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Secondary Electron Emission From Accelerator Materials[†,*]

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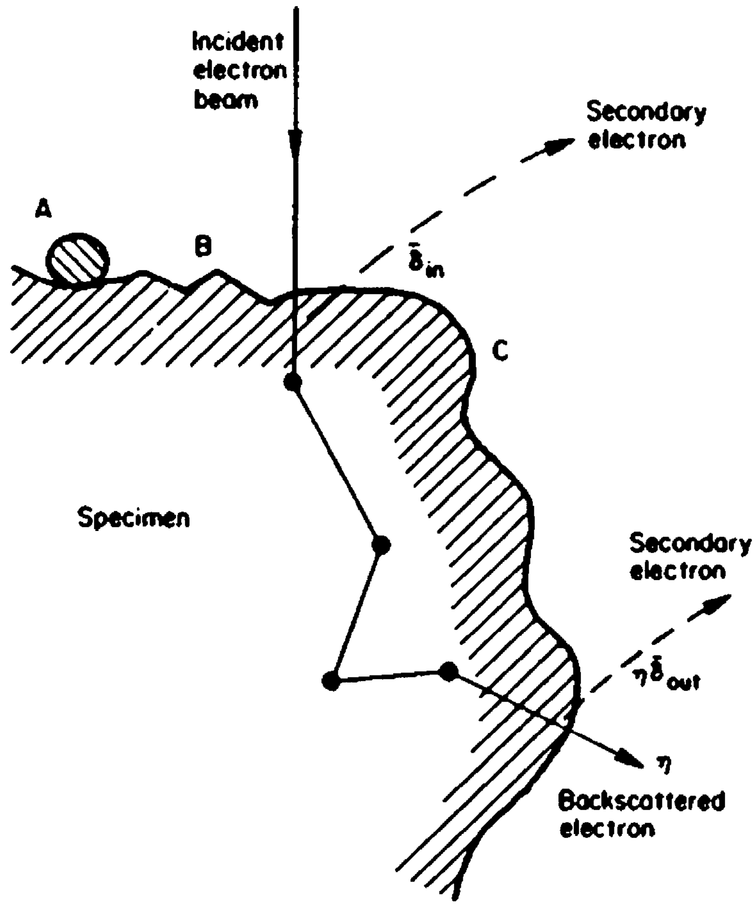
Motivations

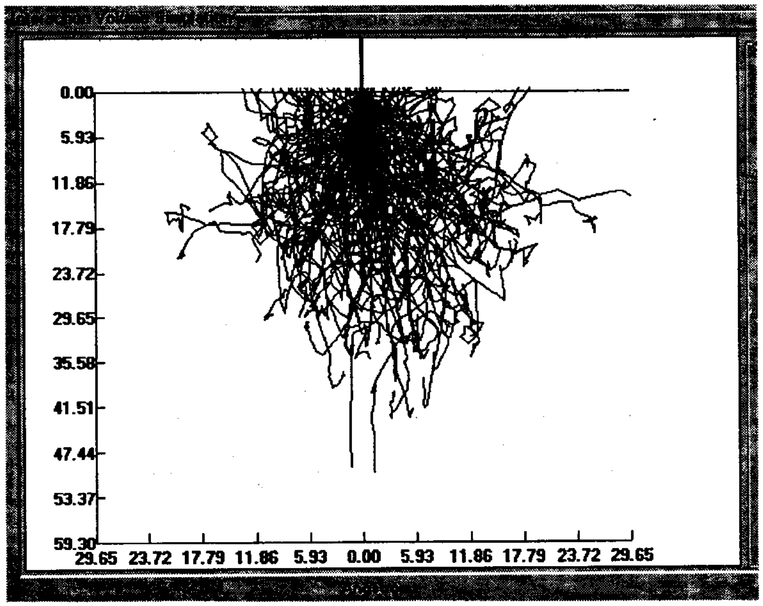
- Suppress electron emission from high rf surface field components, e.g., SPEAR storage ring cavity tuners (1973).
- Find a coating for superconducting Nb oxidation prevention (1980).
- Develop a simple method for TiN-coating of LER Al alloy beam chambers (1998).
- Measure yields as a function of primary electron incidence angle, for simulating of the "electron cloud effect (1999)."

