Cross sections of EUV PAGs: Influence of Concentration, Electron Energy, and Structure

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TWG Presentation
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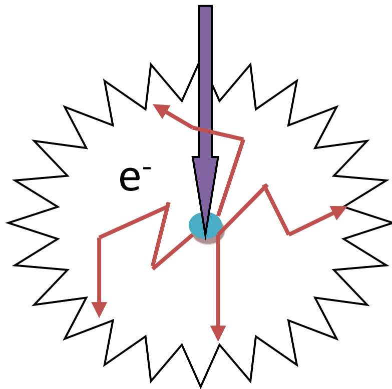
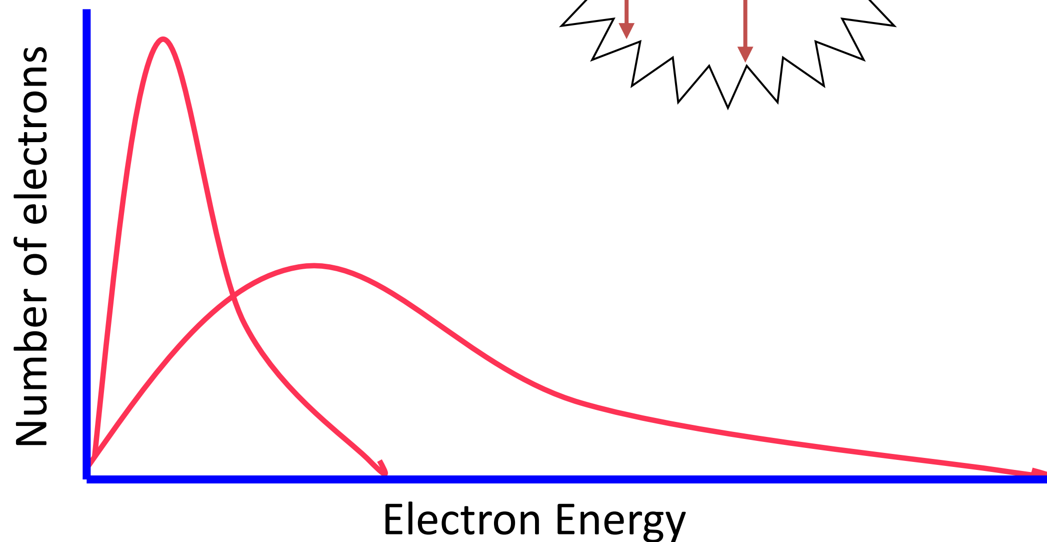
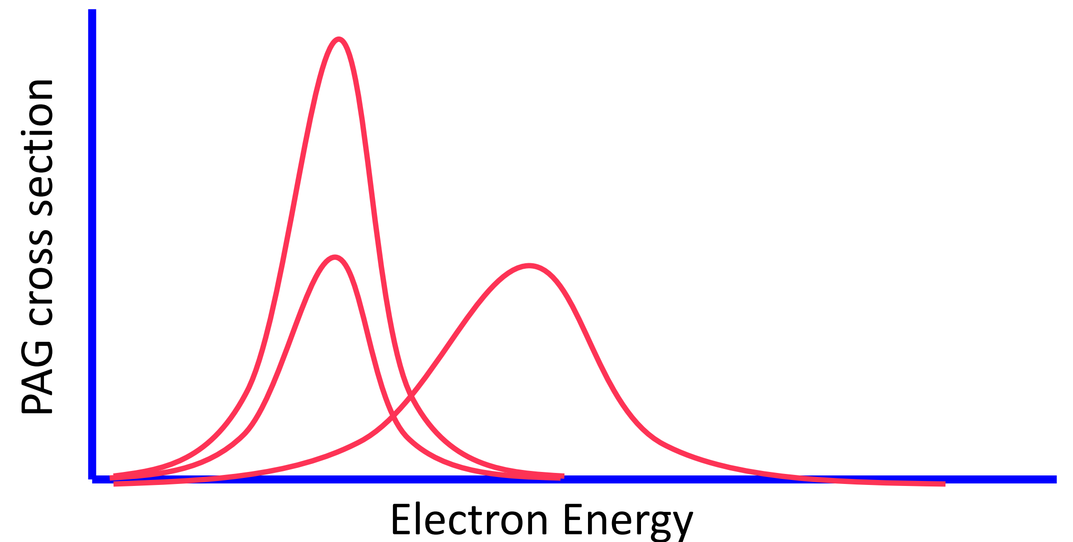
EUV Resist exposures are fundamentally secondary electron chemistry, not primarily photon chemistry

