, and elemental distribution mapping are available.
(Note) This page is shown only at the user login.
Open the operation guide at a click of Specimen button.
Full Image
Specimen
Observation
Comparison
Image File
Condition
Alignment
10μm IJS 10/6/2015
X 1,500 15.0kV SEI SEM WD 4.5mm 17:27:55
X: 0.000 Y: 0.000 R: 0.0 Z: 38.0 T: 0.0
Recipe
Standard User
BEI observation of metals
BEI observation of MR heads
Biological
Ceramics(Conductive)
Ceramics(Nonconductive)
Cross-sectional(Conductive)
Cross-sectional(Nonconductive)
Fine powders(about 1um)
Heavy metals
Light metals
Lower detector(High Mag)
Lower detector(Low Mag)
Set Conditions
SEM Monitor
Vacuum 9.6E-5 Pa
Spec. Surface Offset
2.3 mm
Exchange Position
Home Position
VENT EVAC
Gun
RIBE
RBEI
Image File Observation Condition Alignment


Read the GUIDE ☺
File (F) Edit (E) Function (O) Image Processing (I) Tools (T) Setup (S) Maintenance (M) Help (H)
Observation Accel. Voltage Emission current
OFF ON 15.0kV 82.0µA EMI
Quick1 Quick2 Fine1 Fine2 Freeze Auto ACB Photo ZFC
Probe Current Contrast Brightness Focus Magnification Stigma X Stigma Y D-Mag RDC
Guide Navigator Step Control Stage Map
Basic Operation
Select the function with the buttons on the right.
Full Image
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Specimen
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The exchange process can be confirmed on the SEM monitor window.
Observation
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Condition opens the Observation condition recipe window to set the optimum observation condition.
Alignment permits users to adjust the alignment.
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The multiple image display method is explained.
Analysis
The elemental analysis is performed on this window.
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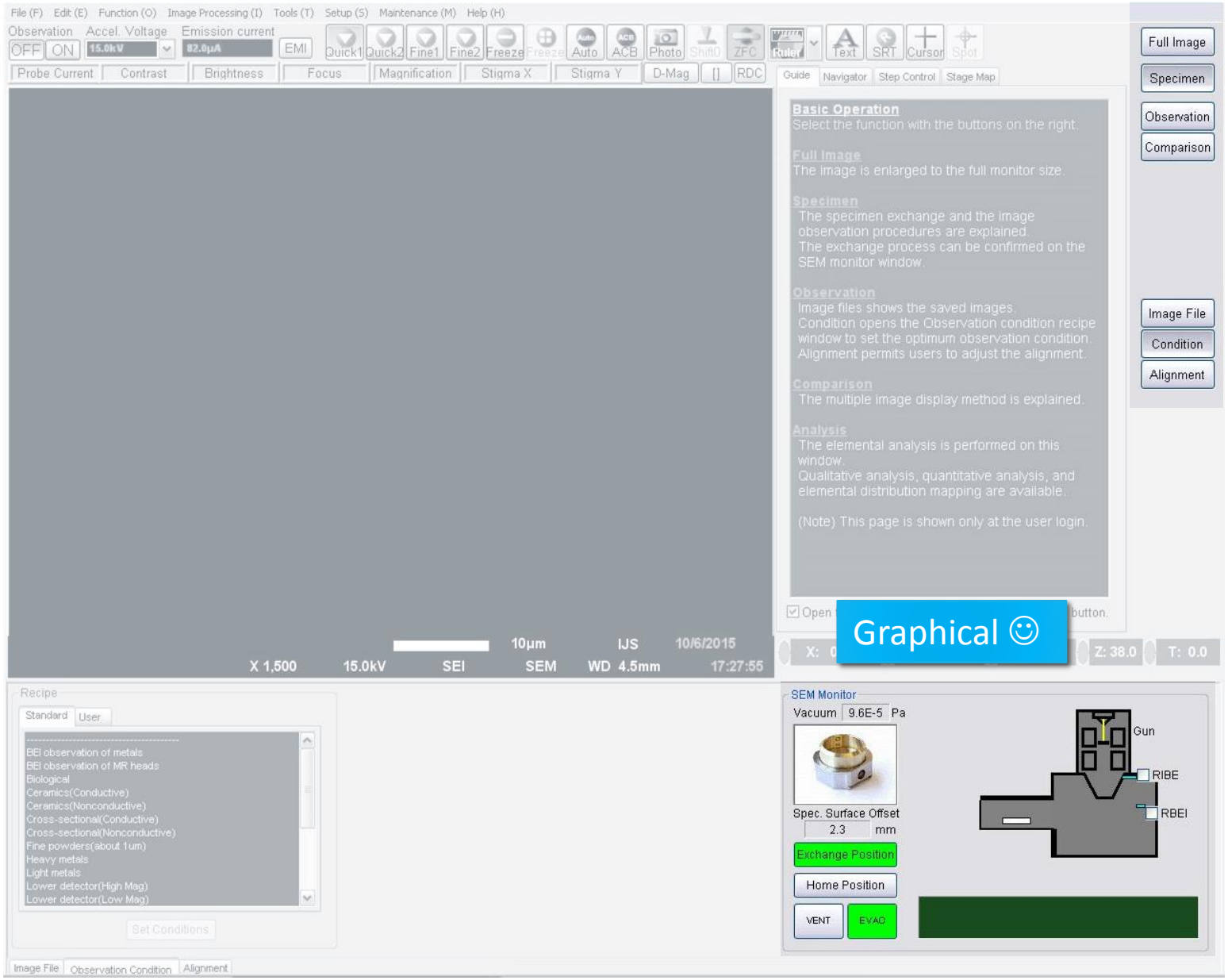
(Note) This page is shown only at the user login.
Open the operation guide at a click of Specimen button.
Full Image
Specimen
Observation
Comparison
Image File
Condition
Alignment
10µm IJS 10/6/2015
X 1,500 15.0kV SEI SEM WD 4.5mm 17:27:55
X: 0.000 Y: 0.000 R: 0.0 Z: 38.0 T: 0.0
Recipe
Standard User
BEI observation of metals
BEI observation of MR heads
Biological
Ceramics(Conductive)
Ceramics(Nonconductive)
Cross-sectional(Conductive)
Cross-sectional(Nonconductive)
Fine powders(about 1um)
Heavy metals
Light metals
Lower detector(High Mag)
Lower detector(Low Mag)
Set Conditions
SEM Monitor
Vacuum 9.6E-5 Pa
Spec. Surface Offset
2.3 mm
Exchange Position
Home Position
VENT EVAC
Gun
RIBE
RBEI
Image File Observation Condition Alignment


File (F) Edit (E) Function (O) Image Processing (I) Tools (T) Setup (S) Maintenance (M) Help (H)
Observation Accel. Voltage Emission current
OFF ON 15.0kV 82.0μA EMI
Quick1 Quick2 Fine1 Fine2 Freeze Auto ACB Photo Shift0 ZFC Ruler Text SRT Cursor Spot
Probe Current Contrast Brightness Focus Magnification Stigma X Stigma Y D-Mag [] RDC
Guide Navigator Step Control Stage Map
Basic Operation
Select the function with the buttons on the right.
Full Image
The image is enlarged to the full monitor size.
Specimen
The specimen exchange and the image observation procedures are explained.
The exchange process can be confirmed on the SEM monitor window.
Observation
Image files shows the saved images.
Condition opens the Observation condition recipe window to set the optimum observation condition.
Alignment permits users to adjust the alignment.
Comparison
The multiple image display method is explained.
Analysis
The elemental analysis is performed on this window.
Qualitative analysis, quantitative analysis, and elemental distribution mapping are available.
(Note) This page is shown only at the user login.
Open button.
Full Image
Specimen
Observation
Comparison
Image File
Condition
Alignment
10μm IJS 10/6/2015
X 1,500 15.0kV SEI SEM WD 4.5mm 17:27:55
X: Z: 38.0 T: 0.0
Graphical ☺
Recipe
Standard User
BEI observation of metals
BEI observation of MR heads
Biological
Ceramics(Conductive)
Ceramics(Nonconductive)
Cross-sectional(Conductive)
Cross-sectional(Nonconductive)
Fine powders(about 1um)
Heavy metals
Light metals
Lower detector(High Mag)
Lower detector(Low Mag)
Set Conditions
Image File Observation Condition Alignment
SEM Monitor
Vacuum 9.6E-5 Pa
Spec. Surface Offset
2.3 mm
Exchange Position
Home Position
VENT EVAC
Gun
RIBE
RBEI

When you start the SEM session on JSM-7600F

CEMM manuals

http://cemm.ijs.si

Home | About us | Equipment | Reservations | News | Gallery | Contact

Scanning electron microscopy

In CEMM we have three scanning electron microscopes: JEOL JXA-840A, JEOL JSM-5800 and JEOL 7600F.

JEOL JSM-5800 (manual JSM-5800)

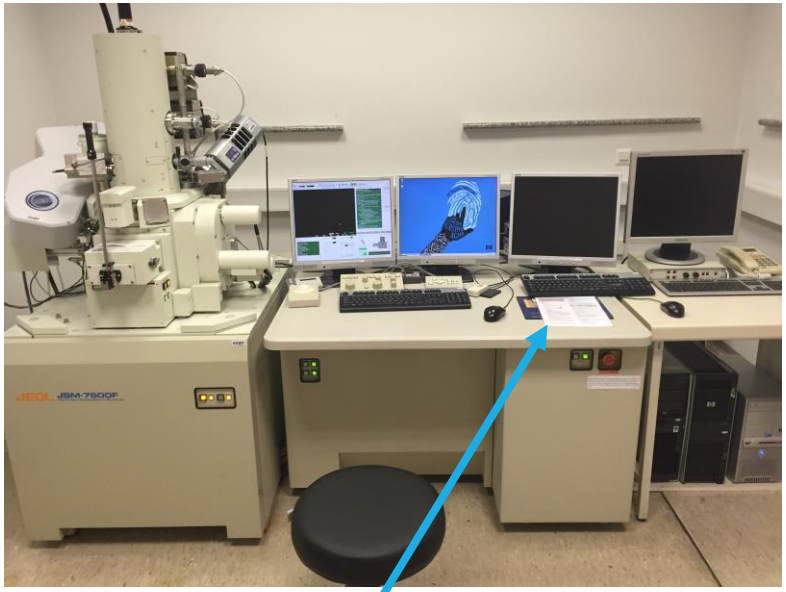
- SE, BE detectors
- Oxford Instruments ISIS 300 EDS
- digital imaging

Jeol JXA-840A (manual JXA-840A)

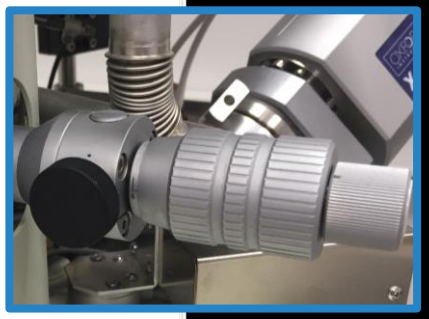
- SE, BE detectors
- Tracor TN 5600 EDS
- 2 WDS spectrometers
- digital imaging

Jeol JSM-7600F (manual JSM-7600F)

- In-Lens Thermal FEG
- SEI, LEI detectors
- BE detectors (RIBE, RBEI)
- INCA Oxford 350 EDS SDD (20mm2)
- INCA Wave 500 spectrometer
- XENOS XeDraw 2 e-lithograph
- EBSD, Channel 5, Oxford Instruments
- r-filter for contaminating SE in BE signals
- prechamber



Short instructions



Set the initial parameters

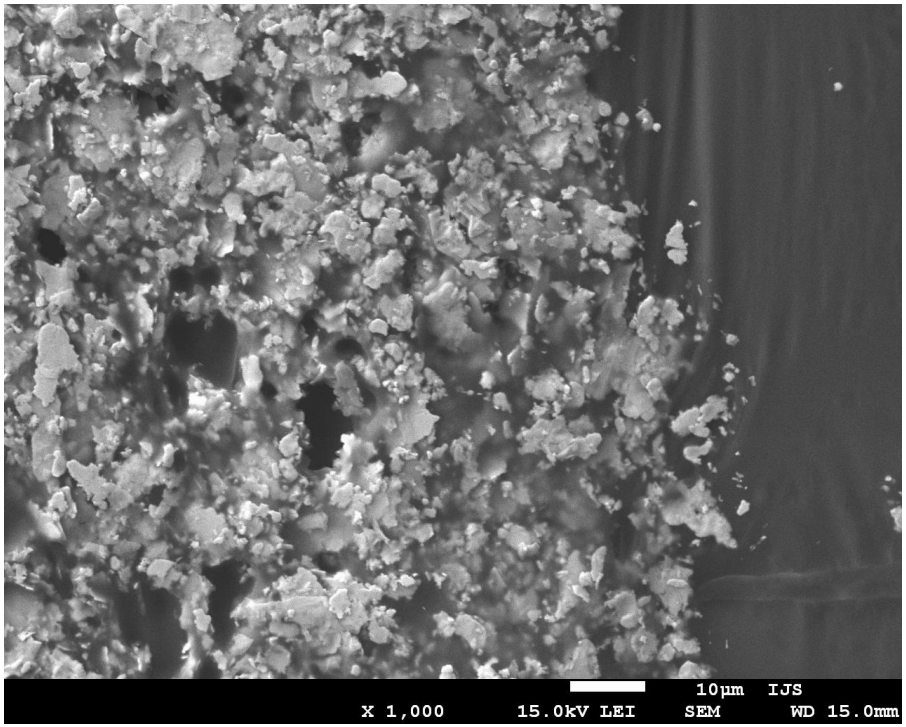
Voltage

Figure removed for copyright reasons.

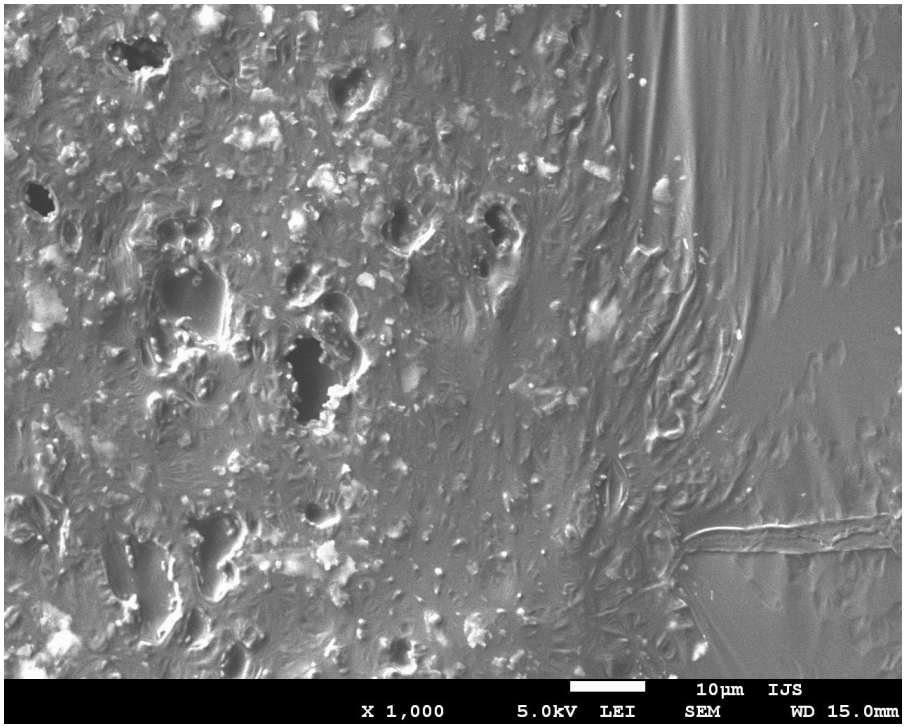
(Images: ammrf)

Voltage

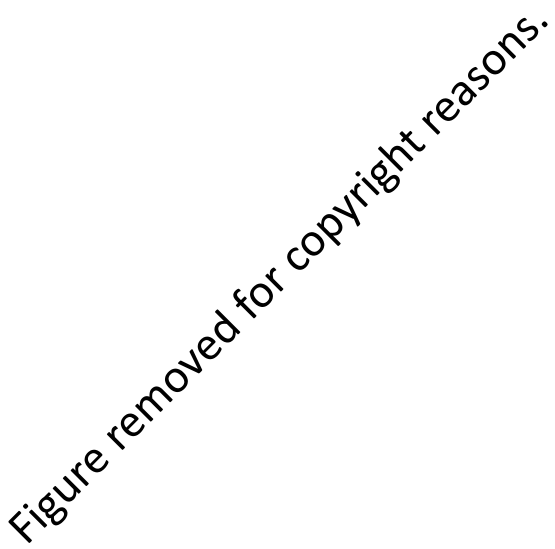
15 kV



5 kV

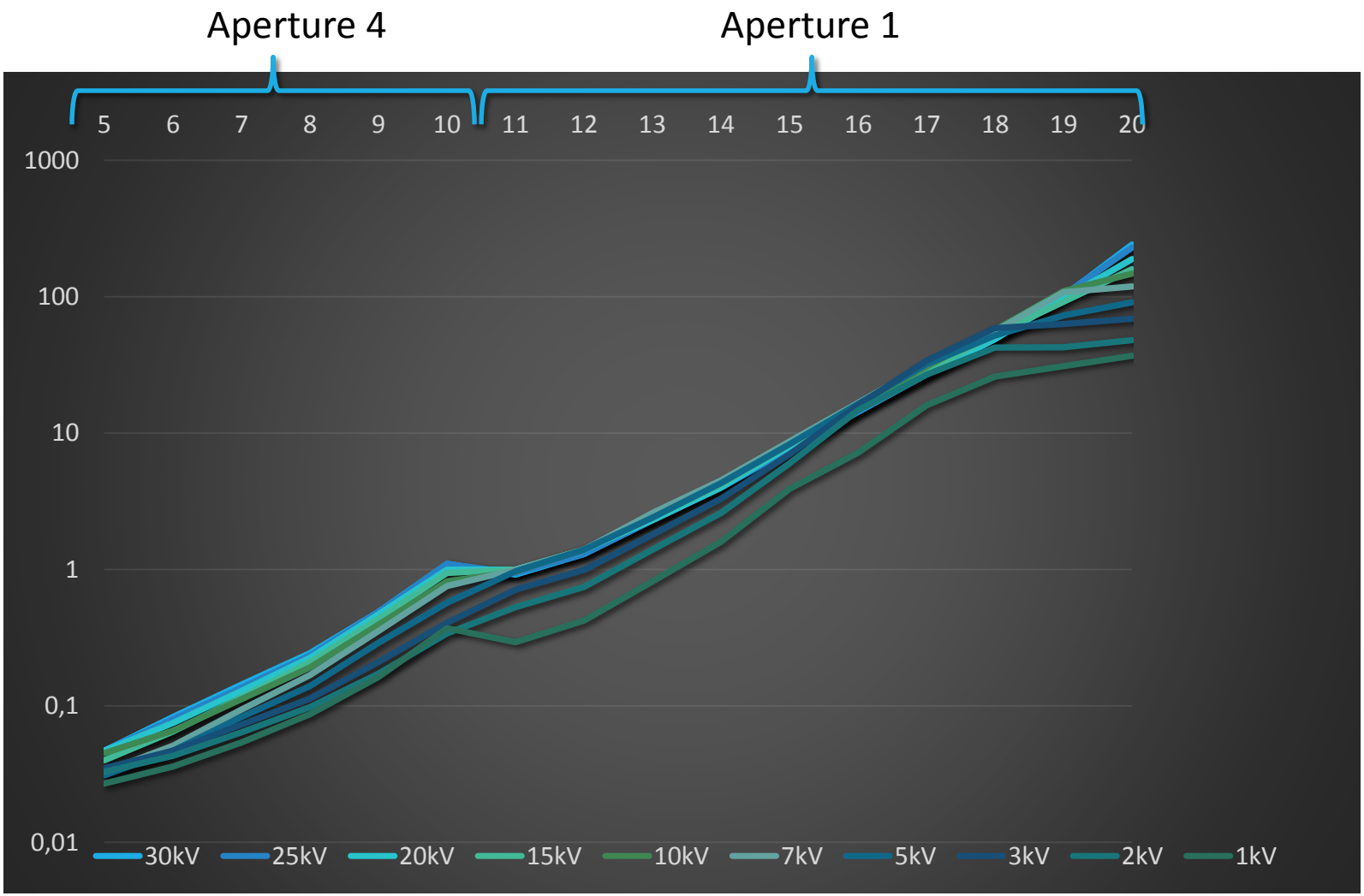


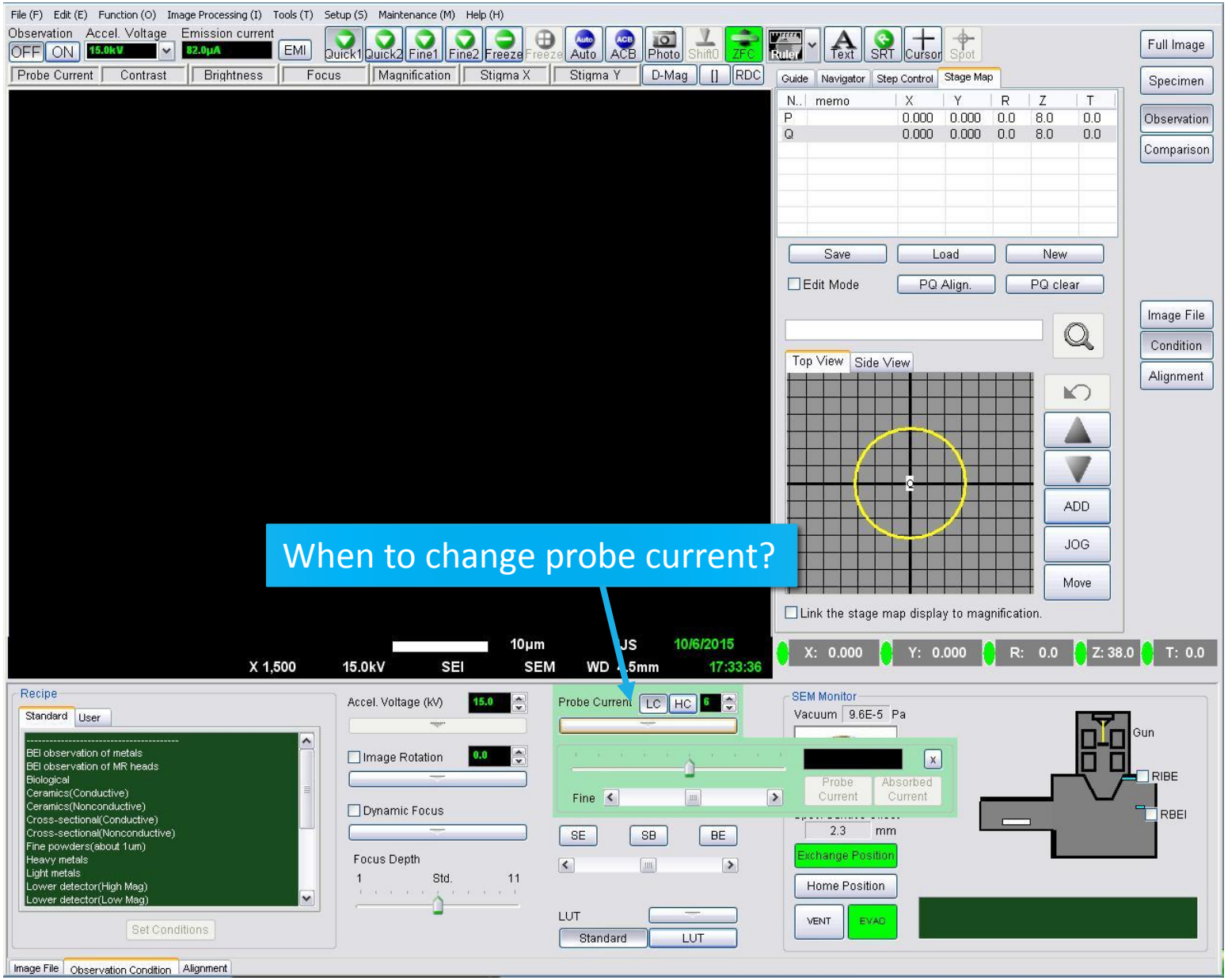
Probe current



(Images: ammrf)

