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Ion Induced Secondary Electron Emission from Solid Metal Surfaces

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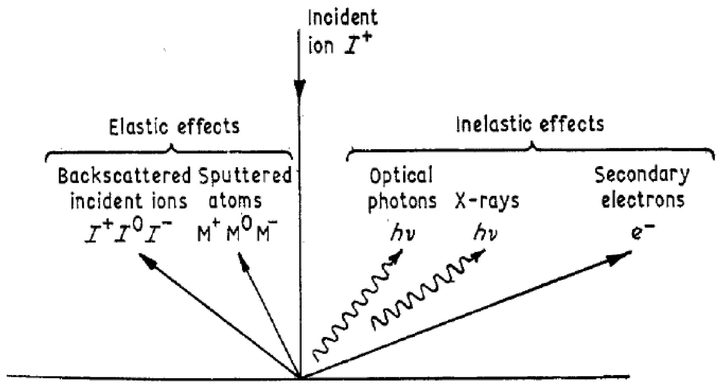
Introduction:

Upon bombarding a solid surface with energetic ions, secondary electron emission (SEE) may be observed. This phenomenon has been harvested for many applications, such as microscopy, voltage breakdowns, and particle multipliers. By understanding how the choice of material along with the surface morphology and composition affects SEE, we will be able to engineer electron emission for various applications. In this work, SEE coefficients and voltage breakdowns will be investigated for various metals. The metal surfaces will be bombarded with He^+ ions with energies ranging between 20 eV – 4 keV.

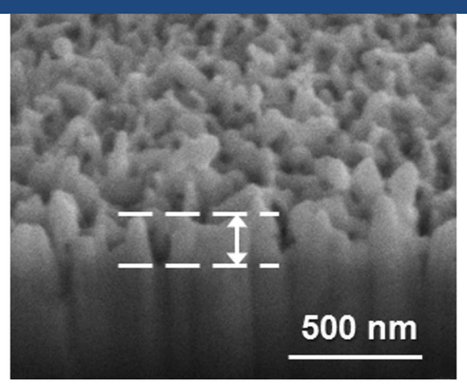


McCraken, G M; The behavior of Surfaces under Ion Bombardment; 1975 Rep. Prog. Phys. **38** 241

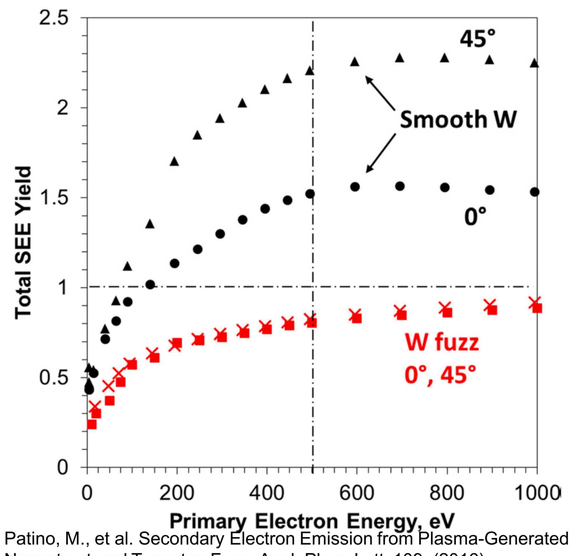
SEE can lead to other scientific phenomena to occur (i.e. surface flashovers) which may have adverse affects on various technologies

Challenges:

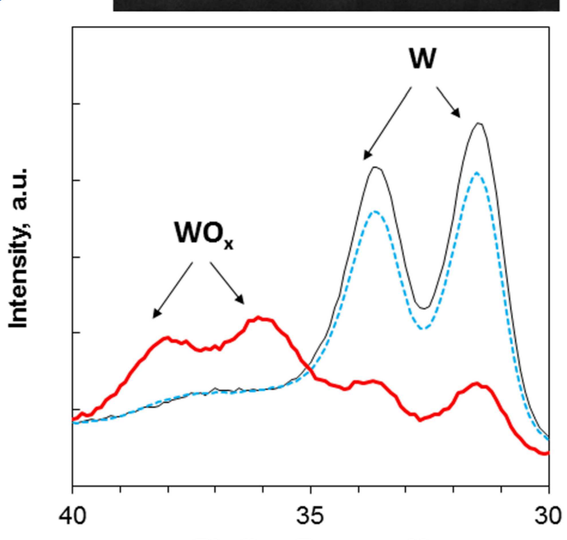
- When exposed to air solid metal surfaces SEE Coefficients (SEEC) are significantly lowered due to adsorbates
- Adsorbate cleaning procedure may alter the metal surface and provide inaccurate SEEC values



