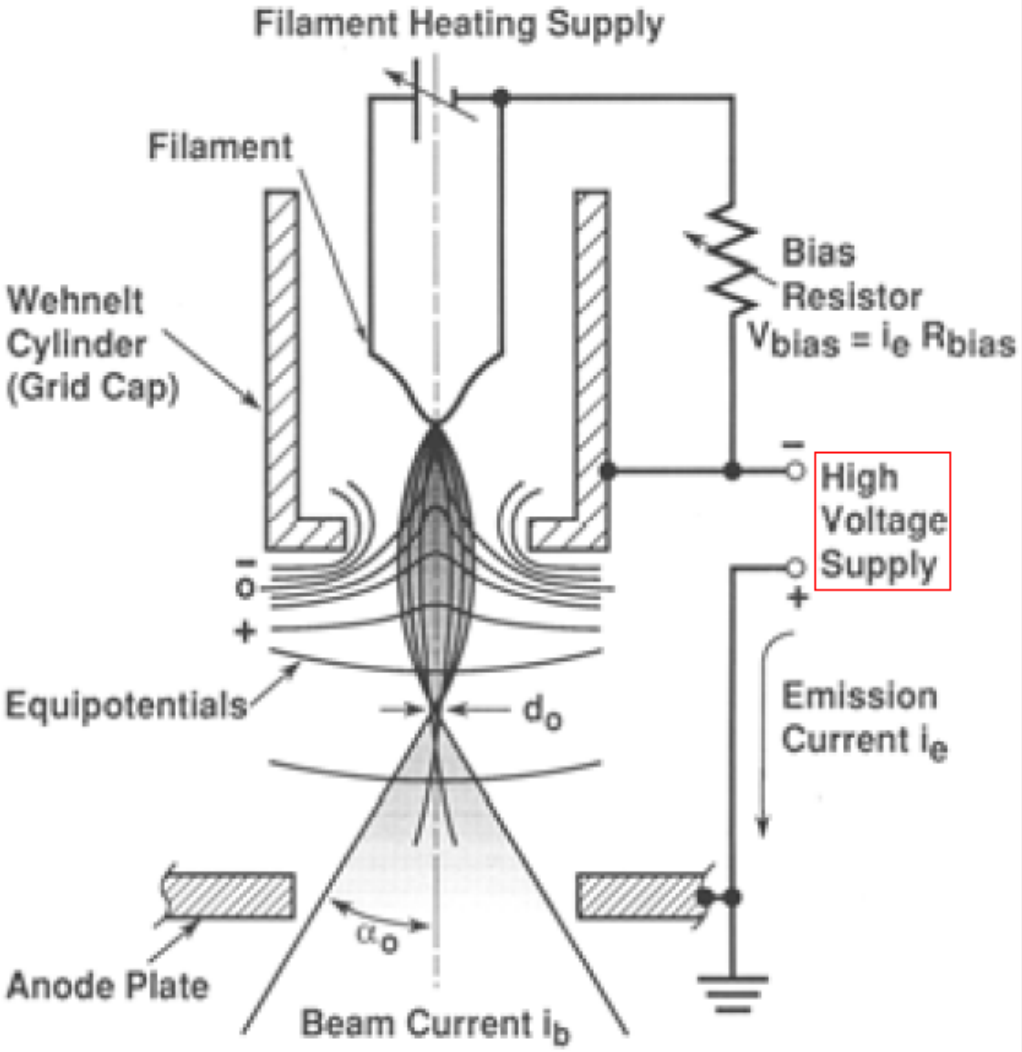
Effect of Accelerating Voltage on SEM Resolution

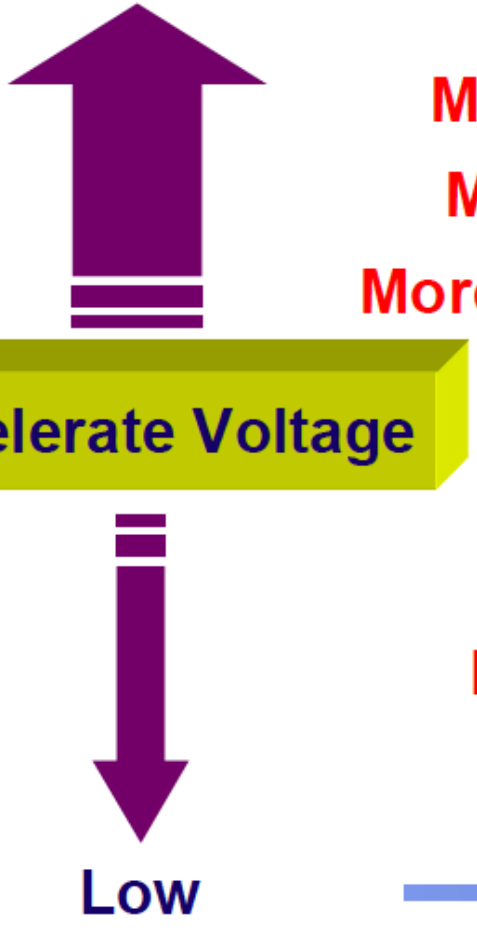
-Milton Wang

Accelerate Voltage

- Accelerating voltage (kV) is the voltage difference between the filament and the anode which accelerates the electron beam towards the anode.
- the greater the kV the greater the power of penetration.



Effect of Accelerate Voltage



High resolution

Smooth Image

Unclear surface structures

More edge effect

More charge-up

More E beam damage

Clear surface structures

Less edge effect

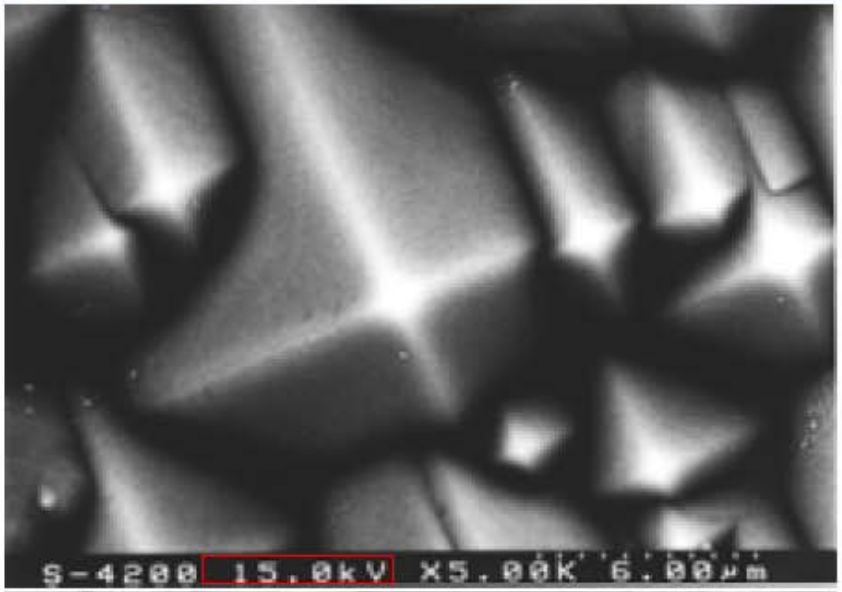
Less charge-up

Less E beam damage

Low resolution

Grainy image

Effects of Accelerate Voltage



High accelerate voltage leads to smooth images, but cannot provide detailed surface information, although the resolution is high!!!