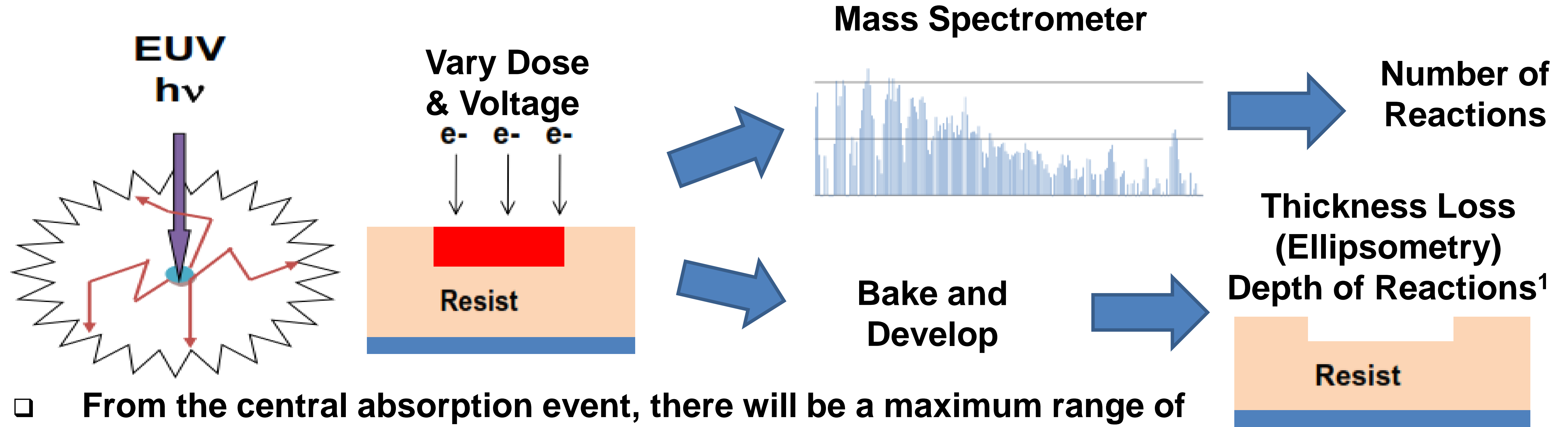


Need to know the number and energy of electrons present in polymer
Need to know the cross section of the PAG to electrons
Larger overlap of electrons with PAG reactivity will be higher efficiency