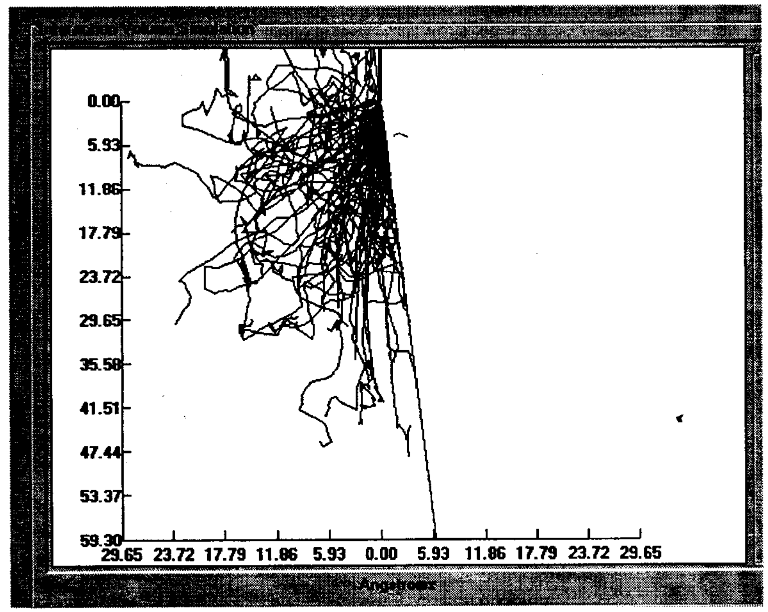
Secondary Emission Generation



Primary Electron Range

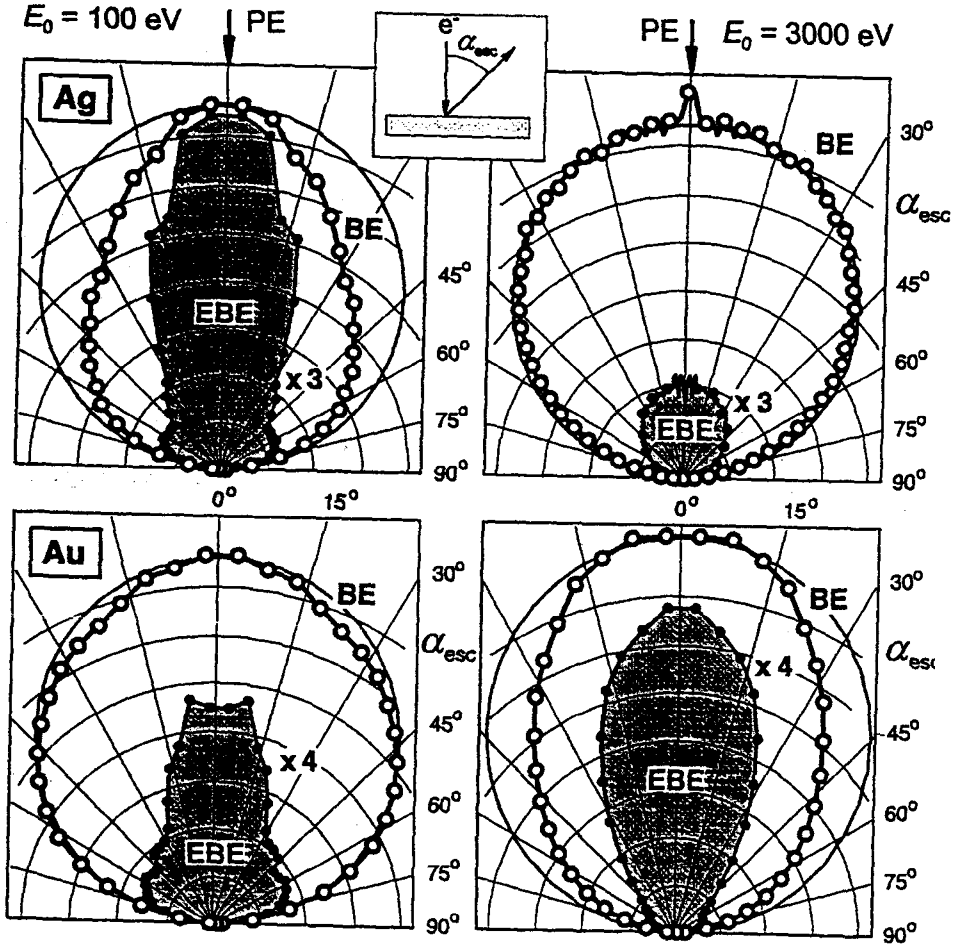
(Axes in angstroms)





$\theta = 0^o$ **$E_p = 500$ eV** **$\theta = 82.5^o$**

Backscattered Primaries- Monte Carlo



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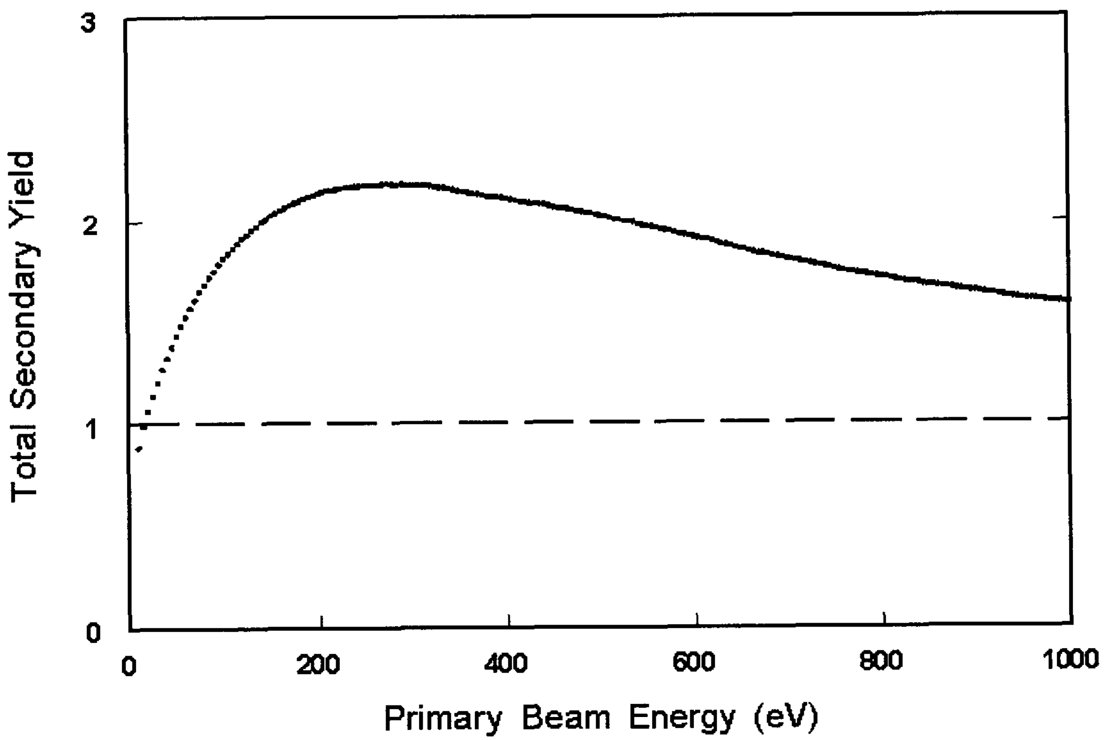
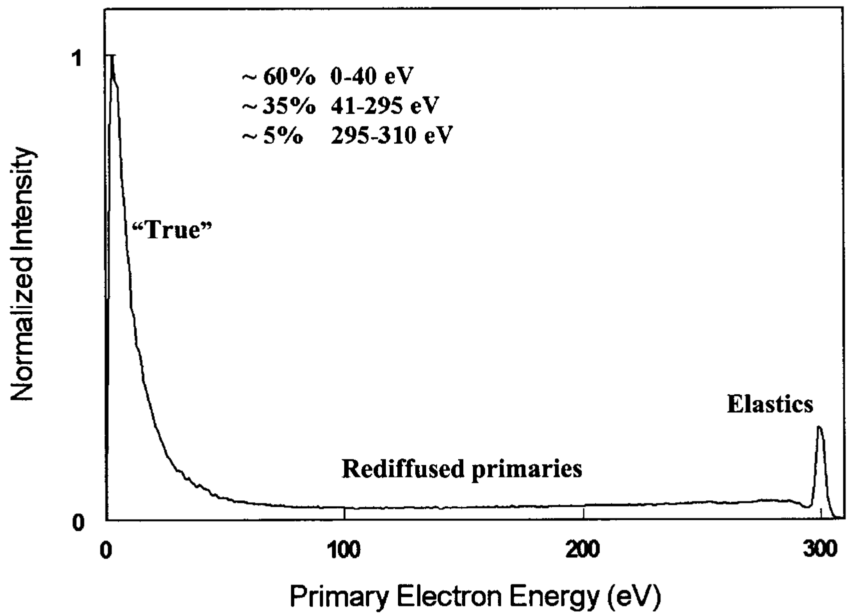
Uncoated 6061 Al Alloy



