Intel update contamination of EUV MET mirrors

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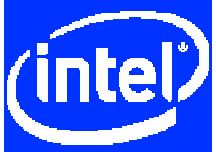
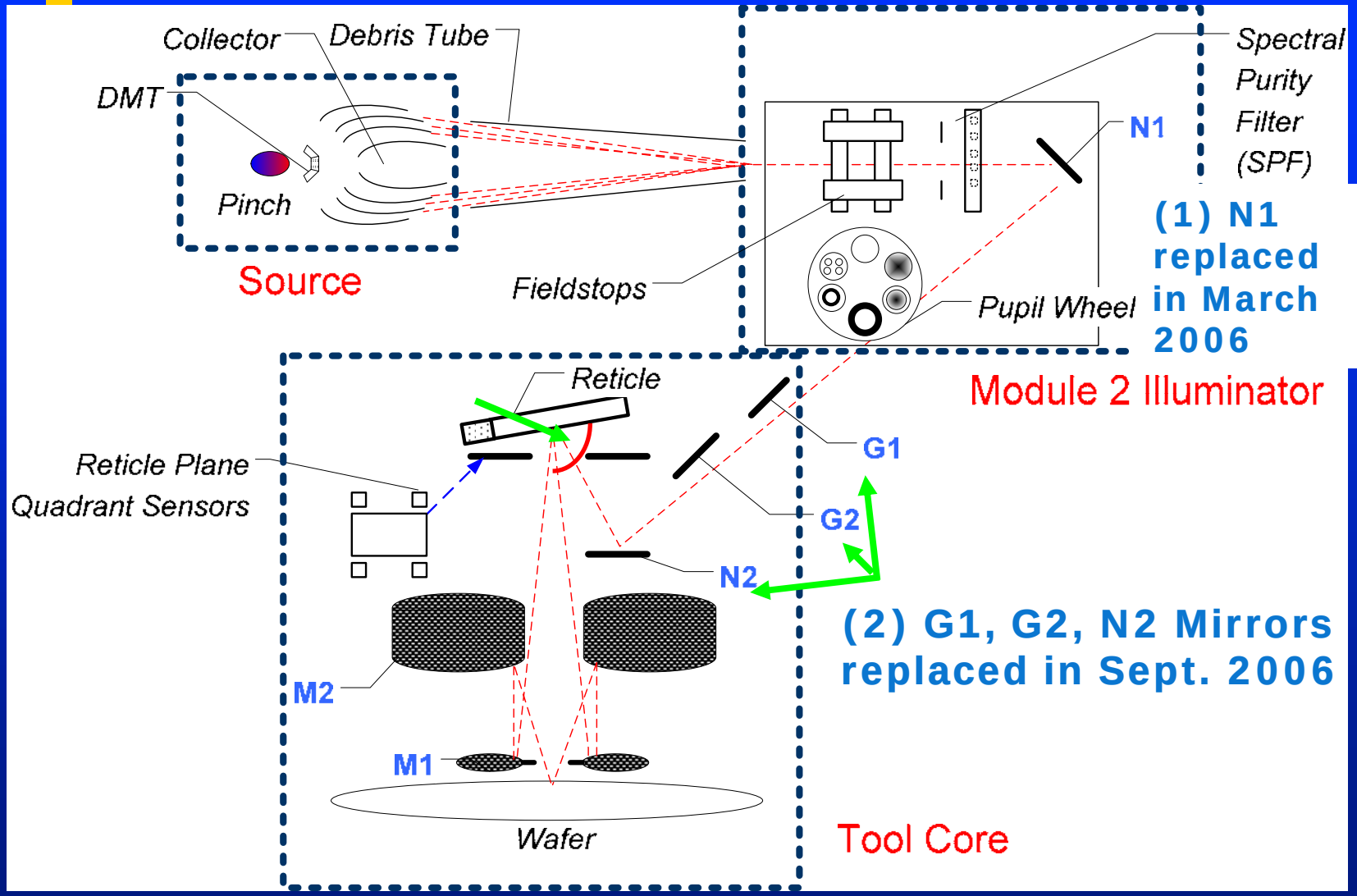