Metal surface morphology and adsorbate composition affect SEEC

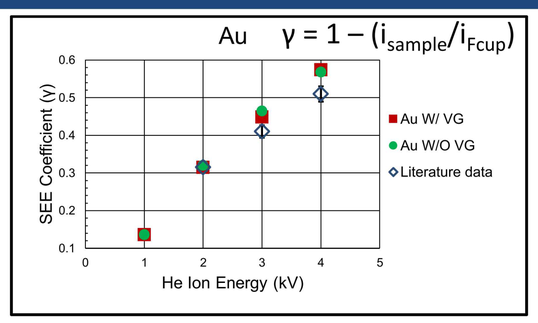


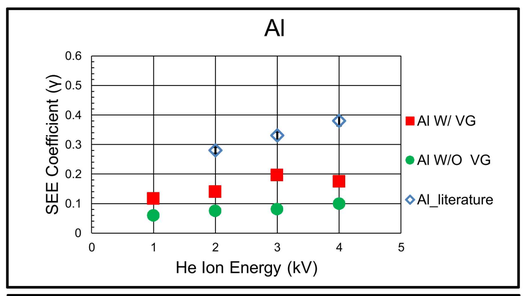
Patino, M., et al. Secondary Electron Emission from Plasma-Generated Nanostructured Tungsten Fuzz. Appl. Phys. Lett. 109, (2016).

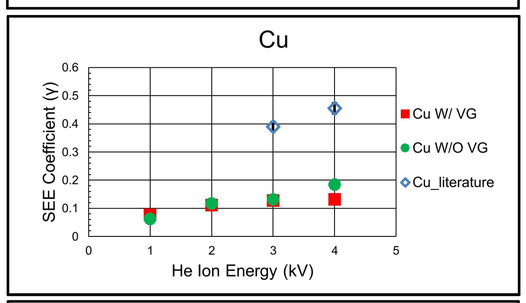


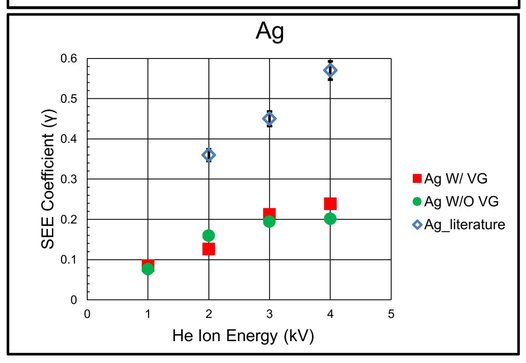
Preliminary Data:

- First, the SEE Coefficient (SEEC) for a relatively inert metal, gold, was measured
- The samples were measured with and without the ion vacuum gauge
- Our results align closely to the values reported in literature (blue open diamonds)

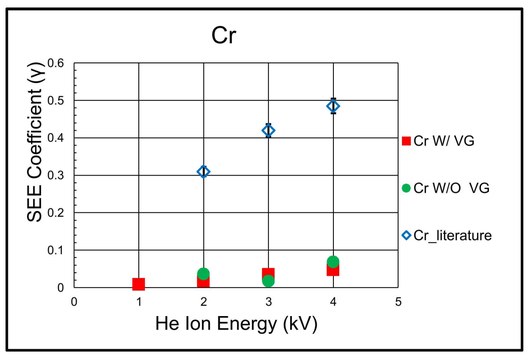








- Using the same experimental conditions from the Au study, the samples were extended to Cu, Ag, Al, and Cr.
- Unlike the Au results, the metals differ significantly from the reported literature values

