REMOVING SURFACE CONTAMINATES FROM SILICON WAFERS

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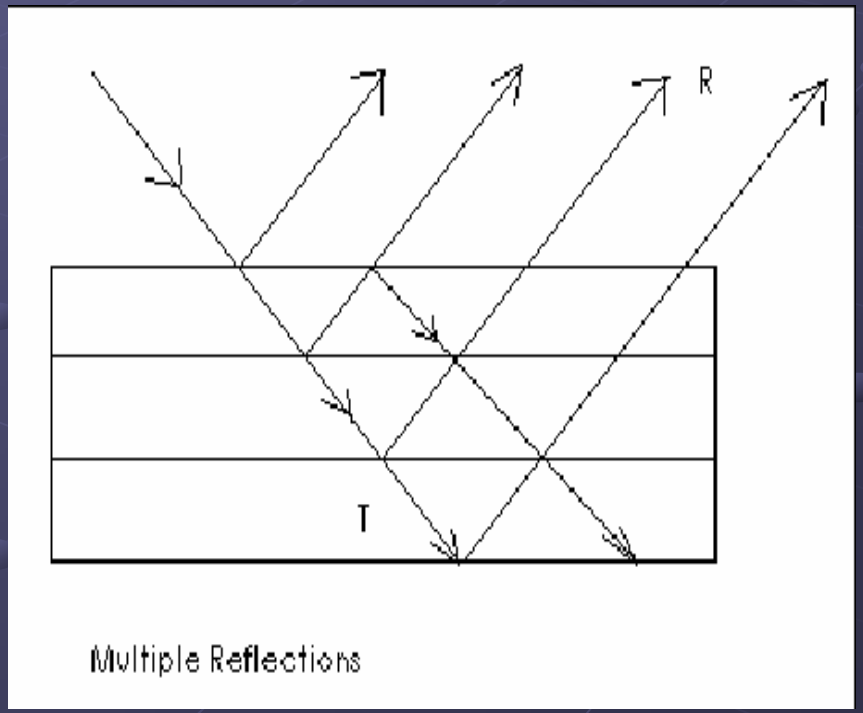
Reflectors in EUV range

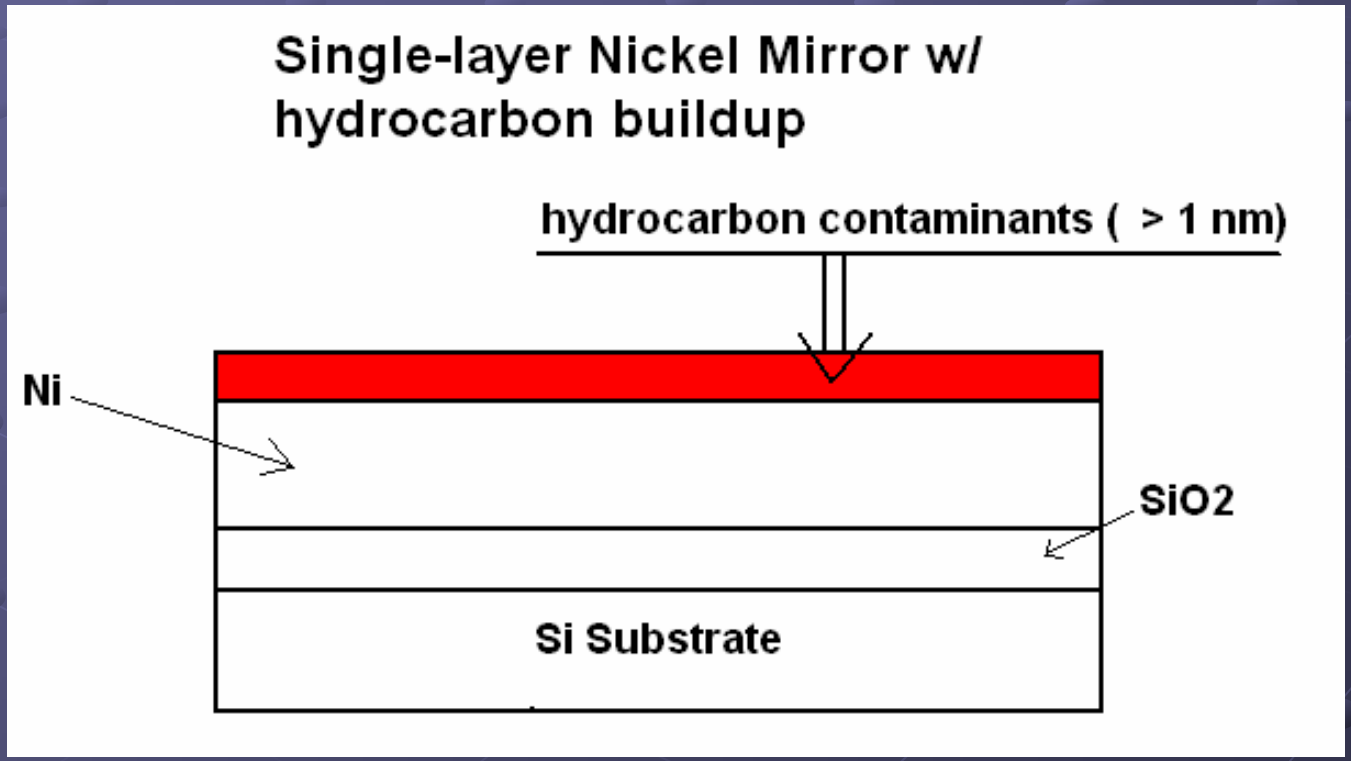
- EUV range is about 100-1000Å
- General Challenges:
  - multilayers required
  - absorption
  - high vacuum needed
- Applications
  - XUV lithography
  - Soft x-ray microscopy
  - Astronomy
- Complex index of refraction: ñ=n+ik