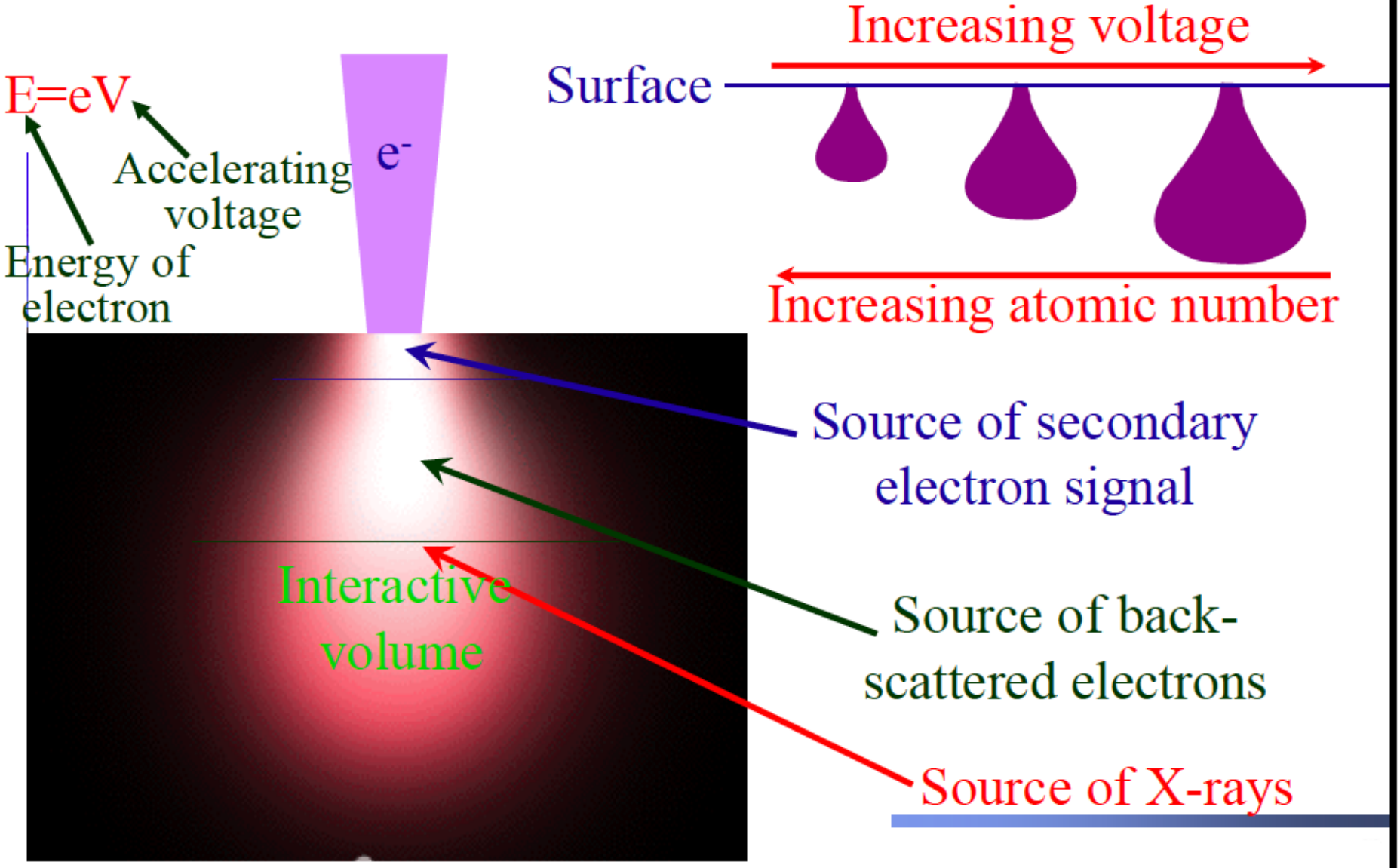
Low accelerate voltage leads to grainy images, but can provide detailed surface information, although the resolution is poor when compared with high accelerate voltage !!!