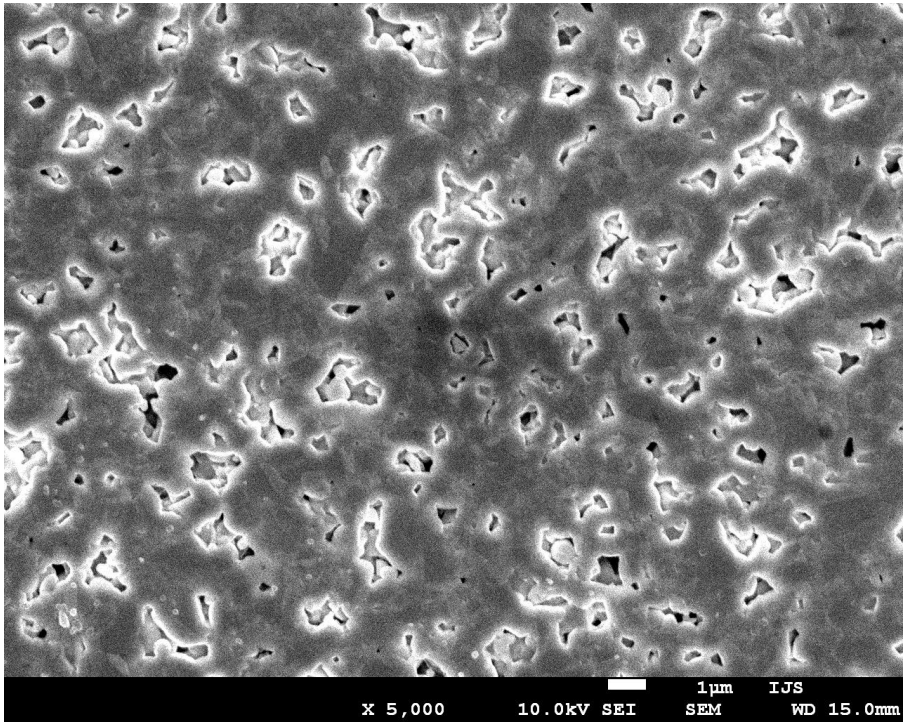
Probe current vs PC Values



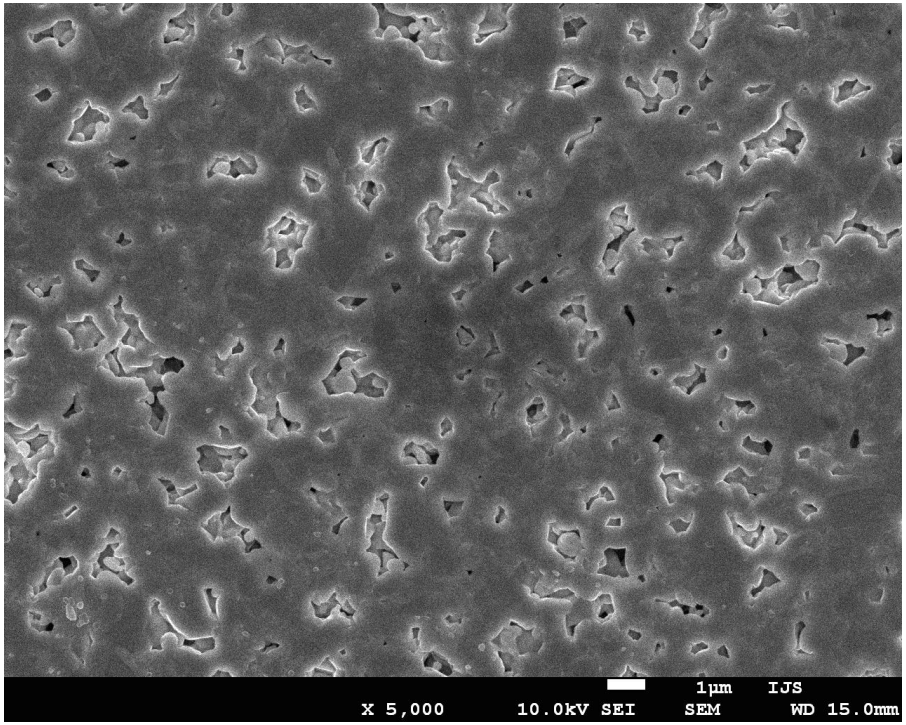

When to change probe current?

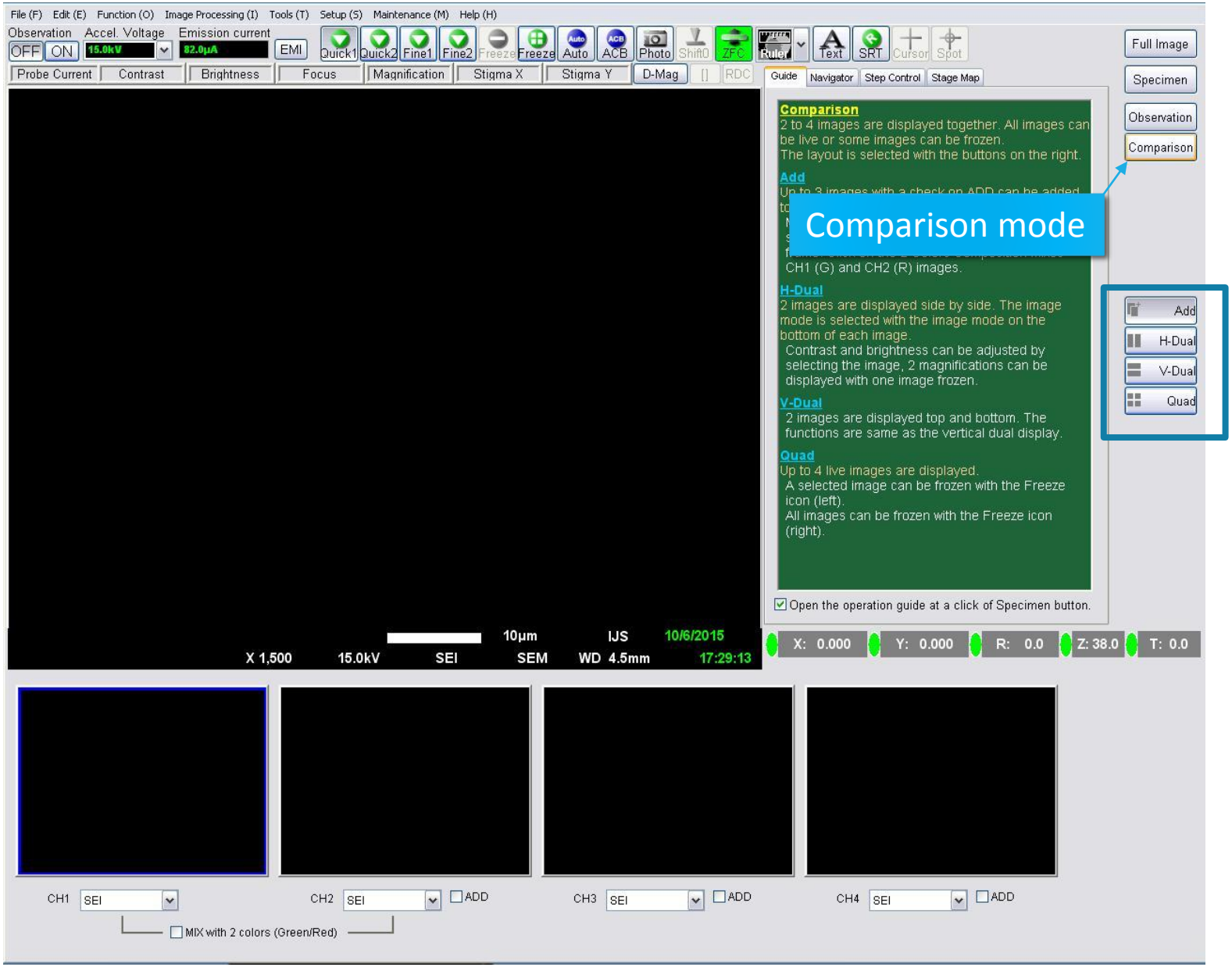
Probe current

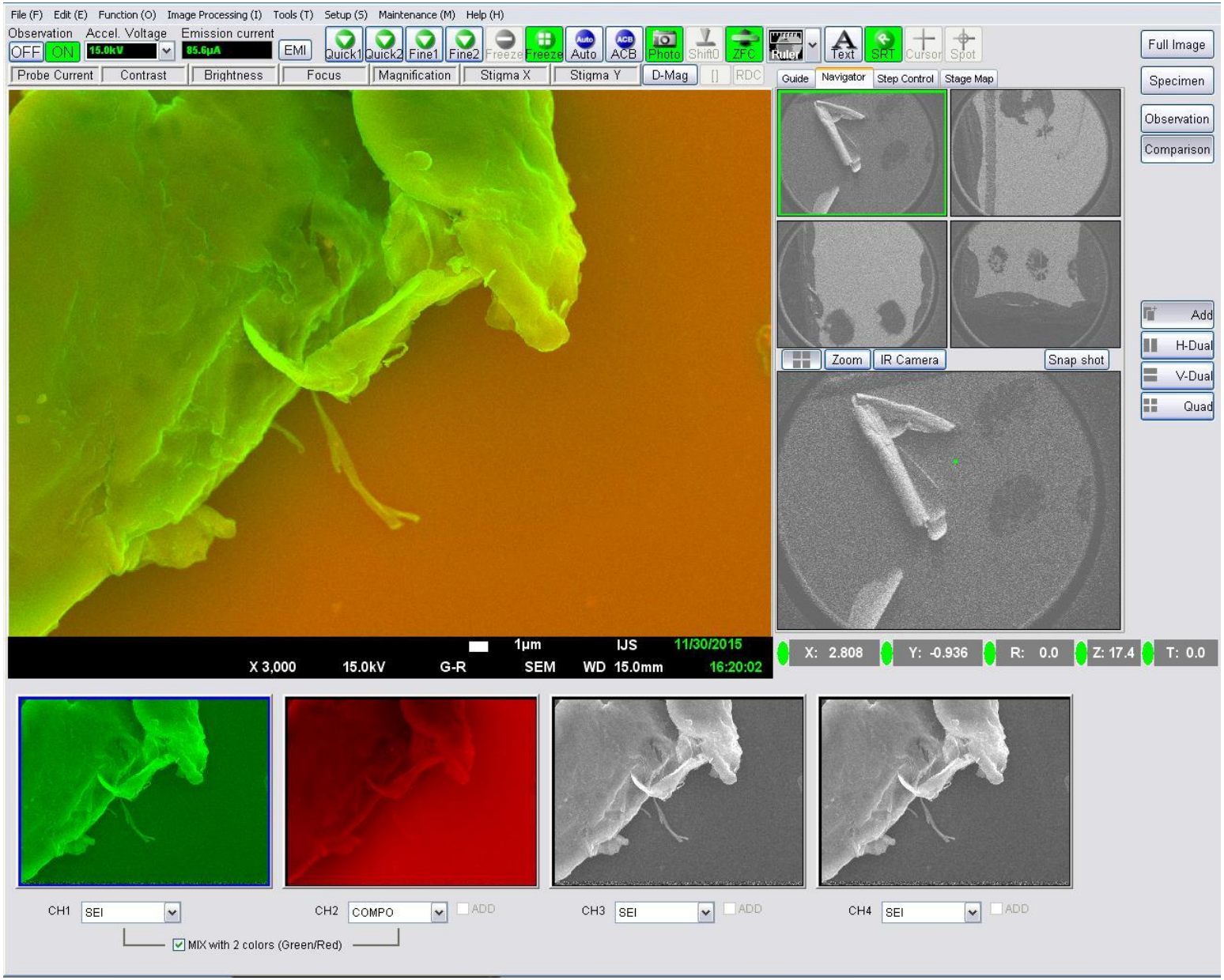
PC 8 → 0,35 nA



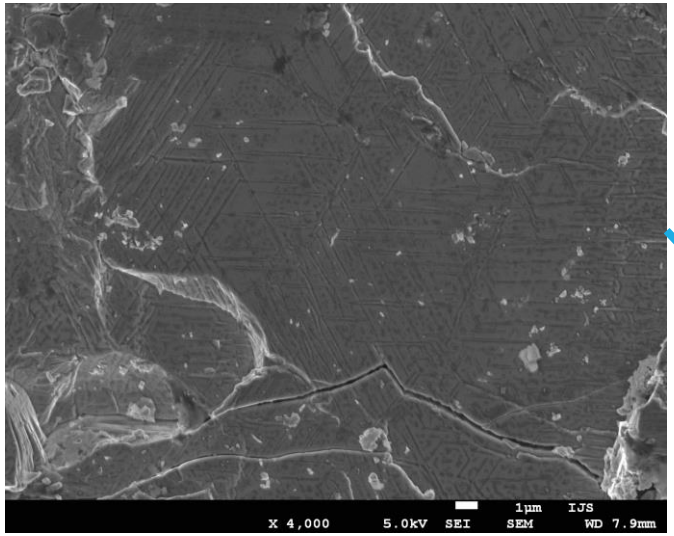
PC 6 → 0,08 nA

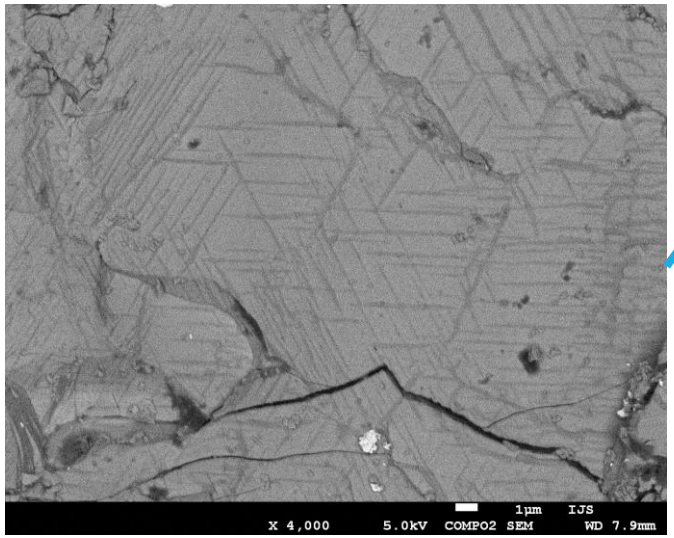


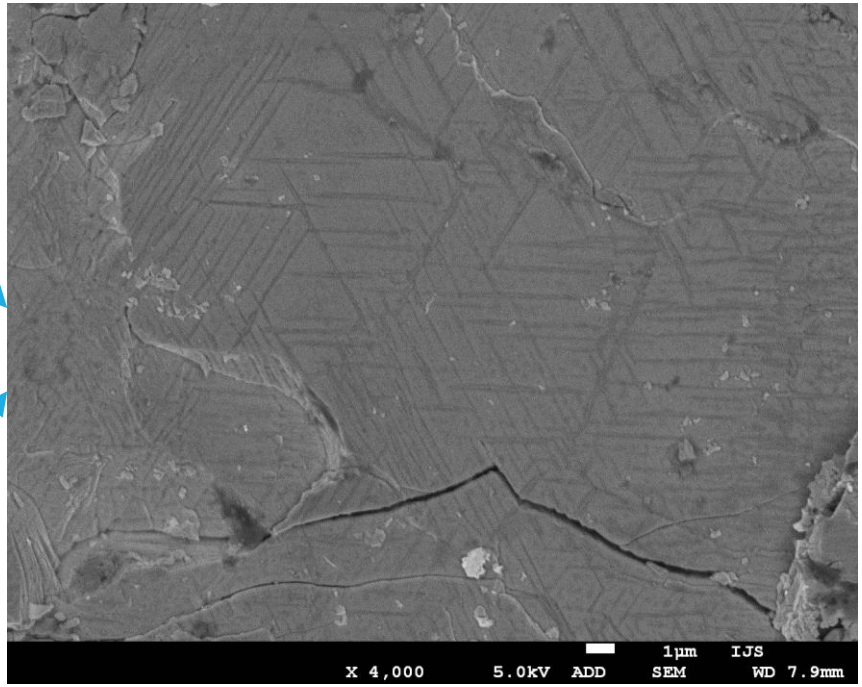

File (F) Edit (E) Function (O) Image Processing (I) Tools (T) Setup (S) Maintenance (M) Help (H)
Observation
Accel. Voltage
Emission current
OFF
ON
15.0kV
82.0µA
EMI
Quick1
Quick2
Fine1
Fine2
Freeze
Freeze
Auto
ACB
Photo
Shift0
ZFC
Ruler
Text
SRT
Cursor
Spot
Probe Current
Contrast
Brightness
Focus
Magnification
Stigma X
Stigma Y
D-Mag
RDC
Guide
Navigator
Step Control
Stage Map
Full Image
Specimen
Observation
Comparison
Comparison
2 to 4 images are displayed together. All images can be live or some images can be frozen.
The layout is selected with the buttons on the right.
Add
CH1 (G) and CH2 (R) images.
H-Dual
2 images are displayed side by side. The image mode is selected with the image mode on the bottom of each image.
Contrast and brightness can be adjusted by selecting the image, 2 magnifications can be displayed with one image frozen.
V-Dual
2 images are displayed top and bottom. The functions are same as the vertical dual display.
Quad
Up to 4 live images are displayed.
A selected image can be frozen with the Freeze icon (left).
All images can be frozen with the Freeze icon (right).
Comparison mode
Add
H-Dual
V-Dual
Quad
Open the operation guide at a click of Specimen button.
10µm
IJS
10/6/2015
X 1,500
15.0kV
SEI
SEM
WD 4.5mm
17:29:13
X: 0.000
Y: 0.000
R: 0.0
Z: 38.0
T: 0.0
CH1
SEI
CH2
SEI
ADD
CH3
SEI
ADD
CH4
SEI
ADD
MIX with 2 colors (Green/Red)


File (F) Edit (E) Function (O) Image Processing (I) Tools (T) Setup (S) Maintenance (M) Help (H)
Observation
OFF ON
Accel. Voltage
15.0kV
Emission current
85.6µA
EMI
Quick1 Quick2 Fine1 Fine2 Freeze Freeze Auto ACB Photo Shift0 ZFC Ruler Text SRT Cursor Spot
Probe Current Contrast Brightness Focus Magnification Stigma X Stigma Y D-Mag [] RDC
Guide Navigator Step Control Stage Map
Full Image
Specimen
Observation
Comparison
Add
H-Dual
V-Dual
Quad
Zoom IR Camera Snap shot
1µm IJS 11/30/2015
X 3,000 15.0kV G-R SEM WD 15.0mm 16:20:02
X: 2.808 Y: -0.936 R: 0.0 Z: 17.4 T: 0.0
CH1 SEI
CH2 COMPO ADD
CH3 SEI ADD
CH4 SEI ADD
MIX with 2 colors (Green/Red)

ADD (SEI + COMPO)



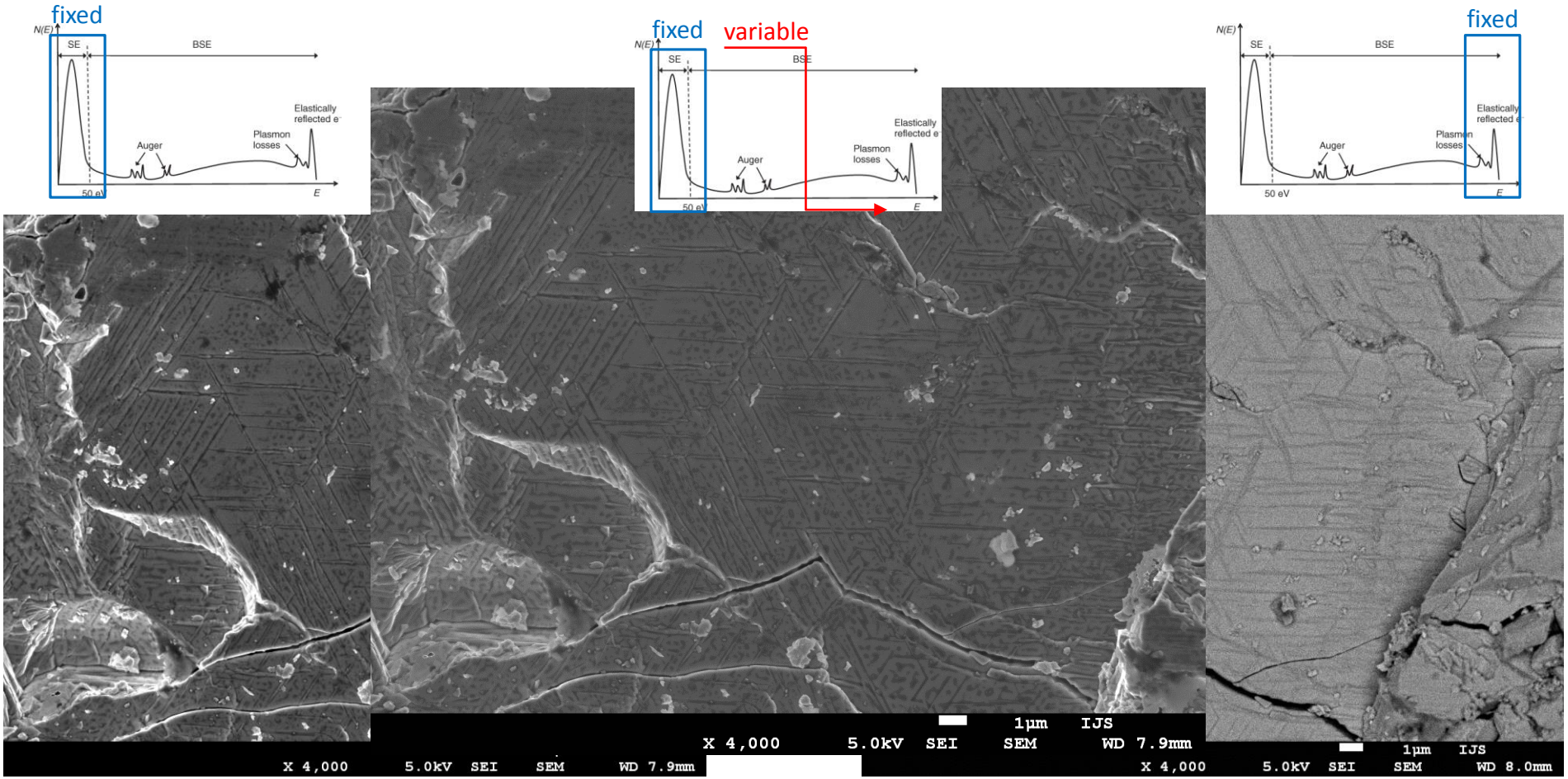




Remember R-filter?