Energy Distribution Of Secondaries



TiN/Al

Experimental Questions To Answer

- What is the secondary electron yield (SEY), as a function of primary energy and incidence angle?

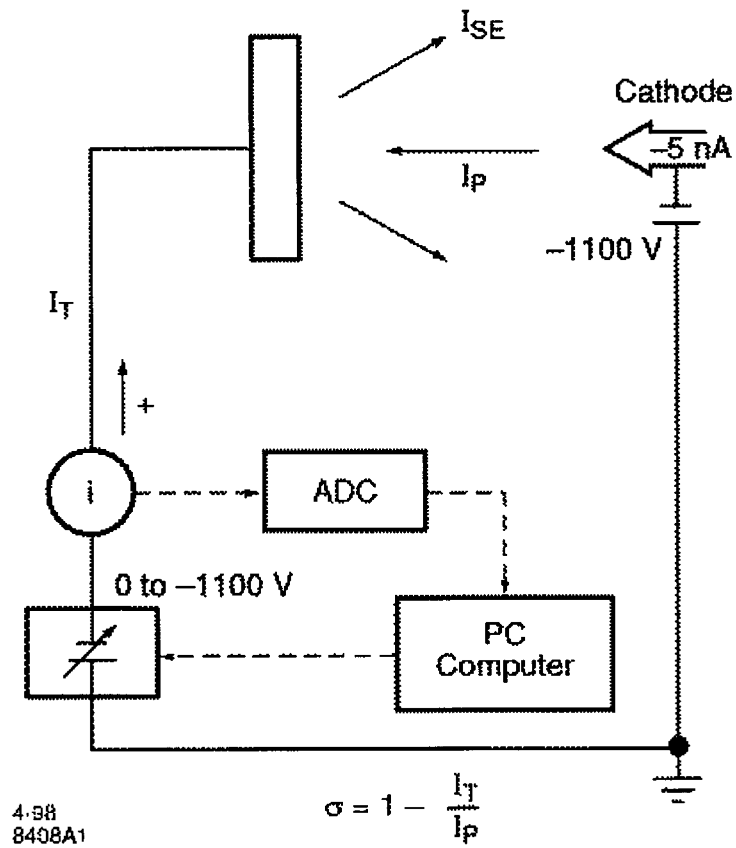
- Measure the energy distribution of secondaries.

- How does the yield change with “conditioning”, and what is responsible for the change?

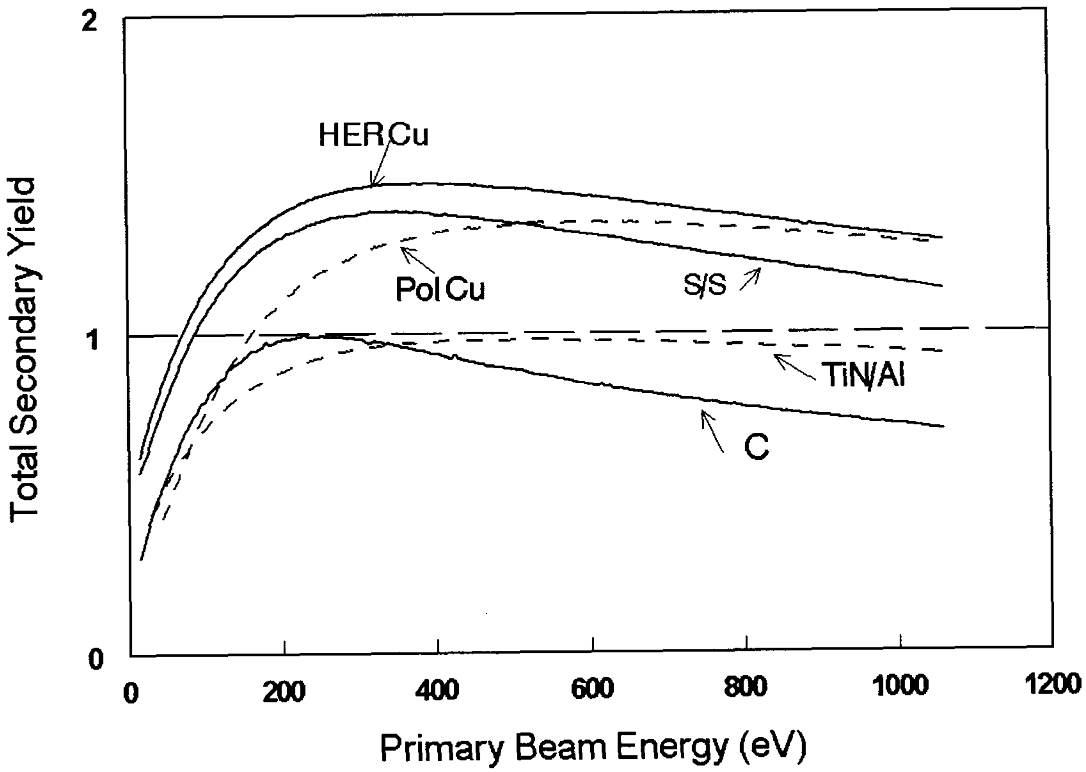
Measured Materials

- LER 6061 Al alloy, TiN-coated
- 304 Stainless Steel
- HER OFE Cu
- Polished OFE Cu, for W-band acceleration