Kanaya-Okayama Depth Penetration Formula

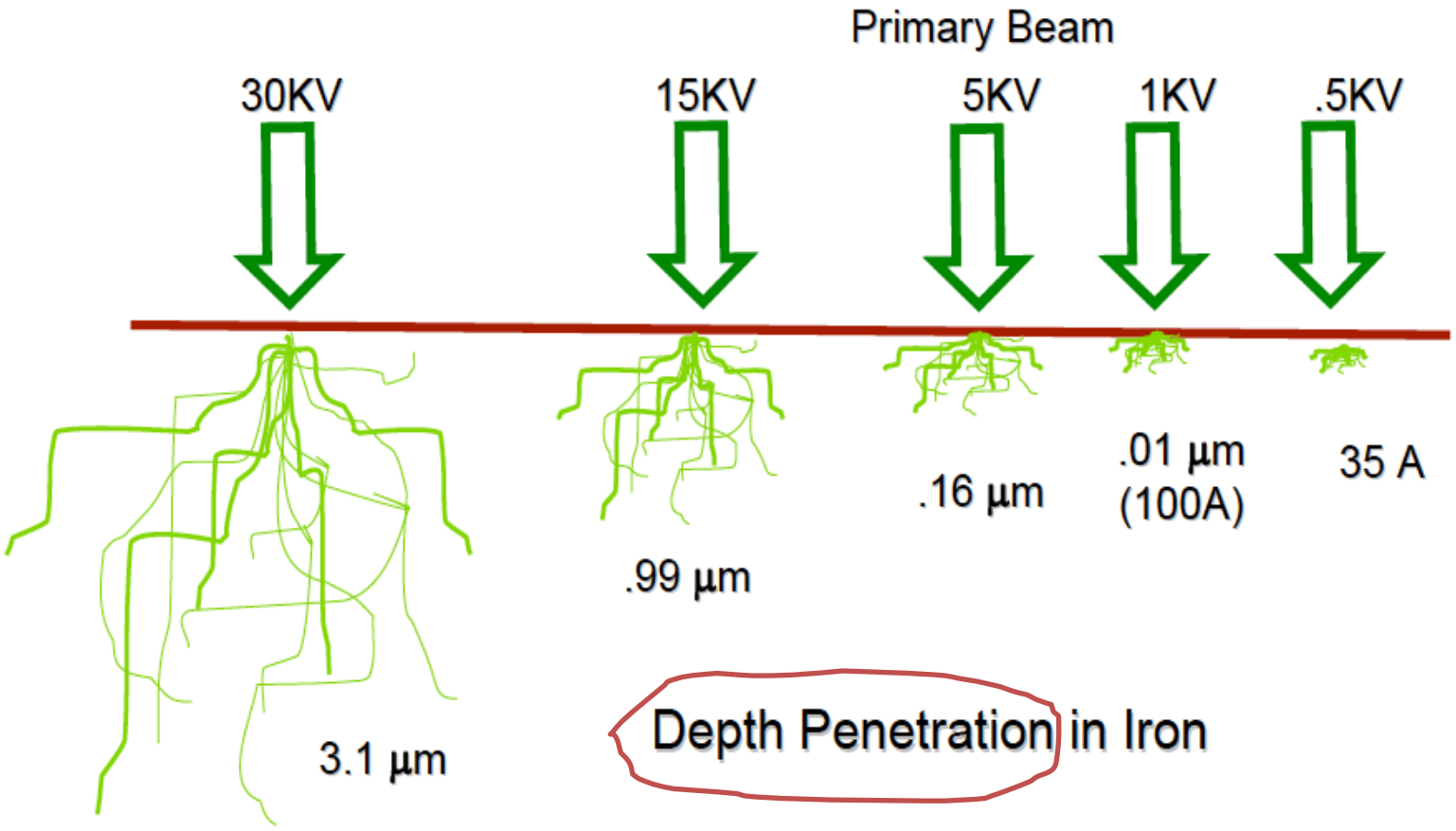
$$R = \frac{0.0276\ A\ E^{1.67}}{(Z^{0.89}\ \rho)}\ \mu m$$

R= Depth Penetration
A= Atomic Weight (g/mole)
E= Beam Energy (KV)
Z= Atomic number
ρ = density (g/cm)^2

Interactive Volume and Signals



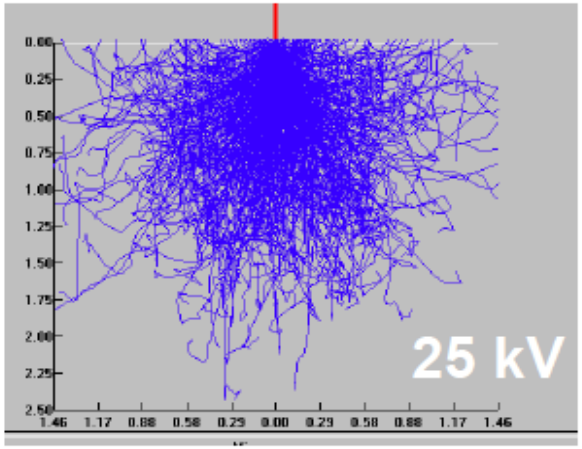
The Affect of Accelerating Voltage

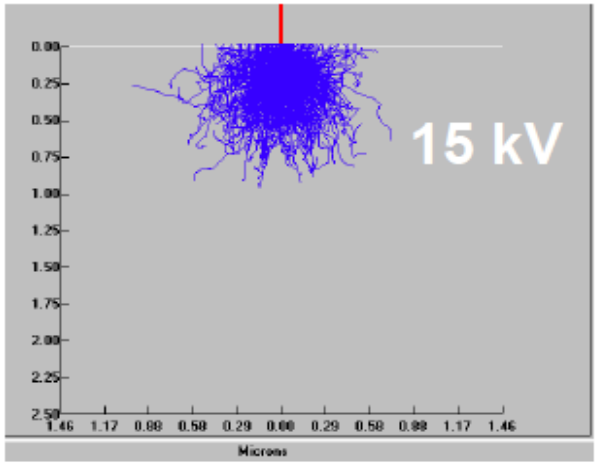


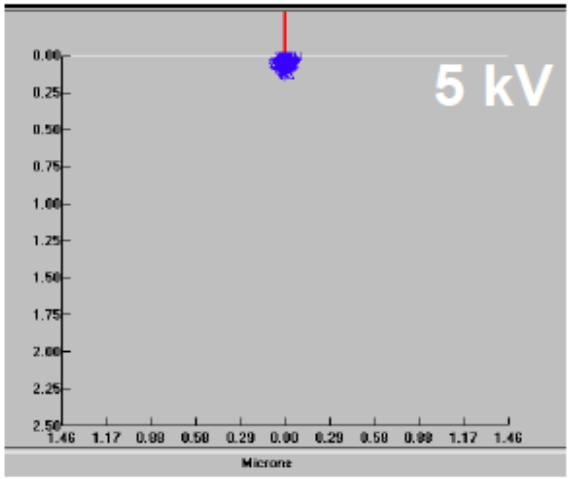
(predictions from the KO formula)

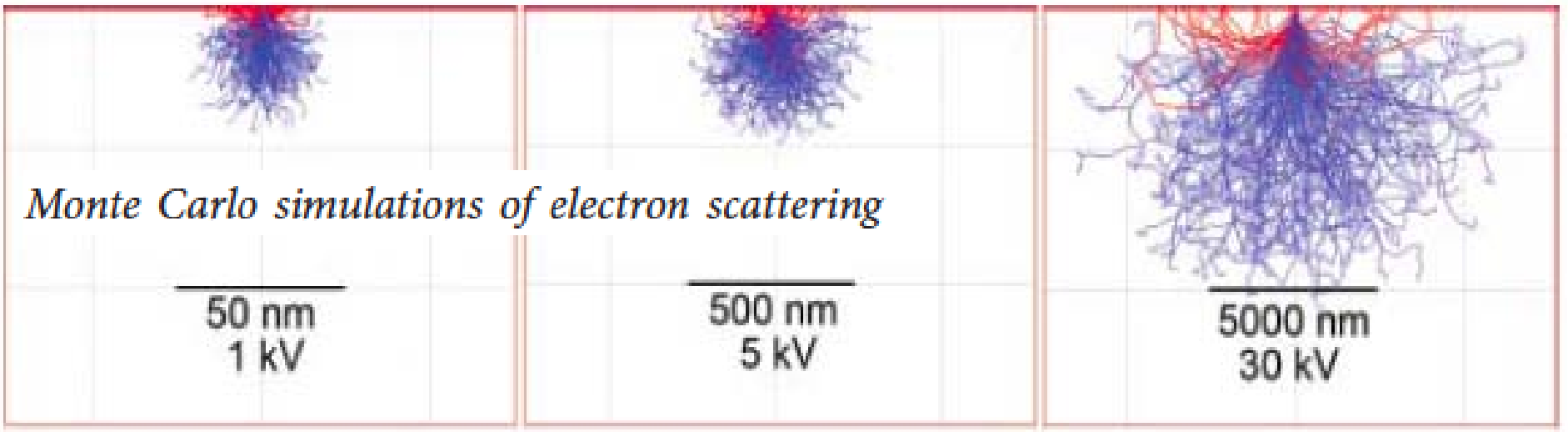
Interaction Volume vs Accelerating Voltage

