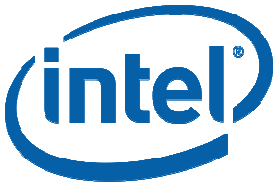
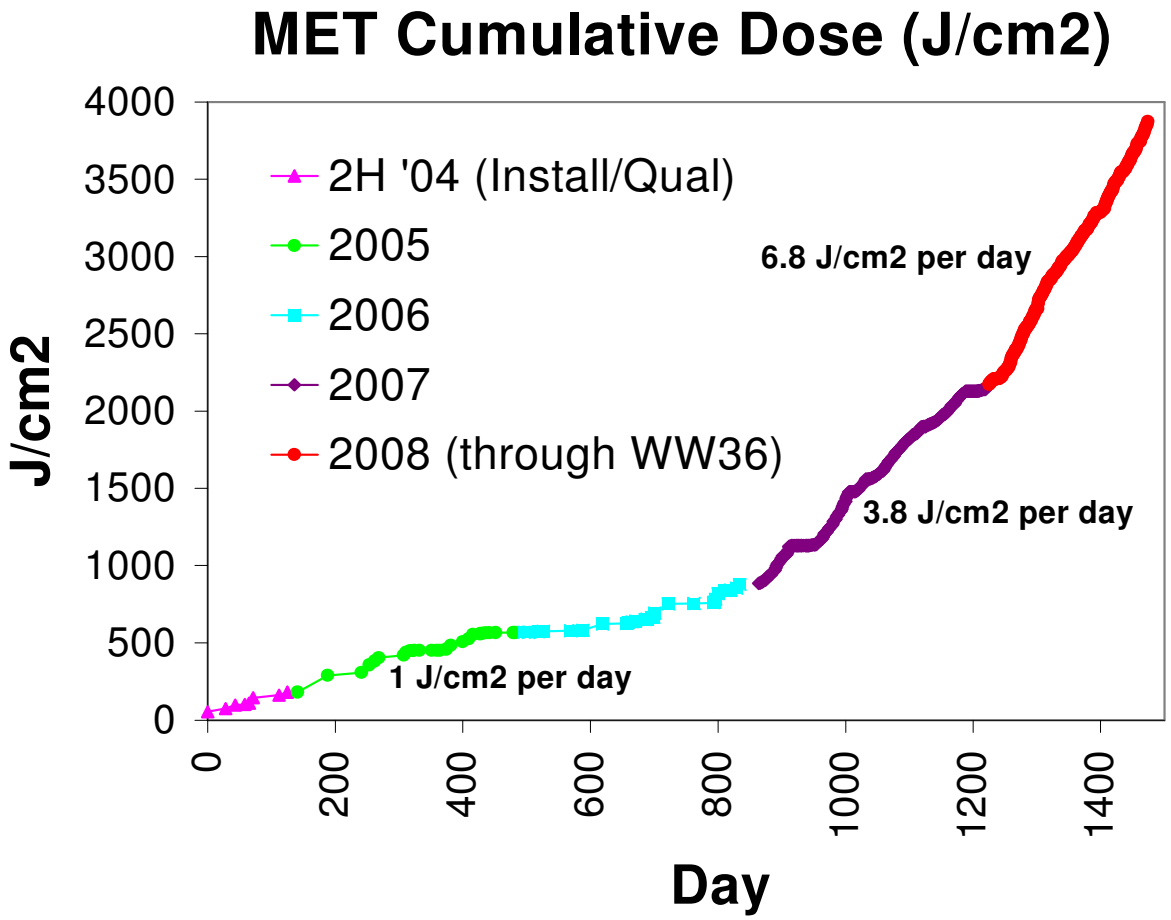