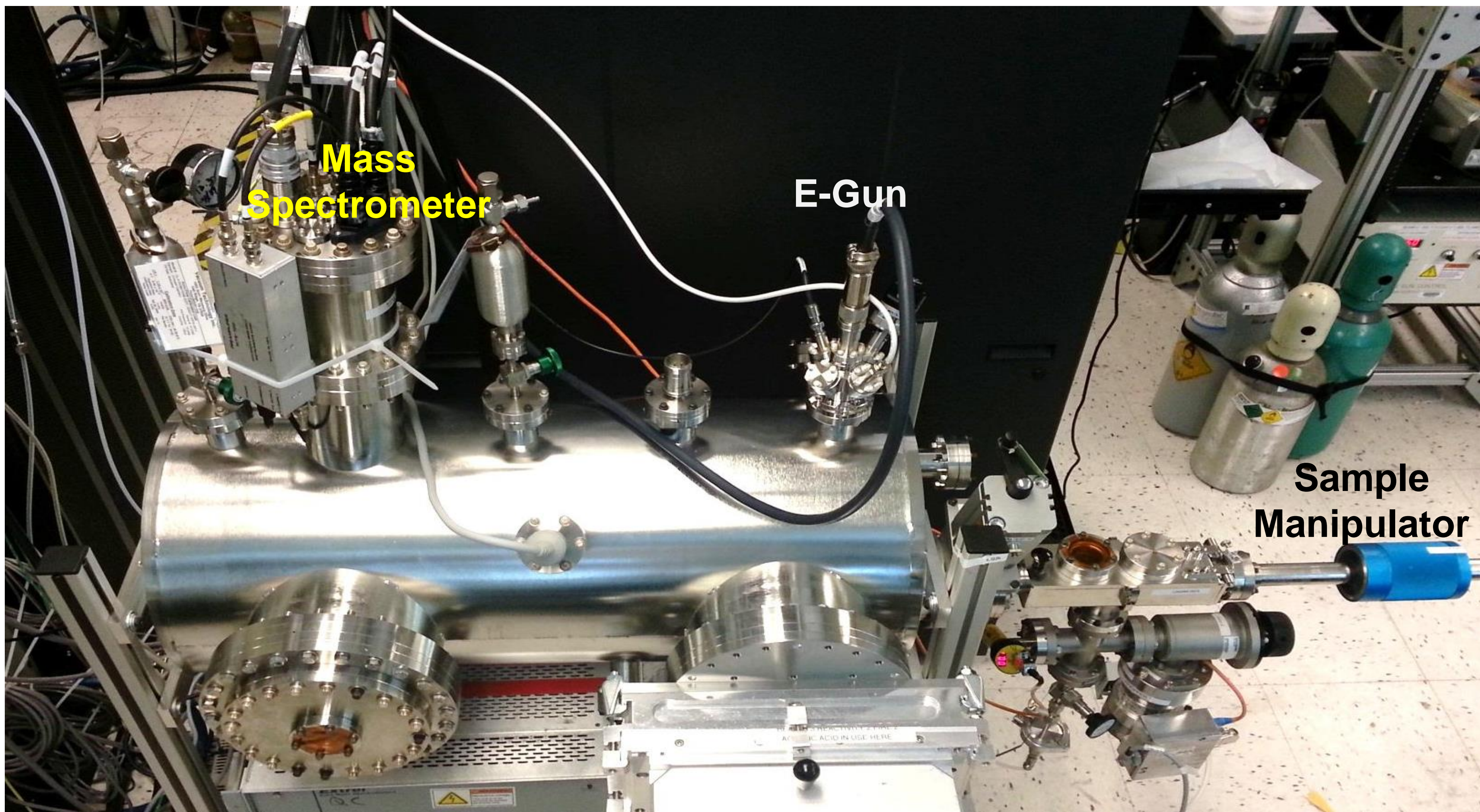
E-Beam Reaction Rate and Depth Studies



- From the central absorption event, there will be a maximum range of e- movement
- We measure the range by top down exposures and measure the depth to represent the lateral electron travel away from the EUV absorption site
- We measure number of reactions by mass spectrometry

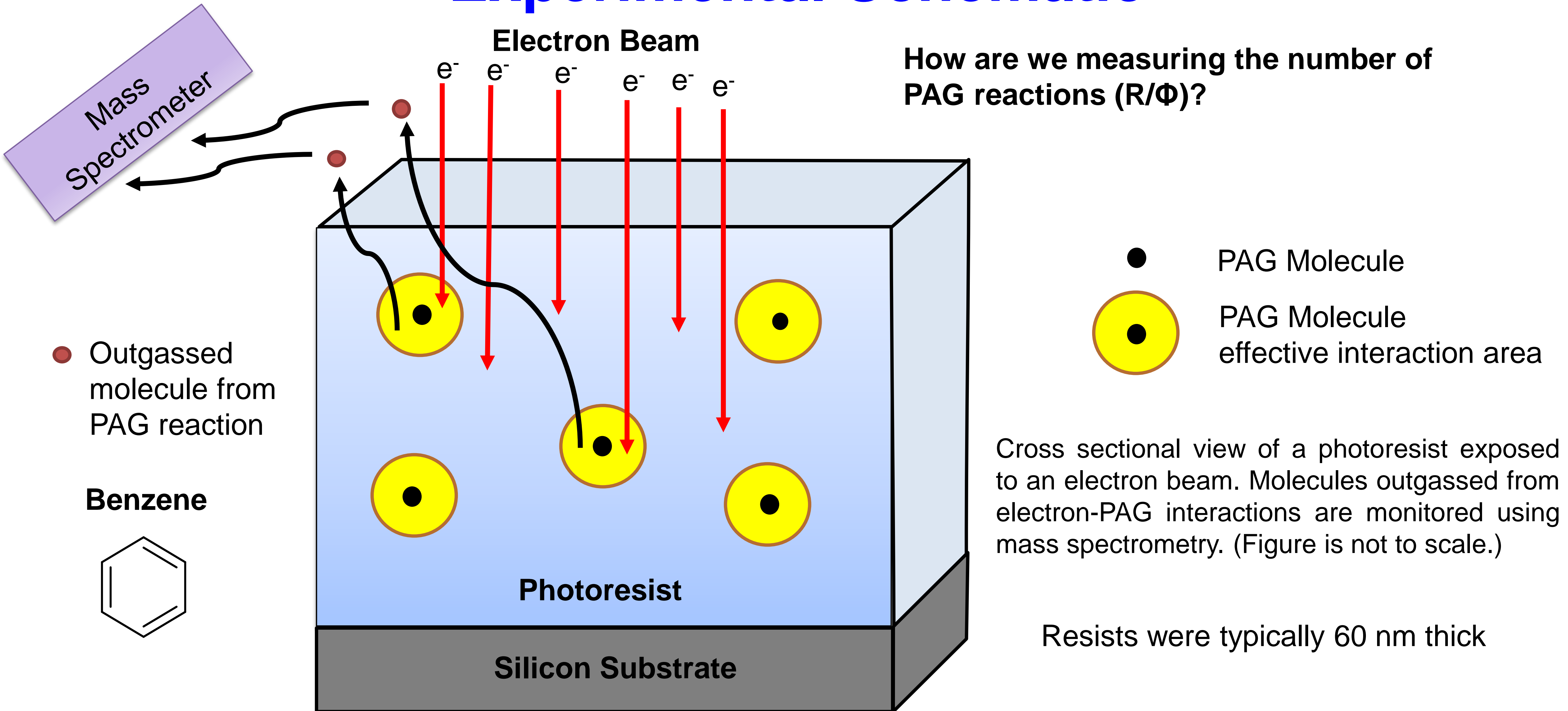
1. Amrit Narasimhan, Steven Grzeskowiak, Bharath Srivats, et al., "Studying secondary electron behavior in EUV resists using experimentation and modeling", Proceedings of SPIE Vol. 9422, 942208 (2015) SPIE Digital Library

