



Witness Plate Testing and electron versus EUV outgassing

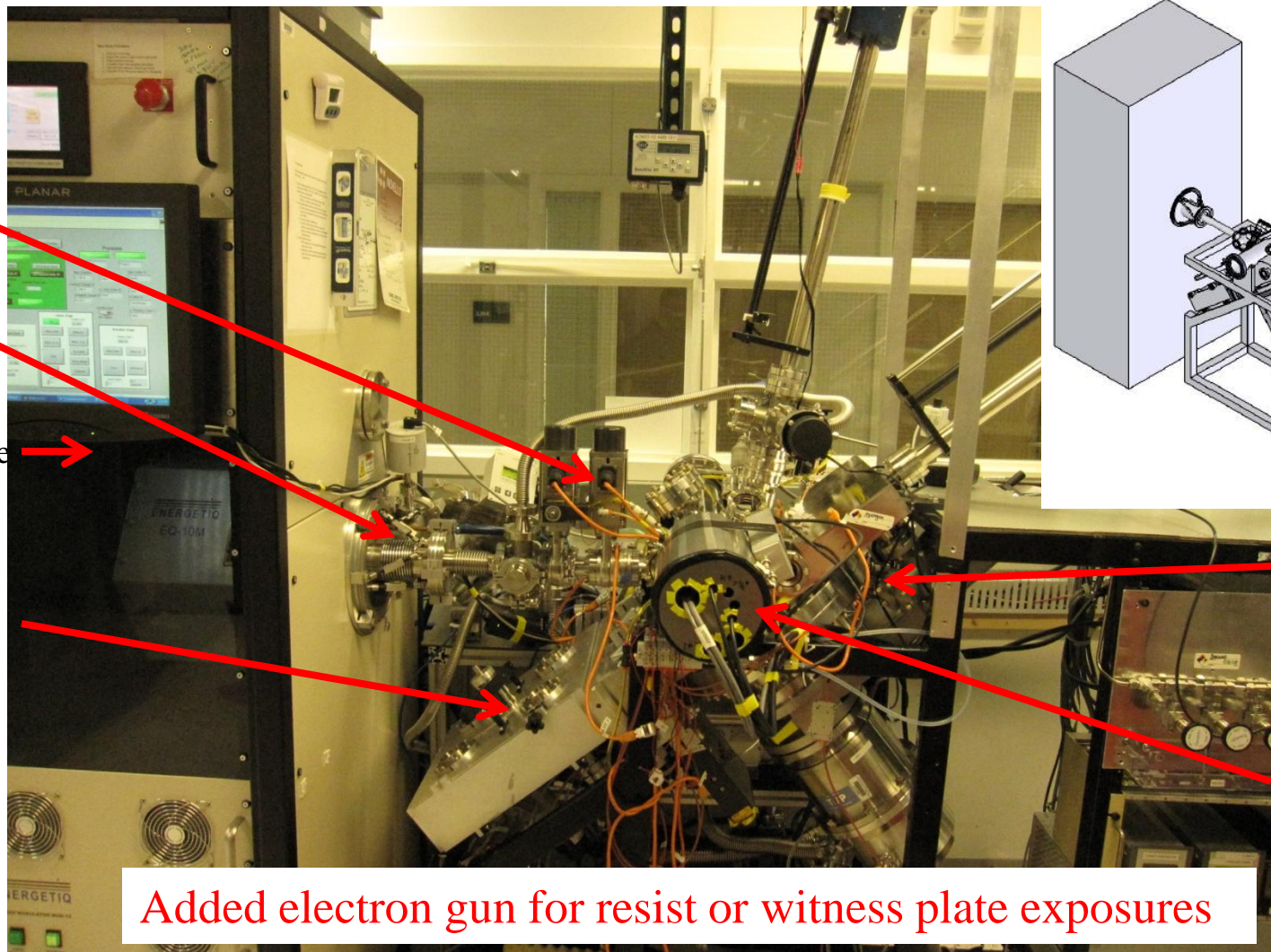
Greg Denbeaux, Alin Antohe
College of Nanoscale Science and Engineering
University at Albany

Karen Petrillo
SEMATECH/IBM

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Current Resist Outgassing and eXposure (ROX) Tool



