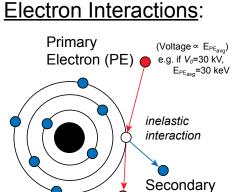
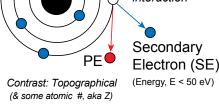
## Scanning Electron Microscopy (SEM) Concepts



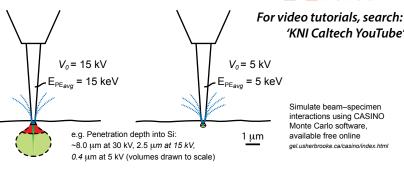
EDS.WDS

(X-ray)



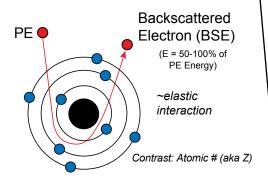


## Voltage: Piece Controls the energy of electrons $V_0 = 30 \text{ kV}$ Chromatic aberrations (E₀ spread from $E_{PEavg} = 30 \text{ keV}$ source) and spherical aberrations (electromagnetic lens imperfections) worsen at low $V_0$ , causing poorer resolution SE signal per unit current Specimen Surface -SEs Interaction Volume X-rays - Continuum (Background) and Fluorescent X-rays Current:

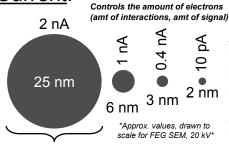


For non-conductive specimens, deeper penetration at high  $V_o$  builds charge, decreases image quality; For conductive specimens, smaller  $\lambda$  -- and less severe aberrations -- at high  $V_{\lambda}$  increases resolution.

Volume  $\propto$  Voltage  $\propto$  E<sub>PEavg</sub> $\propto$  1/ $\lambda$ <sub>PE</sub>



Contrast: Elemental Composition



Probe Diameter at Focal Plane

Tip: Select the smallest current that you need that also gives you WD enough signal for the detector/application that you are using (see table below). For imaging, if contrast is below ~75%, you should consider going to a lower current for better resolution.

## Working Distance (WD): objective lens in focus Surface $\alpha_{p_{(10 mm)}} < \alpha_{p_{(5 mm)}}$ focal plane Long WD increases depth of field. Short WD increases resolution $(\alpha_n = beam convergence angle)$ $\uparrow \alpha_{\scriptscriptstyle D}$ ↓ Depth of Field ↑ Resolution

TLD (SE)

ETD (SE.

Probe Current Probe Diameter Signal ↑ Resolution

Characteristic X-ray (0.1 < E < 30 keV, characteristic of electron transition energy)

**Detectors:** 

\*Tip: In the absence of a dedicated BSED, switch to a negative bias (e.g. -50 V) on the TLD to reject low energy SEs and operate it as a de facto BSED (works best in Immersion Mode). Also, you can Increase the positive bias of the ETD or TLD to pull in lower energy SEs and thus boost the signal.

Detector	Signal	<b>Recommended Current</b>	Information Detected
<b>Everhart-Thornley Detector (ETD)</b> <sup>1,2,3,4</sup>	SE	1-200 pA (Spot 1-3)	Surface Topography
Through-the-Lens Detector (TLD) <sup>1,2,3</sup>	SE*	1-200 pA (Spot 1-3)	Surface Topography
Backscattered Electron Detector (BSED) <sup>4</sup>	BSE	50 pA - 2 nA (Spot 2-5)	Atomic # (Z) Contrast
Energy Dispersive Spectroscopy (EDS) <sup>2,3</sup>	X-ray	100 pA - 10 nA (Spot 3-7)	<b>Elemental Composition</b>
Wavelength Dispersive Spectroscopy (WDS) <sup>2</sup>	X-ray	100 pA - 10 nA (Spot 3-7)	<b>Elemental Composition</b>

Interest line of sight positive bias (+) Matthew Sullivan Hunt, PhD

Mounted in: 1 = FEI Nova 600; 2= FEI Nova 200; 3 = FEI Sirion; 4 = FEI Quanta 200 F