Electron Resist Interaction Chamber (ERIC)

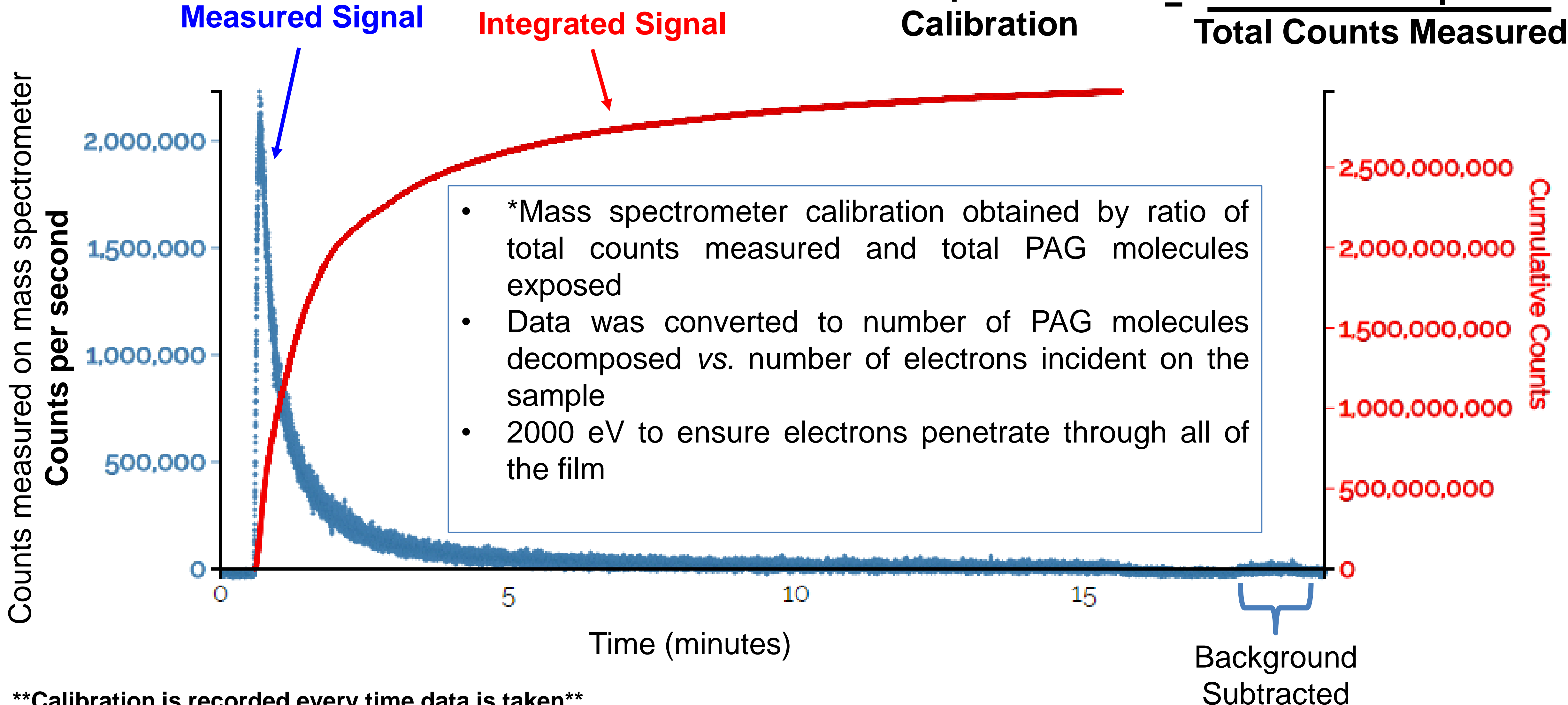


Expose EUV resist from 80-2000 eV across a wide range of doses and collect real-time outgassing information using mass spectrometry