Intel MET cold trap results and related data

IEUVI Optics Contamination TWG
Lake Tahoe, 10/2/2008

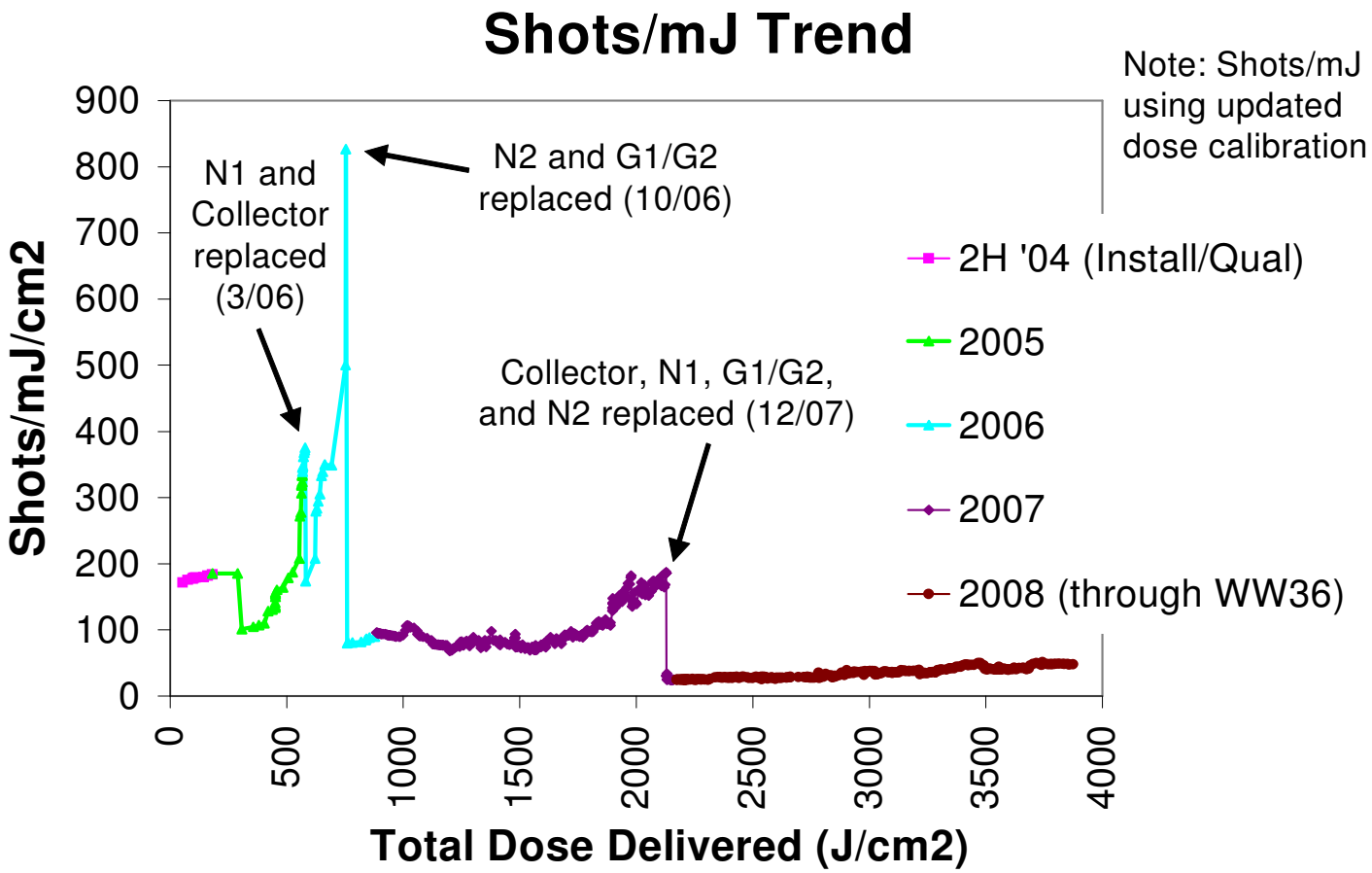
Roman Caudillo

MET Productivity as measured by cumulative dose delivered

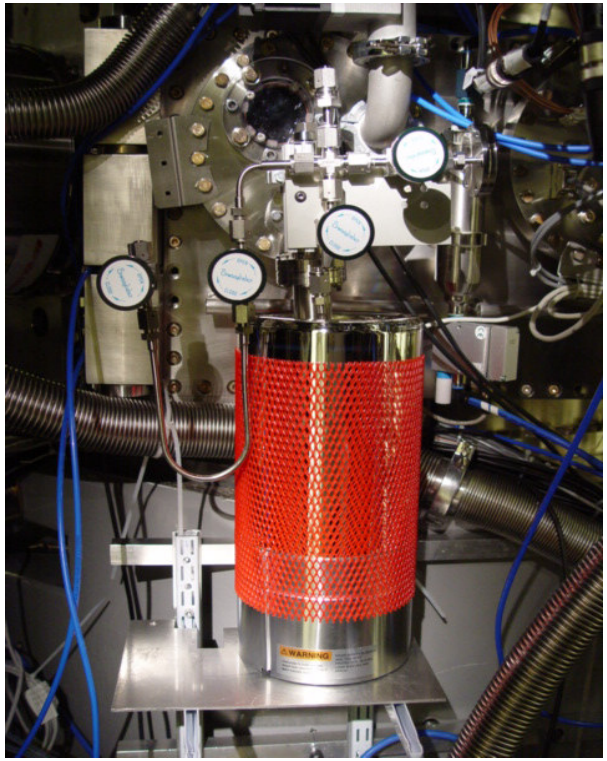


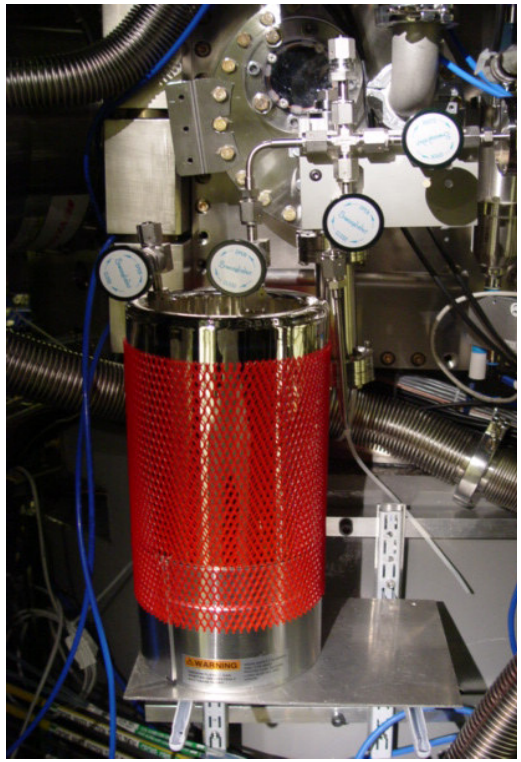
Note: Dose calculated using updated dose calibration (based on NIST calibrated photodiode)