Multiple Reflections

Hydrocarbon Contaminants

- Airborne hydrocarbons accumulate on mirror surfaces.

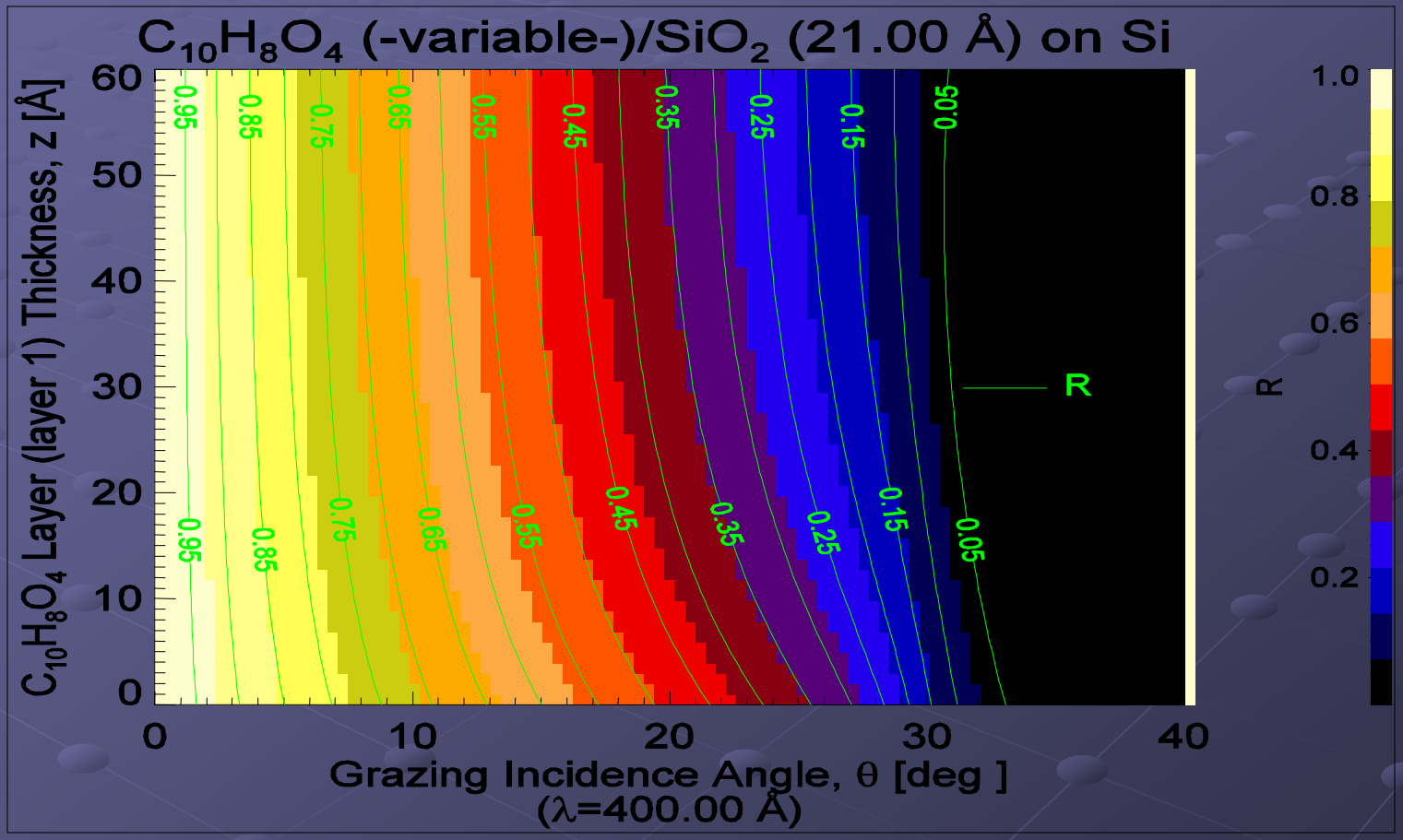


Buildup Rates

- Spectroscopic Ellipsometry indicates the thickness of deposits.

Description of Exposure	Duration of Exposure	Apparent Thickness
Left in Open Air	425.5 hrs	2.1 nm
Touched w/ latex glove	10 sec	1.6 nm
Touched w/ finger	10 sec	14.3 nm