Better control of where SE, BSE and x-rays are produced at lower beam voltages



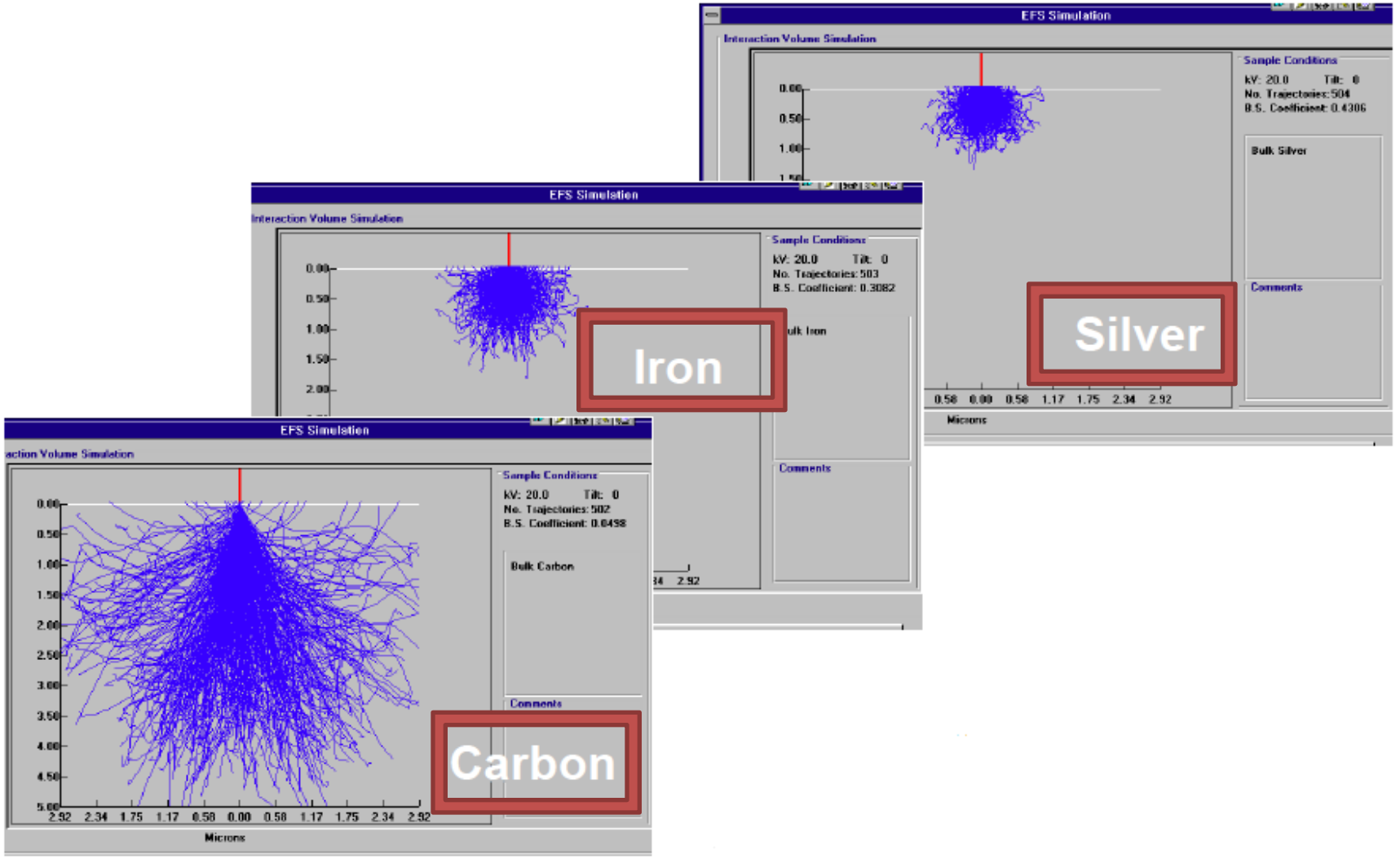




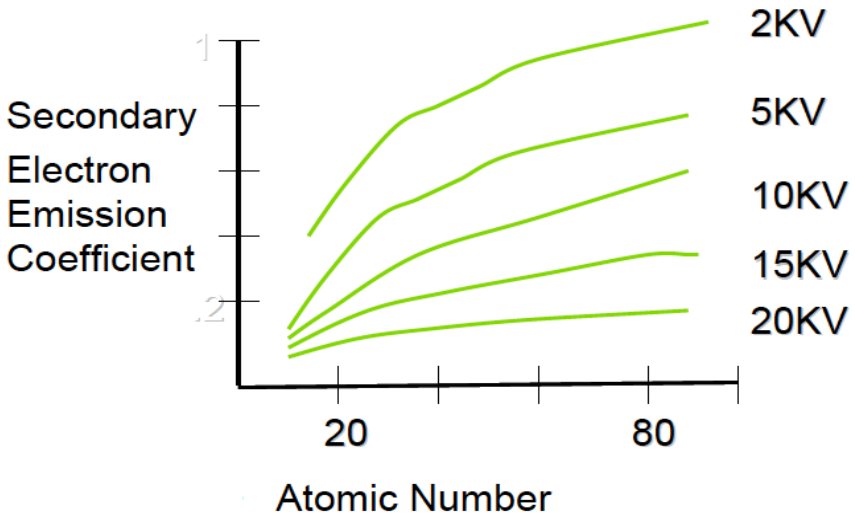


Interaction Volume –Sample Composition

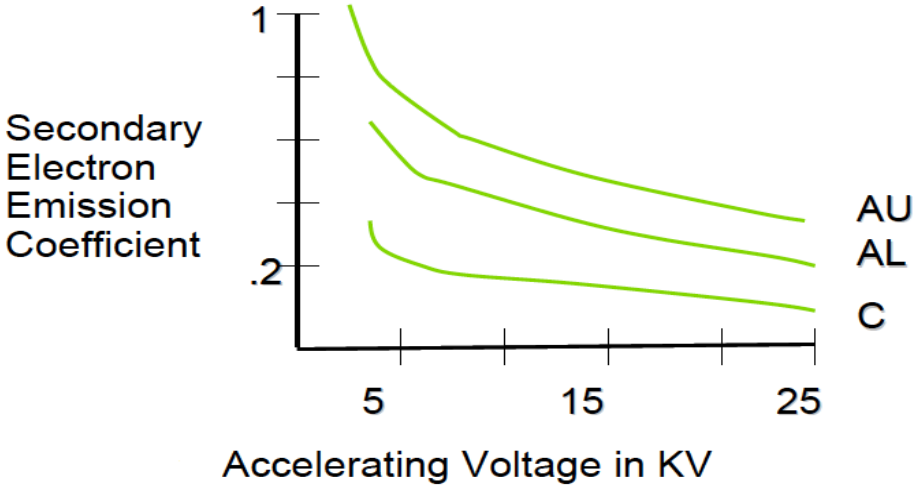
(20 kV incident beam in all 3 cases)



SE Electron Emission Coefficient Vs Atomic Number at Various KV