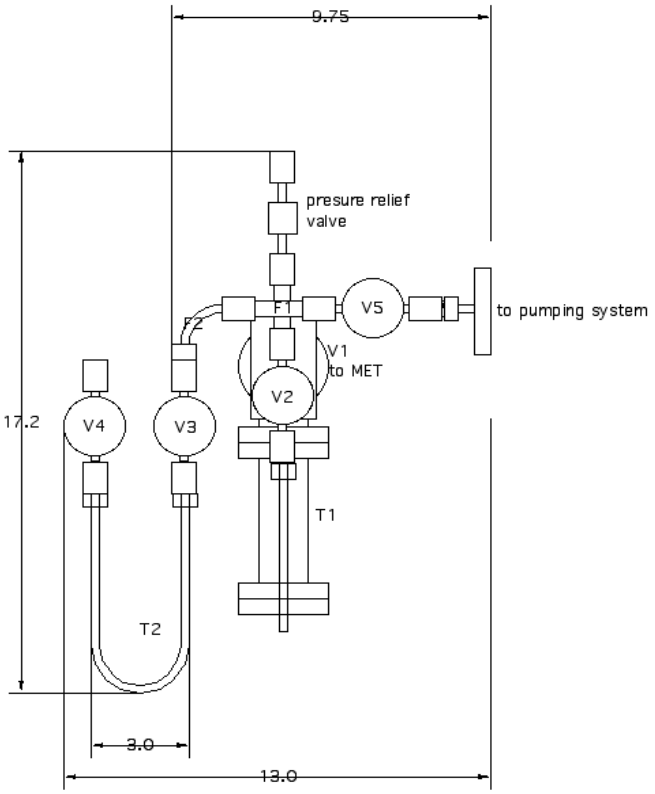
High productivity enabled by high wafer plane power



Cold Trap Overview







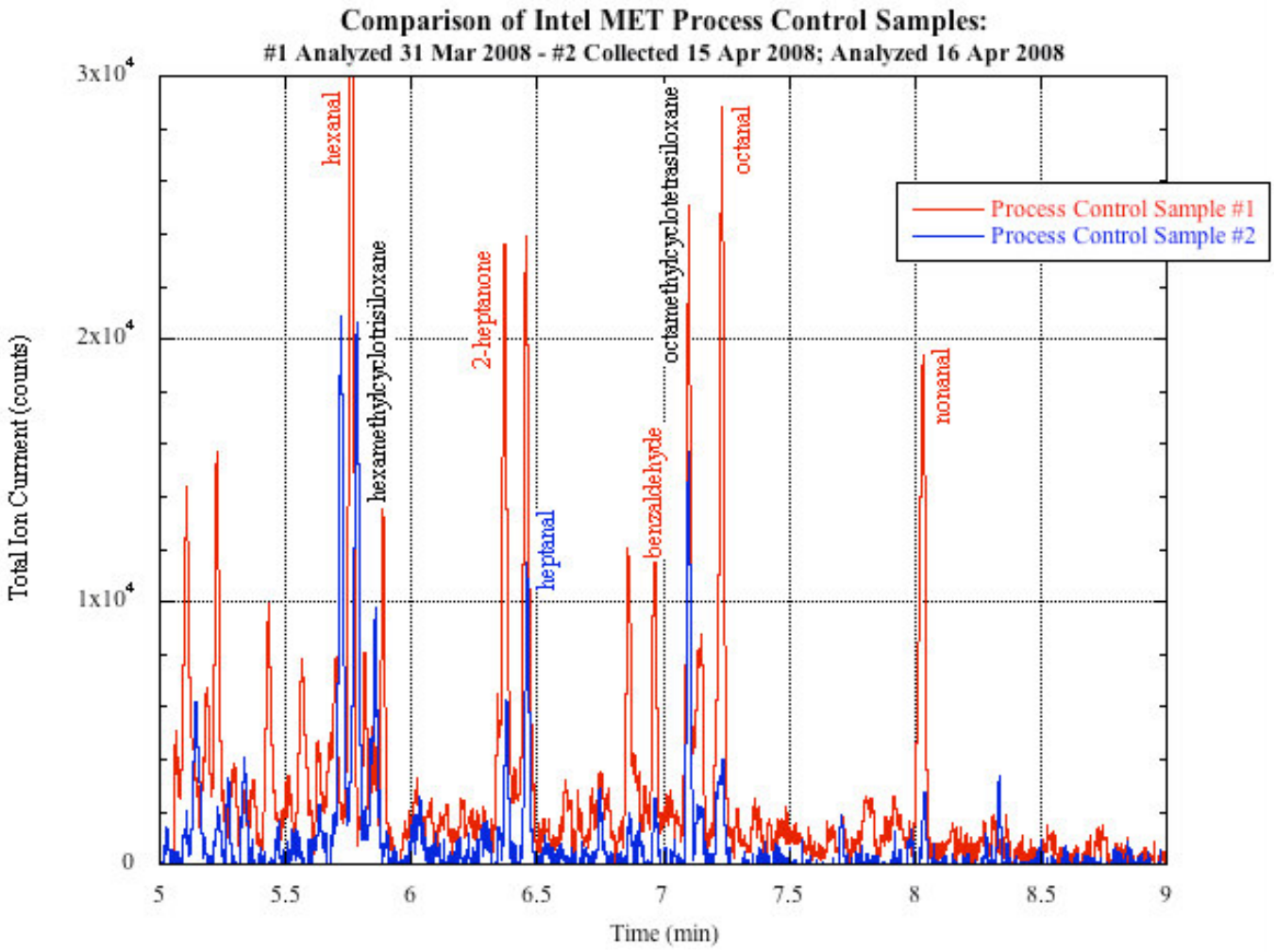
- Goal is to identify the source of the carbon that leads to contamination on the most contaminated optics, i.e. the illuminator optics
- However, first cold trap was set up to sample the wafer section (far from illuminator optics but closer to resist wafers) due to space limitations on the MET

