

SEM For NF

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IAEA Regional Training Course on
Practical Introduction to Nuclear
Forensics

Science. Ingenuity. Sustainability.

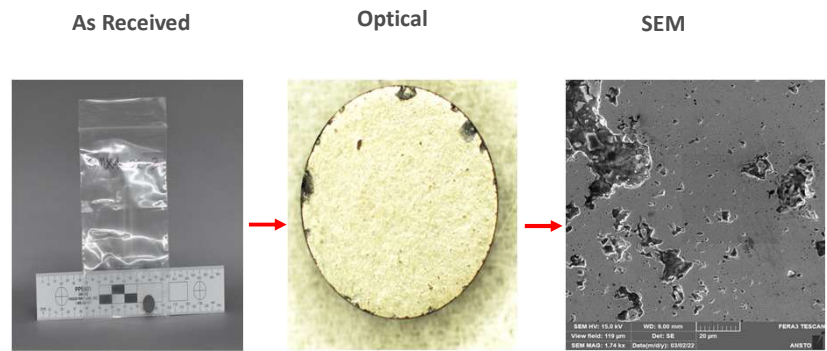
Learning Objectives

1. Why use SEM?
2. SEM structure
3. Signal generation
4. Detectors
5. Sample preparation
6. Adjusting image settings



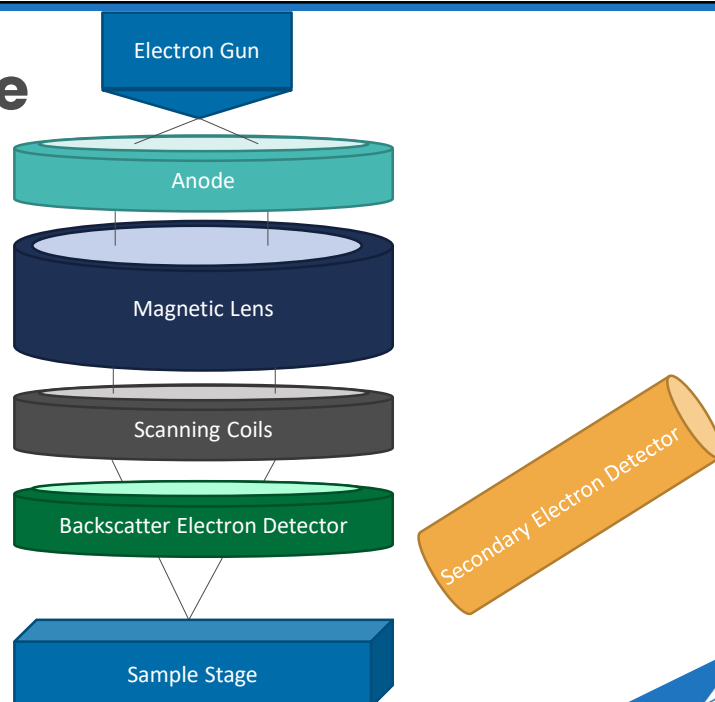
Why Use SEM?

- High resolution
- Range of magnification
- Depth of field
- X-ray analysis
- Crystal structure