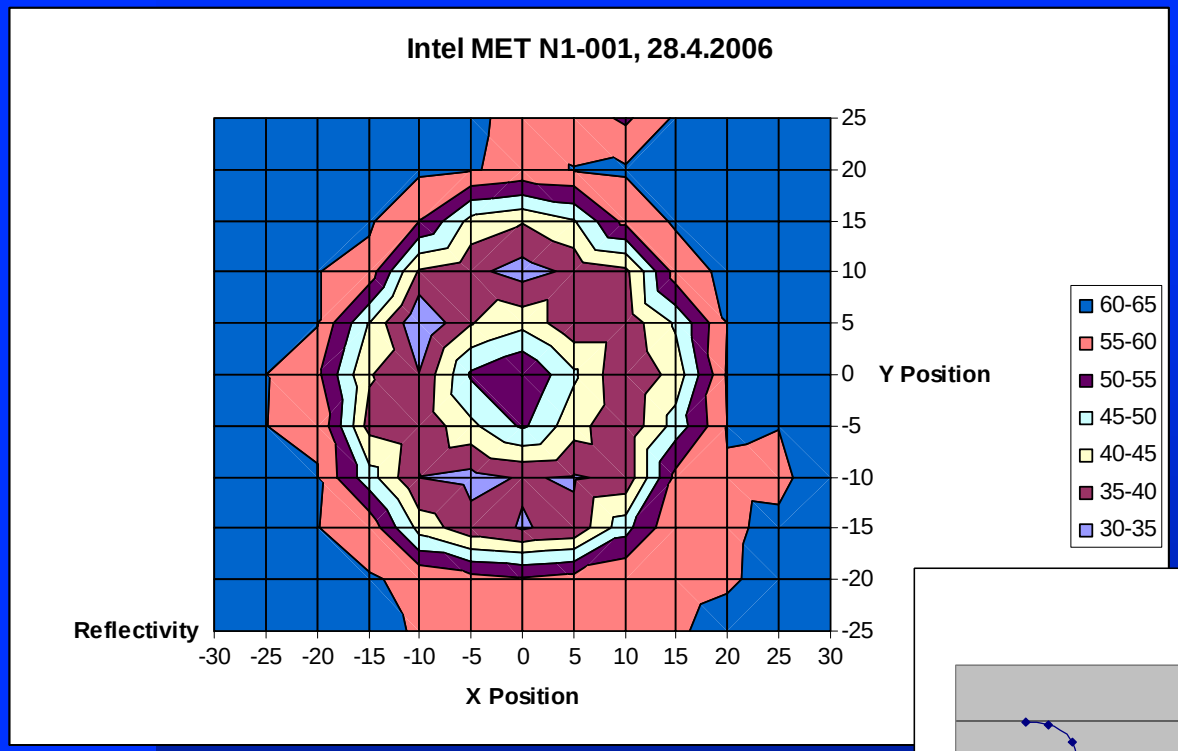
Summary

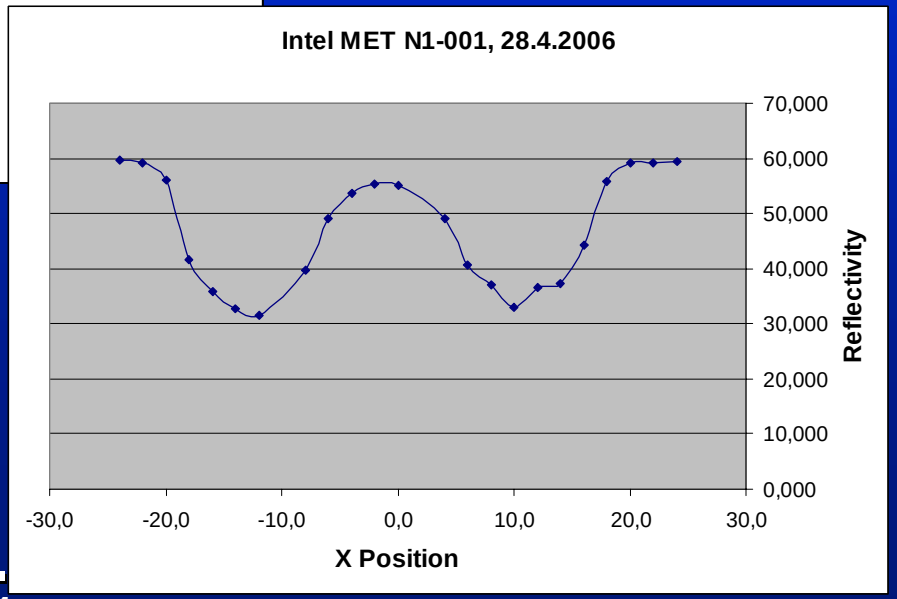
- Intel replaced mirrors twice over the last year in the illumination optics of the MET
- Indicator is low wafer plane power owing to mirror contamination
  - > 100 shots/mJ
  - Imaging performance can degrade due to system vibration and/or drift
  - Throughput slows to a crawl
- N1, normal incidence mirror showed reduction in average reflectivity from 64% to 41%
- G1 average reflectance decreased from 78% to 50% whereas G2 average reflectance dropped from 66% to 10%
- Major source of contamination is carbon