The same image as SEI with active R-filter (SB mode).

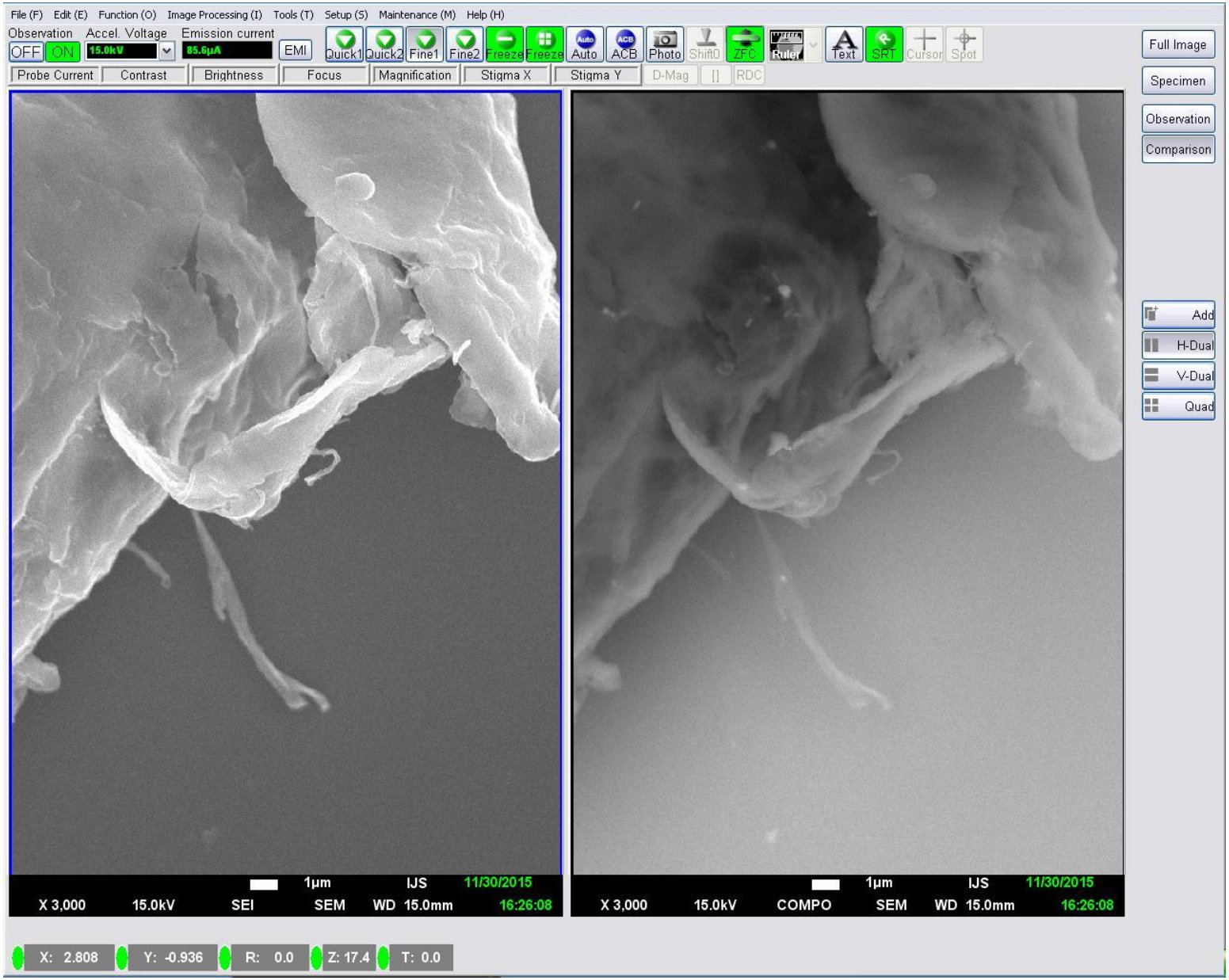
R filter – electrostatic lens

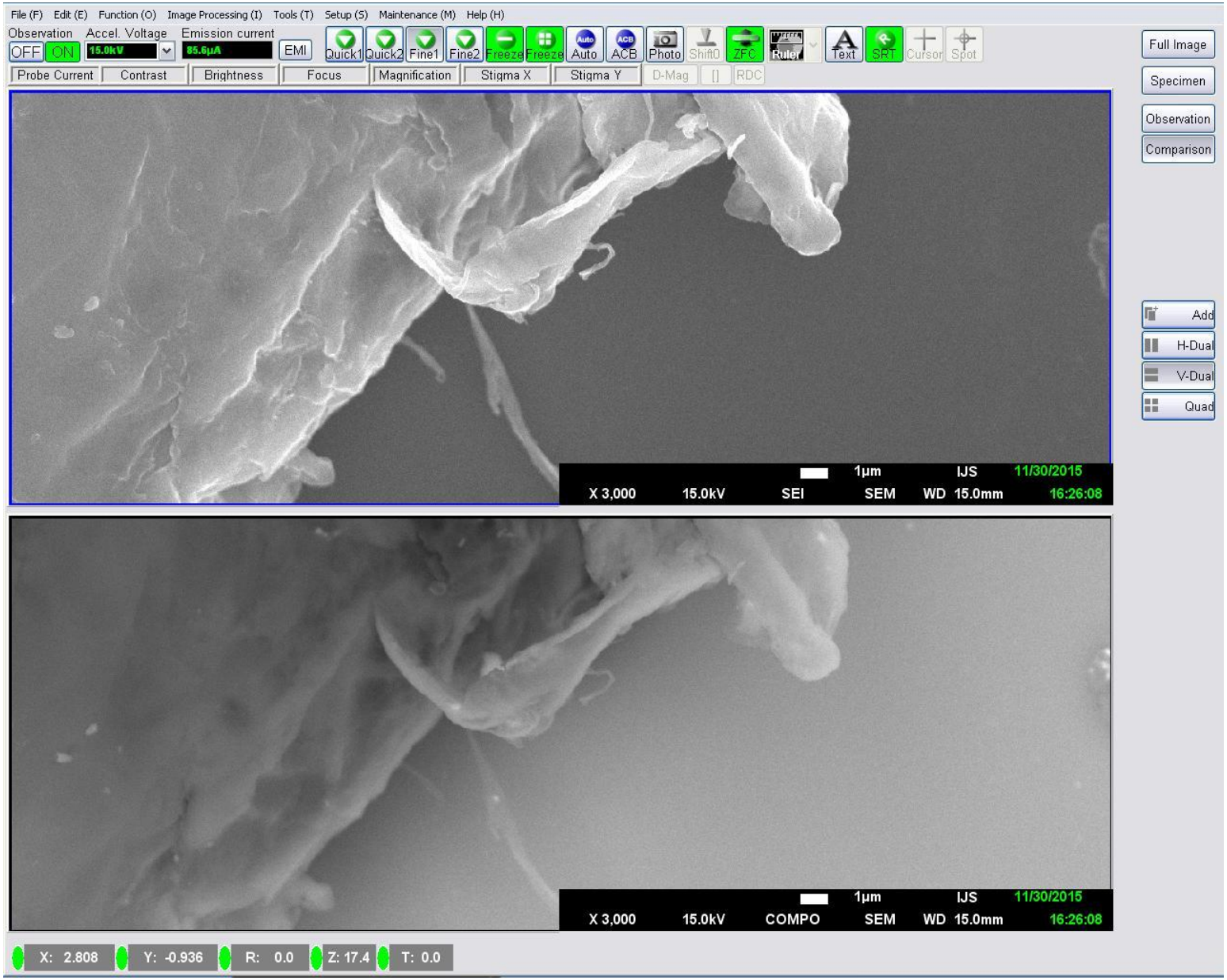


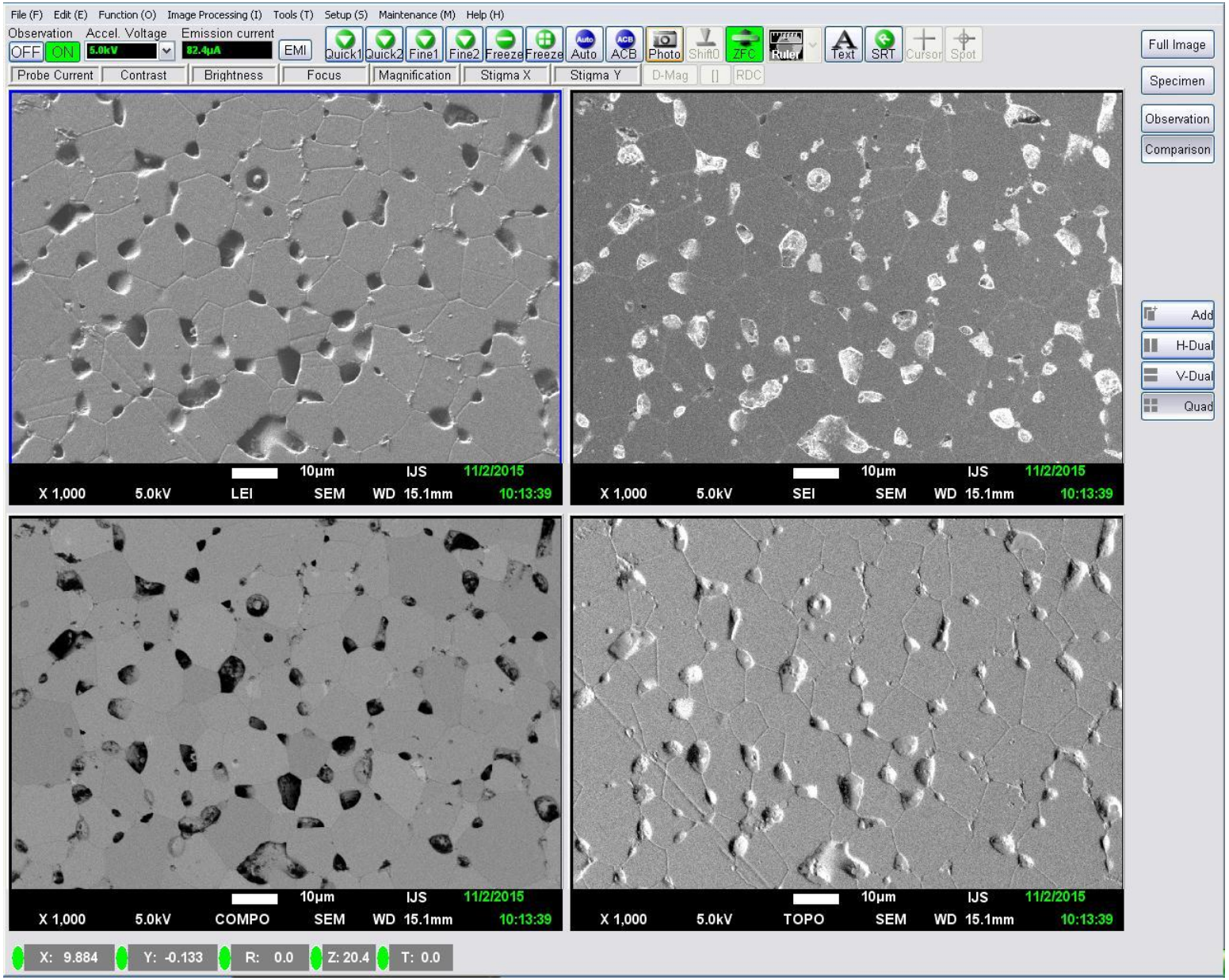
SE mode

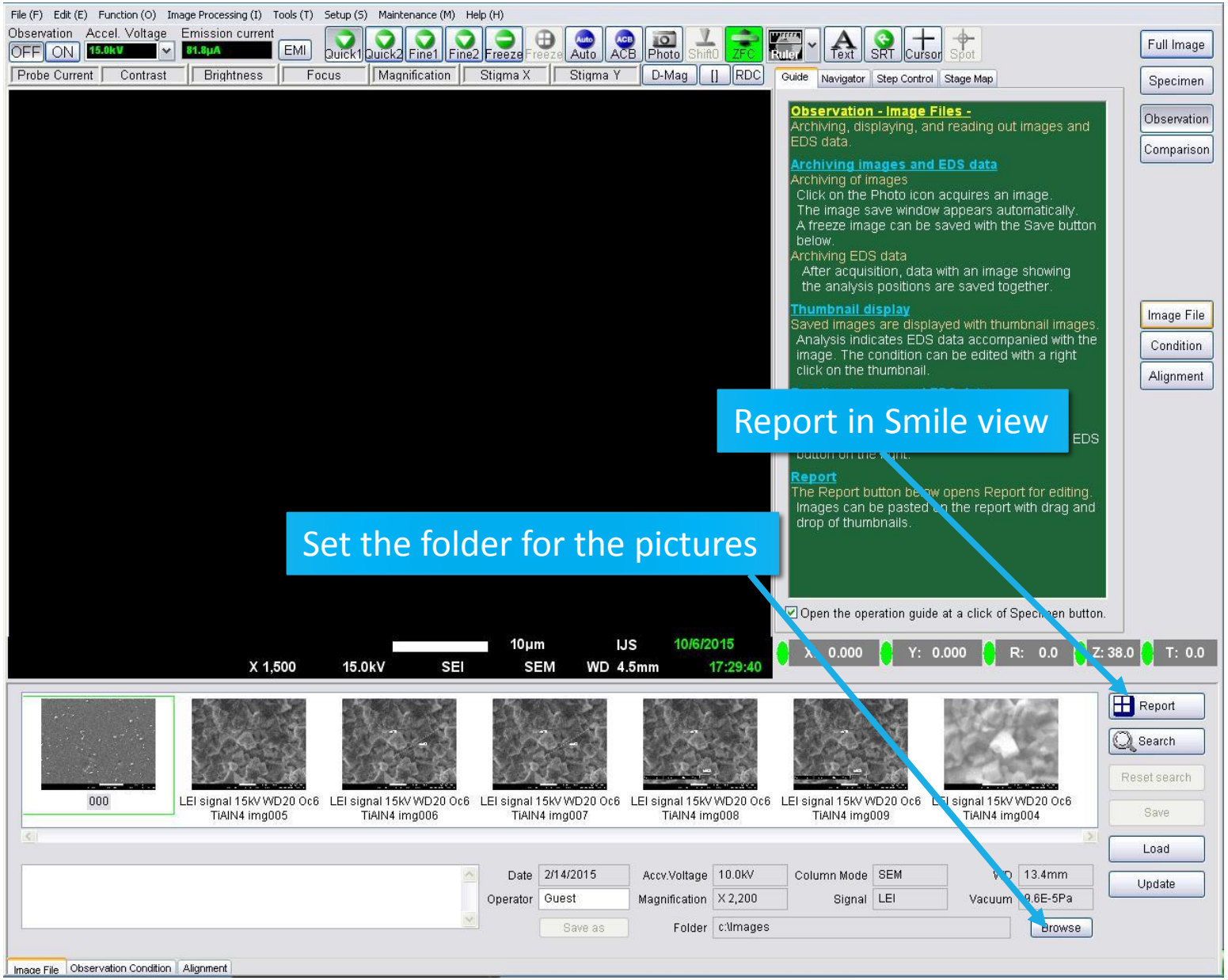
SB mode

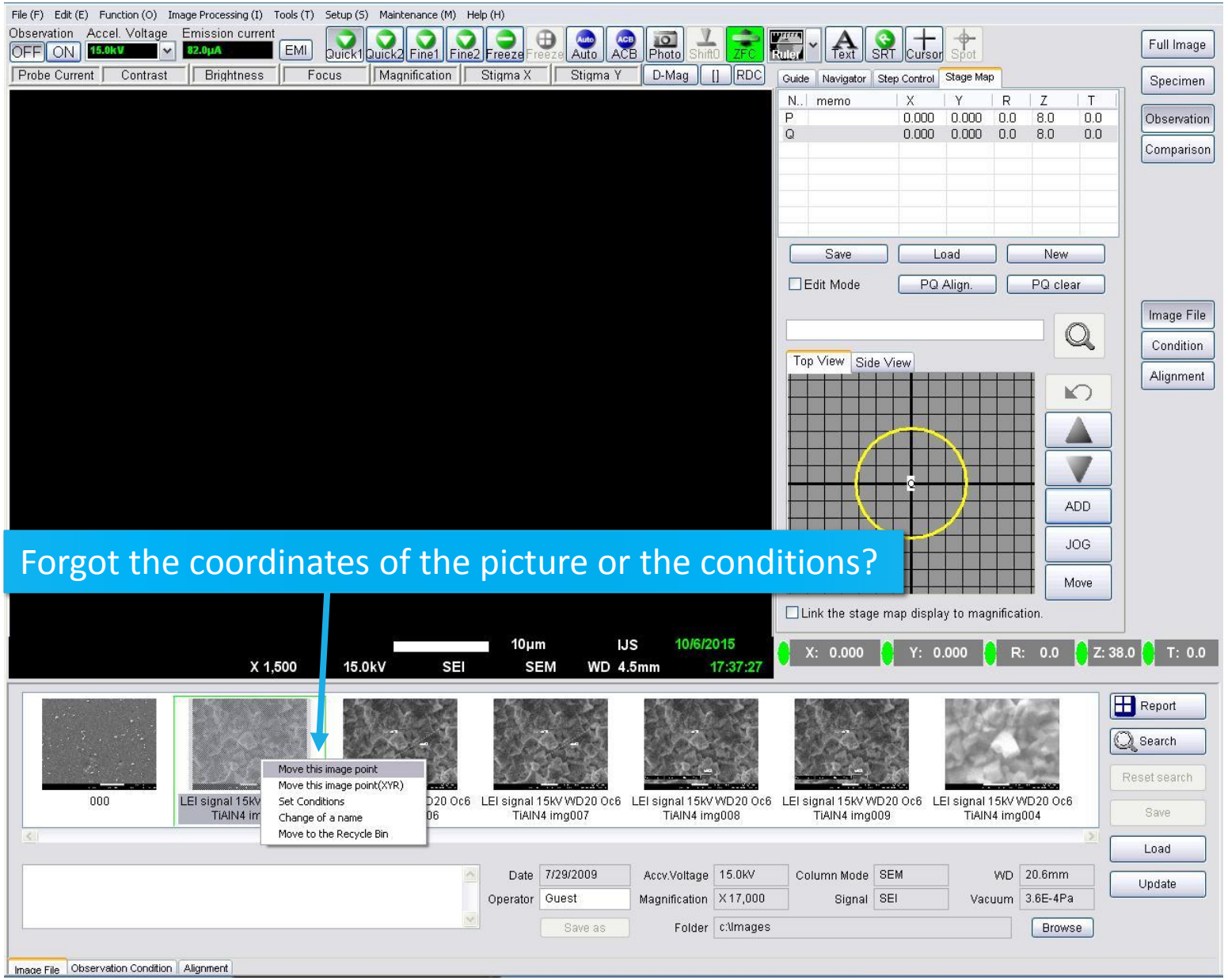
BE mode


File (F) Edit (E) Function (O) Image Processing (I) Tools (T) Setup (S) Maintenance (M) Help (H)
Observation Accel. Voltage Emission current
OFF ON 15.0kV 85.6µA EMI
Quick1 Quick2 Fine1 Fine2 Freeze Freeze Auto ACB Photo Shift0 ZFC Ruler Text SRT Cursor Spot
Probe Current Contrast Brightness Focus Magnification Stigma X Stigma Y D-Mag [] RDC
Full Image
Specimen
Observation
Comparison
Add
H-Dual
V-Dual
Quad
1µm IJS 11/30/2015
X 3,000 15.0kV SEI SEM WD 15.0mm 16:26:08
1µm IJS 11/30/2015
X 3,000 15.0kV COMPO SEM WD 15.0mm 16:26:08
X: 2.808 Y: -0.936 R: 0.0 Z: 17.4 T: 0.0