Yield Measurement Schematic

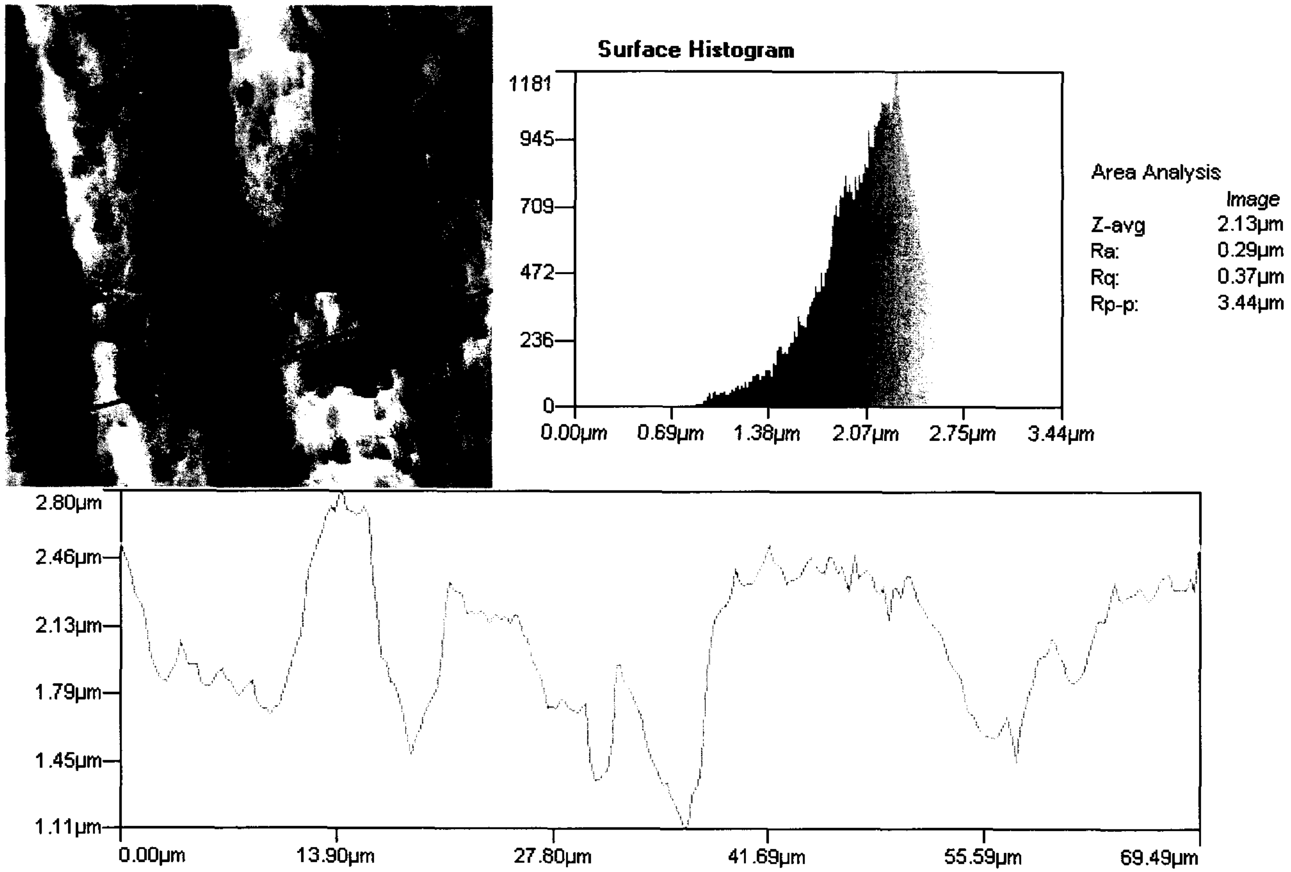


Some Accelerator Materials and C

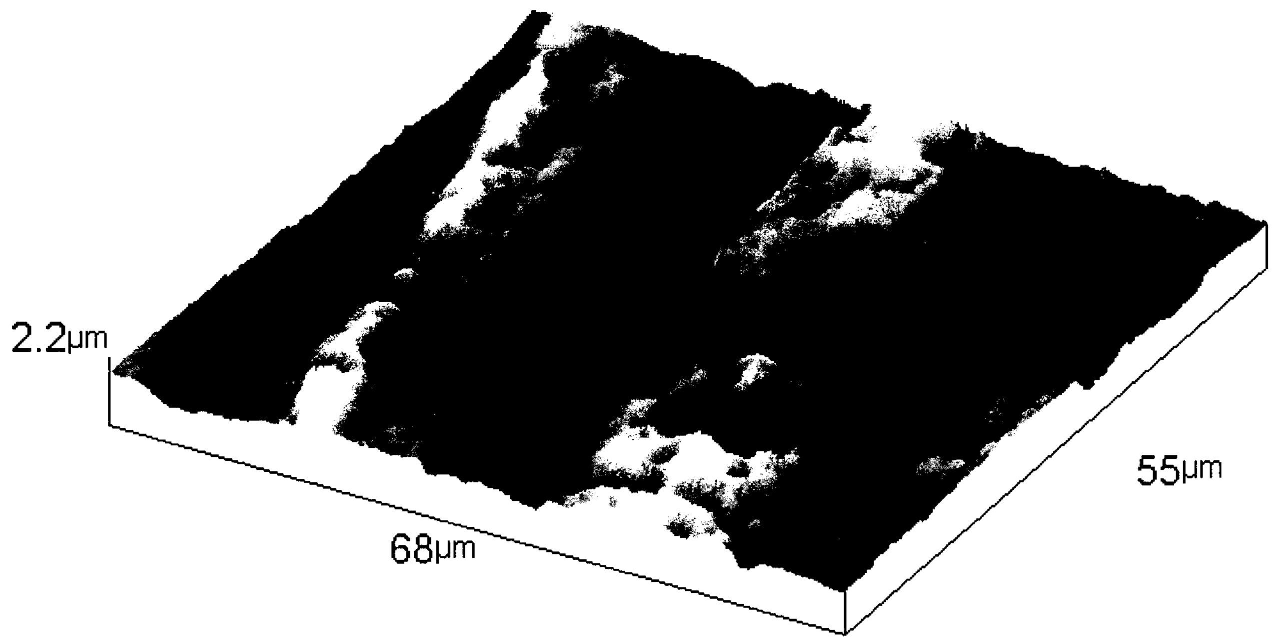


Lightly Sputtered

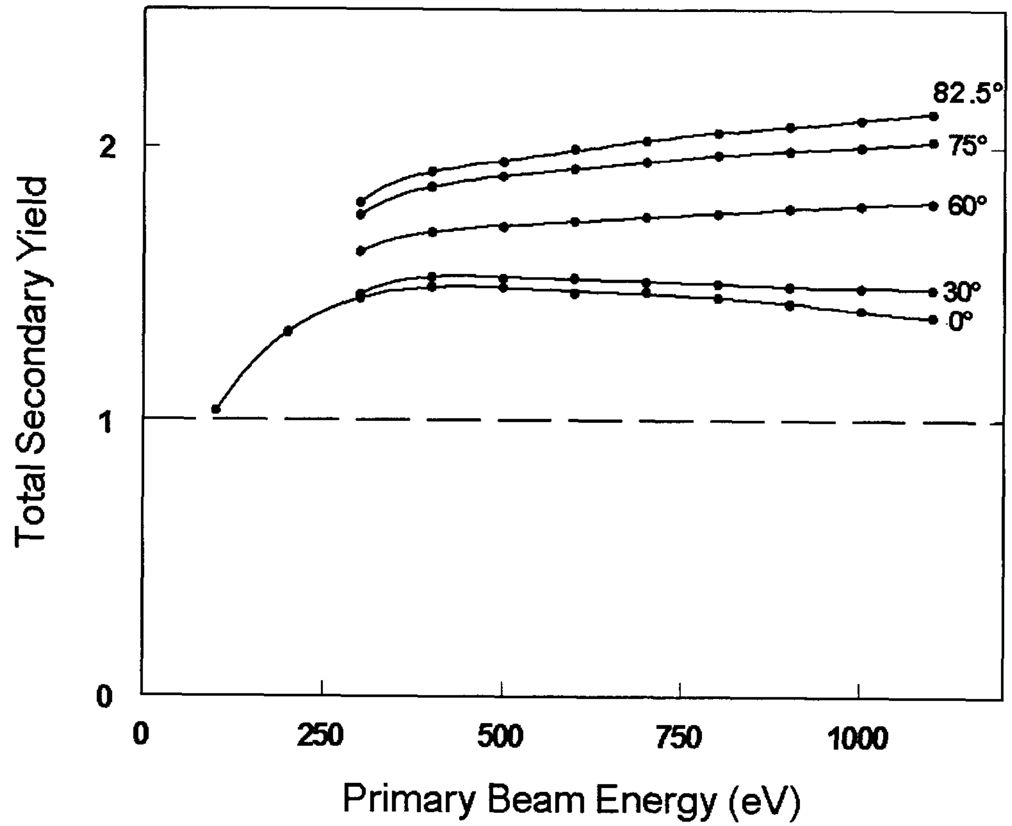