Cold trap samples collected to date:

Date collected	Sample ID	Sample time (h)	Transfer t (h)	Transfer T (C)
29-Feb	MET Idle #1	1.25	3	100
3-Mar	U-tube Control	NA	NA	NA
3-Mar	MET Exposing	1	4.25	144
21-Mar	Fab Air Sample	1	NA	NA
28-Mar	PCS #1	NA	NA	150
15-Apr	PCS #2	NA	NA	150
21-Apr	MET Idle #2	1	1	110
26-Jun	PCS #3	NA	NA	150
27-Jun	MET Idle #3	1	1	110

- First samples that were collected (blue font) were used to develop a reliable sample collection procedure but did not provide useable data.
- Most recent samples that were collected (also blue font) also did not provide useable data, due to aging (>2 months between sample collection and GC/MS measurement)
- Samples collected in April (red font) provided some meaningful data
- Appropriate sample collection procedure involves the following:
  - Full day bakeout of cold trap for cleaning
  - Collecting a process control sample to establish cold trap background levels
  - Finally, the actual collection of a sample exposed to the MET chamber

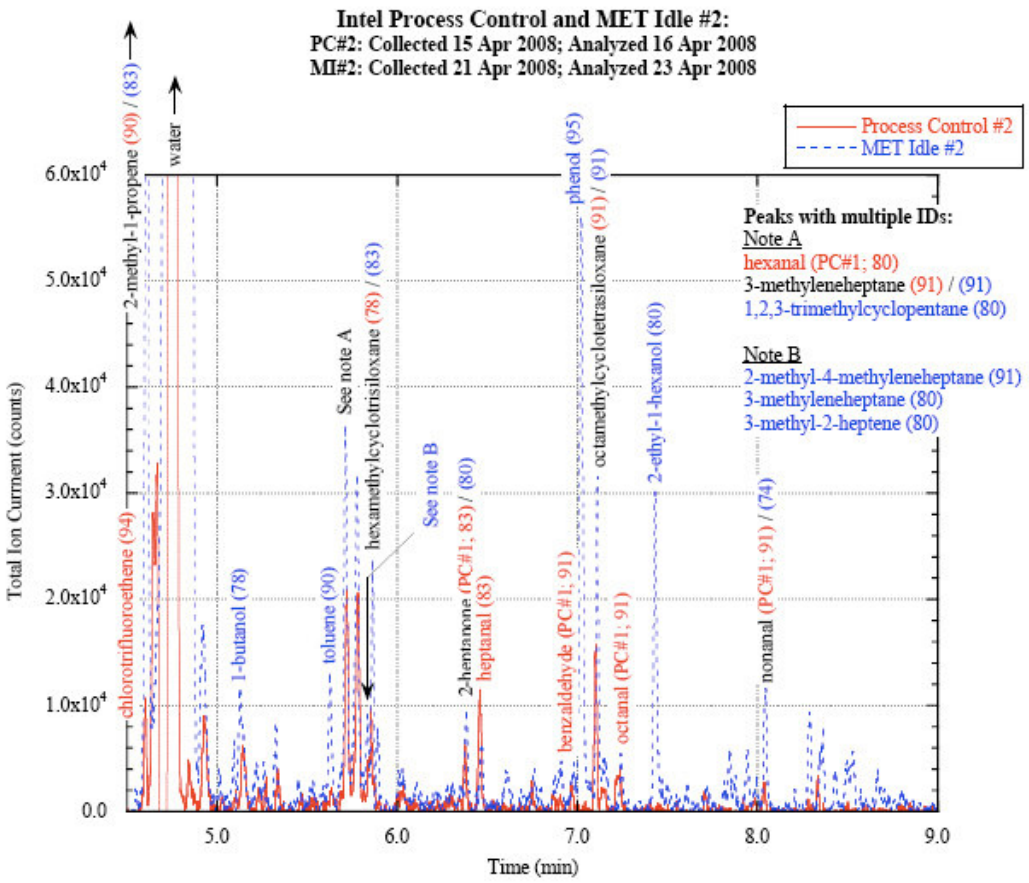
GC/MS Analysis: Results of cold trap bake out