Zr Filter

Collector

Energetiq Source

300 mm wafer
Load Lock

Photodiode

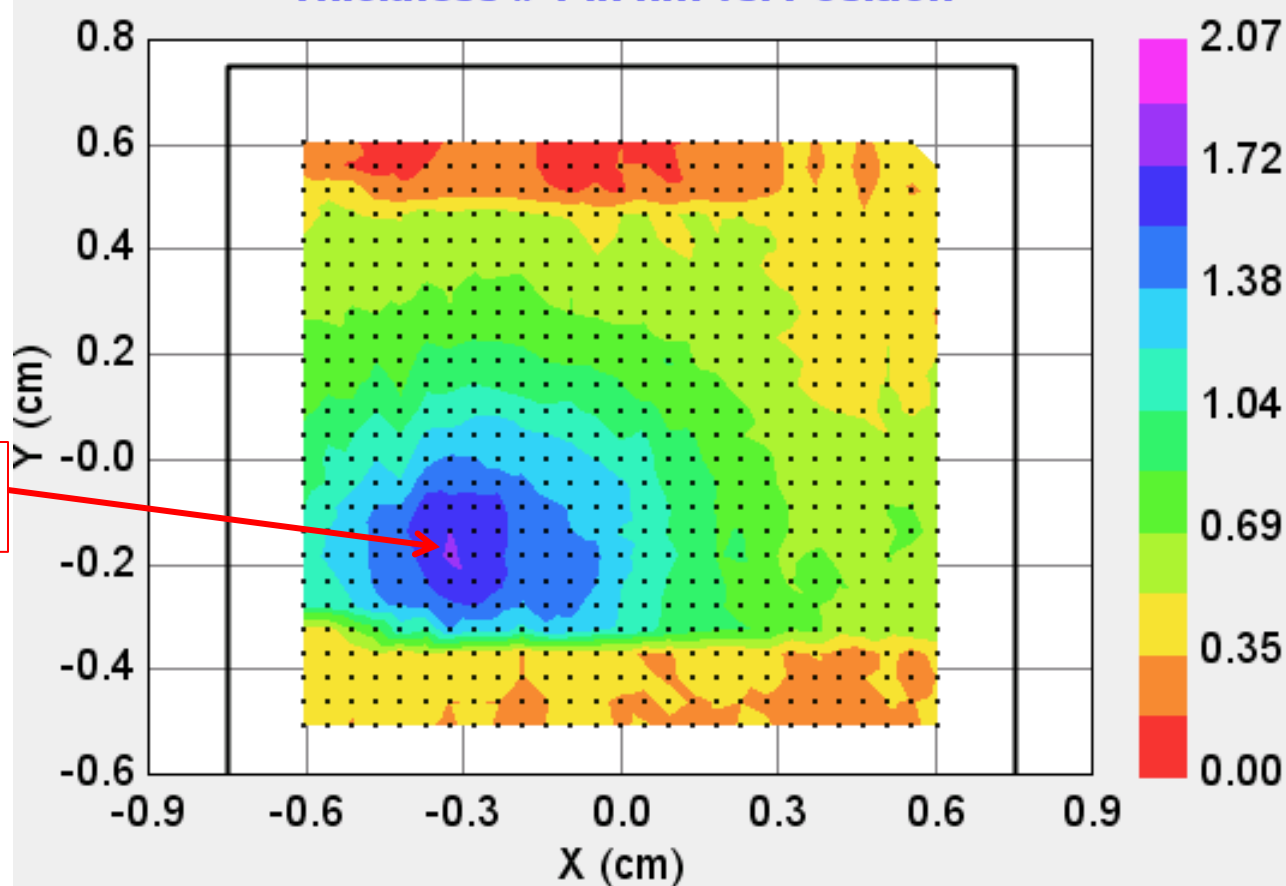
Mass
spectrometer

Added electron gun for resist or witness plate exposures



Sample EUV witness plate result (Ellipsometry)

Thickness # 1 in nm vs. Position



Measurable contamination
in illuminated spot

Witness plate testing with EUV is ongoing and can provide measurable results
Witness plate testing with electrons is in progress
Metrology may be more time consuming than exposures