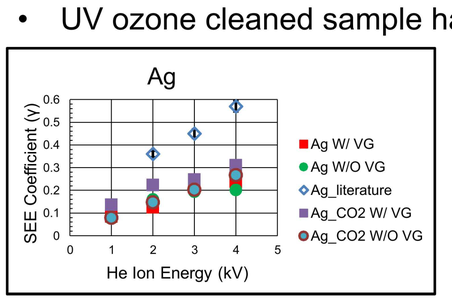


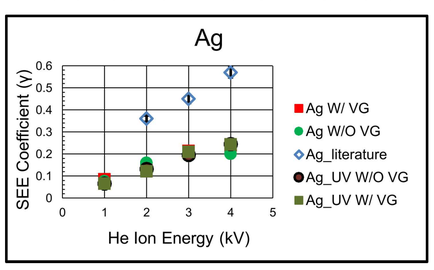
Surface adsorbates have drastically reduced the SEEC

Baragiola, R. A., et al. Electron emissions from clean metal surfaces induced by low-energy light ions. Physical Review B, 19, 121, (1979).

Preliminary Data: Surface Cleaning

- Ag sample underwent two different surface cleaning techniques, CO_2 blasting and UV ozone
- SEEC values were measured in the same manner as above
- CO_2 blasted Ag sample resulted in slightly higher SEEC values, but still differed from literature values
- UV ozone cleaned sample had little affect on the SEEC value

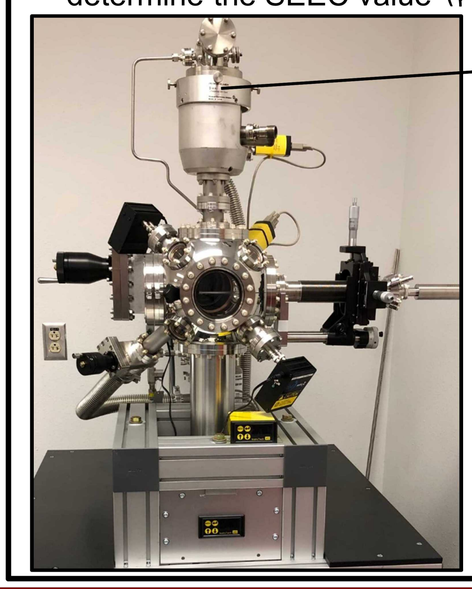




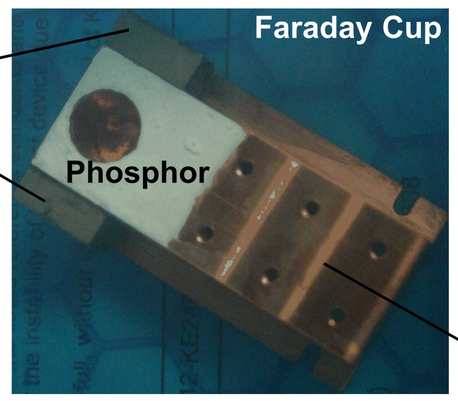
Surface cleaning can have an affect on the SEEC value

Experimental Setup:

- Samples are mounted and pumped down overnight to a final chamber pressure of ~ $7*10^{-8}$ Torr
- The current is measured for the faraday cup and the metal sample and used to determine the SEEC value ($\gamma = 1 - (i_{sample}/i_{faradaycup})$)



5 keV Differential Sputter Ion Gun (produces ions with tunable energy between 1 - 5 keV)

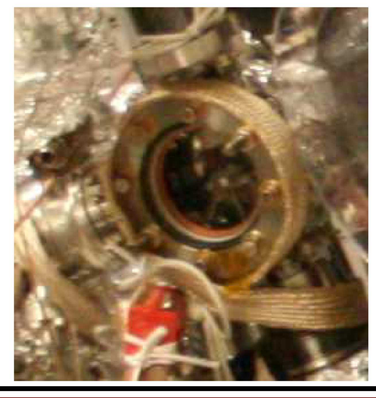


Conclusion

- SEE Coefficients (SEEC) were measured for various metal surfaces
  - Au sample agrees with literature values
- Efforts were given to remove adsorbates from the metals surface via CO_2 and UV Ozone cleaning
  - CO_2 cleaning improved the SEEC, were as, UV Ozone cleaning lowered SEEC

Future Work

- Develop an in-situ cleaning for metal surfaces
- Investigate SEEC for surface modified metal substrates (i.e. nano-indentation)
- Explore the relationship between SEEC and Voltage breakdowns
- Install a lower energy ion gun
- Extend study to other materials
- Observe the affects of bias on SEEC
- Understand surface composition relationship to SEEC



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