- Major peaks in the post-bake spectrum are reduced by an average of 73% (ranging from 52% to 86%) from the peak height in the pre-bake spectrum

- Cold trap background levels are low enough to identify primary contaminants in MET

GC/MS Analysis: MET Idle #2 Sample



- Peaks generally appear in both spectra, indicating that the observed materials originate in the MET vacuum and appear in the process control sample due to retention in the trap T1.
- The primary MET vacuum components, ranked by ratio of MET Idle #2 signal to PCS#2 signal, are identified as: phenol, 2-ethyl-1-hexanol, toluene, 2-methyl-1-propene, nonanal, water, and hexamethyl-cyclotrisiloxane.

A closer look at identification of contaminants

Tentative Identification	Time (min)	PC#2 (counts)	MET Idle #2 (counts)	Peak Height Ratio
phenol	7.02	0.9k	56.1k	62.3
2-ethyl-1-hexanol	7.43	0.8k	30.0k	37.5
toluene	5.63	2.3k	13.1k	5.7
2-methyl-1-propene	4.61	29.8k	135.0k	4.5
nonanal	8.04	3.1k	11.6k	3.7
water	4.77	295.9k	757.8k	2.6
hexamethyl-cyclotrisiloxane	5.86	9.7k	23.8k	2.5
octamethyl-cyclotetrasiloxane	7.11	15.8k	31.4k	2.0
unidentified peak	4.92	8.9k	17.34k	2.0
benzaldehyde	6.97	2.3k	4.2k	1.8
1-butanol	5.13	6.4k	11.6k	1.8
hexanal; 3-methylene-heptane; or 1,2,3-trimethyl-cyclopentane	5.71	20.8k	35.9k	1.7
2-methyl-4-methylene-heptane; 3-methylene-heptane; or 3-methyl-2-heptane	5.84	5.2k	8.8k	1.7
unidentified peak	5.78	20.6k	31.9k	1.6
2-heptanone	6.39	6.6k	9.5k	1.4
octanal	7.24	3.9k	5.3k	1.4
heptanal	6.46	11.4k	5.9k	0.5
chloro-trifluoro-ehtene	4.55	10.5k	2.2k	0.2
triphenyl-phosphone oxide; or formyl-methylene-triphenyl-phosphorane	12.63	– [a]	2.5k	– [a]

[a] The peak was not observed in the PC#2 sample; the ratio can not be computed.

- Table displays contaminants in descending order of their peak height relative to the previously collected process control sample
- **Phenol and 2-ethyl-1-hexanol** are the contaminants identified with the highest confidence
- **2-methyl-1-propene (isobutene)** is also one of the major resist outgassing components, however benzene is not observed
- **Phenol** is also present in resist resin, but not commonly seen in resist outgassing