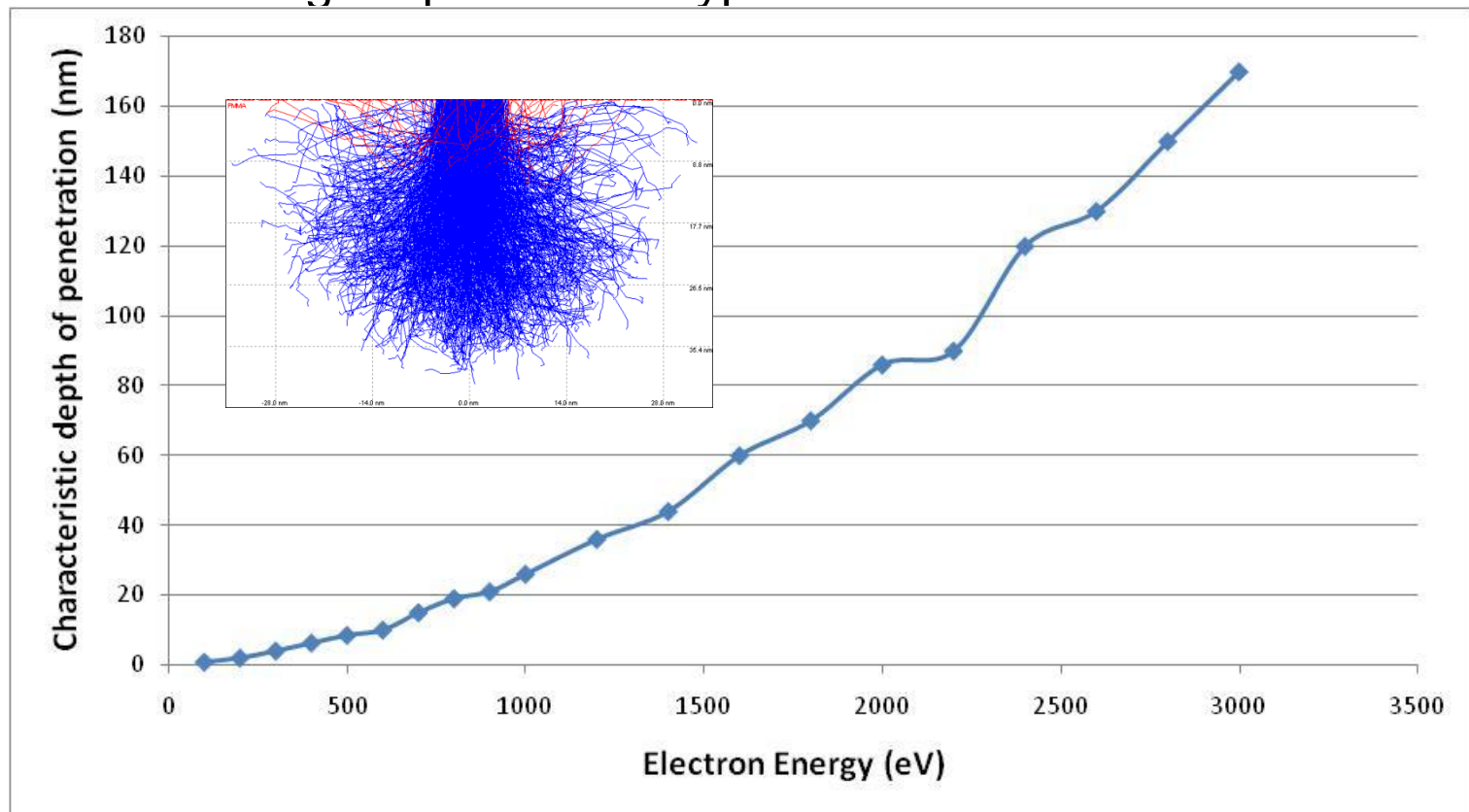
Preliminary electron outgassing measurements

- Dose from electron exposures not yet measured – so compare outgassing after normalization to mass 78 to account for different doses
- Depth of penetration for electrons varies with energy – so low energy exposures are more surface sensitive and have outgassing from a reduced volume of resist
- Rate of outgassing with electron gun is higher than for EUV so exposure time is shorter and outgassing measurement affected by exposure time due to time scale for some outgassing species