MET Schematic



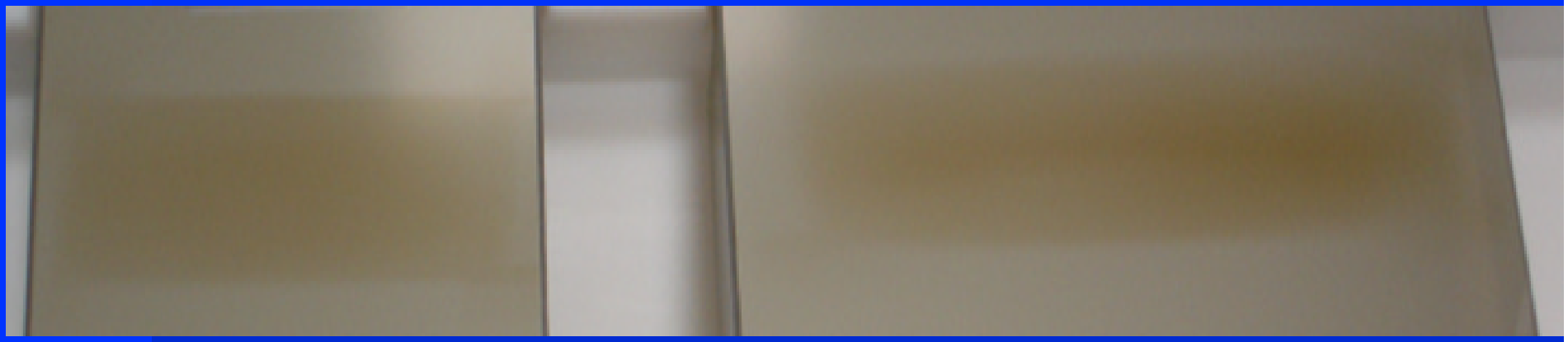
N1 mirror results after 110 million shots