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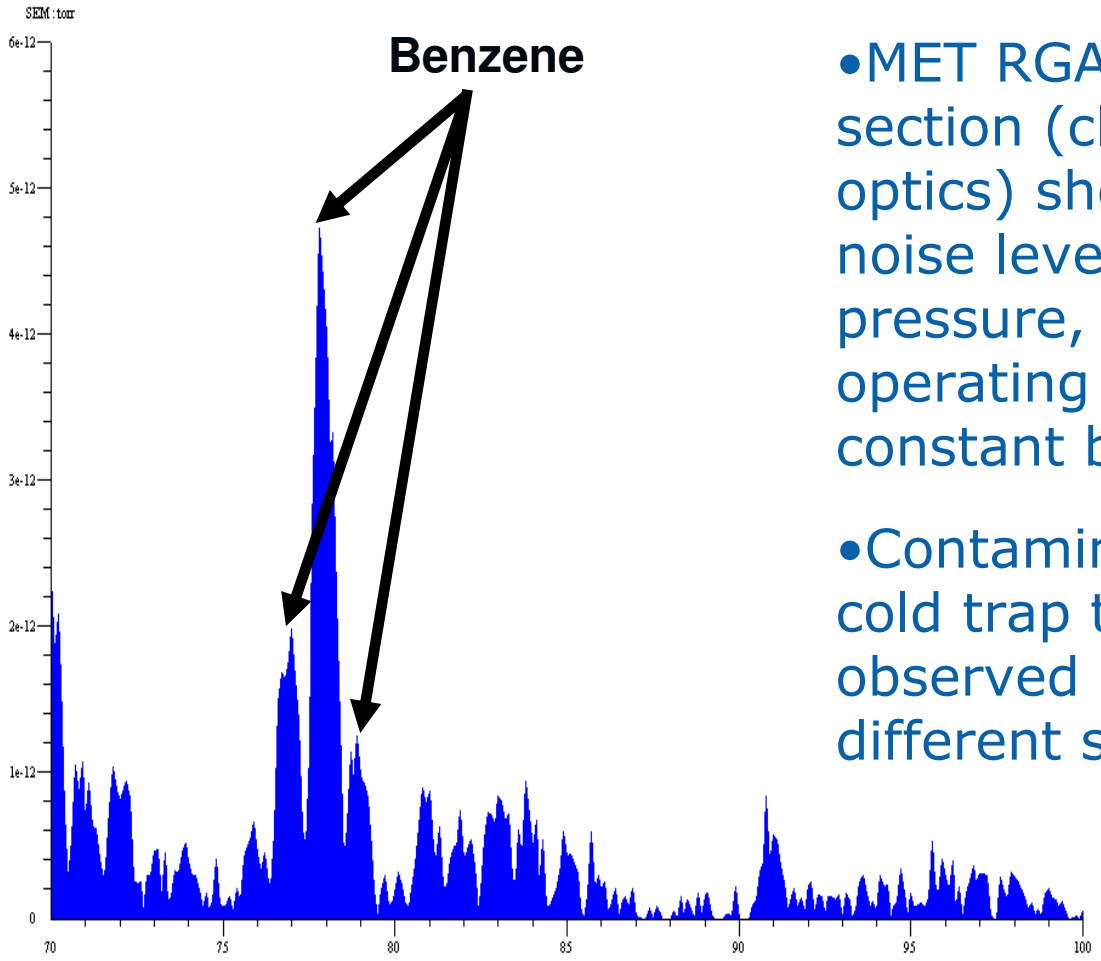
Recommendations for future cold trap experiments

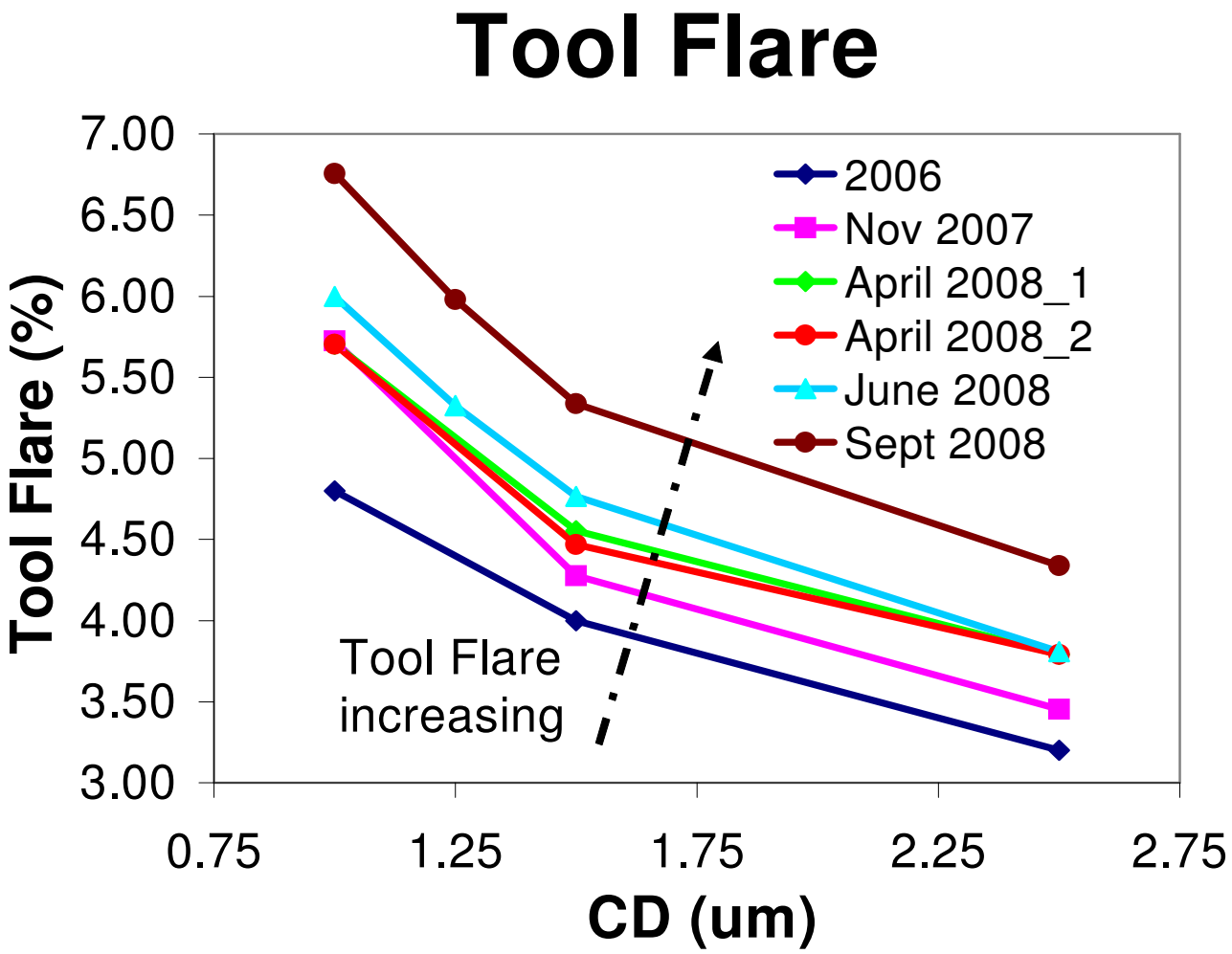
- Need to consistently implement a bakeout procedure between each sample collection (higher T, more even heating, longer bake out time)
- PCS sample should be collected before each sample collection to qualify the T1 trap as clean in addition to establishing a background spectrum
  - Need to establish a "clean" spec for PCS samples
- **A new trap containing less retentive stainless steel should replace the current quartz mesh trap**
- Following the above should increase confidence in the observed contaminants, then can try varying conditions during sample collection for better learning