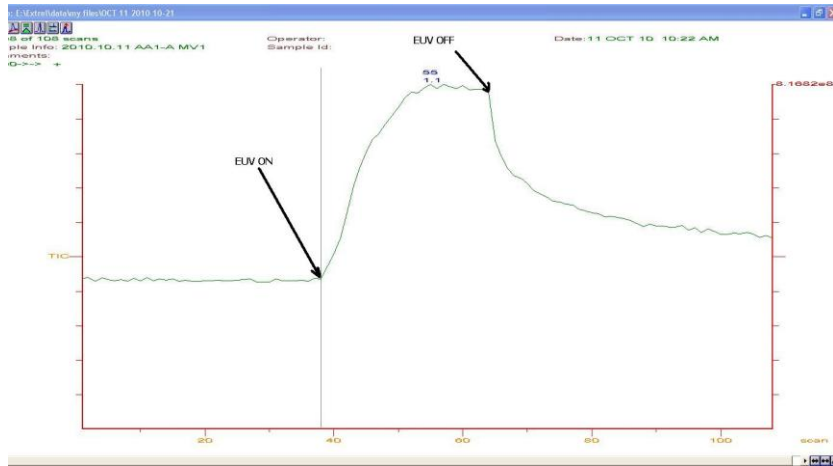
Depth of penetration for electrons varies with energy

- Use CASINO simulation software
- 100 eV electrons only penetrate about 1 nm
- 1500 eV and higher penetrates typical resist thicknesses

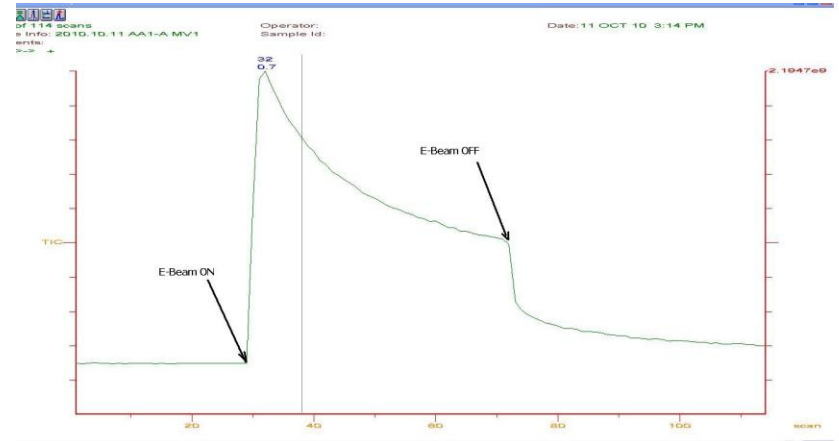




Electron versus EUV outgassing exposures



EUV



E-Gun (low current setting)

- Electron guns can provide approximately two orders of magnitude faster exposures
- Since time scale for outgassing affects measurement, faster exposures will give some differences in results
- These tests done at same time scale so dose is not the same
- To reduce effect of changing intensity and dose, results scaled to mass 78