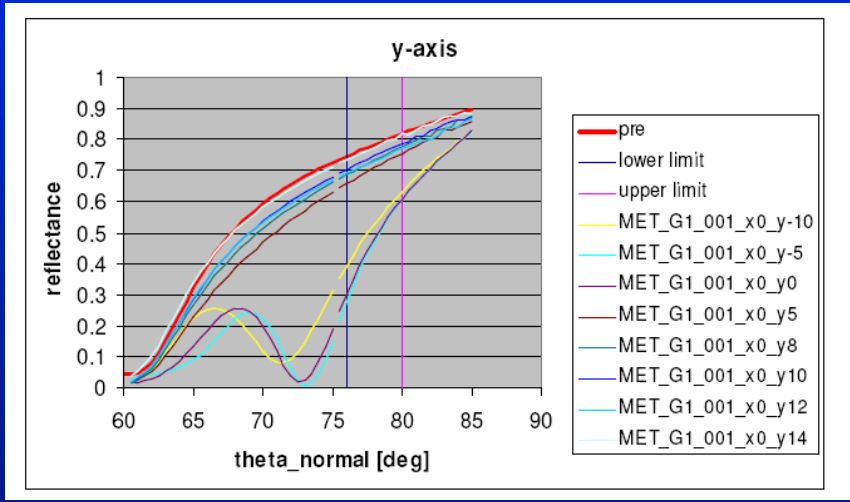


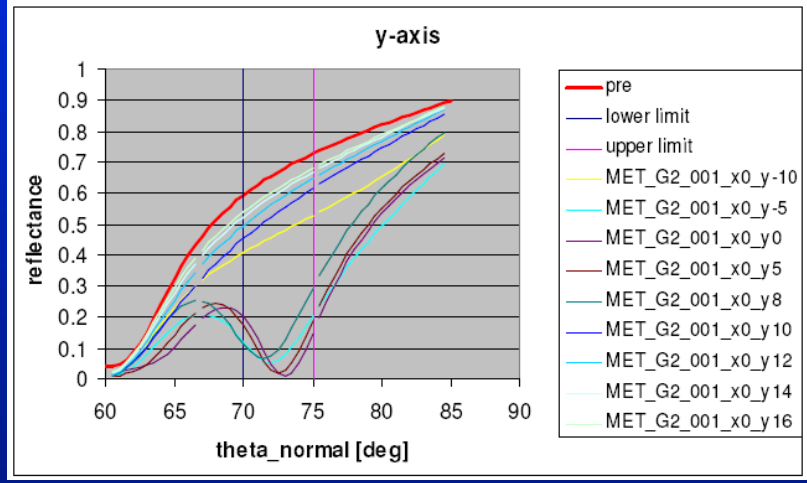


- Reflectivity dropped from 64% to minimum 32%, 41% average reflectance
- C:O:Si ~70%:20%:10%.