Comparison to MET RGA Scans



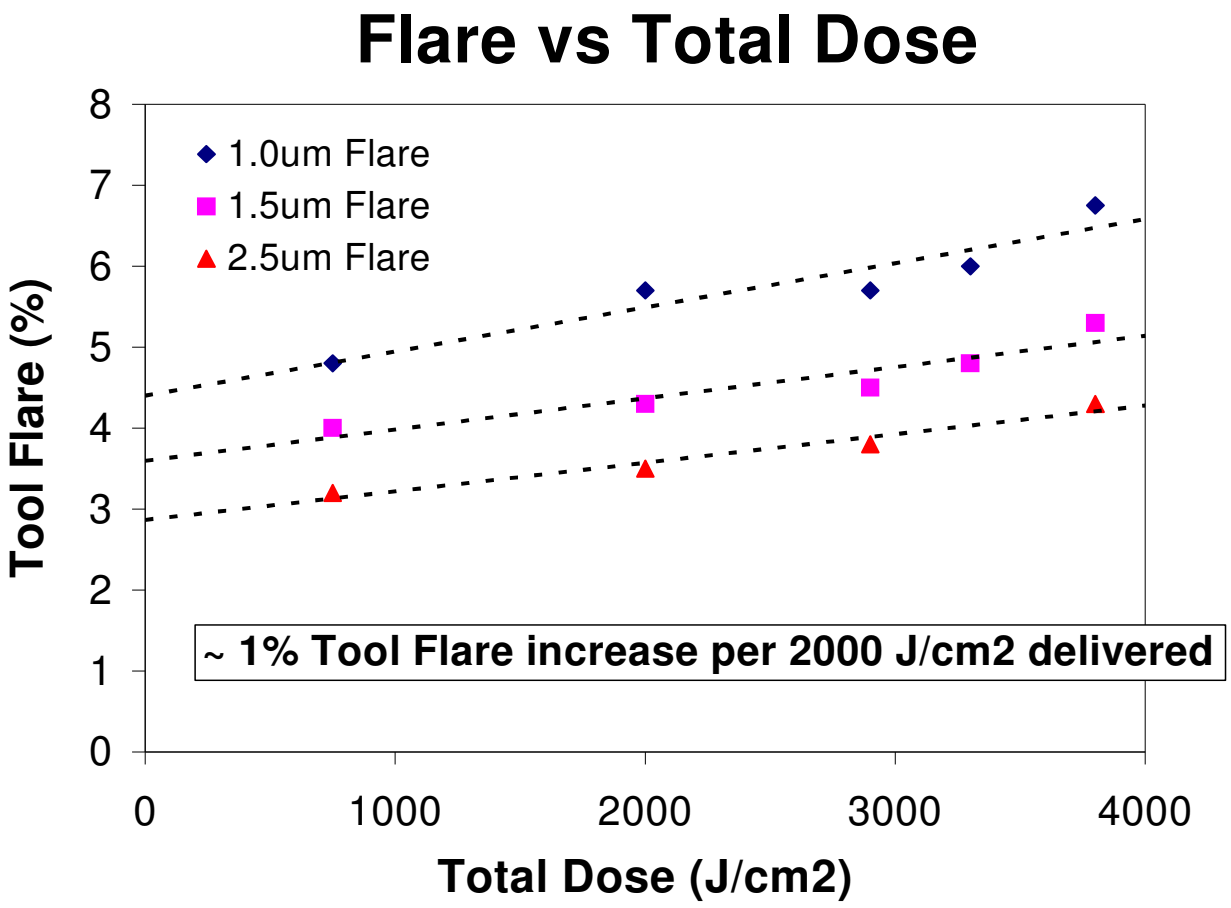
- MET RGA scans in the reticle section (closer to illuminator optics) show **benzene** above noise level, but at low partial pressure, and irregardless of operating condition (i.e. constant background)
- Contaminants identified by cold trap technique are not observed (different sections and different sensitivities)