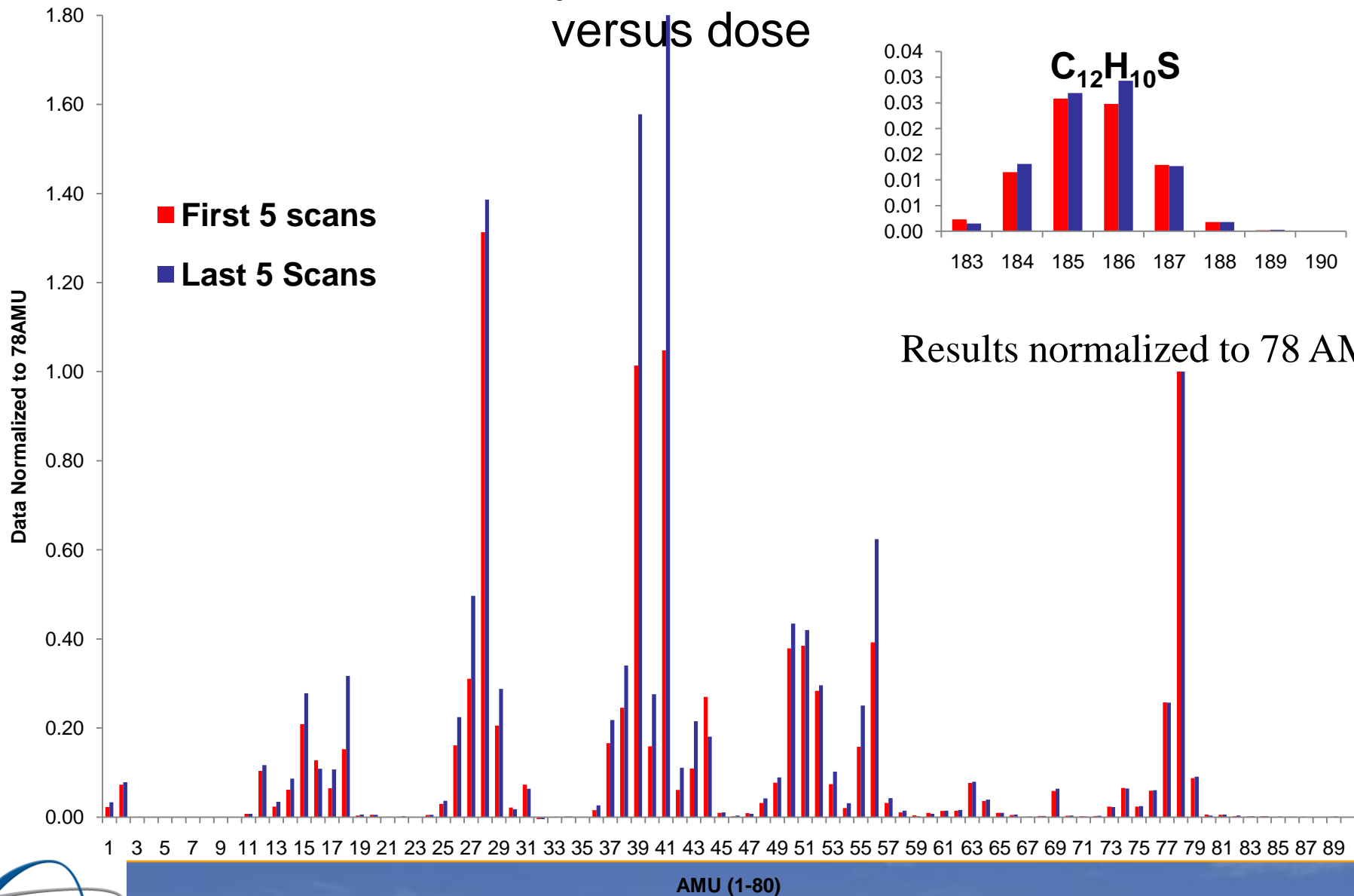


Comparison of electron versus EUV outgassing for open source resist (from Robert Brainard's group at CNSE)

- 92% polymer
 - PHS/Sty/TBAH (65/20/15 mole ratio)
- 7.5% PAG
 - triphenylsulfonium nonaflate
- 0.5% base
 - tetrabutylammonium hydroxide