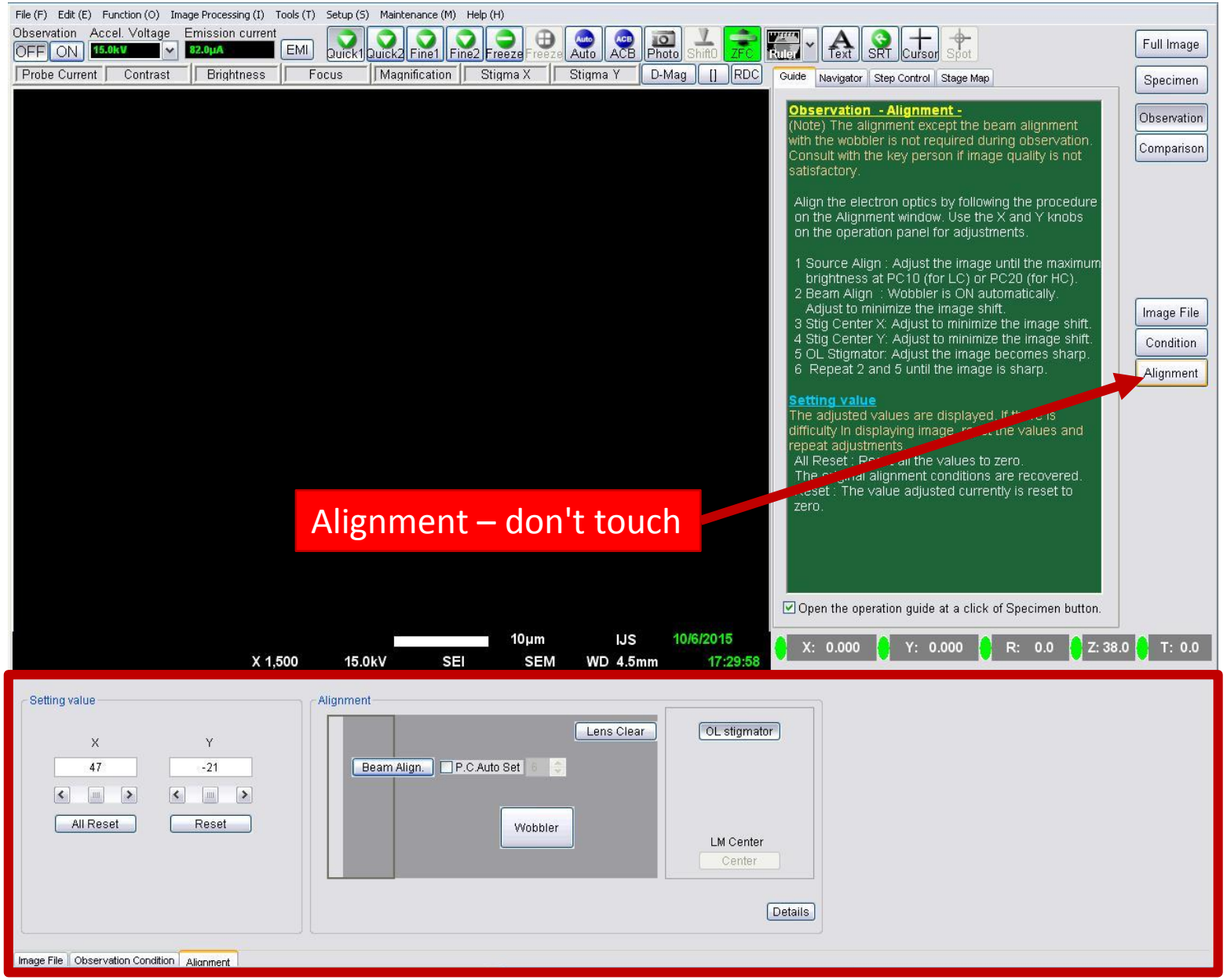

File (F) Edit (E) Function (O) Image Processing (I) Tools (T) Setup (S) Maintenance (M) Help (H)
Observation Accel. Voltage Emission current
OFF ON 15.0kV 85.6µA EMI
Quick1 Quick2 Fine1 Fine2 Freeze Freeze Auto ACB Photo Shift0 ZFC Ruler Text SRT Cursor Spot
Probe Current Contrast Brightness Focus Magnification Stigma X Stigma Y D-Mag [] RDC
Full Image
Specimen
Observation
Comparison
Add
H-Dual
V-Dual
Quad
1µm IJS 11/30/2015
X 3,000 15.0kV SEI SEM WD 15.0mm 16:26:08
1µm IJS 11/30/2015
X 3,000 15.0kV COMPO SEM WD 15.0mm 16:26:08
X: 2.808 Y: -0.936 R: 0.0 Z: 17.4 T: 0.0


File (F) Edit (E) Function (O) Image Processing (I) Tools (T) Setup (S) Maintenance (M) Help (H)
Observation Accel. Voltage Emission current
OFF ON 5.0kV 82.4µA EMI
Quick1 Quick2 Fine1 Fine2 Freeze Freeze Auto ACB Photo Shift0 ZFC Ruler Text SRT Cursor Spot
Probe Current Contrast Brightness Focus Magnification Stigma X Stigma Y D-Mag [] RDC
Full Image
Specimen
Observation
Comparison
Add
H-Dual
V-Dual
Quad
10µm IJS 11/2/2015
X 1,000 5.0kV LEI SEM WD 15.1mm 10:13:39
10µm IJS 11/2/2015
X 1,000 5.0kV SEI SEM WD 15.1mm 10:13:39
10µm IJS 11/2/2015
X 1,000 5.0kV COMPO SEM WD 15.1mm 10:13:39
10µm IJS 11/2/2015
X 1,000 5.0kV TOPO SEM WD 15.1mm 10:13:39
X: 9.884 Y: -0.133 R: 0.0 Z: 20.4 T: 0.0

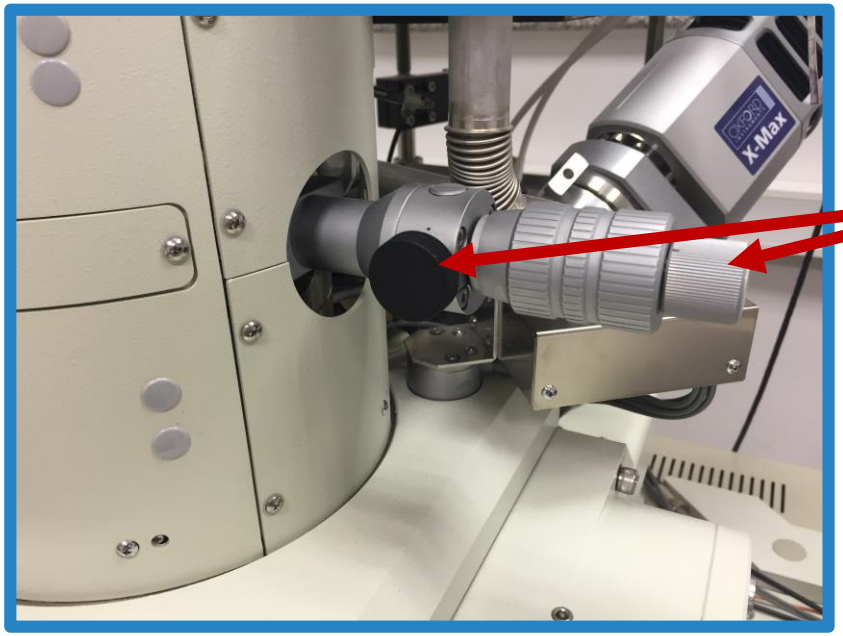

Report in Smile view
Set the folder for the pictures



maja.koblar@ijs.si

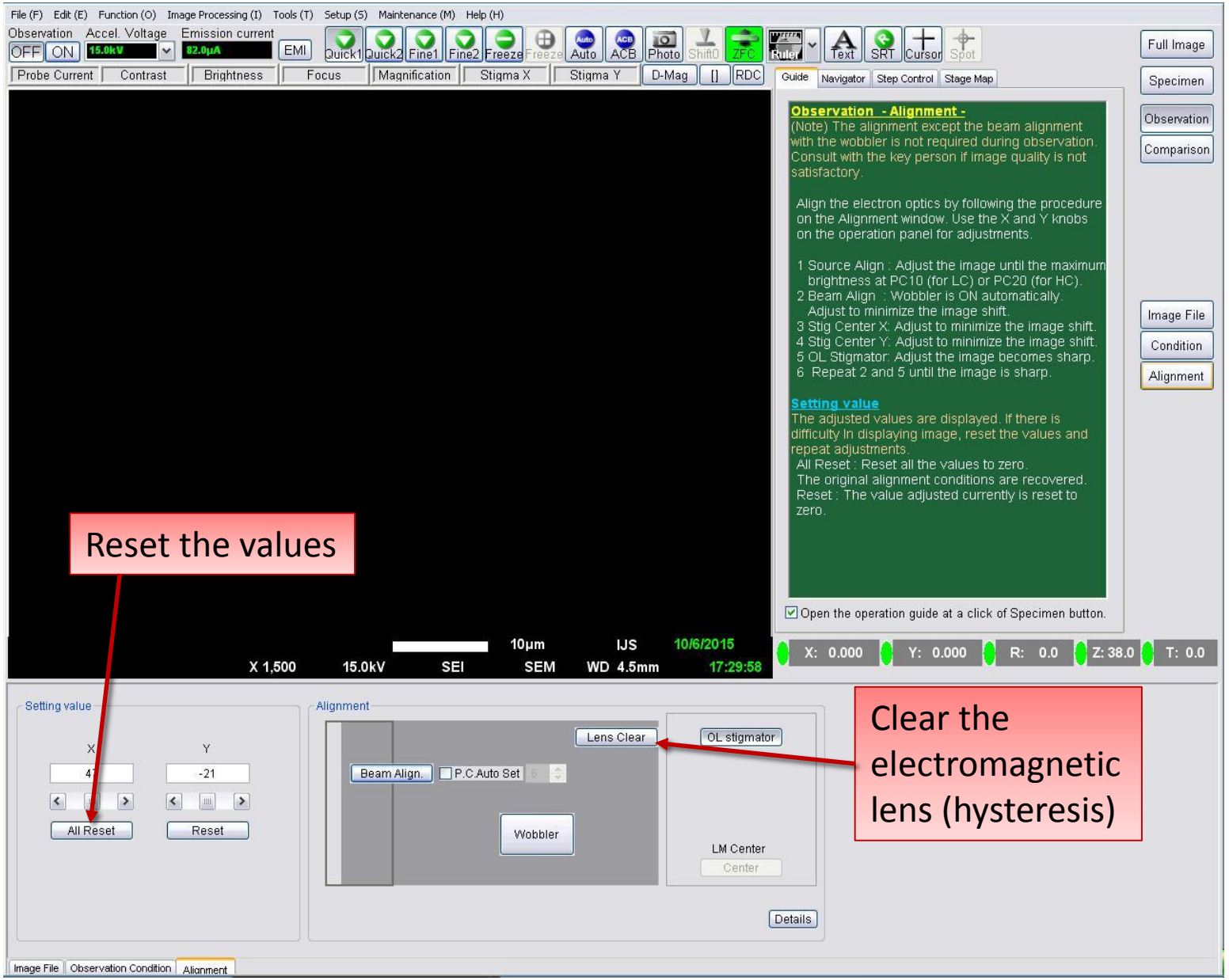


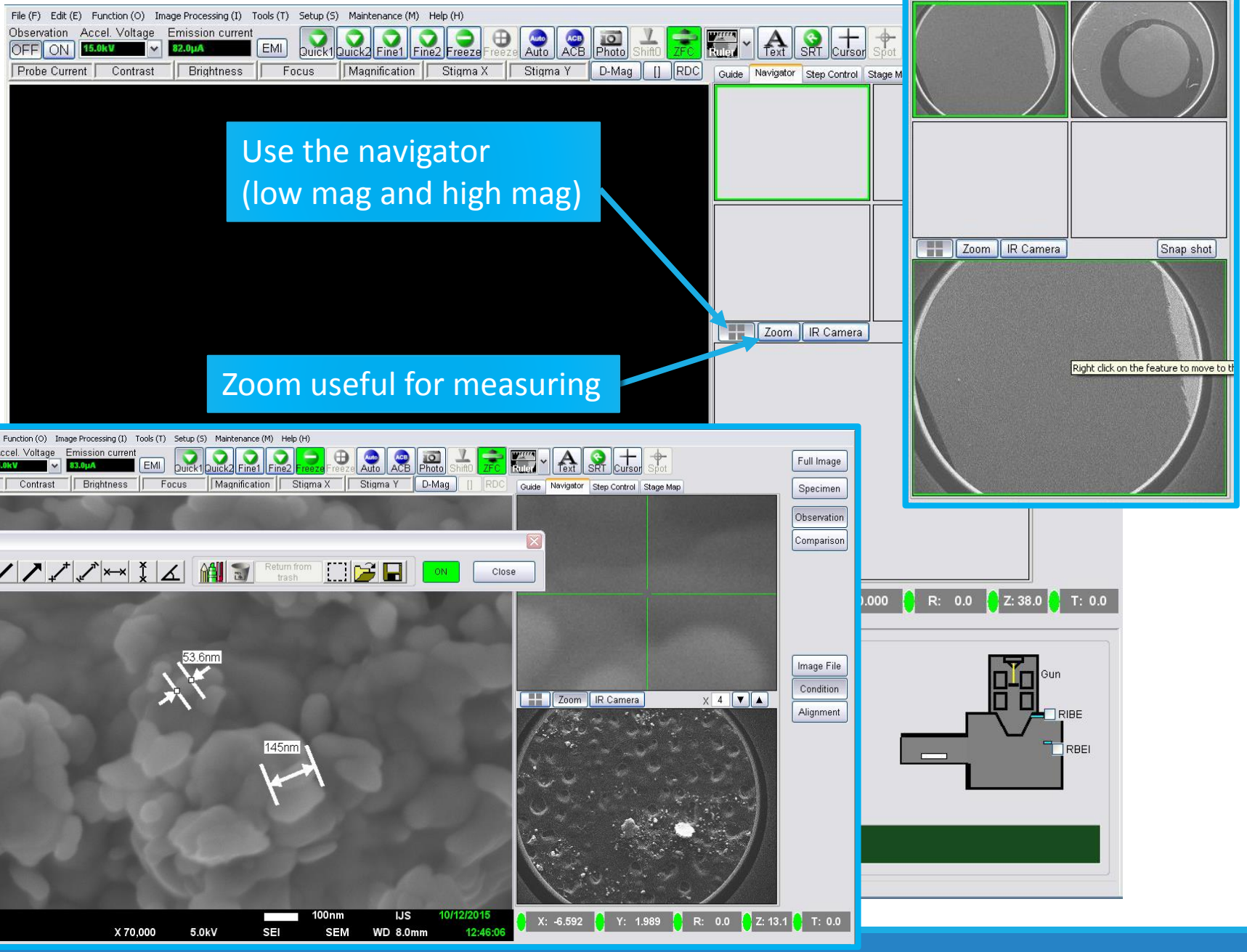
maja.koblar@ijs.si

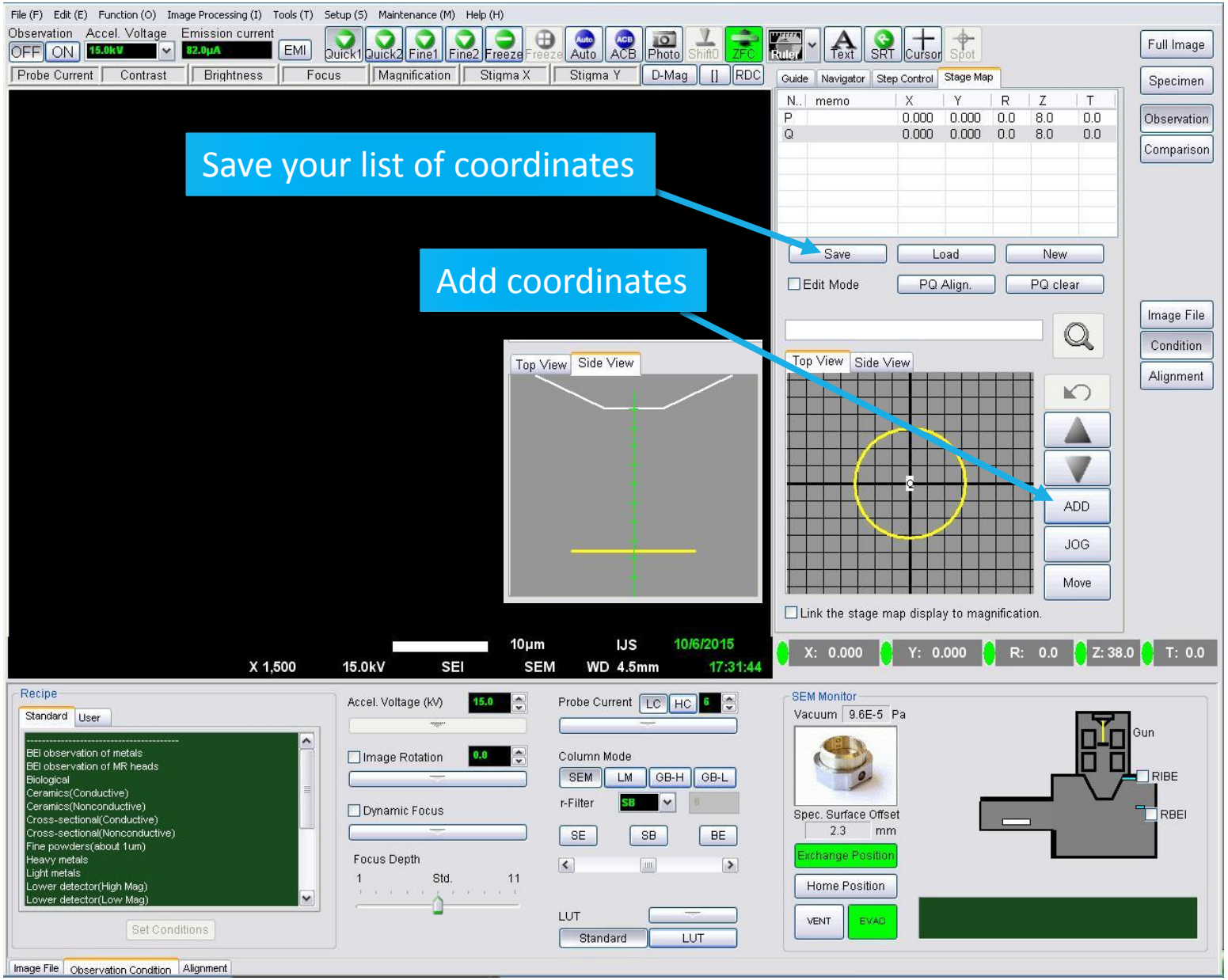


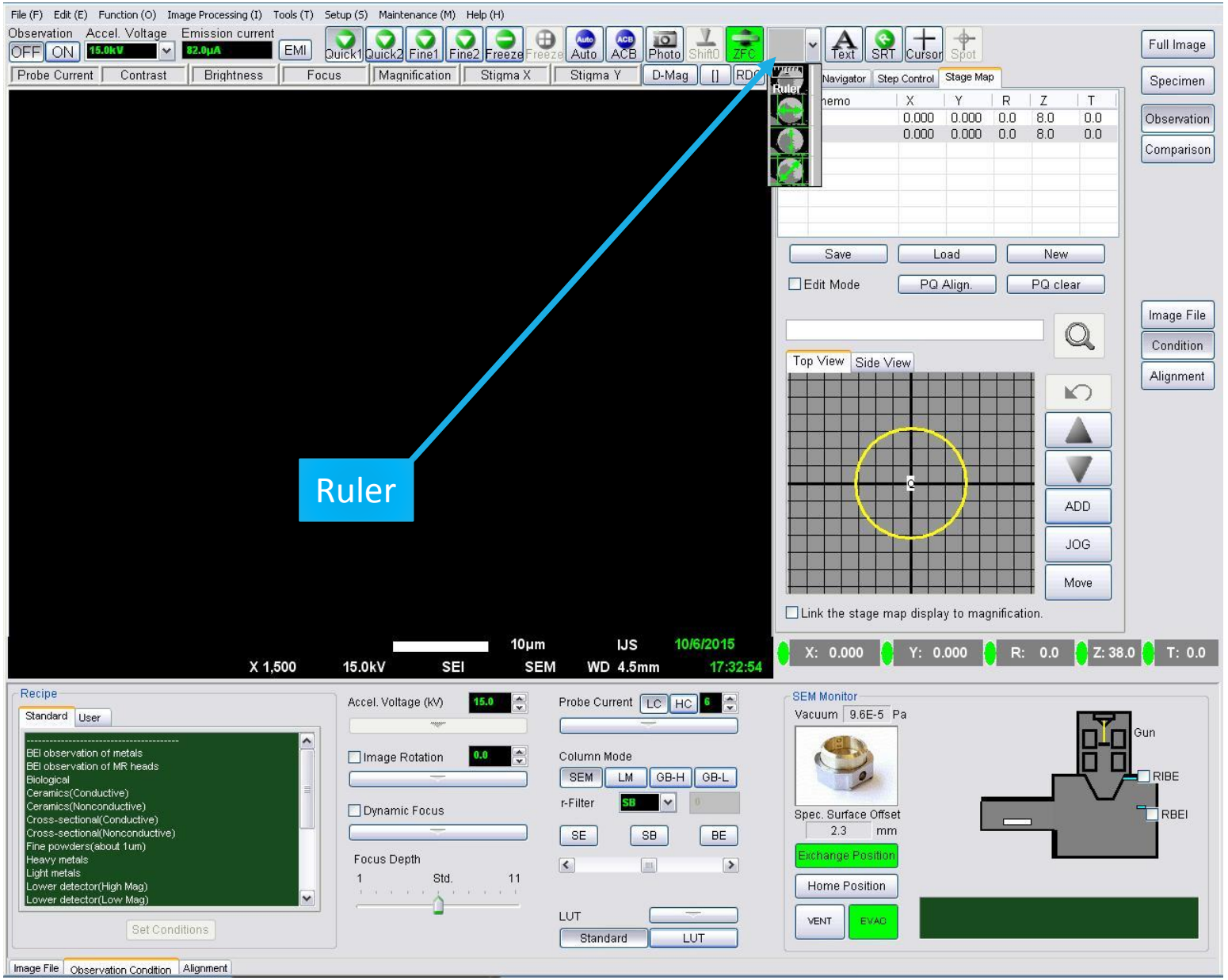
Used only for alignment procedure (don't touch)