MET Tool flare trend over time



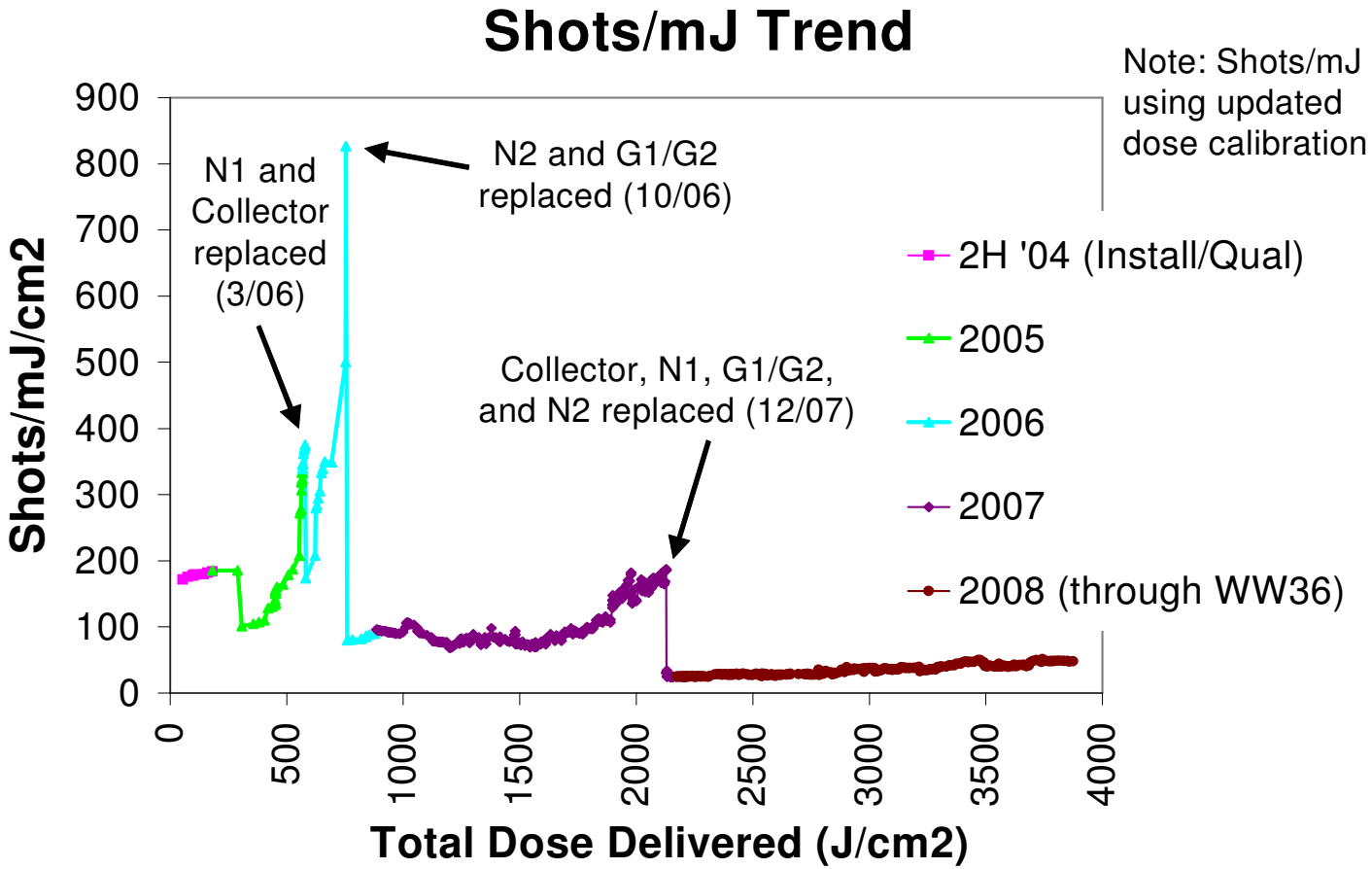
Rate of tool flare increase as a function of dose delivered

•Are the projection optics contaminating significantly over time?



High wafer plane power with original projection optics suggests not

- Tool Flare increase is a function of MSFR increasing, not necessarily carbon contamination build-up



Questions?

Back-up slides

Measuring flare on MET

MEASURED FLARE – MASK FLARE = TOOL FLARE

$$\frac{E0}{E0_{island\ feature}} \qquad \frac{\text{Absorber Reflectivity}}{\text{ML Reflectivity}}$$

KEY POINTS:

- Flare measurements made using resist clearing method (Kirk's Method)
- Projection Optics have never been replaced on Intel MET
- Contamination may increase MSFR and HSFR on PO, thus increasing tool flare over time, however wafer plane power indicates that any contamination must be minimal