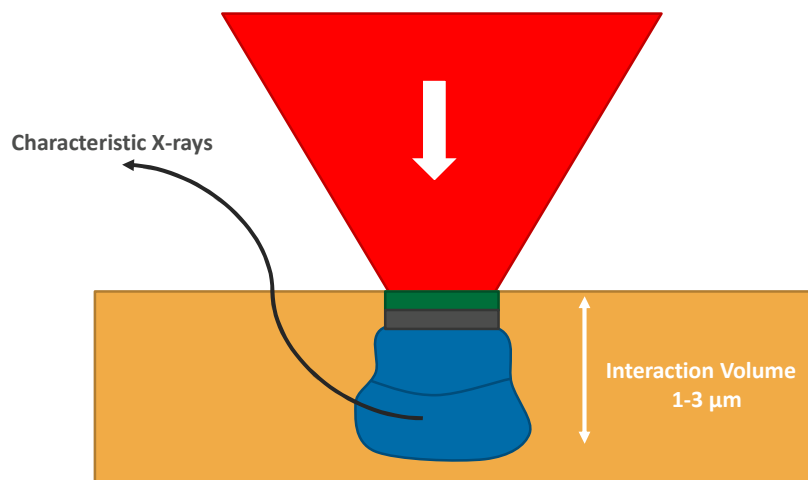


CMX-4 ES-3 LEU pellet sample

SEM Structure



Signal generation



Electron Beam

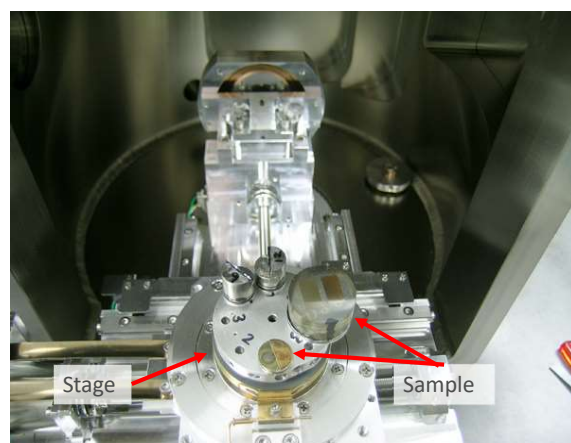
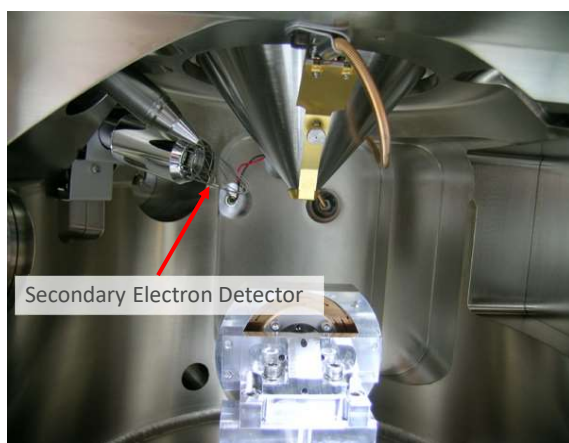
Auger Electrons

Secondary Electrons

Backscattered Electrons

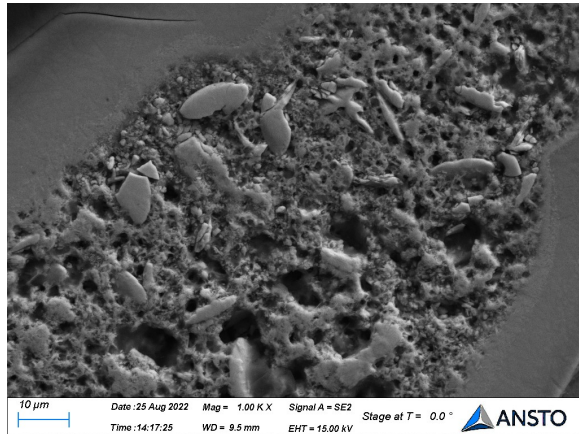
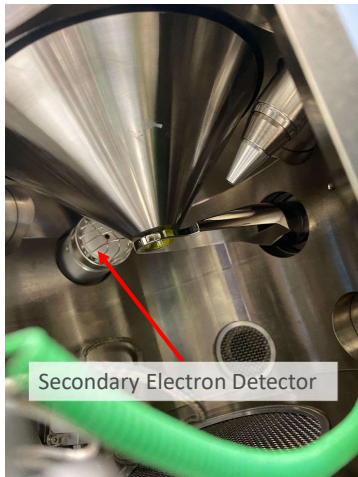
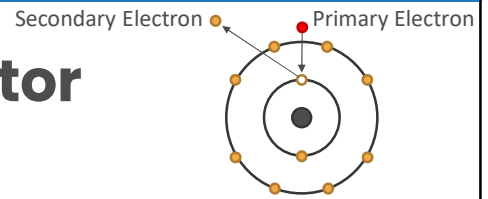
ANSTO