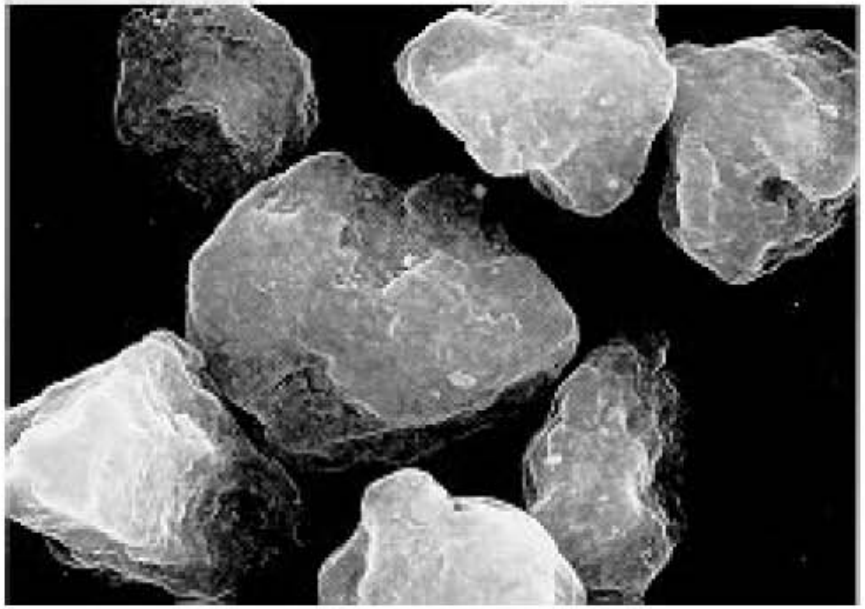


SE Emission Coefficient Vs. KV at Various Atomic Numbers

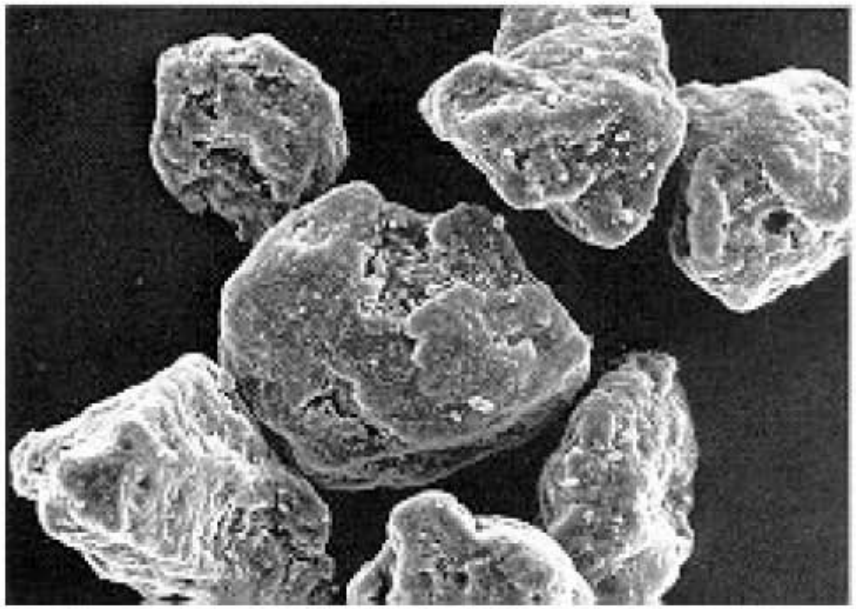


Effects on Increasing Accelerating Voltage

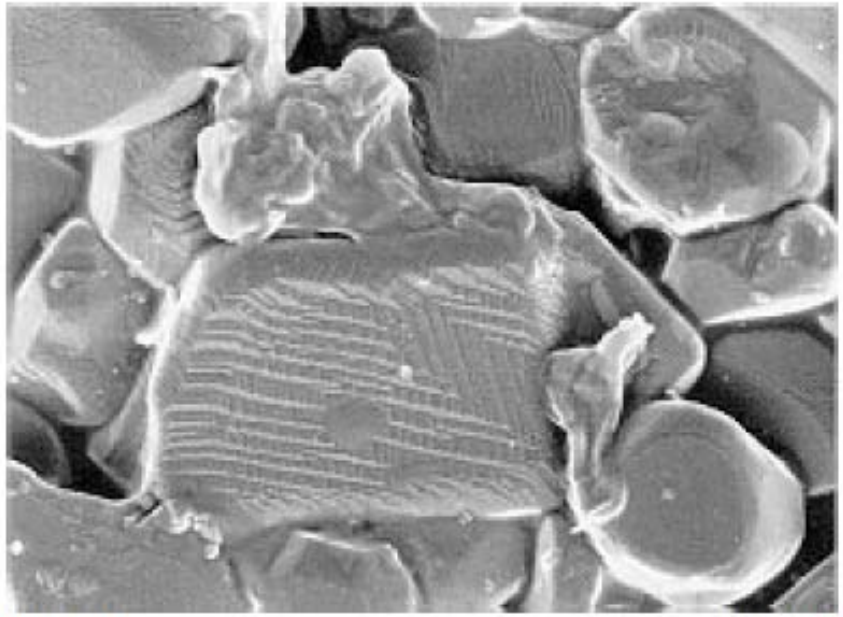
- 1) Lack of detailed structures of specimen surfaces.
- 2) Remarkable edge effect.
- 3) Higher possibility of charge-up.
- 4) Higher possibility of specimen damage.