Experimental Schematic



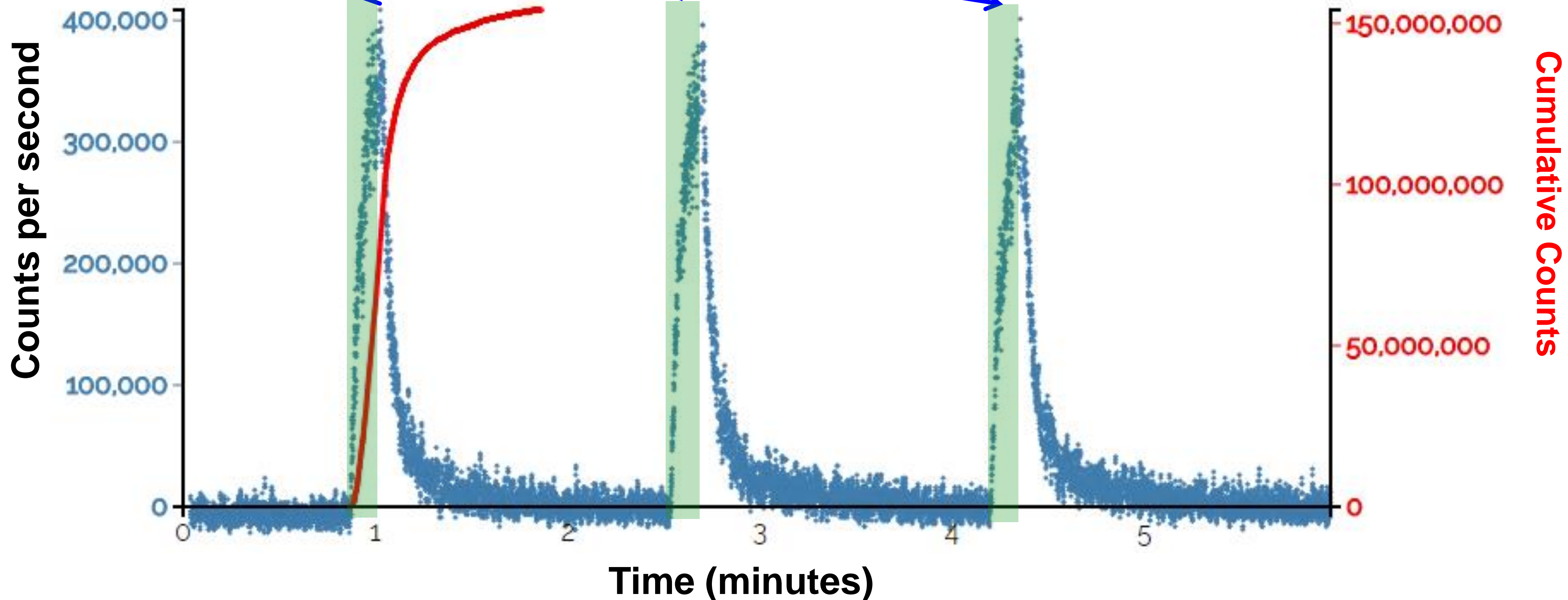
Calibration of Mass Spectrometer



Example of PAG Reaction Measurements

For improved accuracy, repeated measurements were performed with multiple smaller dose exposures, each providing number of PAG decompositions per electron after applying the calibration

Exposure Conditions are chosen such that the total dose upon the resist will be exposed in linear regime



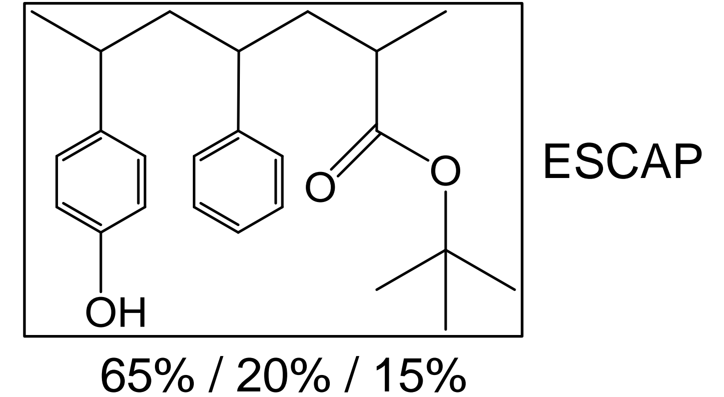
Resists Studied

Formulation (4 wt.% solids):