SEM Structure



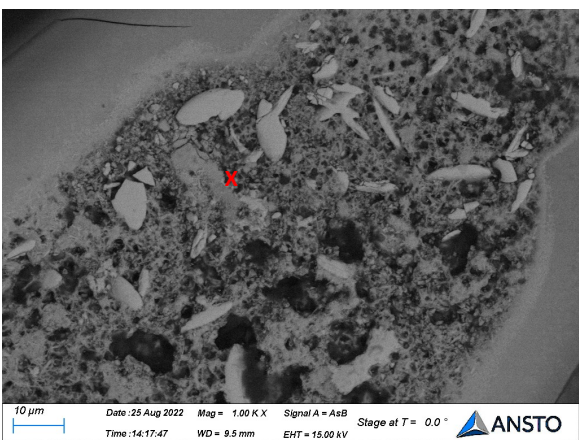
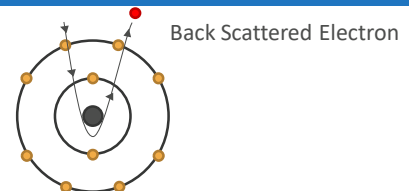
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Secondary Electron Detector



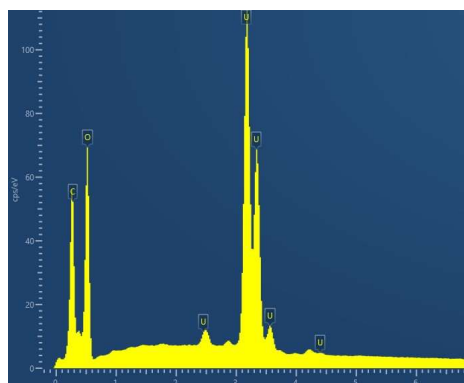
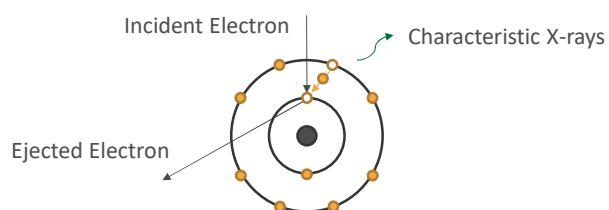
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Back Scatter Detector



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X-ray detector



Electron Back Scatter Detector

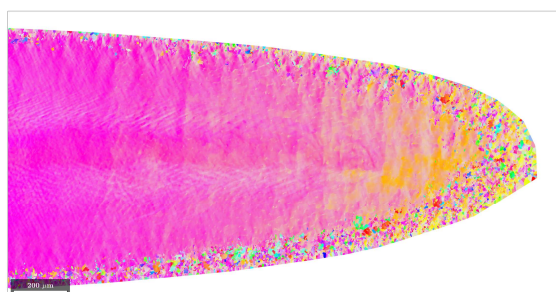
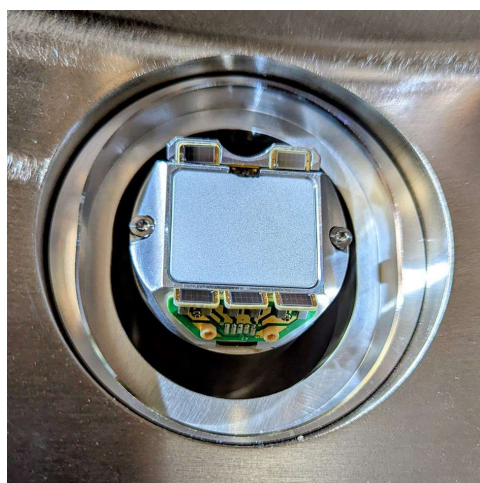
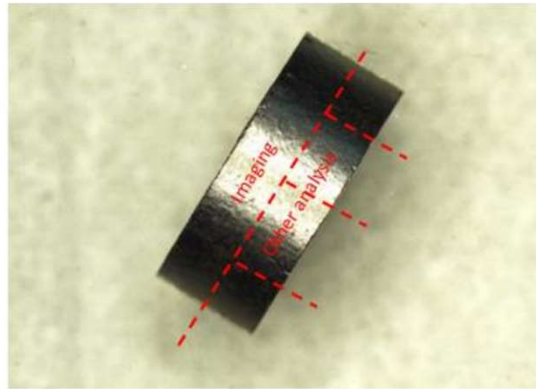


Image courtesy of Ondrej Muransky from NFC

Sample preparation

- Types of sample preparation:

- Sectioning
- Resin mounting
- Polishing
- Carbon or gold coating
- Impacted
- Raw material on stub



Optical microscope image of CMX-4 ES-3 LEU pellet with sections lined indicating portions of the sample cut for SEM imaging and other analyses.