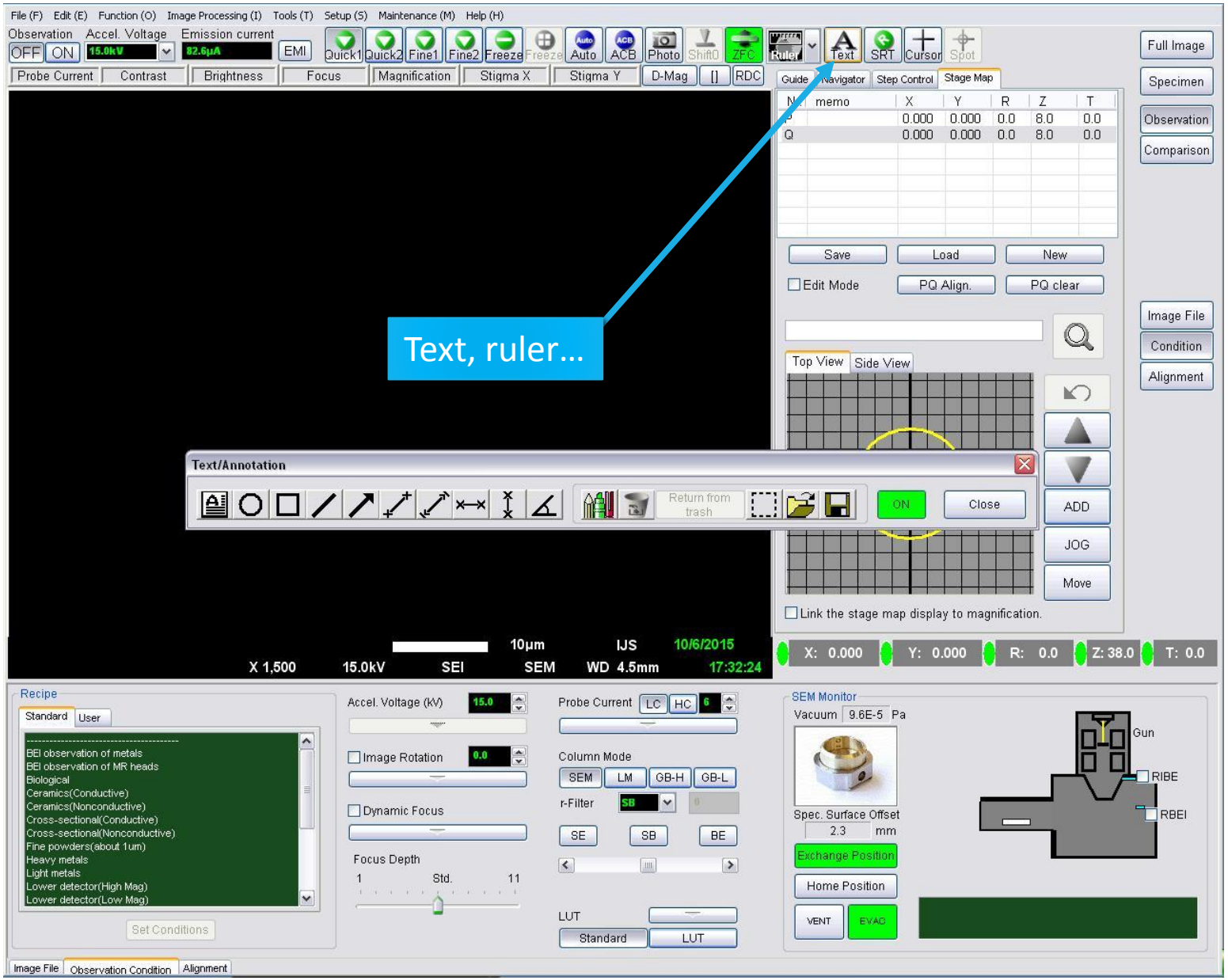
Non magnetic sample!
WD = 4.5 mm
PC = 6
Aperture 4
U = 15 kV


Reset the values
Clear the electromagnetic lens (hysteresis)
Observation - Alignment -
Setting value
All Reset
Reset
Lens Clear
OL stigmator
Beam Align.
P.C.Auto Set
Wobbler
LM Center
Center
Details


Use the navigator
(low mag and high mag)
Zoom useful for measuring
Zoom
IR Camera
Snap shot
Right click on the feature to move to th
53.6nm
145nm
Gun
RIBE
RBEI
X 70,000
5.0kV
SEI
SEM
WD 8.0mm
100nm
IJS
10/12/2015
12:46:06


Save your list of coordinates
Add coordinates
File (F) Edit (E) Function (O) Image Processing (I) Tools (T) Setup (S) Maintenance (M) Help (H)
Observation Accel. Voltage Emission current
OFF ON 15.0kV 82.0µA EMI
Quick1 Quick2 Fine1 Fine2 Freeze Freeze Auto ACB Photo Shift0 ZFC Ruler Text SRT Cursor Spot
Probe Current Contrast Brightness Focus Magnification Stigma X Stigma Y D-Mag [] RDC
Guide Navigator Step Control Stage Map
N.. memo X Y R Z T
P 0.000 0.000 0.0 8.0 0.0
Q 0.000 0.000 0.0 8.0 0.0
Save Load New
Edit Mode PQ Align. PQ clear
Top View Side View
ADD JOG Move
Link the stage map display to magnification.
Full Image Specimen Observation Comparison Image File Condition Alignment
10µm IJS 10/6/2015
X 1,500 15.0kV SEI SEM WD 4.5mm 17:31:44
X: 0.000 Y: 0.000 R: 0.0 Z: 38.0 T: 0.0
Recipe
Standard User
BEI observation of metals
BEI observation of MR heads
Biological
Ceramics(Conductive)
Ceramics(Nonconductive)
Cross-sectional(Conductive)
Cross-sectional(Nonconductive)
Fine powders(about 1um)
Heavy metals
Light metals
Lower detector(High Mag)
Lower detector(Low Mag)
Set Conditions
Accel. Voltage (kV) 15.0
Image Rotation 0.0
Dynamic Focus
Focus Depth
1 Std. 11
Probe Current LC HC 6
Column Mode
SEM LM GB-H GB-L
r-Filter SB
SE SB BE
LUT
Standard LUT
SEM Monitor
Vacuum 9.6E-5 Pa
Spec. Surface Offset
2.3 mm
Exchange Position
Home Position
VENT EVAC
Gun
RIBE
RBEI
Image File Observation Condition Alignment


Ruler
File (F) Edit (E) Function (O) Image Processing (I) Tools (T) Setup (S) Maintenance (M) Help (H)
Observation Accel. Voltage Emission current
OFF ON 15.0kV 82.0µA EMI
Quick1 Quick2 Fine1 Fine2 Freeze Auto ACB Photo Shift0 ZFC
Text SRT Cursor Spot
Probe Current Contrast Brightness Focus Magnification Stigma X Stigma Y D-Mag
Full Image Specimen Observation Comparison
Navigator Step Control Stage Map
X Y R Z T
0.000 0.000 0.0 8.0 0.0
Save Load New
Edit Mode PQ Align. PQ clear
Top View Side View
ADD JOG Move
Image File Condition Alignment
Link the stage map display to magnification.
10µm IJS 10/6/2015
X 1,500 15.0kV SEI SEM WD 4.5mm 17:32:54
X: 0.000 Y: 0.000 R: 0.0 Z: 38.0 T: 0.0
Recipe
Standard User
BEI observation of metals
BEI observation of MR heads
Biological
Ceramics(Conductive)
Ceramics(Nonconductive)
Cross-sectional(Conductive)
Cross-sectional(Nonconductive)
Fine powders(about 1um)
Heavy metals
Light metals
Lower detector(High Mag)
Lower detector(Low Mag)
Set Conditions
Accel. Voltage (kV) 15.0
Image Rotation 0.0
Dynamic Focus
Focus Depth
1 Std. 11
Probe Current LC HC 6
Column Mode
SEM LM GB-H GB-L
r-Filter SB
SE SB BE
LUT
Standard LUT
SEM Monitor
Vacuum 9.6E-5 Pa
Spec. Surface Offset
2.3 mm
Exchange Position
Home Position
VENT EVAC
Gun
RIBE
RBEI
Image File Observation Condition Alignment


Text, ruler…
File (F) Edit (E) Function (O) Image Processing (I) Tools (T) Setup (S) Maintenance (M) Help (H)
Observation Accel. Voltage Emission current
OFF ON 15.0kV 82.6µA EMI
Quick1 Quick2 Fine1 Fine2 Freeze Freeze Auto ACB Photo Shift0 ZFC Ruler Text SRT Cursor Spot
Probe Current Contrast Brightness Focus Magnification Stigma X Stigma Y D-Mag [] RDC
Guide Navigator Step Control Stage Map
N memo X Y R Z T
P 0.000 0.000 0.0 8.0 0.0
Q 0.000 0.000 0.0 8.0 0.0
Save Load New
Edit Mode PQ Align. PQ clear
Top View Side View
Link the stage map display to magnification.
Full Image
Specimen
Observation
Comparison
Image File
Condition
Alignment
ADD
JOG
Move
Text/Annotation
Return from trash
ON
Close
10µm IJS 10/6/2015
X 1,500 15.0kV SEI SEM WD 4.5mm 17:32:24
X: 0.000 Y: 0.000 R: 0.0 Z: 38.0 T: 0.0
Recipe
Standard User
BEI observation of metals
BEI observation of MR heads
Biological
Ceramics(Conductive)
Ceramics(Nonconductive)
Cross-sectional(Conductive)
Cross-sectional(Nonconductive)
Fine powders(about 1um)
Heavy metals
Light metals
Lower detector(High Mag)
Lower detector(Low Mag)
Set Conditions
Accel. Voltage (kV) 15.0
Image Rotation 0.0
Dynamic Focus
Focus Depth
1 Std. 11
Probe Current LC HC 6
Column Mode
SEM LM GB-H GB-L
r-Filter SB
SE SB BE
LUT
Standard LUT
SEM Monitor
Vacuum 9.6E-5 Pa
Spec. Surface Offset
2.3 mm
Exchange Position
Home Position
VENT EVAC
Gun
RIBE
RBEI
Image File Observation Condition Alignment

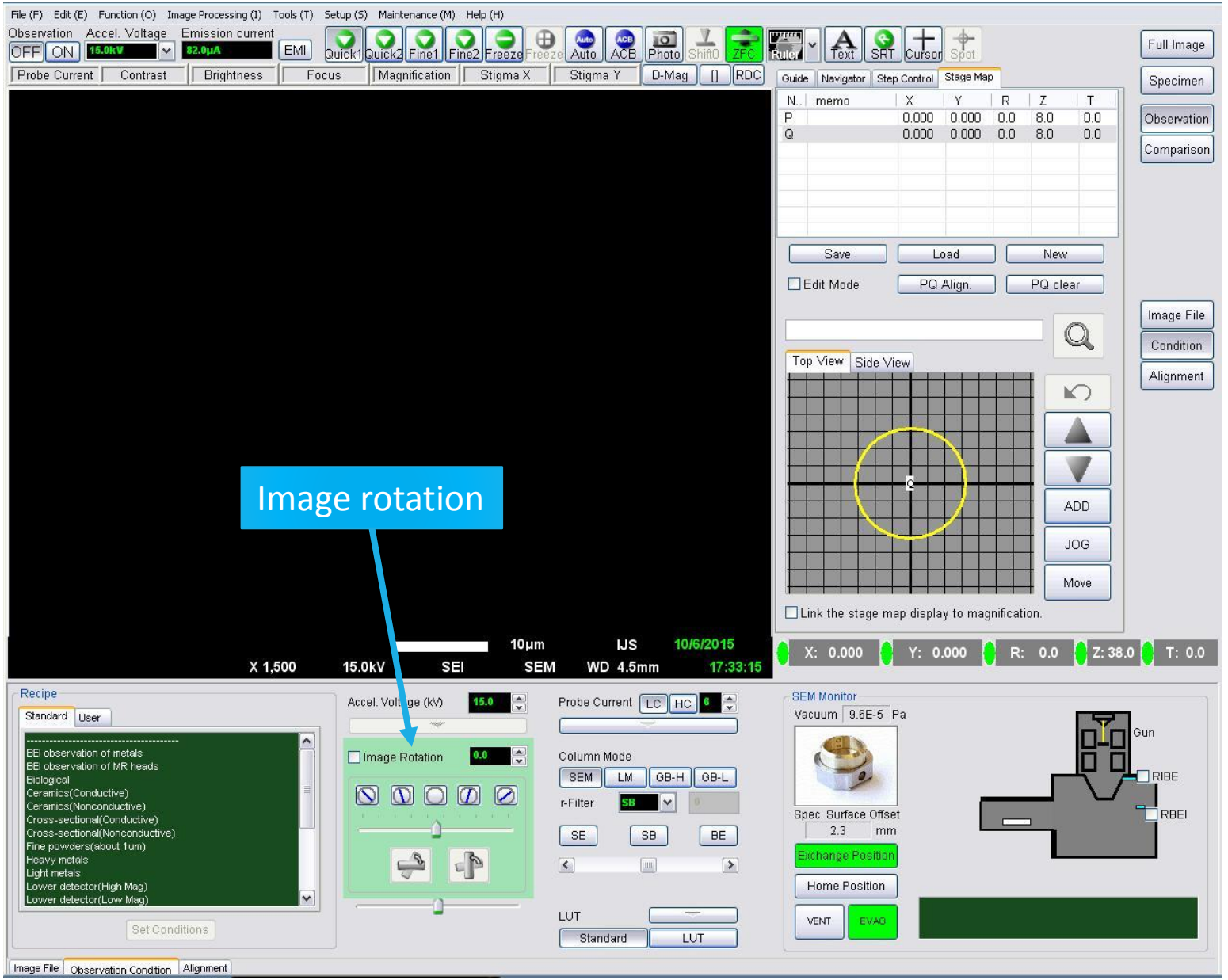
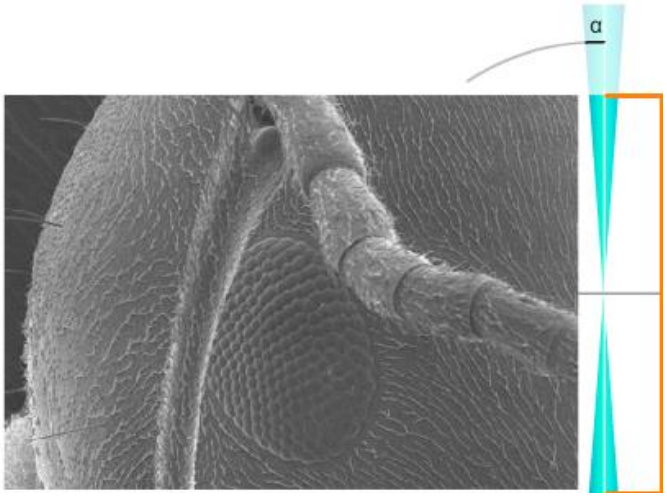
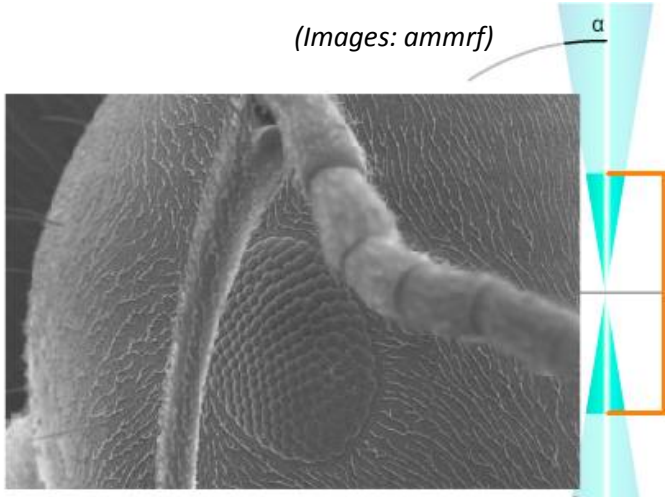


Image rotation

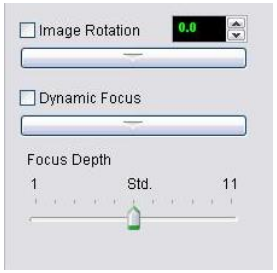
WD and DOF



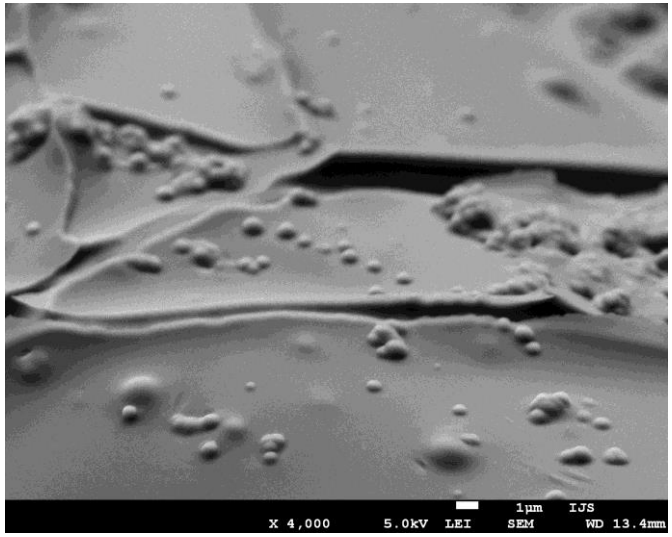
(Images: ammrf)