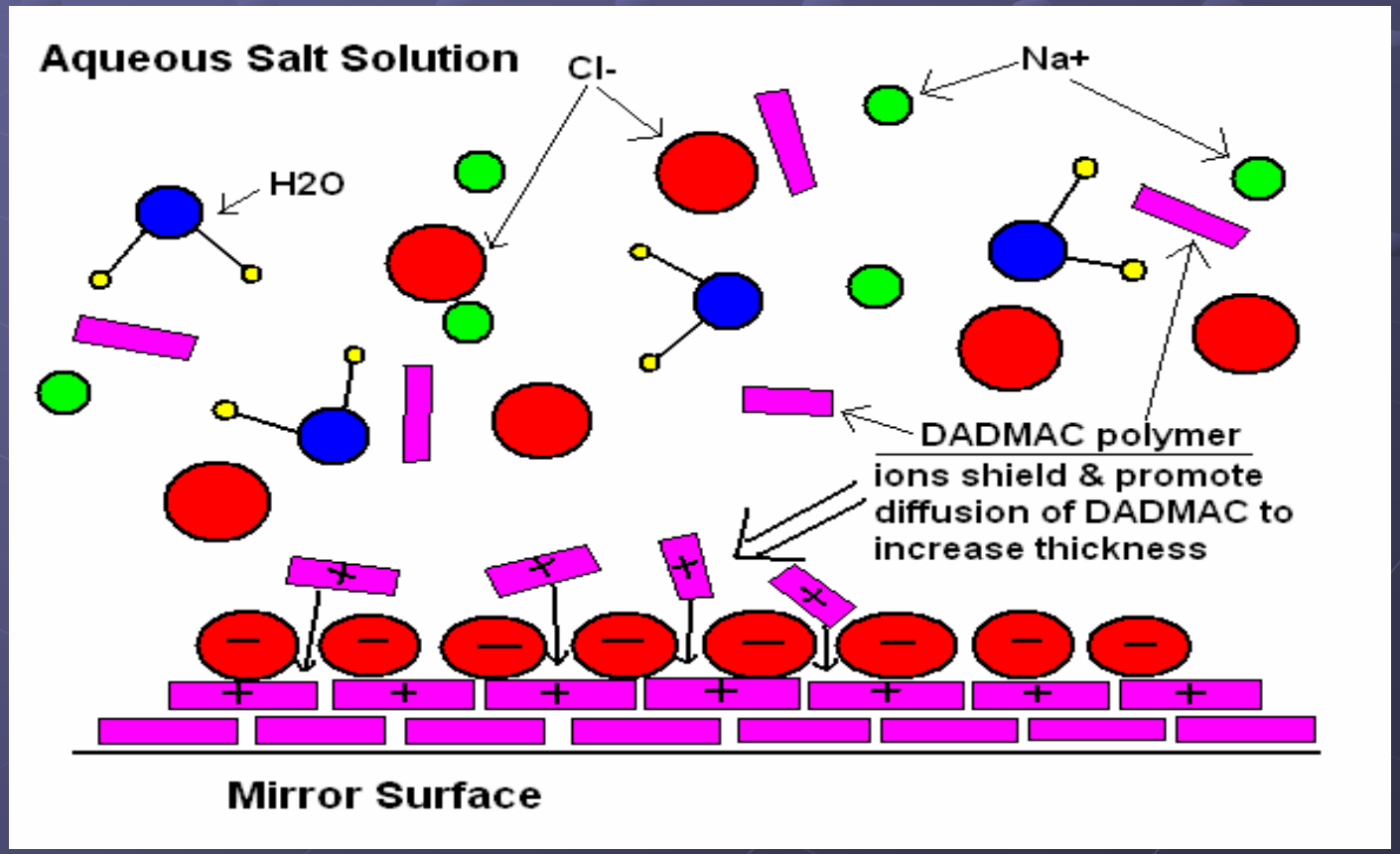
Hydrocarbon Buildups Lower Reflectance



Reduced Reflectance with Hydrocarbon Thickness. Theoretical change in reflectance vs. grazing angle and organic thickness. (at λ=40.0 nm)

Preparing a Standard Contaminant

- DADMAC (polydiallyldimethyl-ammonium chloride) is used as the standard contaminant which coats the surface.
- Salt concentration affects shielding and eventual thickness of DADMAC layer.