LER Chamber Topography



LER Chamber Topography



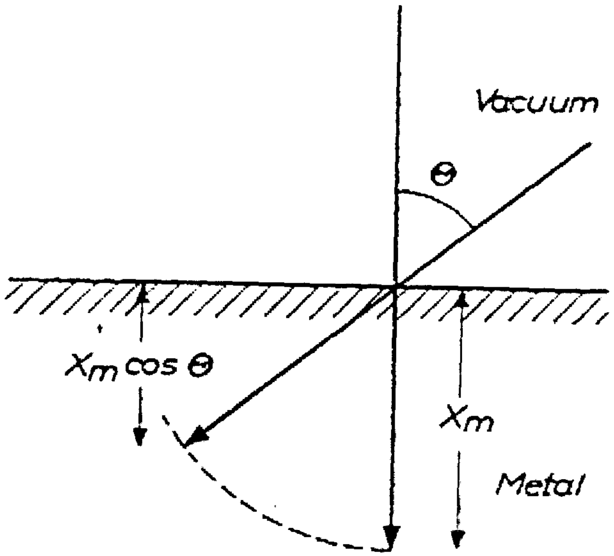
Yield vs. Incidence Angle



TiN/Al, Grooves Parallel To Primary Electron Beam, No Conditioning

Yield vs. Angle

(after Bruining)