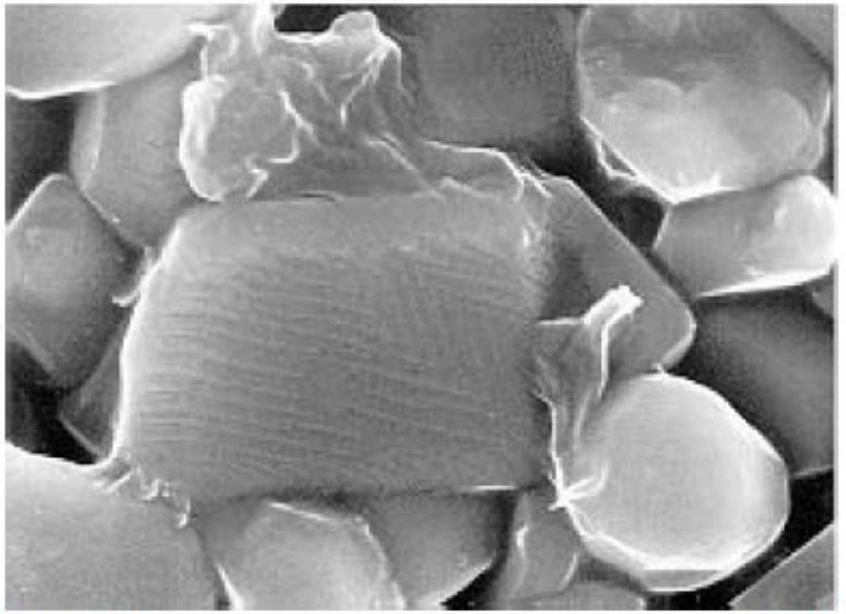
(a) 30 kV x 2,500



(a) 5 kV x 2,500

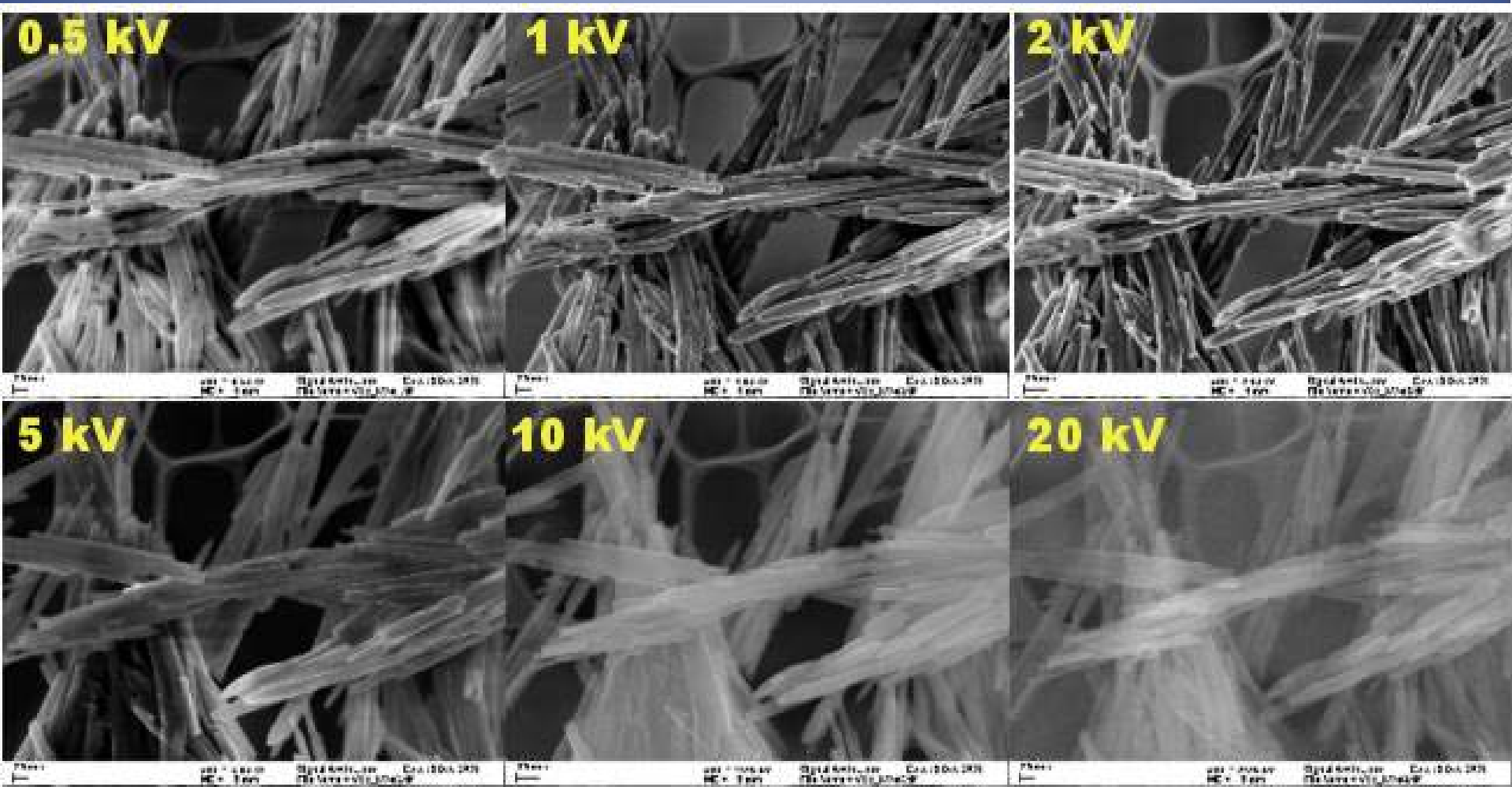


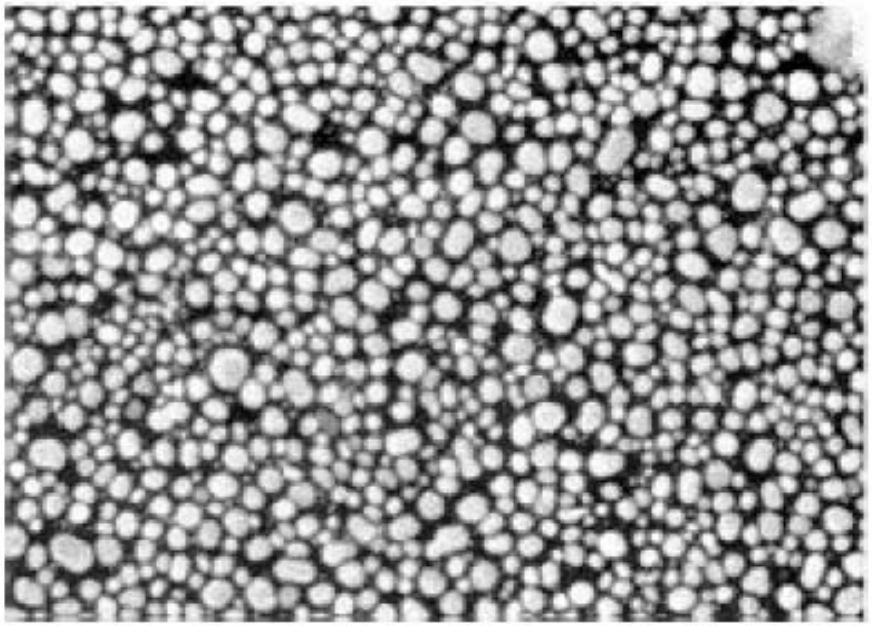
(a) 5 kV x7,200



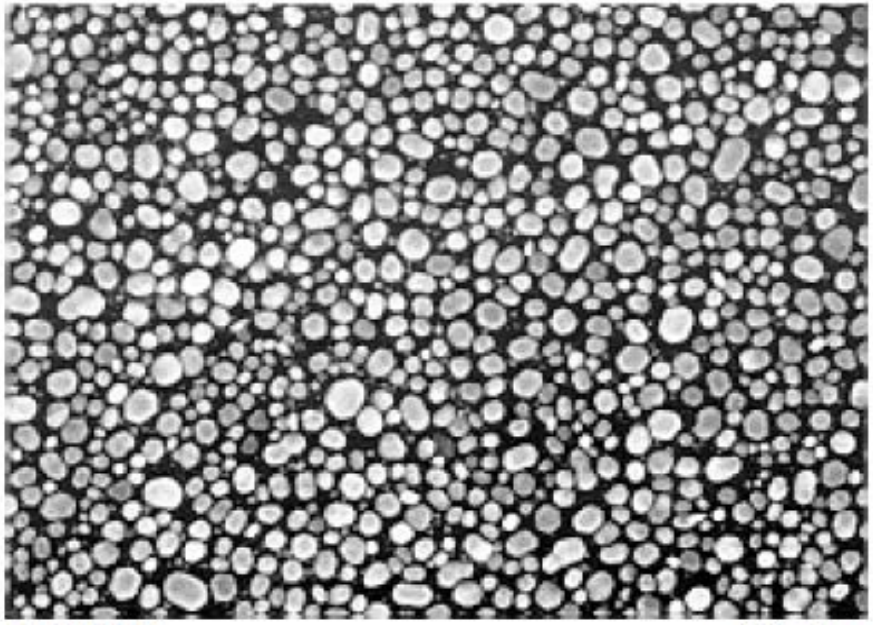
(b) 25 kV x7,200

SEM: Imaging with Secondary Electrons
Voltage Dependence of Contrast

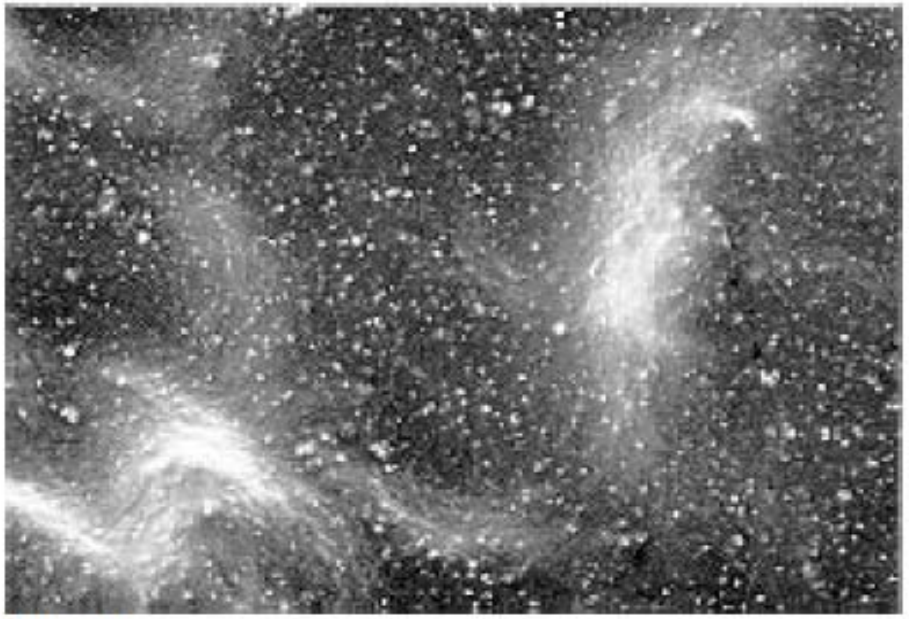