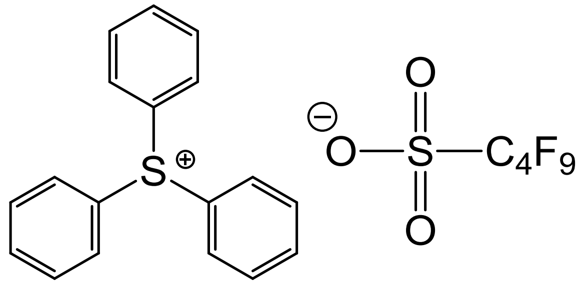
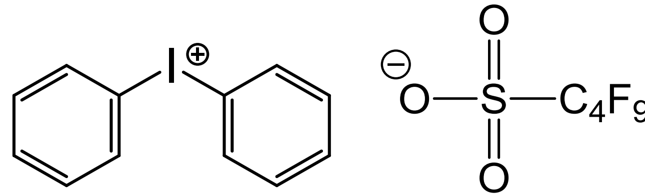
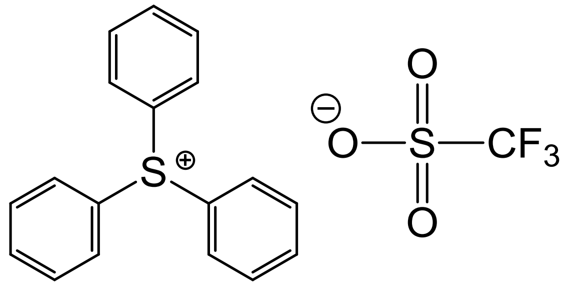
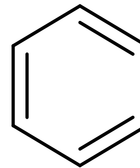
Spin Coat:
3700 RPM, 45s

Post Application Bake:
120 °C, 60s

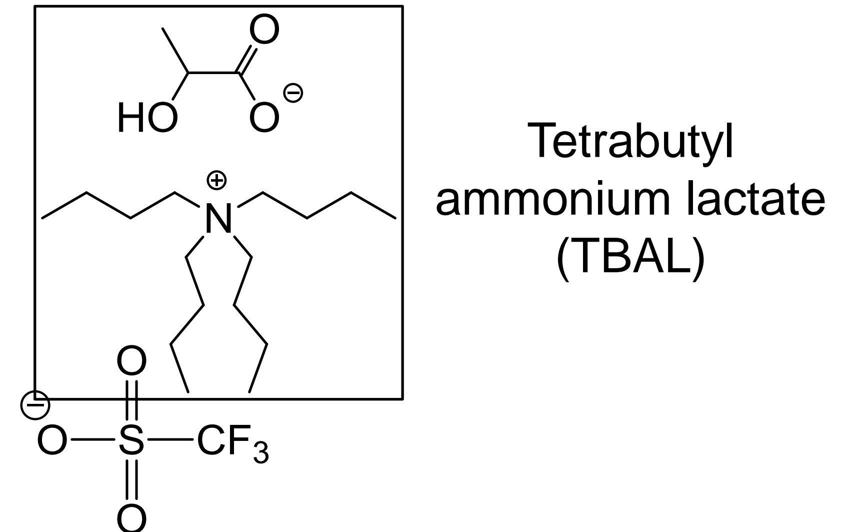
83.5 wt.% Polymer



15 wt.% PAG

	Triphenylsulfonium	Diphenyliodonium
Nonaflate		
Triflate		**All 3 outgas benzene** 

1.5 wt.% Base



We chose three different PAGs, and varied the cation and anion

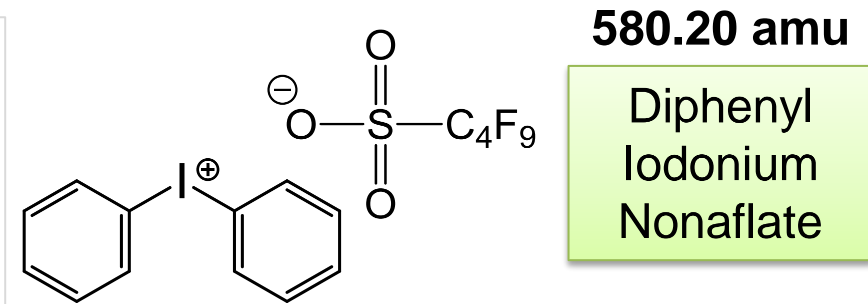
PAG Reactions Per Incident Electron

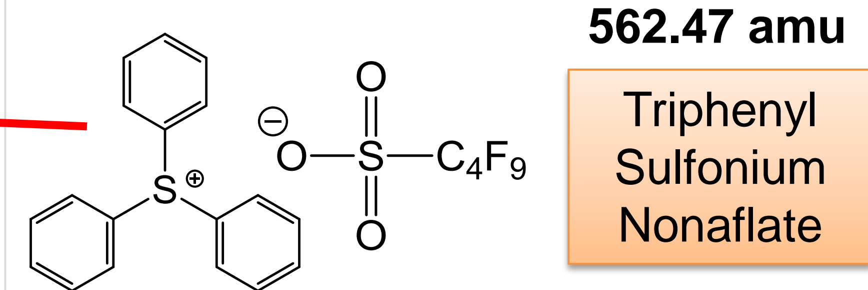
Typical dose was 0.5 μC for all data points