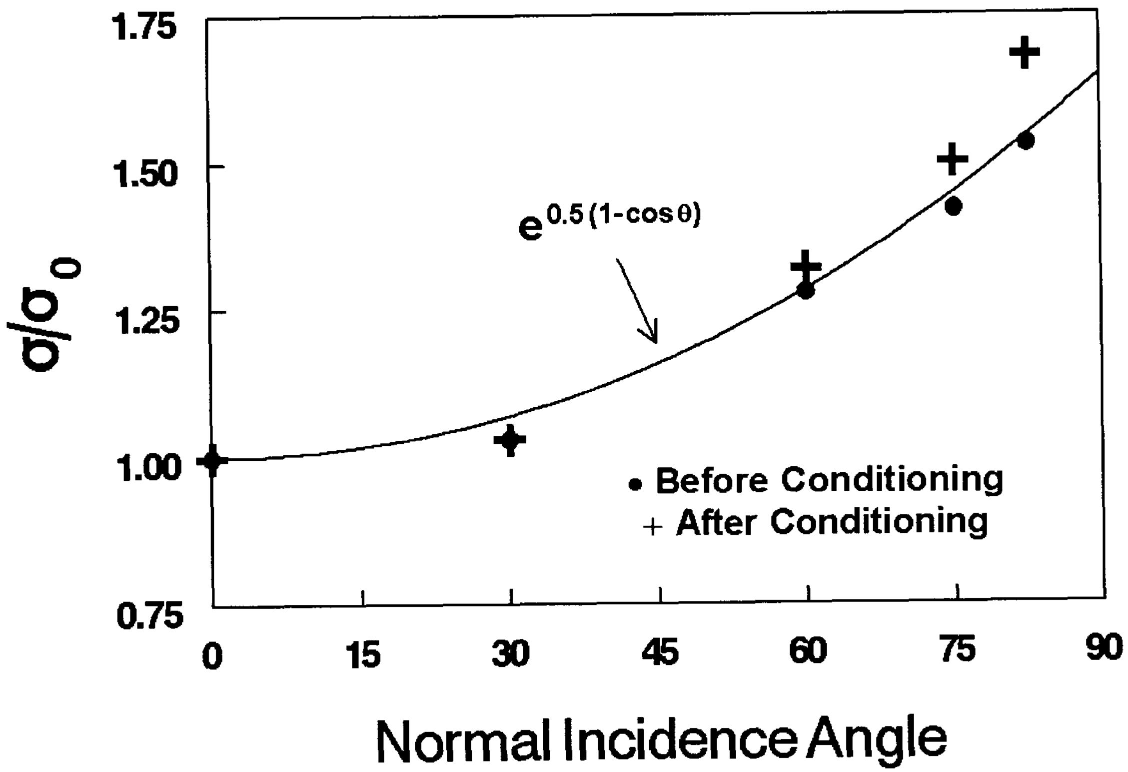


$$\sigma_0 = N_s\, e^{-\alpha X_m}$$

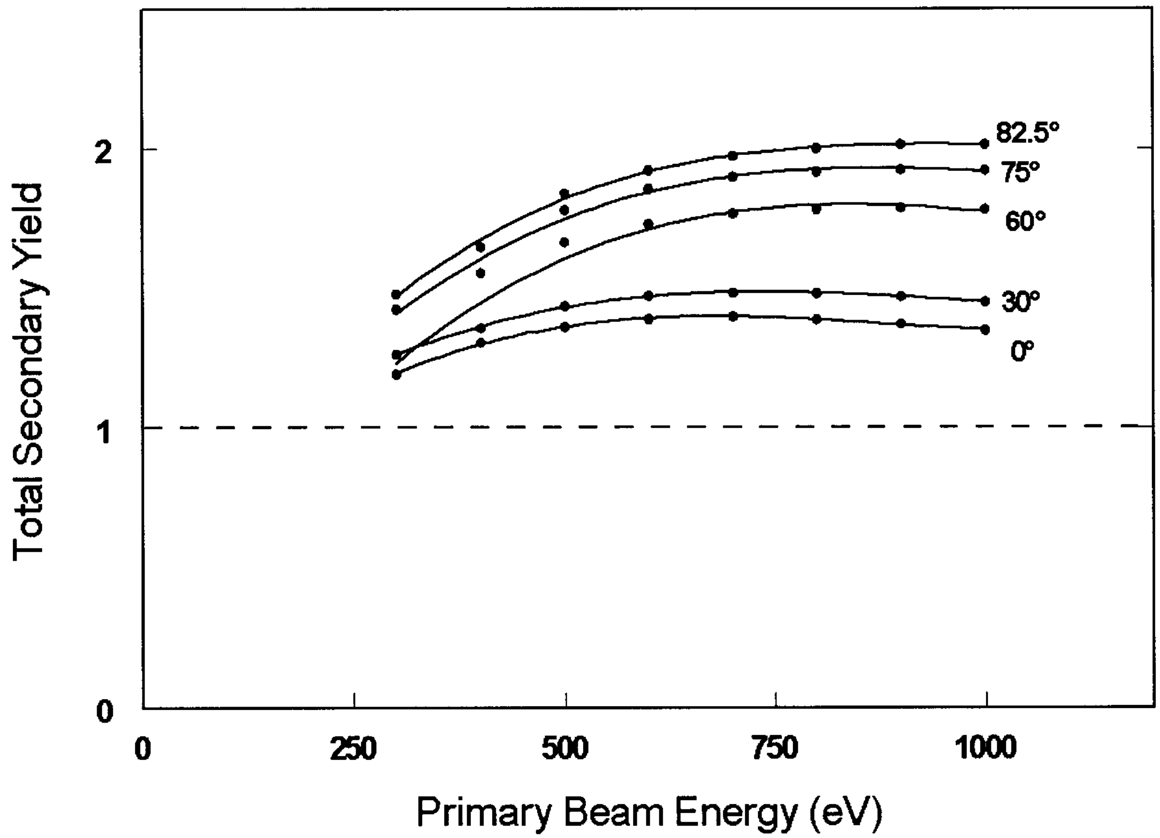
$$\sigma_\theta = N_s\, e^{-(\alpha X_m \cos \theta)}$$