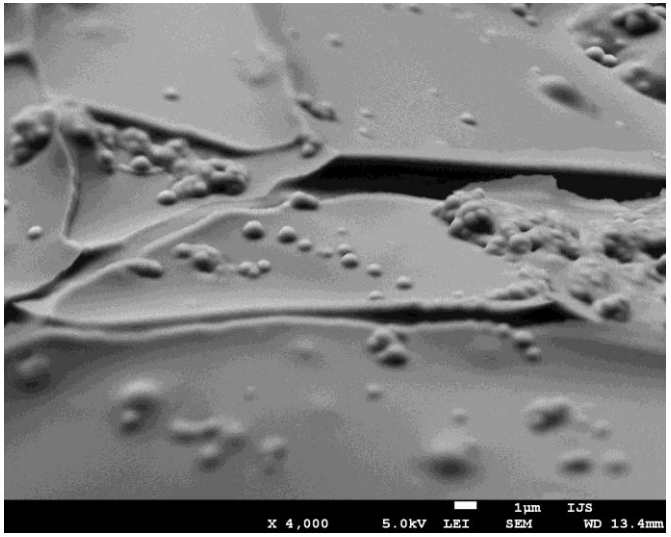


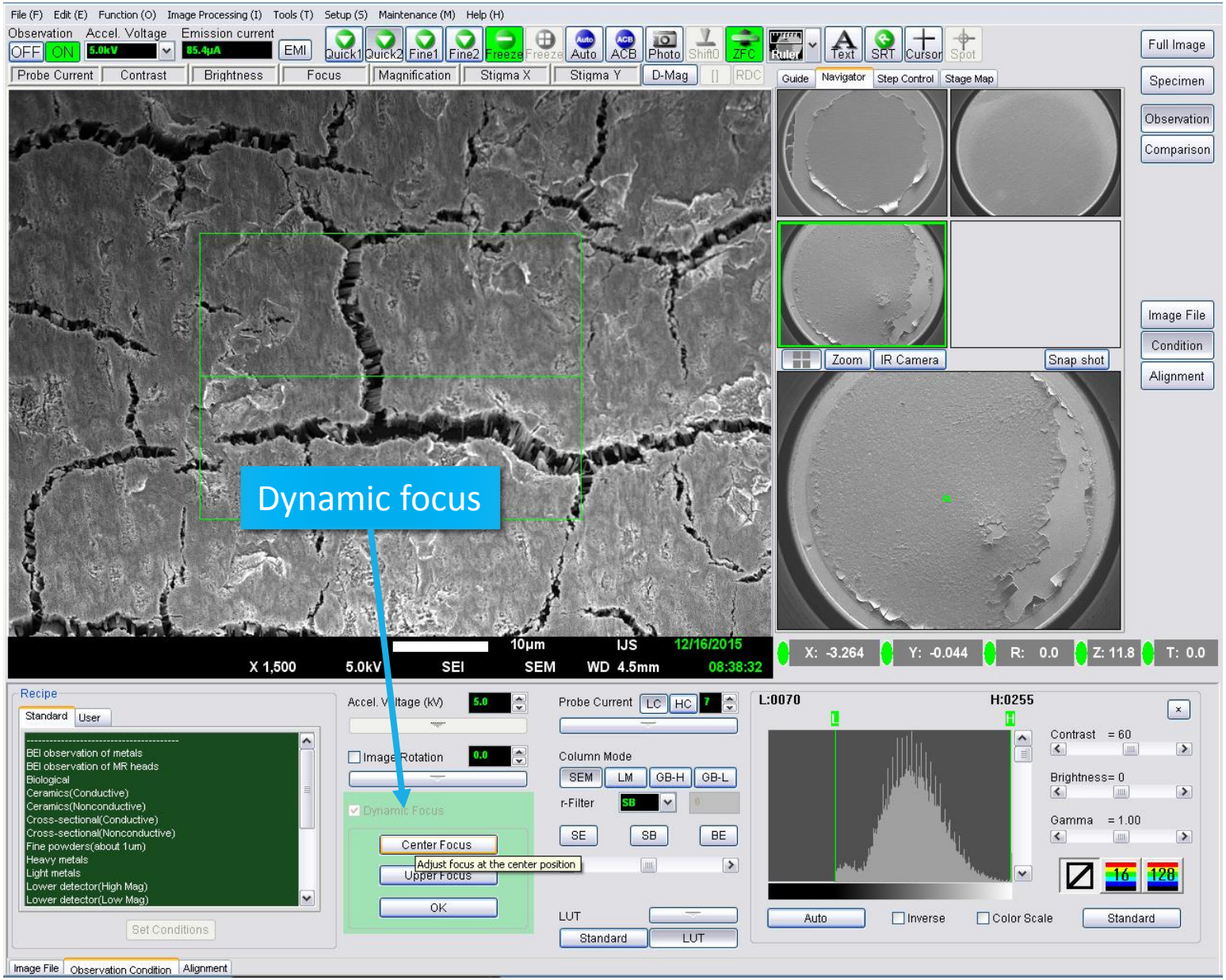
Dynamic focus

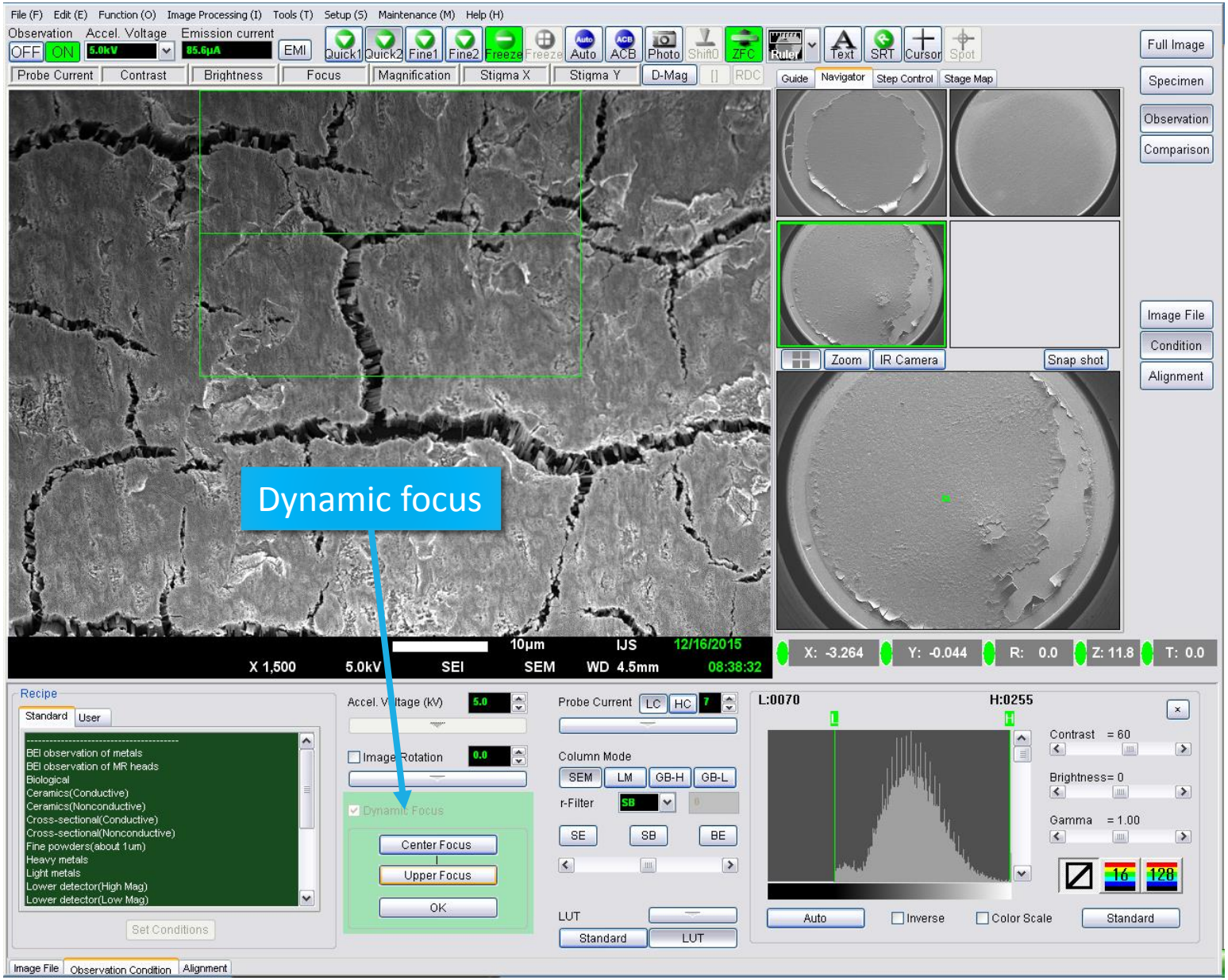


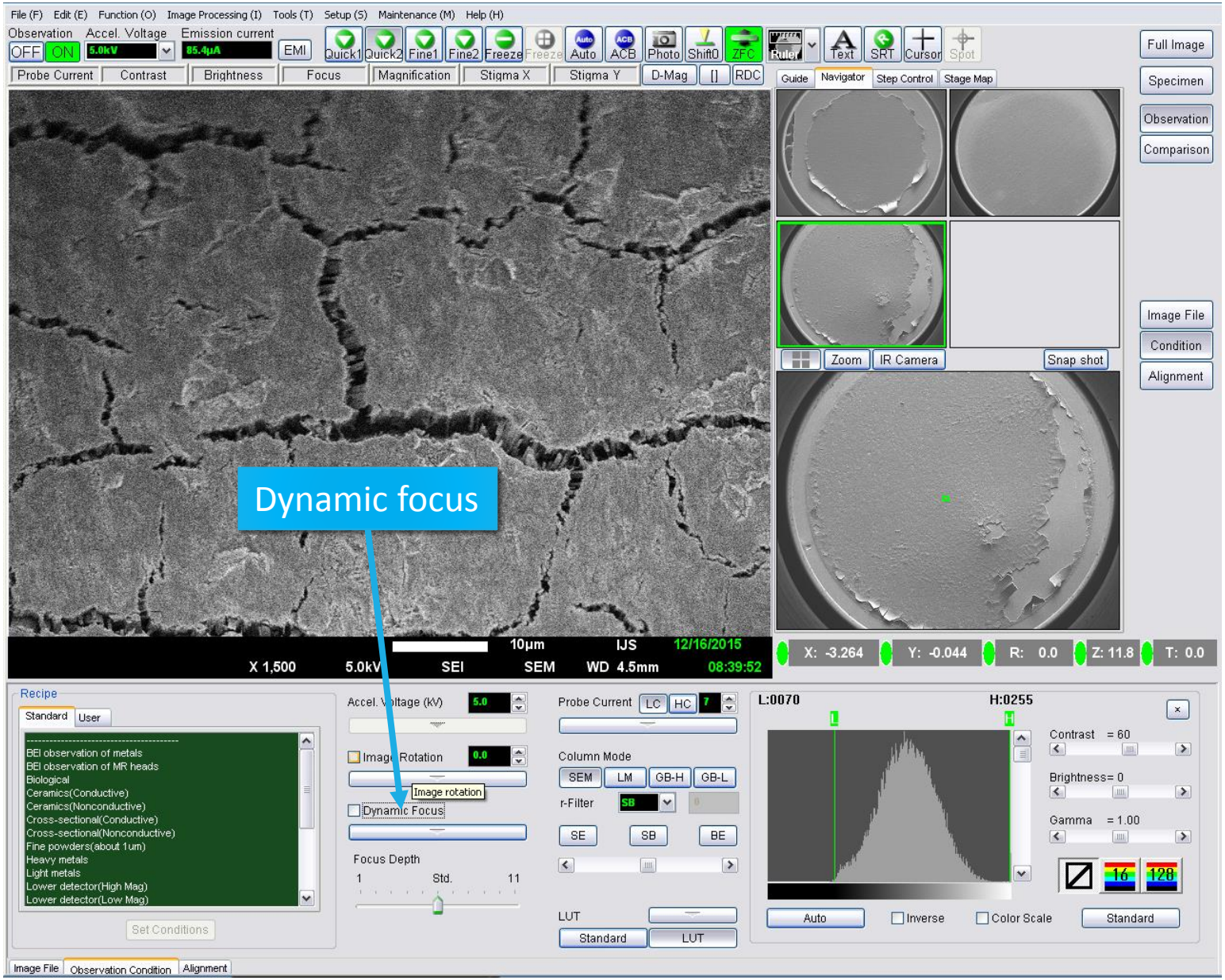
Problem?
Scale bar!






Dynamic focus
File (F) Edit (E) Function (O) Image Processing (I) Tools (T) Setup (S) Maintenance (M) Help (H)
Observation Accel. Voltage Emission current
OFF ON 5.0kV 85.4µA EMI
Quick1 Quick2 Fine1 Fine2 Freeze Auto ACB Photo Shift0 ZFC Ruler Text SRT Cursor Spot
Probe Current Contrast Brightness Focus Magnification Stigma X Stigma Y D-Mag RDC
Guide Navigator Step Control Stage Map
Full Image
Specimen
Observation
Comparison
Image File
Condition
Alignment
Zoom IR Camera Snap shot
10µm IJS 12/16/2015
X 1,500 5.0kV SEI SEM WD 4.5mm 08:38:32
X: -3.264 Y: -0.044 R: 0.0 Z: 11.8 T: 0.0
Recipe
Standard User
BEI observation of metals
BEI observation of MR heads
Biological
Ceramics(Conductive)
Ceramics(Nonconductive)
Cross-sectional(Conductive)
Cross-sectional(Nonconductive)
Fine powders(about 1um)
Heavy metals
Light metals
Lower detector(High Mag)
Lower detector(Low Mag)
Set Conditions
Accel. Voltage (kV) 5.0
Image Rotation 0.0
Dynamic Focus
Center Focus
Adjust focus at the center position
Upper Focus
OK
Probe Current LC HC 7
Column Mode
SEM LM GB-H GB-L
r-Filter SB
SE SB BE
LUT
Standard LUT
L:0070 H:0255
Contrast = 60
Brightness= 0
Gamma = 1.00
16 128
Auto Inverse Color Scale Standard
Image File Observation Condition Alignment


Dynamic focus
File (F) Edit (E) Function (O) Image Processing (I) Tools (T) Setup (S) Maintenance (M) Help (H)
Observation Accel. Voltage Emission current
OFF ON 5.0kV 85.6µA EMI
Quick1 Quick2 Fine1 Fine2 Freeze Auto ACB Photo Shift0 ZFC Ruler Text SRT Cursor Spot
Probe Current Contrast Brightness Focus Magnification Stigma X Stigma Y D-Mag
Guide Navigator Step Control Stage Map
Full Image
Specimen
Observation
Comparison
Image File
Condition
Alignment
Zoom IR Camera Snap shot
10µm IJS 12/16/2015
X 1,500 5.0kV SEI SEM WD 4.5mm 08:38:32
X: -3.264 Y: -0.044 R: 0.0 Z: 11.8 T: 0.0
Recipe
Standard User
BEI observation of metals
BEI observation of MR heads
Biological
Ceramics(Conductive)
Ceramics(Nonconductive)
Cross-sectional(Conductive)
Cross-sectional(Nonconductive)
Fine powders(about 1um)
Heavy metals
Light metals
Lower detector(High Mag)
Lower detector(Low Mag)
Set Conditions
Accel. Voltage (kV) 5.0
Image Rotation 0.0
Dynamic Focus
Center Focus
Upper Focus
OK
Probe Current LC HC 7
Column Mode
SEM LM GB-H GB-L
r-Filter SB
SE SB BE
LUT
Standard LUT
L:0070 H:0255
Contrast = 60
Brightness= 0
Gamma = 1.00
16 128
Auto Inverse Color Scale Standard
Image File Observation Condition Alignment



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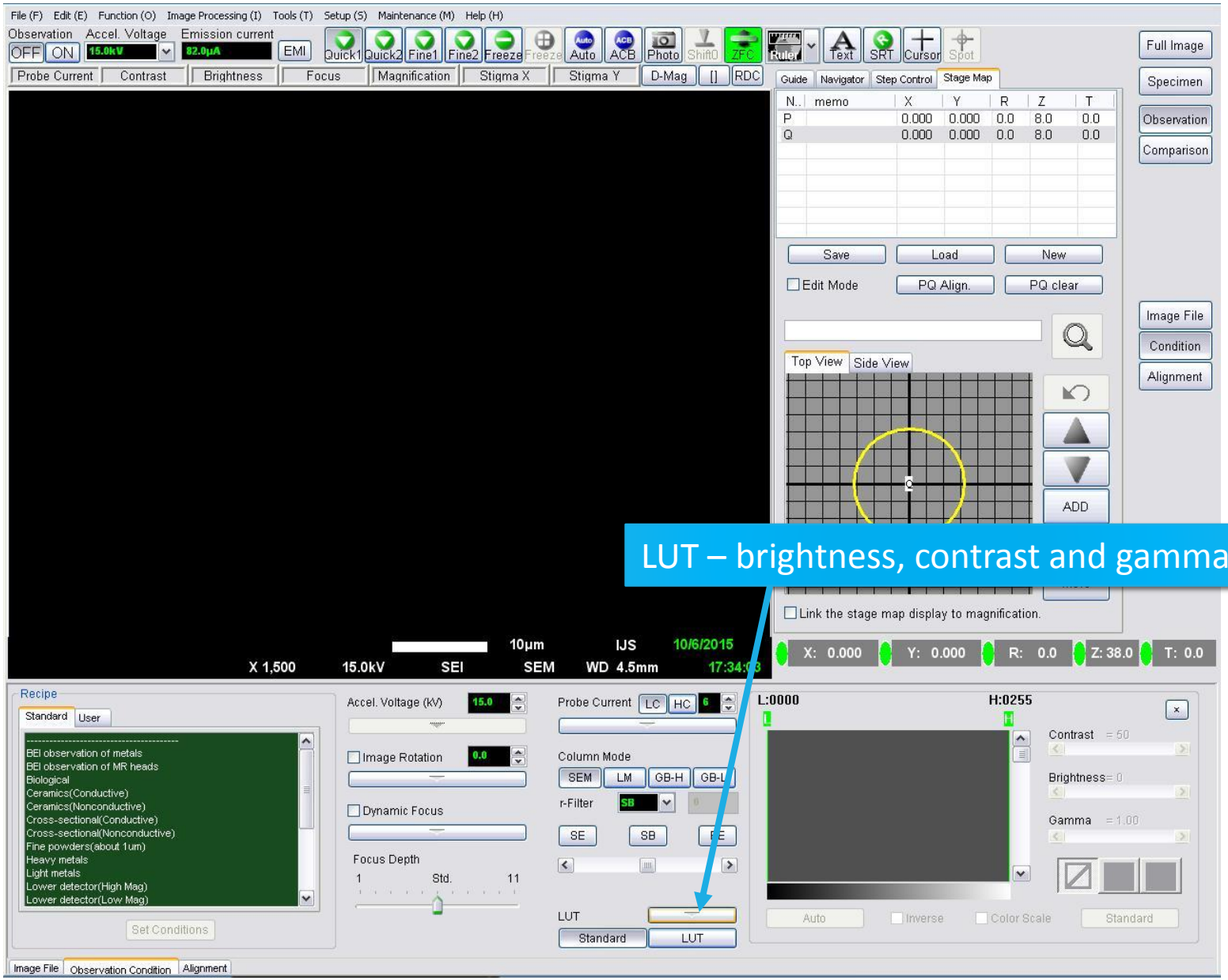
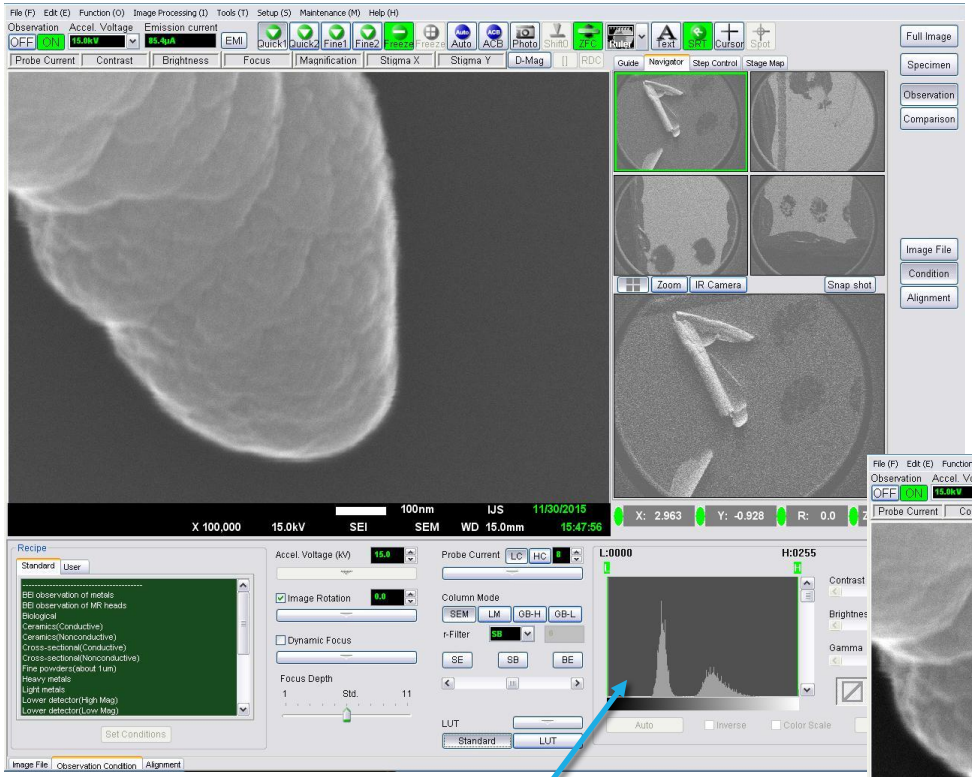
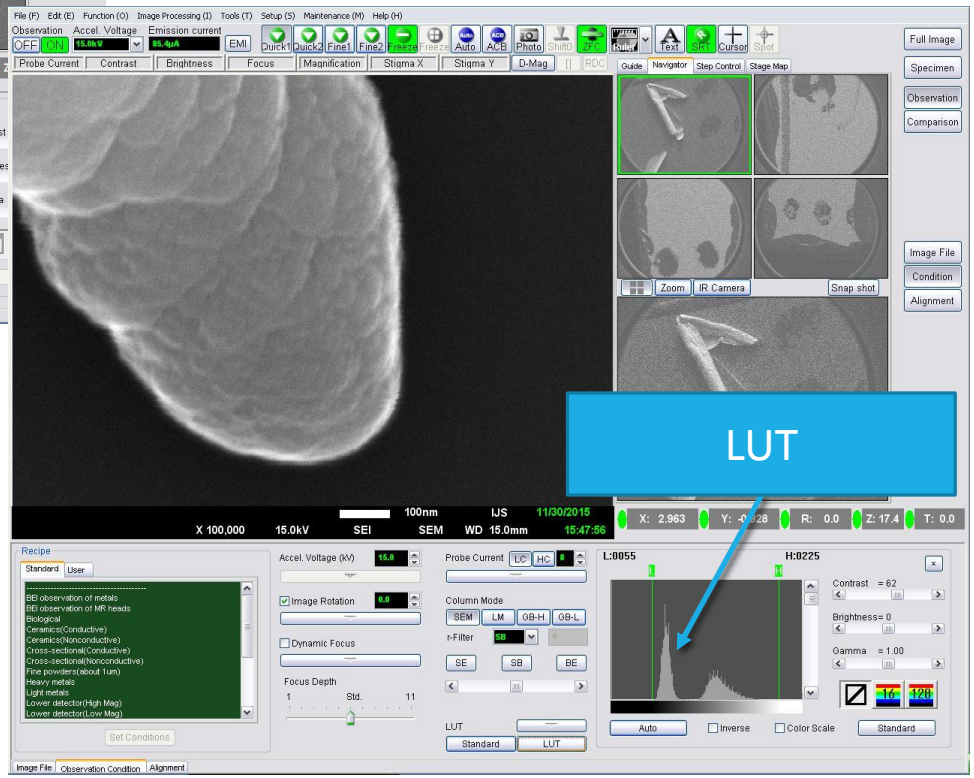

LUT – brightness, contrast and gamma



standard



LUT

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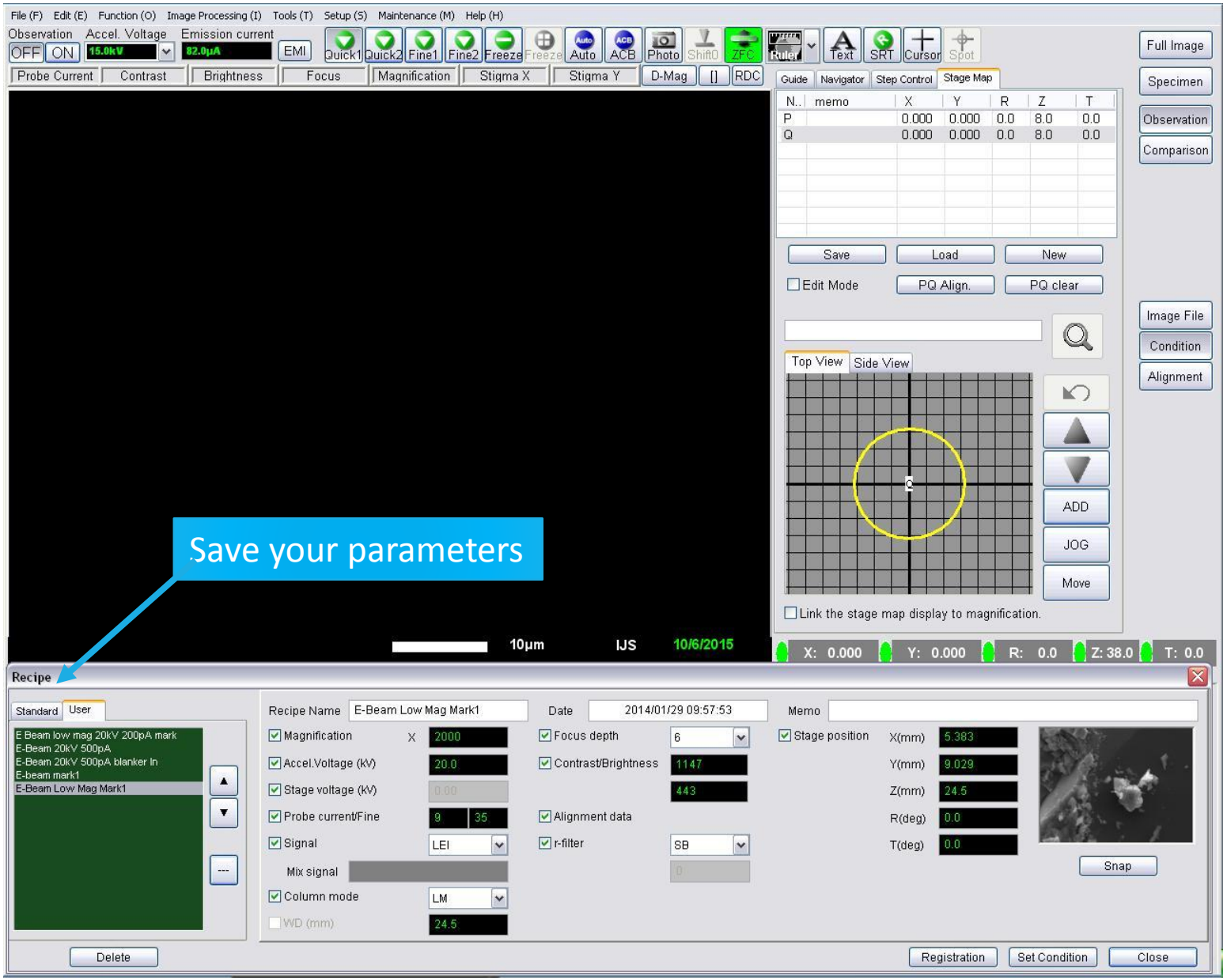
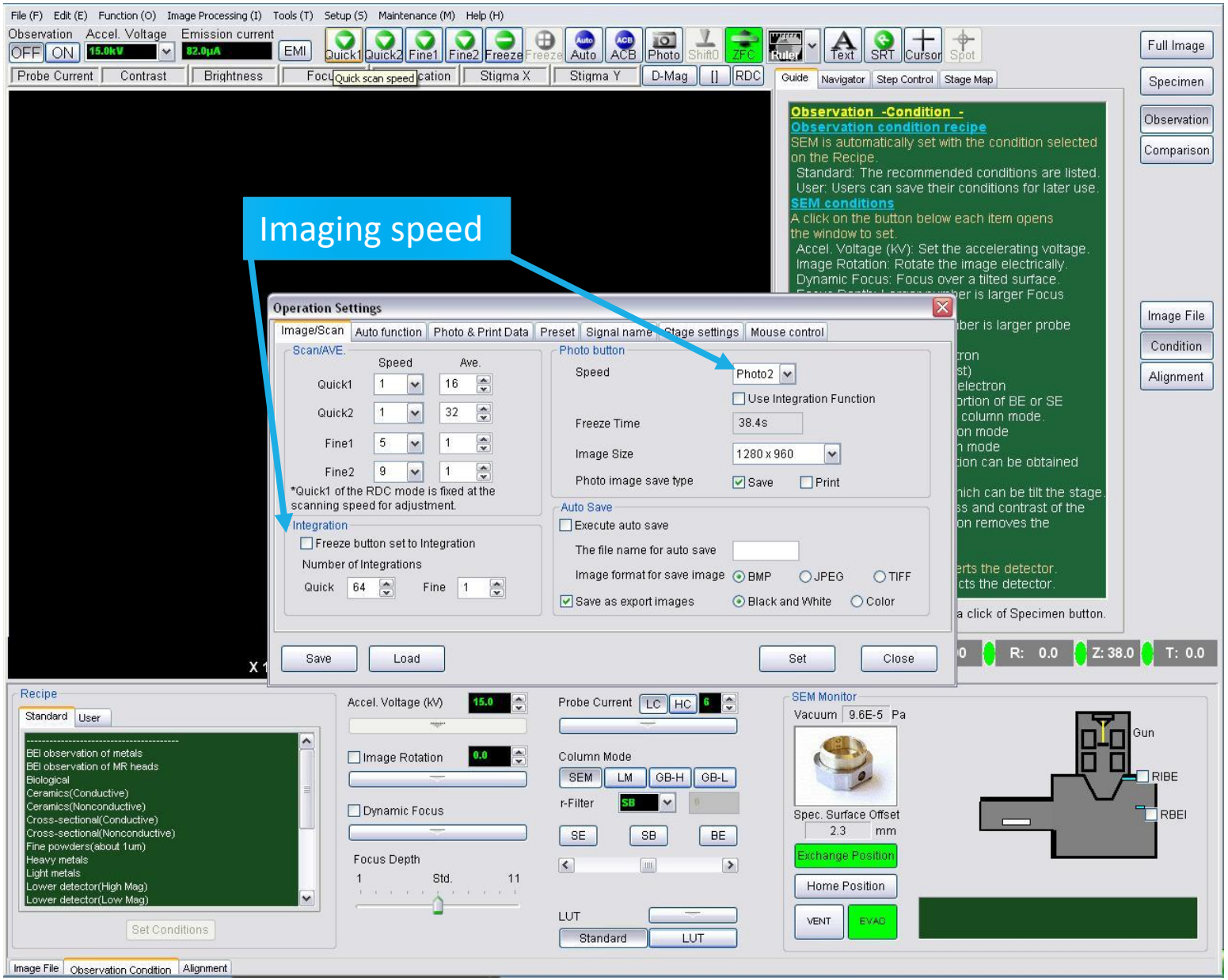