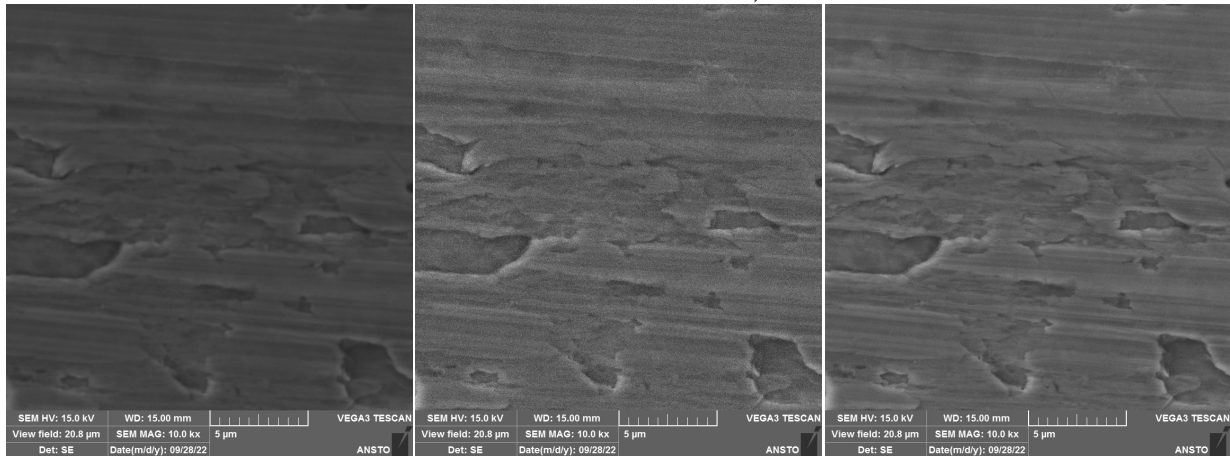
Adjusting image settings

- Aperture / Spot Size

- Resolution
- Noise
- Number of X-rays

Adjusting image settings

Better resolution but less signal



Spot Size: 10
Scan Speed: 7

Spot Size: 5
Scan Speed: 7

Spot Size: 5
Scan Speed: 9

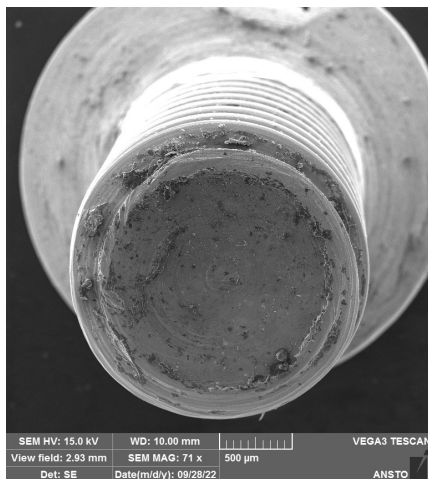


Adjusting image settings

- Working distance
 - Resolution
 - Depth of Field
 - Backscattered electron collection angle
 - Detector geometry

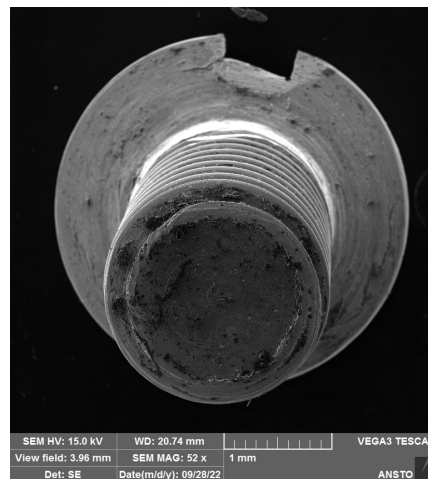


Adjusting image settings



Working Distance: 10 mm

Depth Of Field: 777 μ m



Working Distance: 24 mm

Depth Of Field: 1,720 μ m



Examples of SEM and NF applications

- Nuclear forensics—a methodology providing clues on the origin of illicitly trafficked nuclear materials
- Nuclear Forensic Science: Correlating Measurable Material Parameters to the History of Nuclear Material
- State of practice and emerging application of analytical techniques of nuclear forensic analysis: highlights from the 5th Collaborative Materials Exercise of the Nuclear Forensics International Technical Working Group (ITWG)



Thank You