$$\sigma_\theta / \sigma_0 = e^{\alpha X_m (1-\cos \theta)}$$

Angular Dependance, TiN/Al



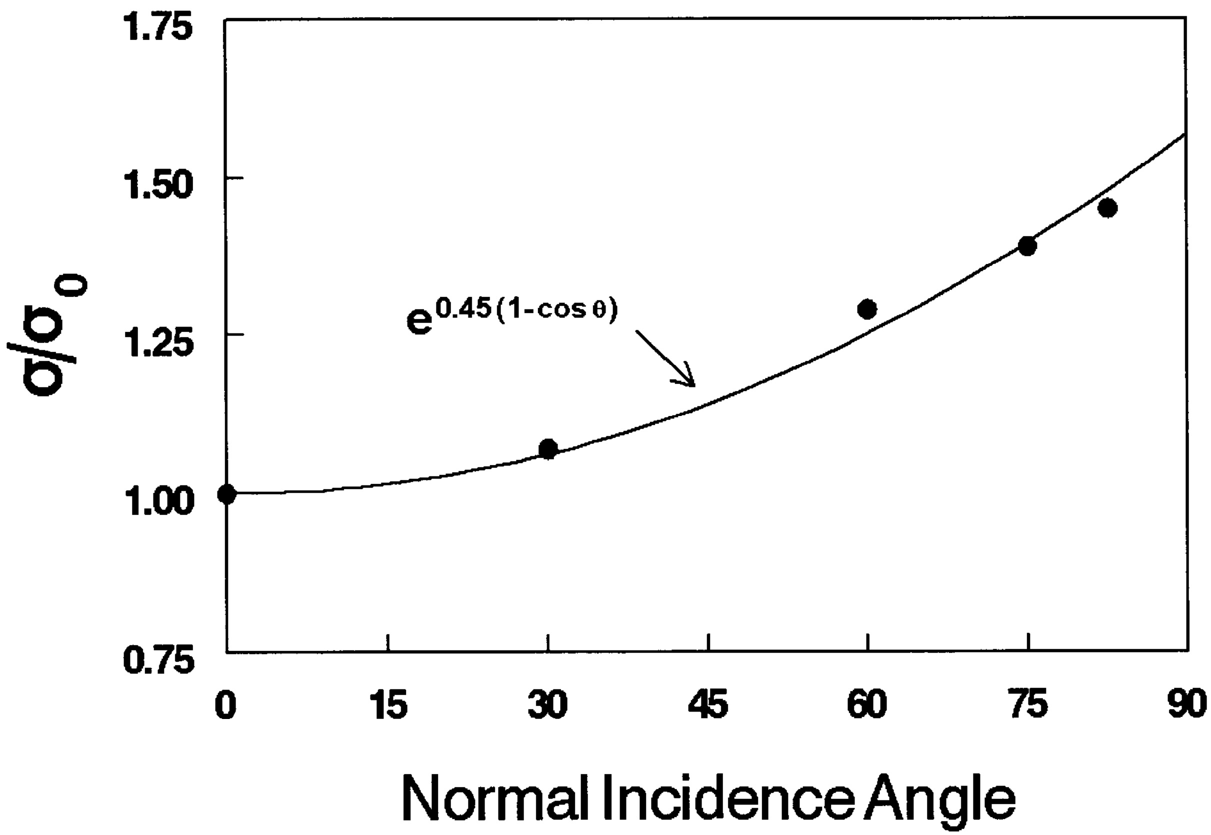
Yield, HER Copper



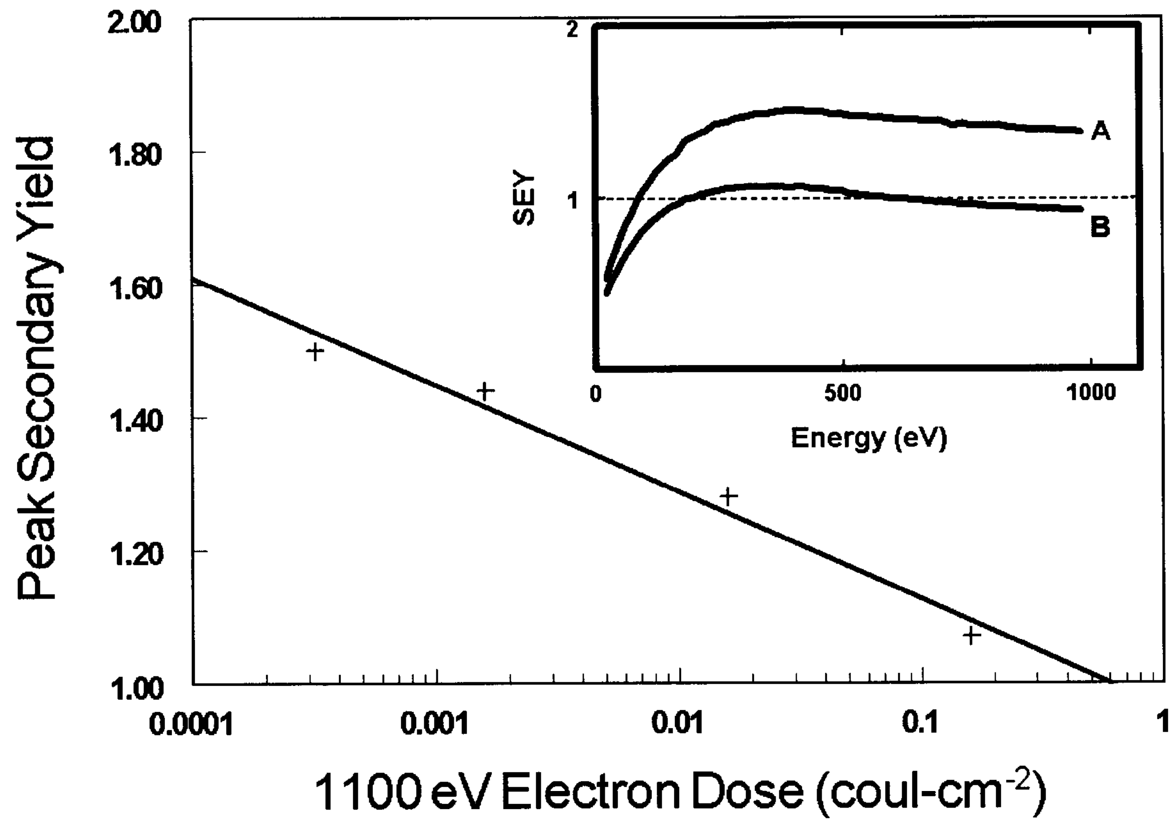
Ar-Ion Conditioned, One Ion/Surface Atom