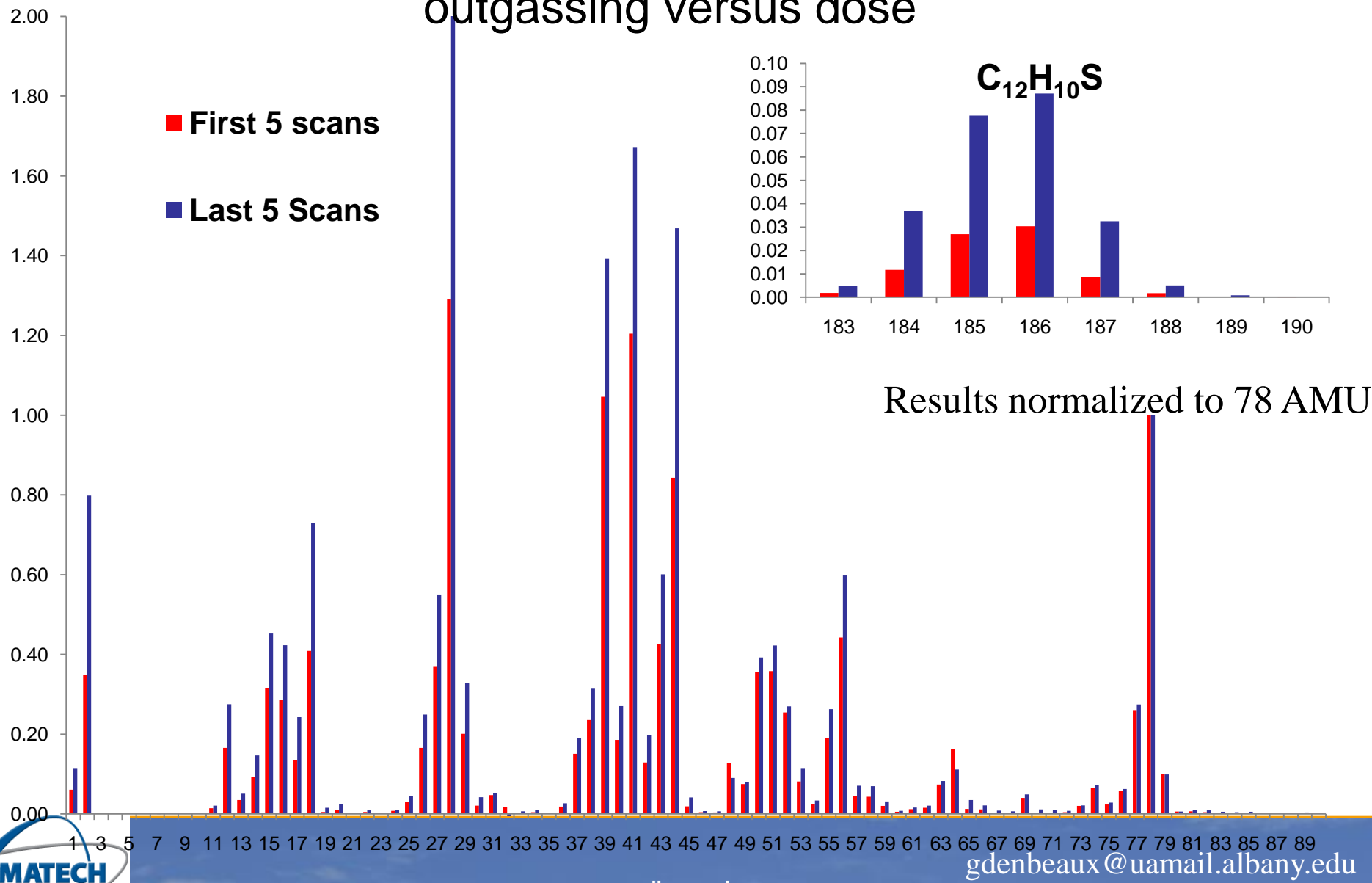


EUV exposures to $\sim 5E_0$ show small changes in outgassing versus dose



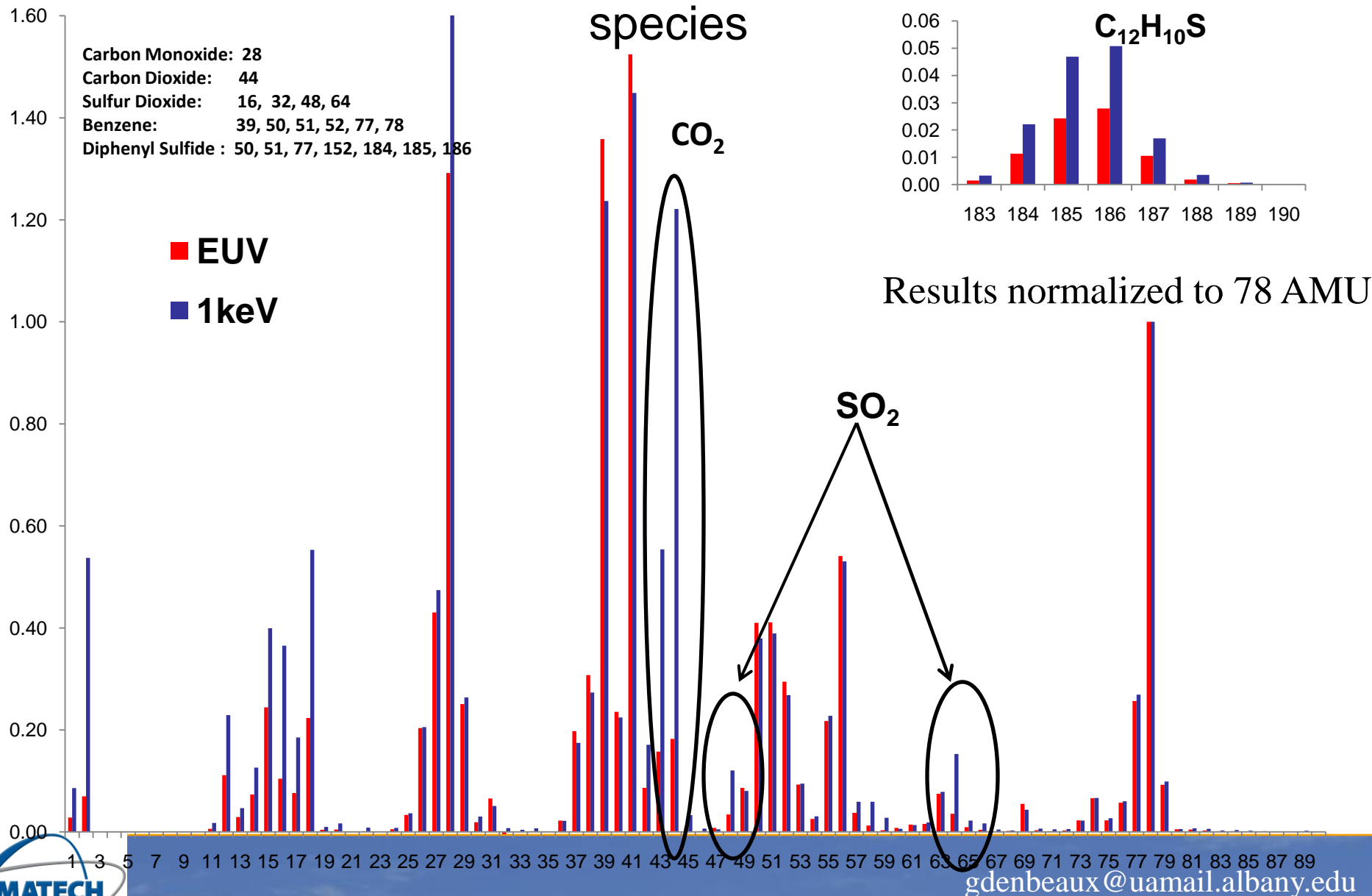


1 keV electron exposures to $\sim 20E_0$ show small changes in outgassing versus dose





Outgassing with EUV or 1 keV electrons are similar for most species





Comparison of outgassing at varied electron energies

AMU	39	41	44	48	50	51	56	64	78	186
Ratio 1keV/EU	1.4	1.4	10.2	4.8	1.1	1.2	1.3	5.4	1.0	1.5
Ratio 3keV/EUV	1.2	1.2	9.3	4.0	1.1	1.1	1.2	4.3	1.0	1.5
Ratio 100eV/EUV	2.1	2.3	7.8	4.4	1.4	1.5	2.0	4.9	1.0	3.2

- After normalization for the dose variations, most species outgas similarly for either exposure mechanism
- For this resist, there is more outgassing for SO₂ and CO₂ for electrons than for EUV
- Changes in electron energy do not have large effect on outgassing species

NOTE: All data normalized to 78AMU



Other resist chemistries may outgas differently...

Resist 1 (commercial supplier) – normalized to 78 AMU

AMU	A	B	C	D	E	F	G	H	I	J
2keV/EUV	2.8	1.6	1.0	2.8	1.9	2.8	3.0	2.4	3.0	4.5
300eV/EUV	3.1	2.0	1.0	3.2	2.1	3.1	2.9	2.3	3.1	4.6
100eV/EUV	4.3	2.2	1.0	4.2	2.4	4.3	4.2	2.8	4.4	4.8

Resist 2 (not a commercial supplier) – normalized to high outgassing mass (not 78)
preliminary data with results only from low energy short penetration depth exposures

AMU	A	B	C	D	E	F	G	H	I	J	K
100eV/EUV	0.1	0.1	3.2	1.0	1.6	7.1	0.4	0.1	1.1	1.9	1.8

We have found **NO** species that outgas from EUV or electrons and not from the other exposure mechanism



Status and Plans

- Witness plate testing with photons ongoing, but exposures are slow
- Testing of electrons as substitute for EUV photons (faster and cheaper) is ongoing
 - Exposures may be fast enough that metrology would be limit to throughput



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