Save your parameters
Recipe
Standard
User
E Beam low mag 20kV 200pA mark
E-Beam 20kV 500pA
E-Beam 20kV 500pA blanker In
E-beam mark1
E-Beam Low Mag Mark1
Recipe Name
E-Beam Low Mag Mark1
Date
2014/01/29 09:57:53
Memo
Magnification
Accel.Voltage (kV)
Stage voltage (kV)
Probe current/Fine
Signal
Mix signal
Column mode
WD (mm)
Focus depth
Contrast/Brightness
Alignment data
r-filter
Stage position
X(mm)
Y(mm)
Z(mm)
R(deg)
T(deg)
Snap
Delete
Registration
Set Condition
Close


Imaging speed
Operation Settings
Image/Scan
Auto function
Photo & Print Data
Preset
Signal name
Stage settings
Mouse control
Scan/AVE.
Speed
Ave.
Quick1
Quick2
Fine1
Fine2
*Quick1 of the RDC mode is fixed at the scanning speed for adjustment.
Integration
Freeze button set to Integration
Number of Integrations
Quick
Fine
Photo button
Speed
Photo2
Use Integration Function
Freeze Time
38.4s
Image Size
1280 x 960
Photo image save type
Save
Print
Auto Save
Execute auto save
The file name for auto save
Image format for save image
BMP
JPEG
TIFF
Save as export images
Black and White
Color
Save
Load
Set
Close
Observation -Condition -
Observation condition recipe
SEM is automatically set with the condition selected on the Recipe.
Standard: The recommended conditions are listed.
User: Users can save their conditions for later use.
SEM conditions
A click on the button below each item opens the window to set.
Accel. Voltage (kV): Set the accelerating voltage.
Image Rotation: Rotate the image electrically.
Dynamic Focus: Focus over a tilted surface.
Full Image
Specimen
Observation
Comparison
Image File
Condition
Alignment
Recipe
Standard
User
BEI observation of metals
BEI observation of MR heads
Biological
Ceramics(Conductive)
Ceramics(Nonconductive)
Cross-sectional(Conductive)
Cross-sectional(Nonconductive)
Fine powders(about 1um)
Heavy metals
Light metals
Lower detector(High Mag)
Lower detector(Low Mag)
Set Conditions
Accel. Voltage (kV)
Image Rotation
Dynamic Focus
Focus Depth
Probe Current
Column Mode
SEM
LM
GB-H
GB-L
r-Filter
SE
SB
BE
LUT
Standard
LUT
SEM Monitor
Vacuum
9.6E-5 Pa
Spec. Surface Offset
2.3 mm
Exchange Position
Home Position
VENT
EVAC
Gun
RIBE
RBEI
Image File
Observation Condition
Alignment

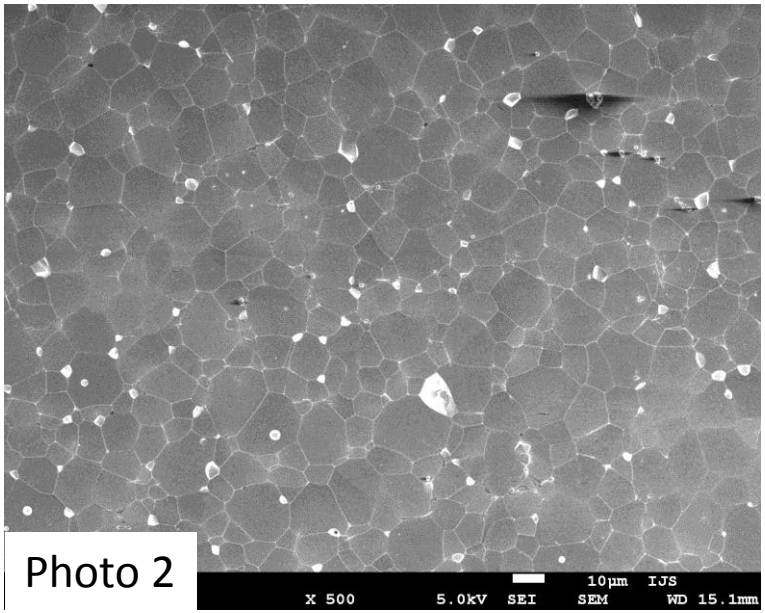
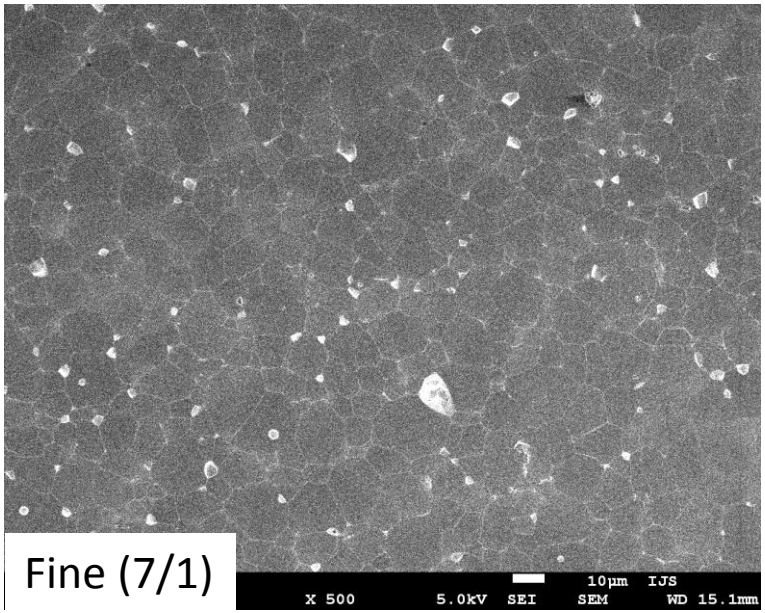
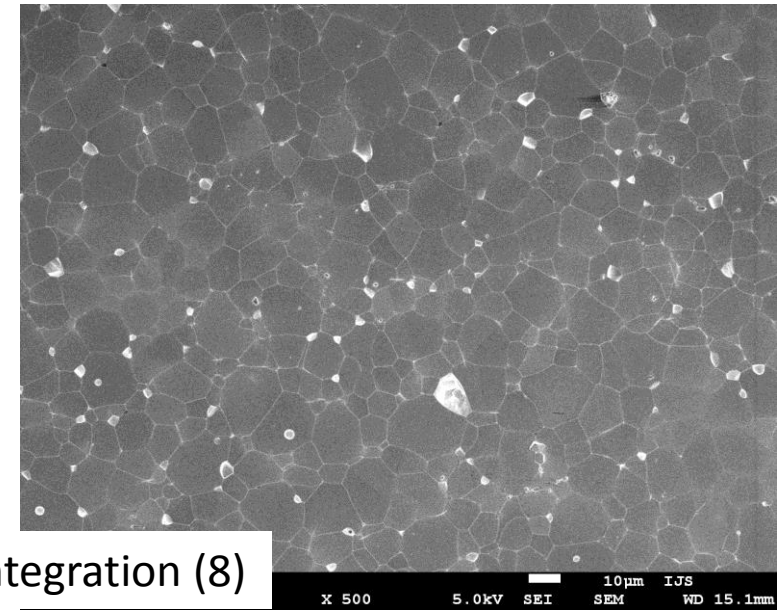


Photo 2



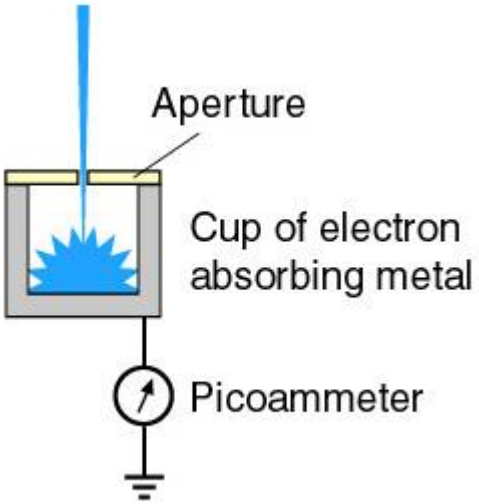
Fine (7/1)

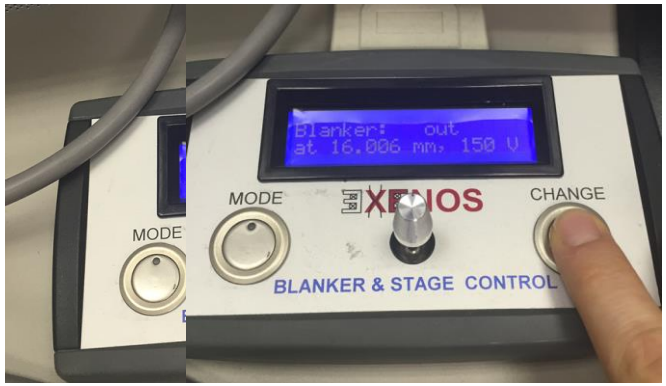


Fine (7/1) + integration (8)

Faraday cup – measure the beam current

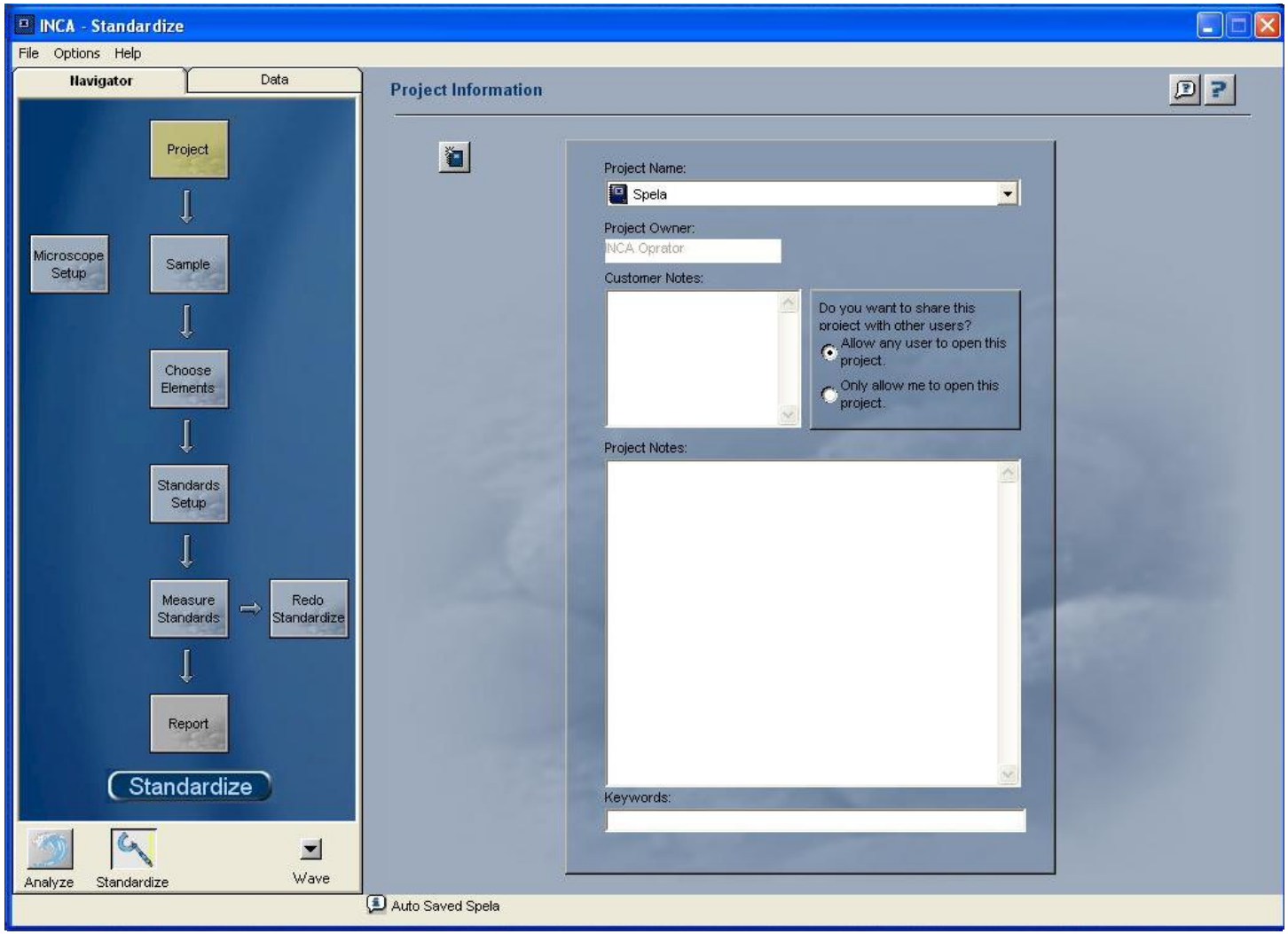
How to measure beam current?



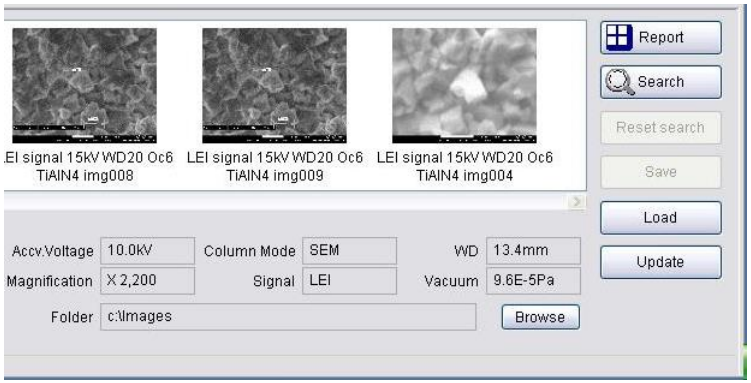


STEPS:

1. Click twice to change to cup
2. Open INCA / Wave
3. Spectrometer direct control
4. Read the current
5. Click once to move out the faraday cup


INCA - Standardize
File
Options
Help
Navigator
Data
Project
Microscope Setup
Sample
Choose Elements
Standards Setup
Measure Standards
Redo Standardize
Report
Standardize
Analyze
Standardize
Wave
Project Information
Project Name:
Spela
Project Owner:
NCA Oprator
Customer Notes:
Do you want to share this project with other users?
Allow any user to open this project.
Only allow me to open this project.
Project Notes:
Keywords:
Auto Saved Spela