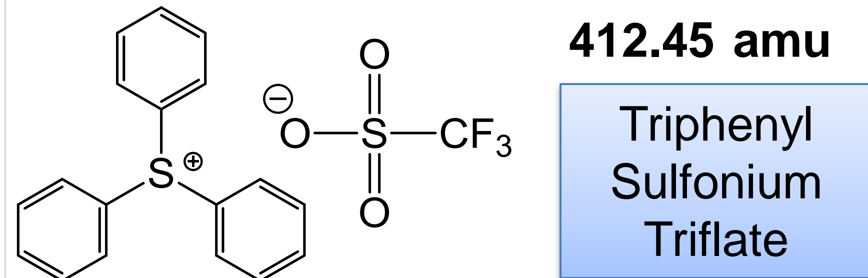
15 wt. % PAG

	80	100	150	250

PAG Reactions per Incident Electron (0–7) vs. Incident Electron Energy (eV) (50–300)

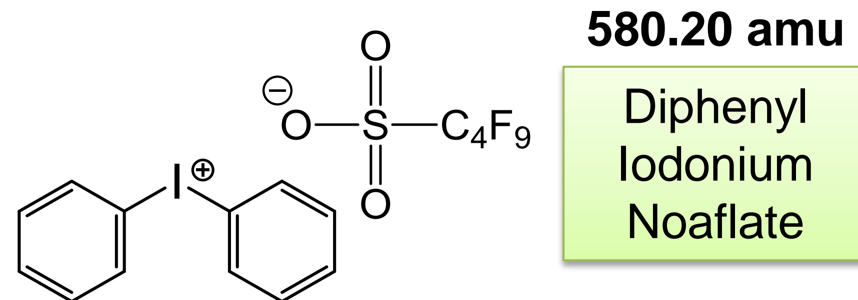






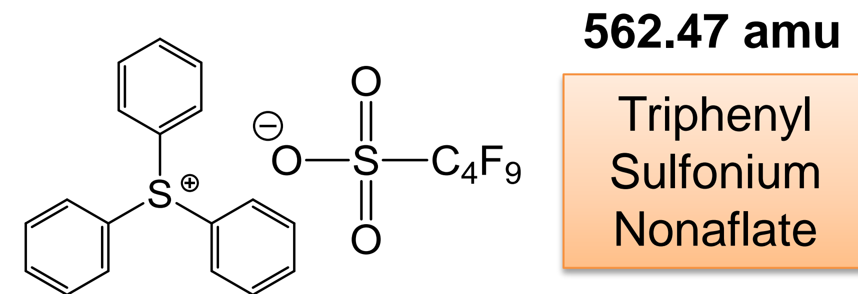
PAG Reactions per e⁻ *vs.* Molecular Weight

PAG Molecular Weight (amu)		



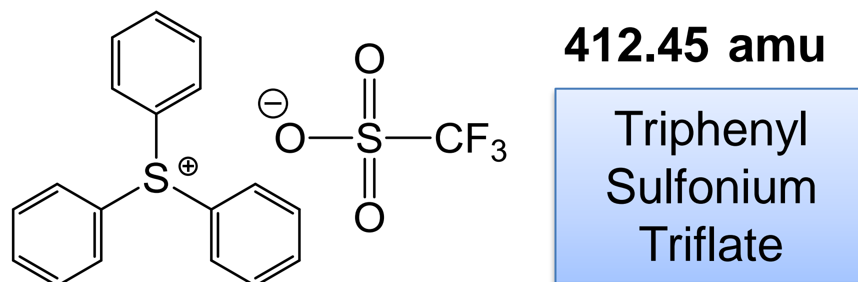
580.20 amu

Diphenyl Iodonium Noaflate



562.47 amu

Triphenyl Sulfonium Nonaflate



412.45 amu

Triphenyl Sulfonium Triflate

PAG Loading: Triphenylsulfonium Nonaflate

Triphenyl Sulfonium Nonaflate

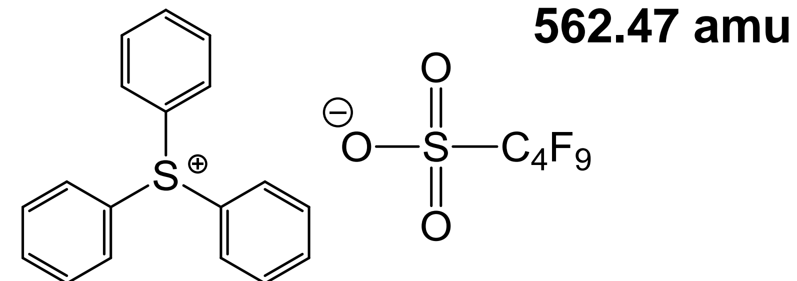
- 2.5 wt%
- 7.5 wt%
- 15 wt%
- 30 wt%
- 50 wt%
- 75 wt%