Four Methods of Cleaning Tested

- Opticlean®
- Oxygen Plasma
- Excimer UV Lamp
- Opticlean® + Oxygen Plasma

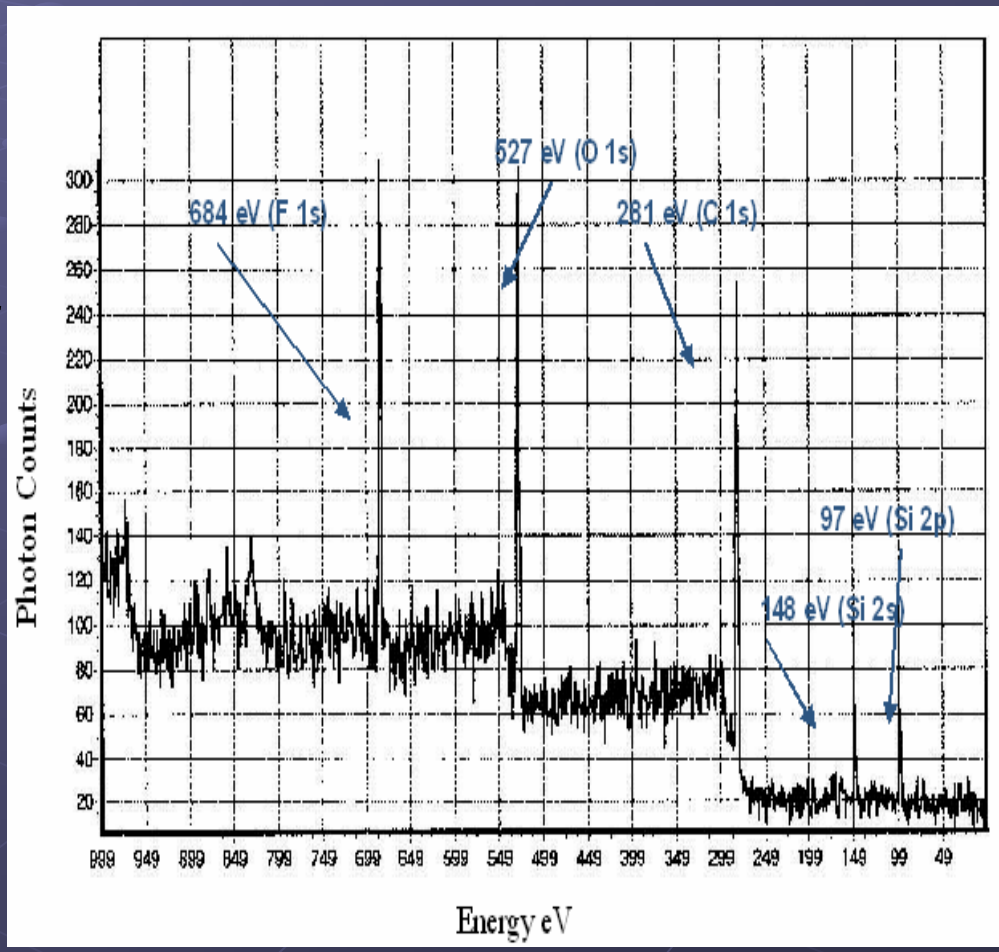
Opticlean®

Procedure:

- Applied with brush, left to dry, peeled off (DADMAC comes too)

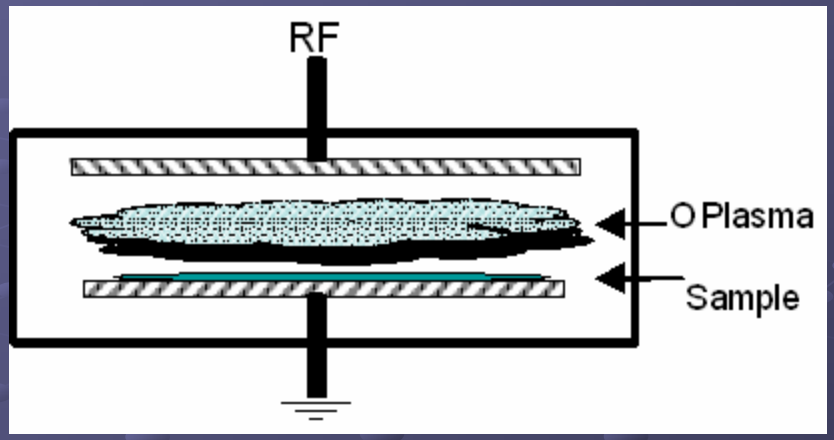
Results:

- 2 nm polymer residue left (ellipsometry)
- XPS revealed the components of Opticlean® (F,O,Si,C), but not heavier metals