G1, G2 replaced after 174 million shots

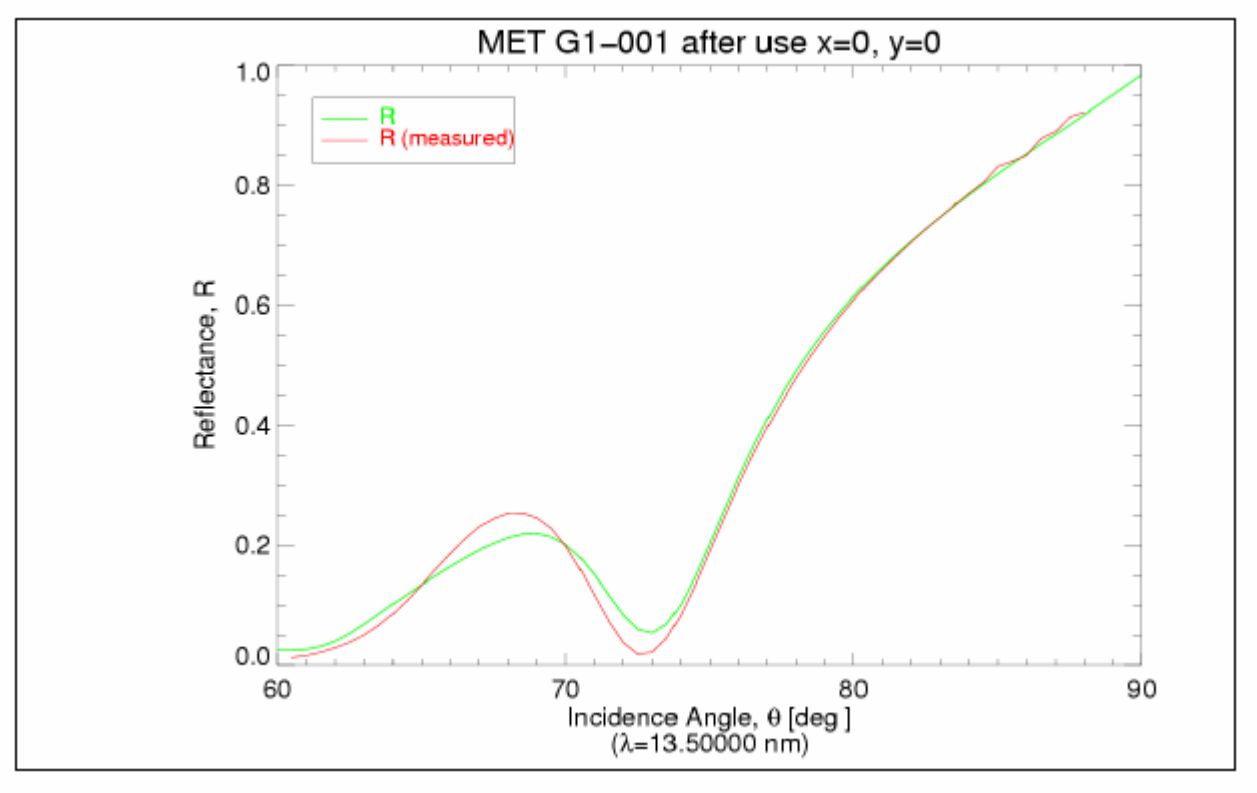






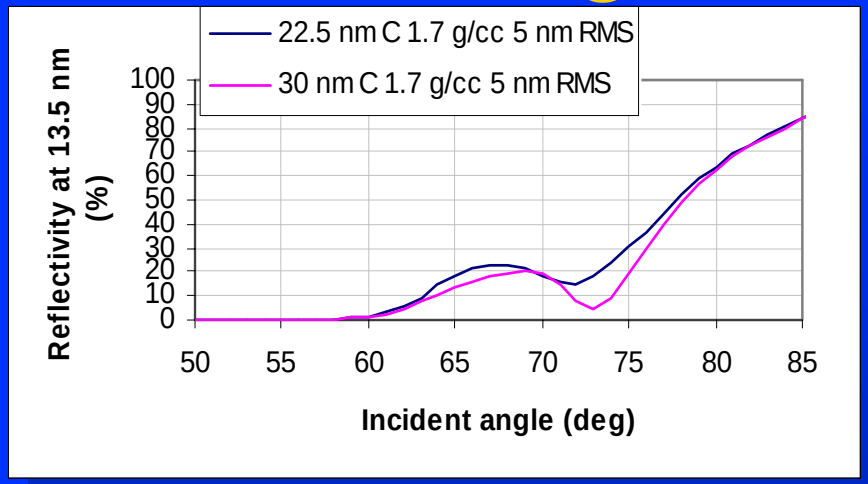
- Degradation of G1 and G2 appear similar, but impact was more from G2 due larger incidence angles
- C:O:Si ratios ~ 85%:10%:5%