SMile View



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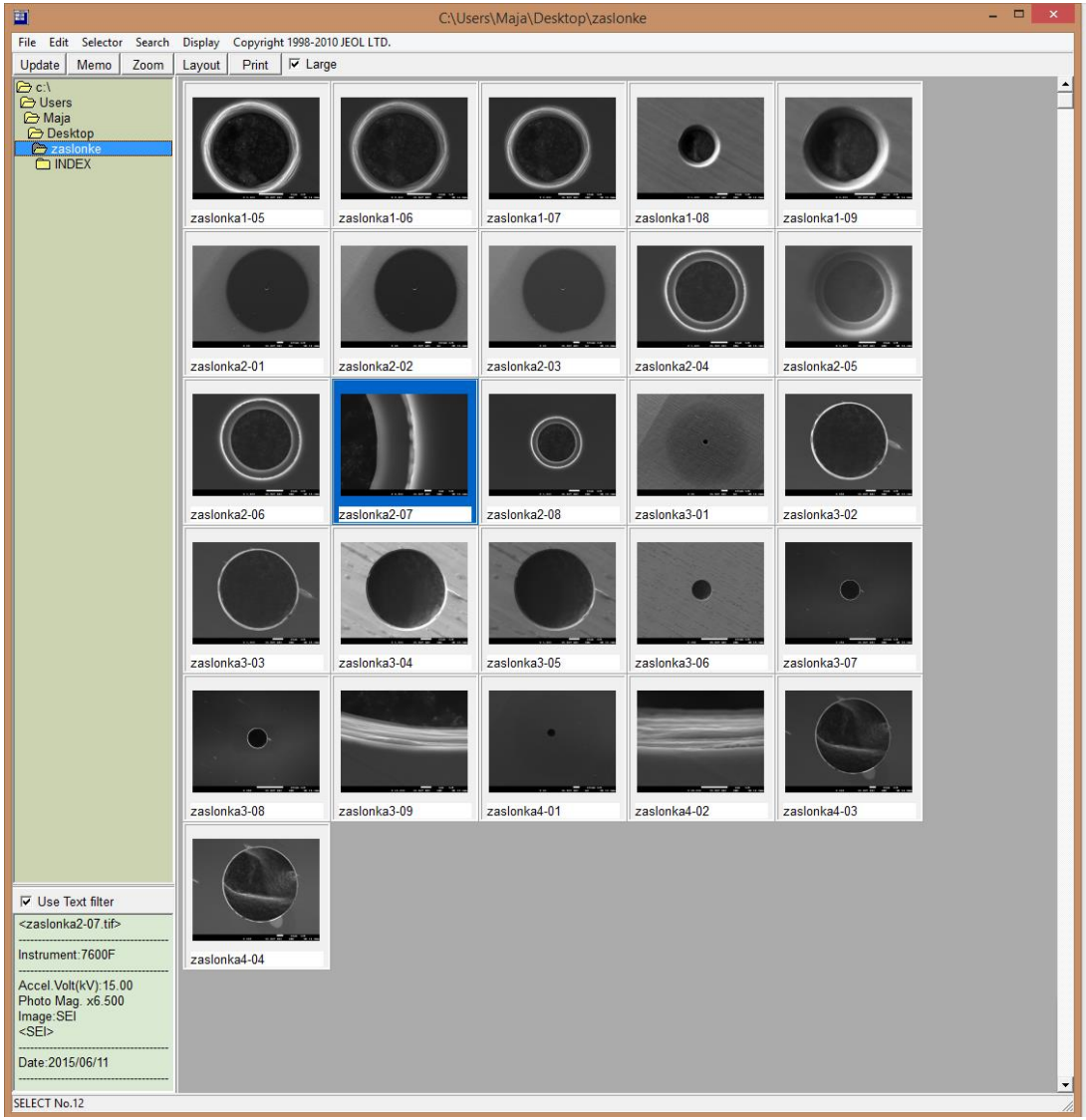
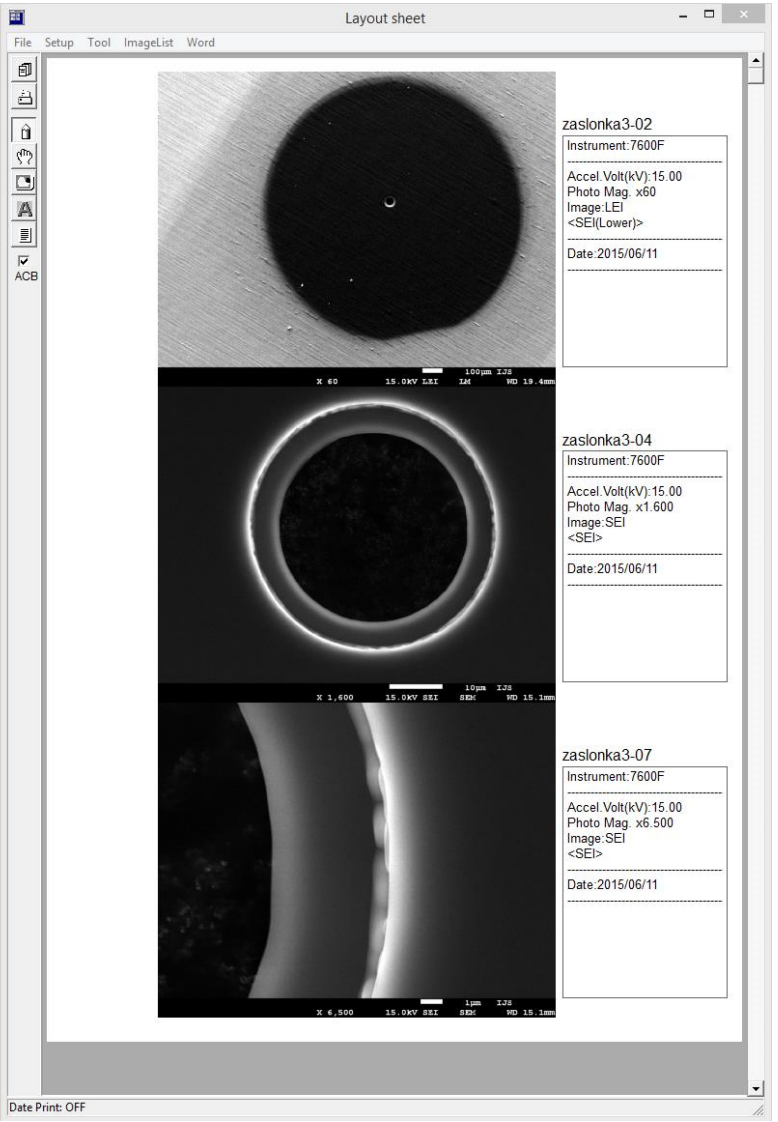
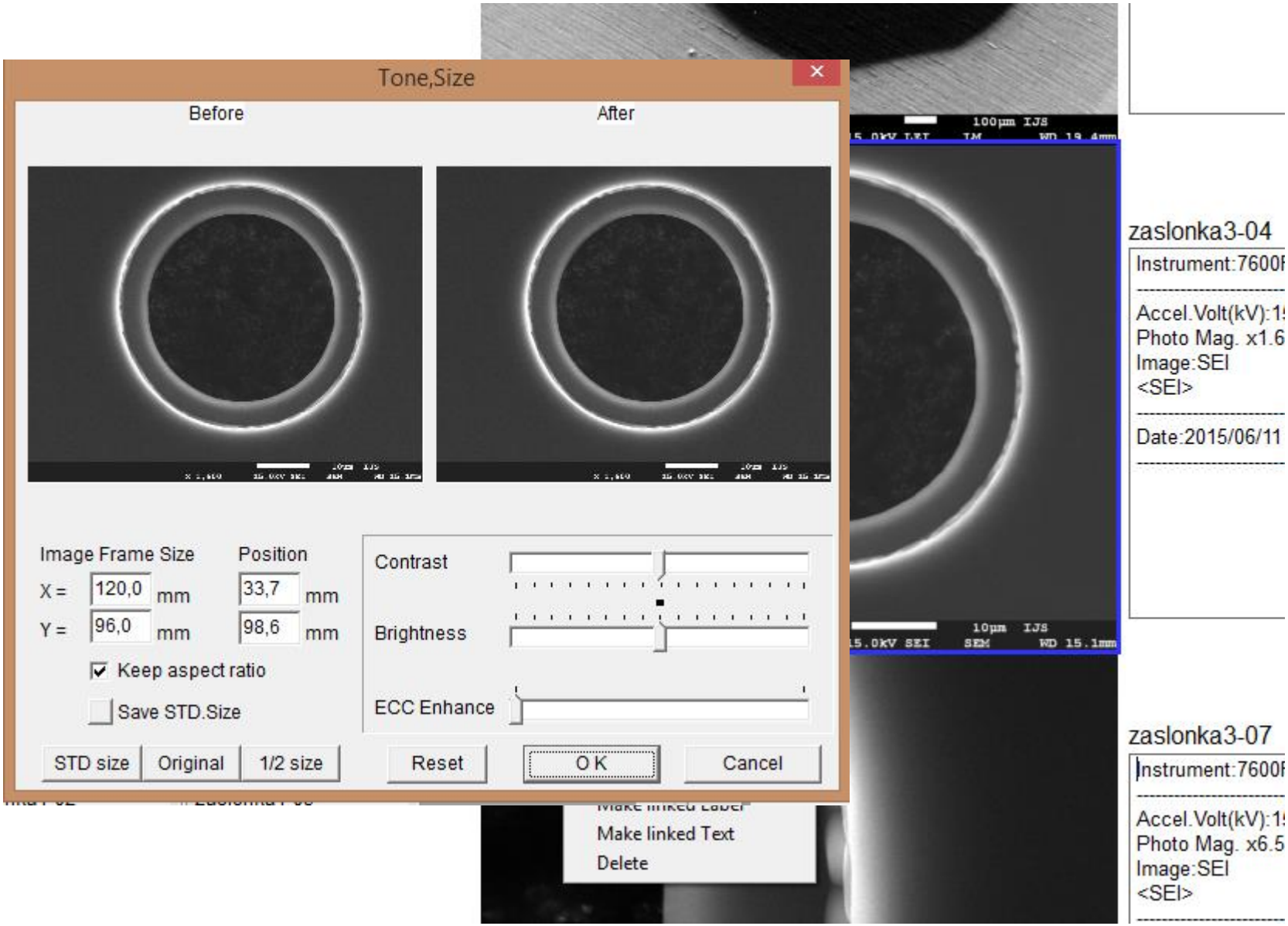
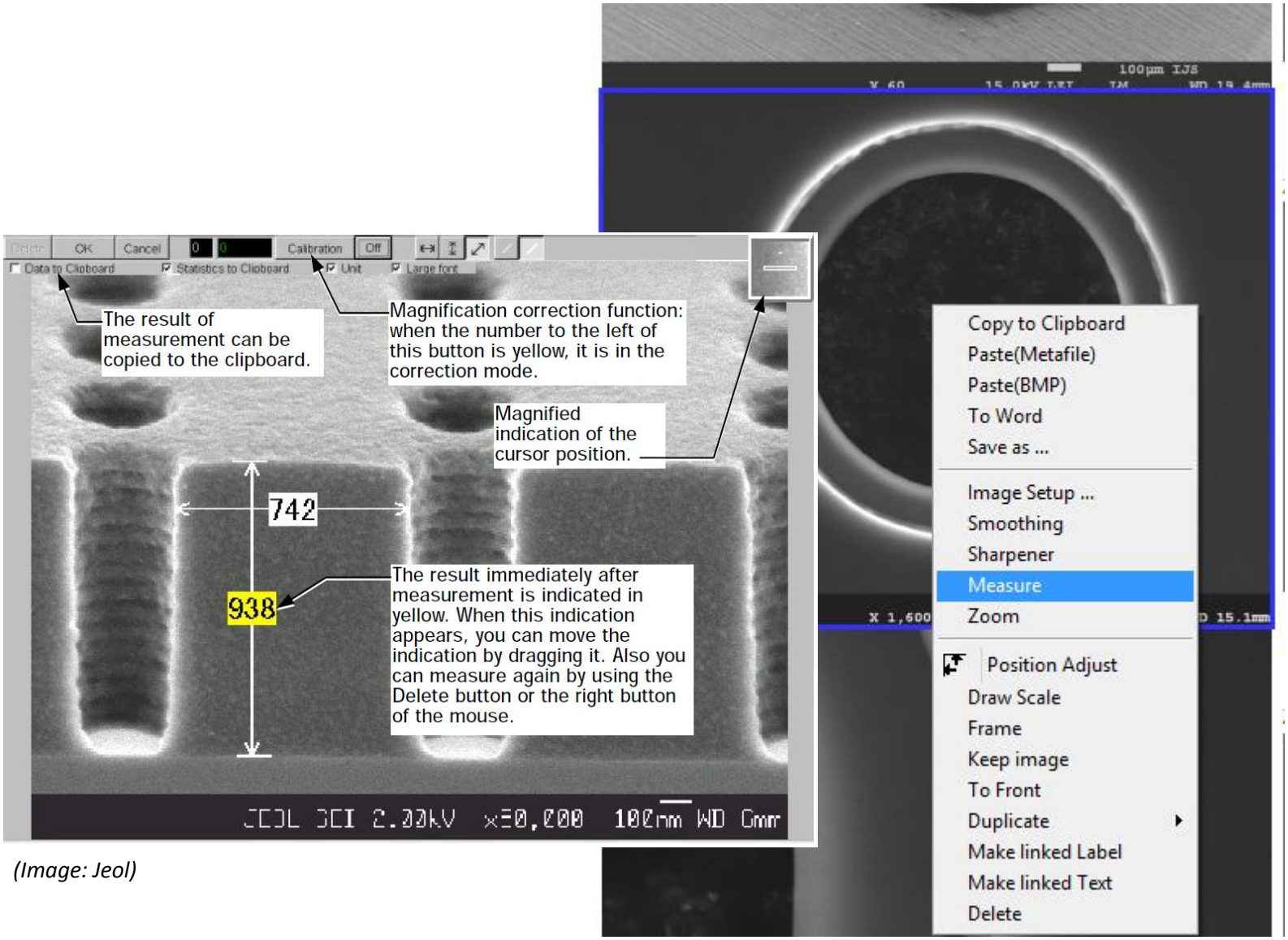

C:\Users\Maja\Desktop\zaslonke
File Edit Selector Search Display Copyright 1998-2010 JEOL LTD.
Update Memo Zoom Layout Print Large
c:\
Users
Maja
Desktop
zaslonke
INDEX
zaslonka1-05
zaslonka1-06
zaslonka1-07
zaslonka1-08
zaslonka1-09
zaslonka2-01
zaslonka2-02
zaslonka2-03
zaslonka2-04
zaslonka2-05
zaslonka2-06
zaslonka2-07
zaslonka2-08
zaslonka3-01
zaslonka3-02
zaslonka3-03
zaslonka3-04
zaslonka3-05
zaslonka3-06
zaslonka3-07
zaslonka3-08
zaslonka3-09
zaslonka4-01
zaslonka4-02
zaslonka4-03
zaslonka4-04
Use Text filter
<zaslonka2-07.tif>
Instrument:7600F
Accel.Volt(kV):15.00
Photo Mag. x6.500
Image:SEI
<SEI>
Date:2015/06/11
SELECT No.12


Layout sheet
File Setup Tool ImageList Word
ACB
zaslonka3-02
Instrument:7600F
Accel.Volt(kV):15.00
Photo Mag. x60
Image:LEI
<SEI(Lower)>
Date:2015/06/11
zaslonka3-04
Instrument:7600F
Accel.Volt(kV):15.00
Photo Mag. x1.600
Image:SEI
<SEI>
Date:2015/06/11
zaslonka3-07
Instrument:7600F
Accel.Volt(kV):15.00
Photo Mag. x6.500
Image:SEI
<SEI>
Date:2015/06/11
Date Print: OFF


Tone,Size
Before
After
Image Frame Size
Position
X = 120,0 mm
33,7 mm
Y = 96,0 mm
98,6 mm
Keep aspect ratio
Save STD.Size
Contrast
Brightness
ECC Enhance
STD size
Original
1/2 size
Reset
O K
Cancel
Make linked Text
Delete
zaslonka3-04
Instrument:7600F
Accel.Volt(kV):15
Photo Mag. x1.6
Image:SEI
<SEI>
Date:2015/06/11
zaslonka3-07
Instrument:7600F
Accel.Volt(kV):15
Photo Mag. x6.5
Image:SEI
<SEI>
100µm IJS
10µm IJS


Delete
OK
Cancel
0
0
Calibration
Off
Data to Clipboard
Statistics to Clipboard
Unit
Large font
The result of measurement can be copied to the clipboard.
Magnification correction function: when the number to the left of this button is yellow, it is in the correction mode.
Magnified indication of the cursor position.
742
938
The result immediately after measurement is indicated in yellow. When this indication appears, you can move the indication by dragging it. Also you can measure again by using the Delete button or the right button of the mouse.
JEOL JCI 2.00kV x50,000 100nm WD 6mm
100µm IJS
X 1,600
Copy to Clipboard
Paste(Metafile)
Paste(BMP)
To Word
Save as ...
Image Setup ...
Smoothing
Sharpener
Measure
Zoom
Position Adjust
Draw Scale
Frame
Keep image
To Front
Duplicate
Make linked Label
Make linked Text
Delete

(Image: Jeol)

Typical mistakes

Sample preperation

The samples are prepared in the room for the preparation.

Dry and dust free!

Use gloves!

Finger thigh!

NO magnetic samples (or iron…)

A) minimal amount as possible!

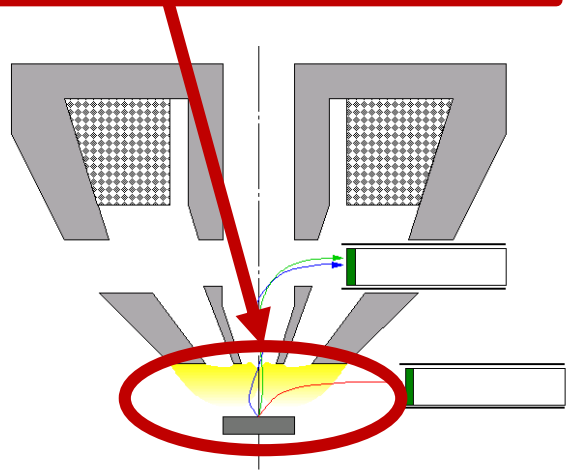
B) fix it very good!

C) use slow movement (x, y and z) under the objective lens!

D) focus, stigmatizm … very slowly!

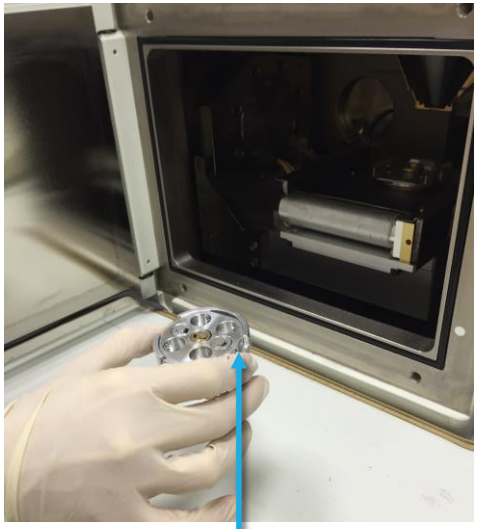
JSM-7600F

JSM-5800

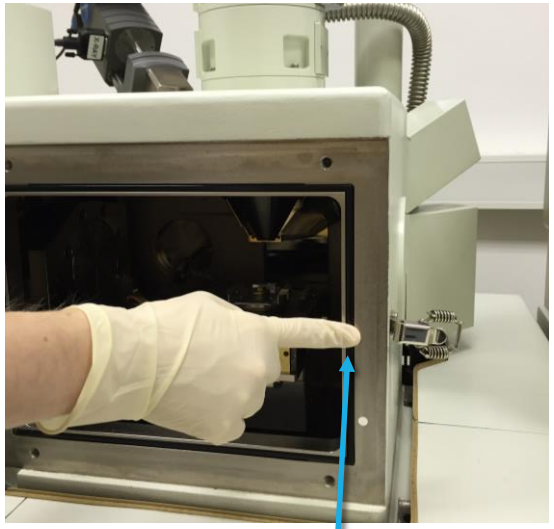


JSM-5800

ON/OFF and SL1/SL2/SL3



DO NOT HIT THE DETECTOR



Clean the o-ring (vacuum)

What is the working distance?

A. The seated distance between the microscopist and the microscope

B. The distance from the specimen to the secondary electron detector

C. The distance from the specimen to the objective lens pole piece

D. The distance from the specimen to X-ray detector

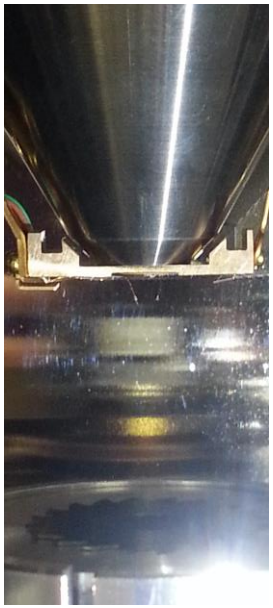
JSM-5800 and JSM-7600F

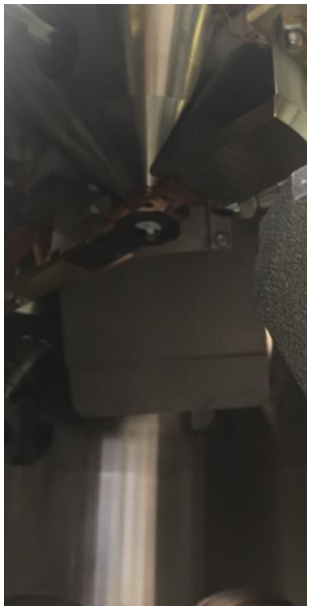
Different height of samples

BSE on 5800 damaged!!
BSE on 7600F carbon tape on it!!

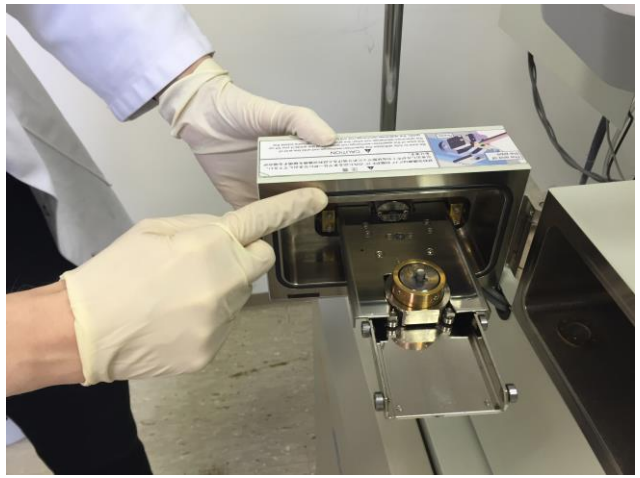
Figure removed for copyright reasons.

(Image: ammrf)



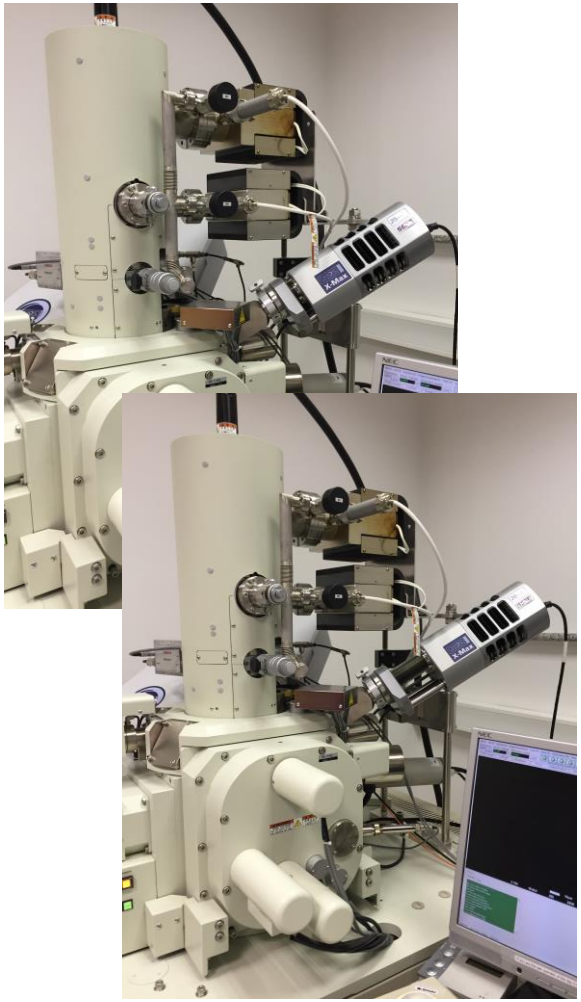


JSM-7600F



How to end a session

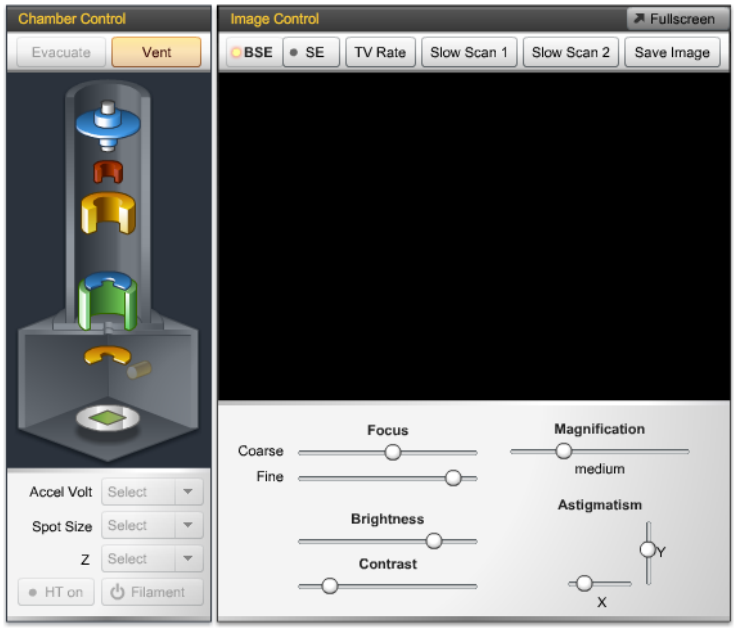
1. Set the initial settings (**apertures!)**
2. Write in the log book (**the emission current**)
3. SEM must be under vacuum
4. Log off INCA
5. For EBSD, WDS – **insert the EDS** detector!

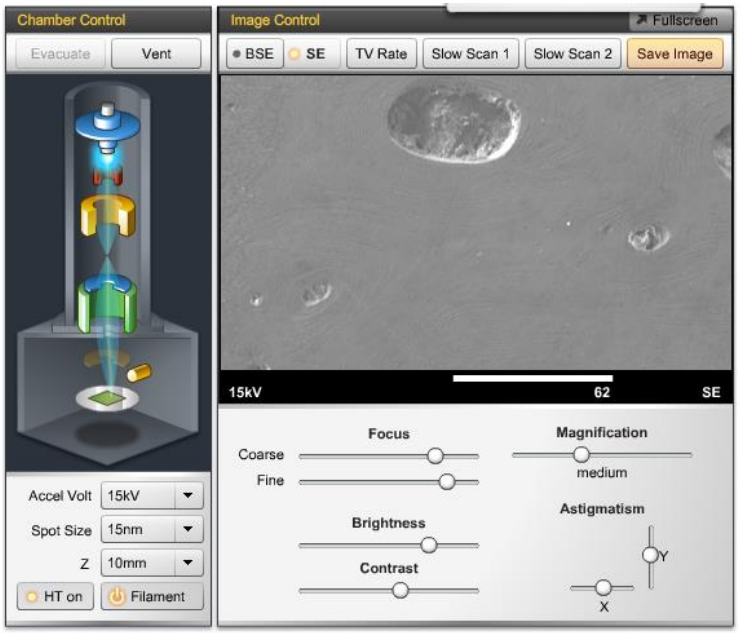


Usefull site

http://www.ammrf.org.au/myscope/

Virtual SEM





http://www.ammrf.org.au/myscope/

Next workshops:

- **EDS**,
- *WDS,
- *EBSD,