Angular Dependance, HER Cu

Ion-Sputtered GDC Simulation

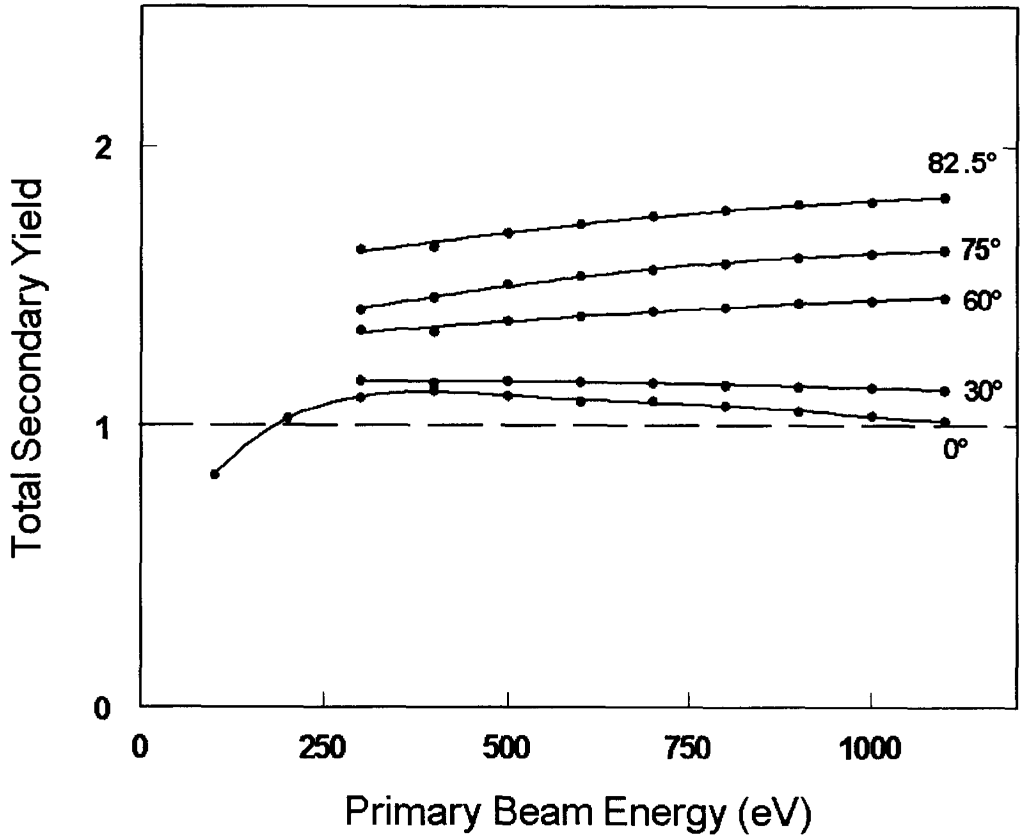


Electron Yield vs. "Conditioning"



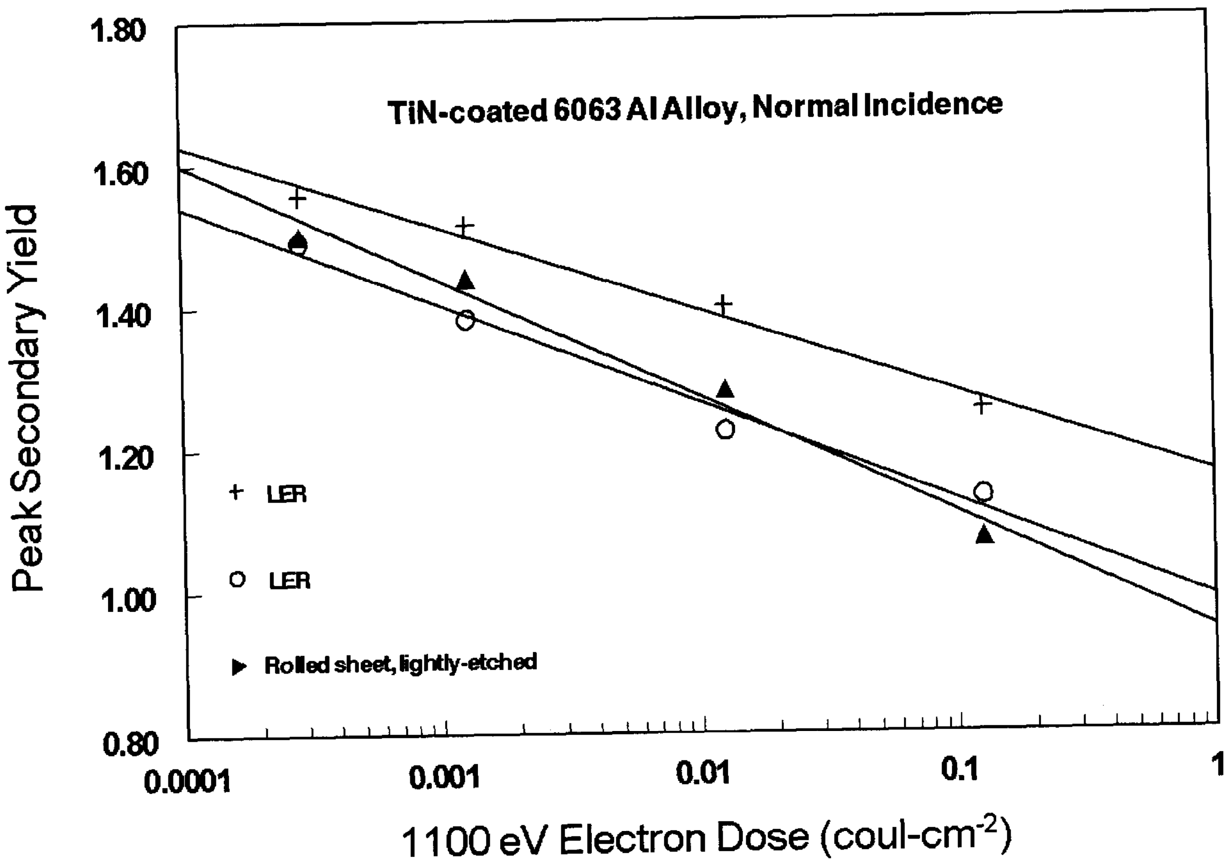
TiN/6061 Al, Smooth Surface

Yield vs. Incidence Angle



TiN/Al, Grooves Parallel To Circulating Beam, 0.2 coul-cm^{-2} Exposure

"Conditioned" TiN/ Al



Conditioning Cross-section

$$\sigma = \sigma_0 \exp(-D\,Q / \in)$$

- σ_0 is the yield prior to bombardment
- D is the dose in coul-cm^{-2}
- Q is the cross-section in cm^2
- $\in$ is the electronic charge in coulombs.

Possible Causes of Electron-Induced SEY Reduction

- Thermal desorption of surface gases.
- Electron desorption of surface gases.
- Dissociation of carboneous gases to carbon.
- Reduction of aromatic HCs to polymers.
- Desorption of water.
- Reduction of high-yield oxides.
- A combination of these.

Conclusions From Data

- Most electron-generated secondaries will have low energy (~ 4 eV) and <1 yield.
- TiN is effective at reducing the yield of Al.
- Electron removal ("conditioning") of H_2O and HCs works (but probably leaves carbon in technical vacuum).
- The yield increase with primary electron beam angle is about that expected.