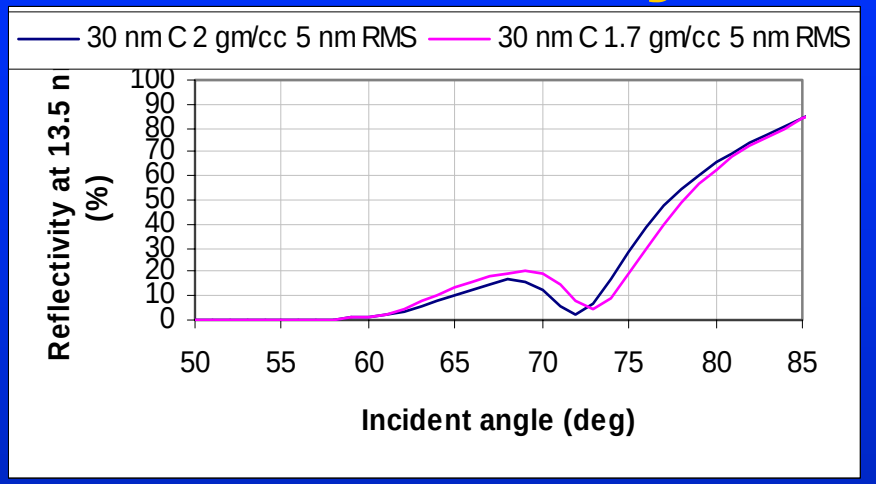
Estimating the thickness by modeling

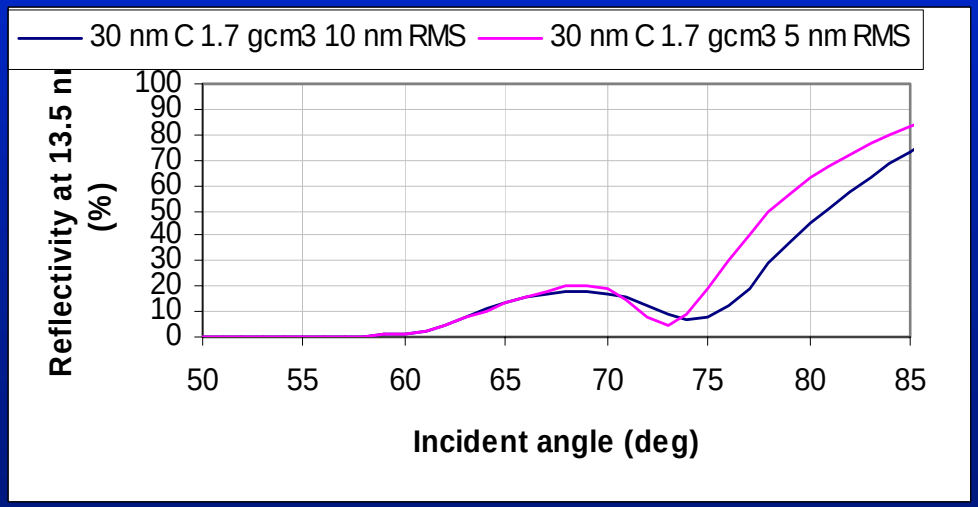


- C thickness estimated at 30 nm

Impact of thickness, density, and roughness on reflectivity

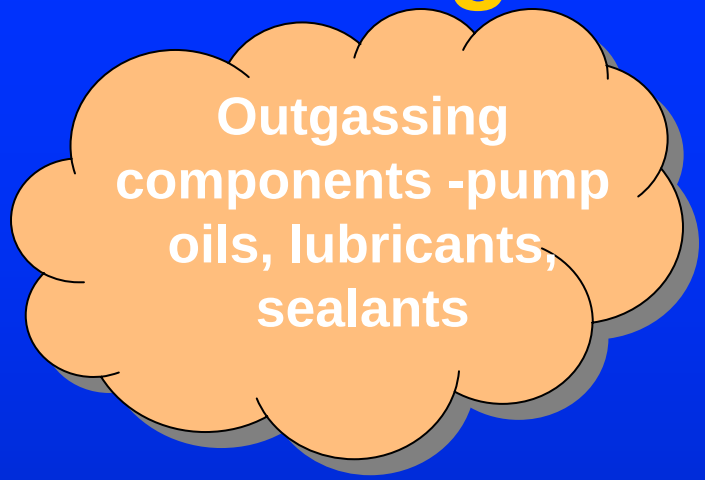






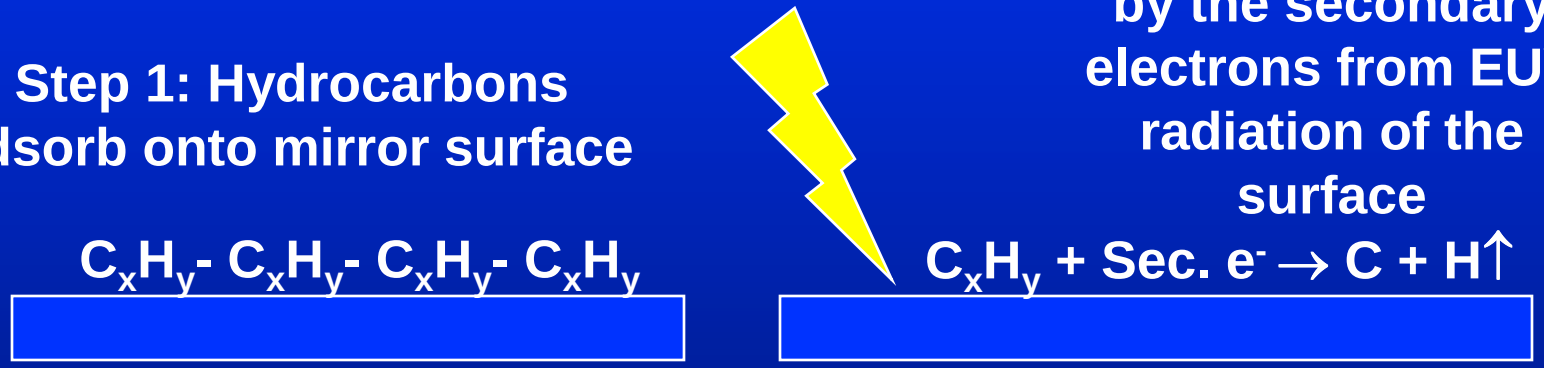
- Multi-dimensional fit needed for G1 and G2 independently

Phenomenological model



Step 1: Hydrocarbons adsorb onto mirror surface

Step 2: Hydrocarbons are broken down into C by the secondary electrons from EUV radiation of the surface



- After ~0.5 nm C growth, surface appears as C capped*
- Carbon growth rates have been found to be independent of the ambient pressure, and inversely proportional to the temperature of the substrate*
  - Rate limiting factor is not arrival rate of adsorbed [HC]s

* Yakshinskiy, T. Madey et al, Proc. SPIE 2007