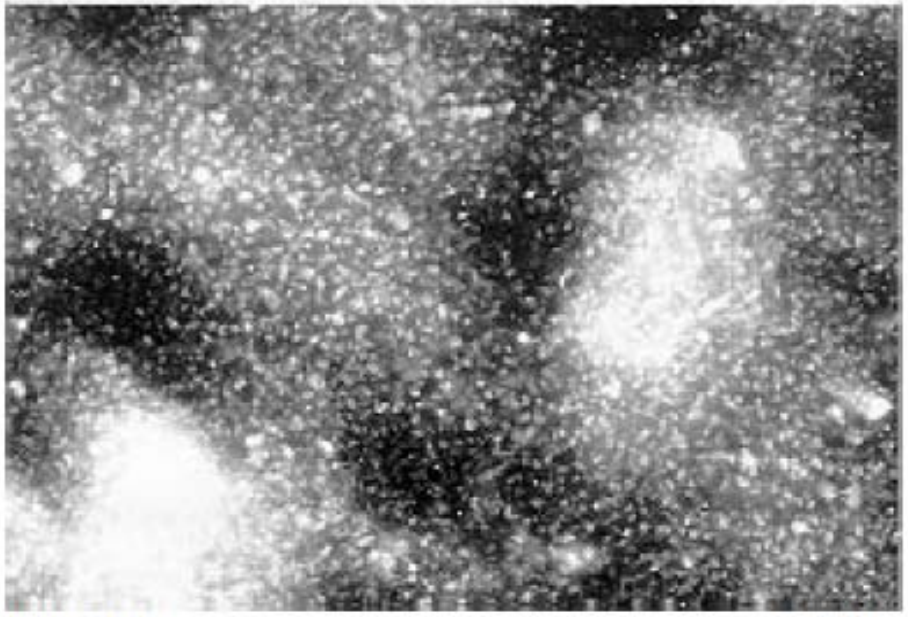
(a) 5 kV x 36,000



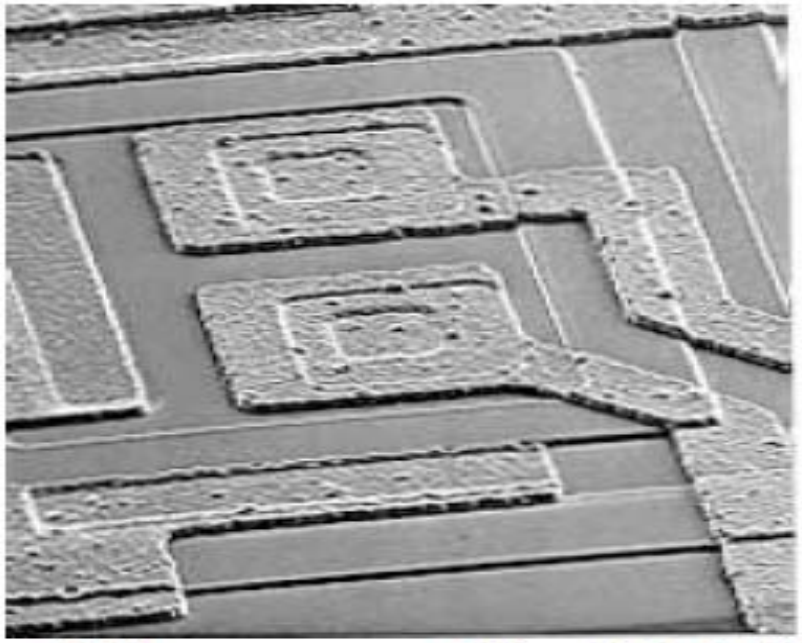
(b) 25 kV x 36,000



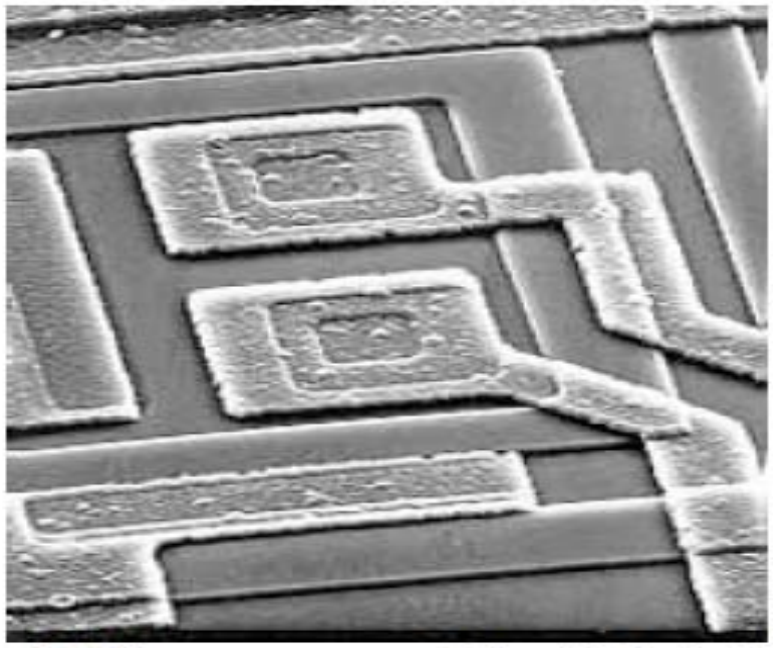
(a) 5 kV



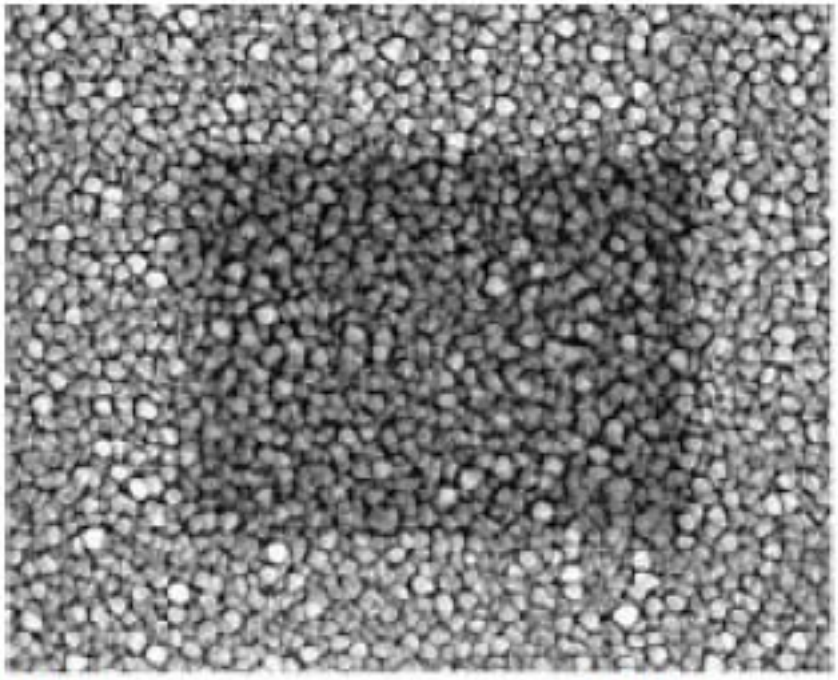
(b) 25 kV x2,200



5 kV x720 Tilt Angle: 50°



>5 kV x720 Tilt Angle: 50°



5 kV x18,000

Effects of Accelerate Voltage

Issues	Accelerate Voltage (kV)
	Low → High
Beam penetration	Shallow ↔ Deep
Resolution	Low — High
Details of surface	Clear — Blurry
Image quality	Soft ↔ Hard
SE signal	Strong — Weak
X-ray analysis	—
Charging	Little — Heavy
Non-Evaporated Obs.	Easy to see
Effect by disturbances	Large — Small

Thanks for your attentions