PAG Reactions per Incident Electron

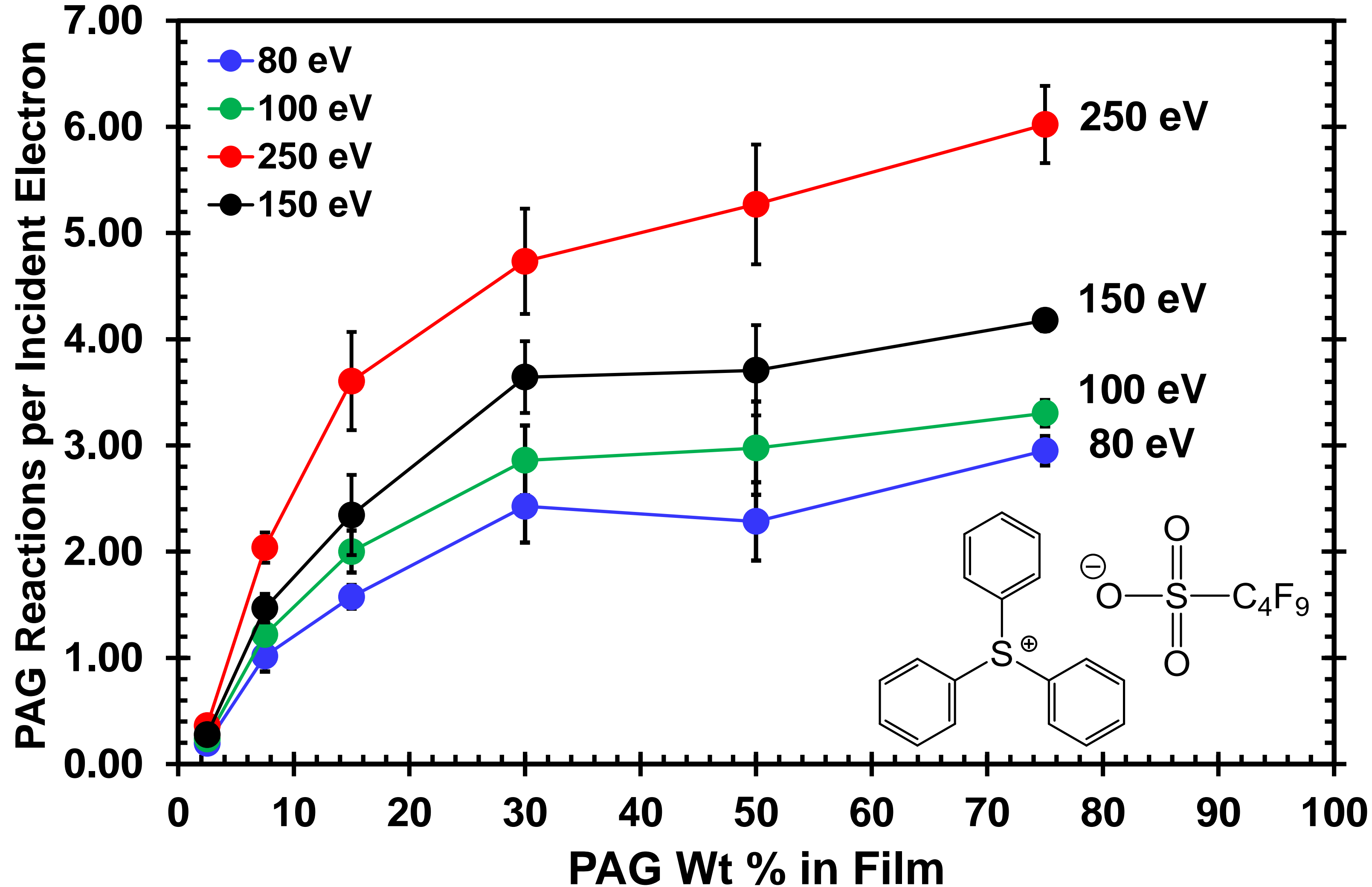
6.0
5.0
4.0
3.0
2.0
1.0
0.0

50 100 150 200 250 300

Incident Electron Energy (eV)



PAG Loading: Triphenylsulfonium Nonaflate



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