used in thin films. Prominent thin-film lines: U-380 eV, V-515 eV, Sc-400 eV.
- No surface damage (SEM)



Oxygen Plasma Procedure

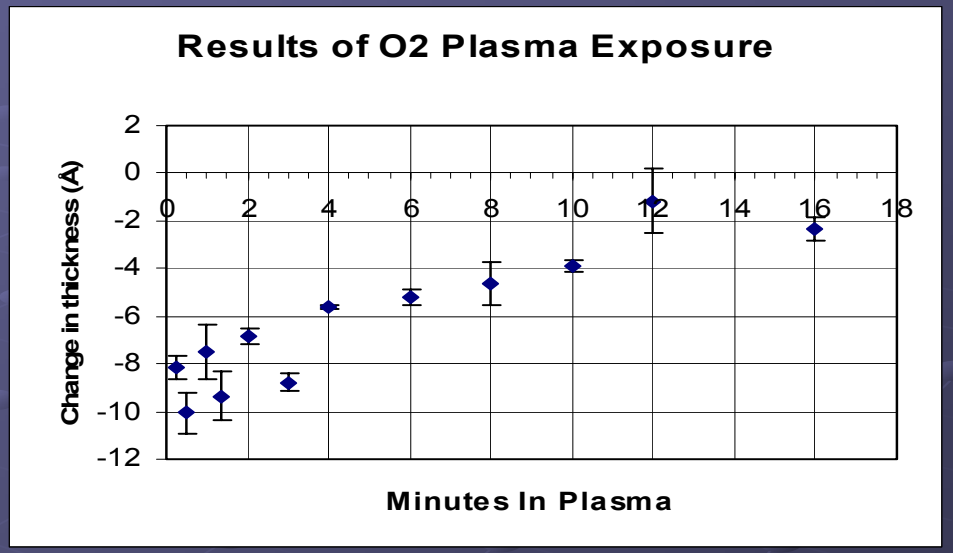
- Oxygen plasma is formed between two capacitor plates by inducing a radio frequency (RF) electric current across the plates.
- High energy ions mechanically break up molecular bonds of the surface molecules and blast them off surface.

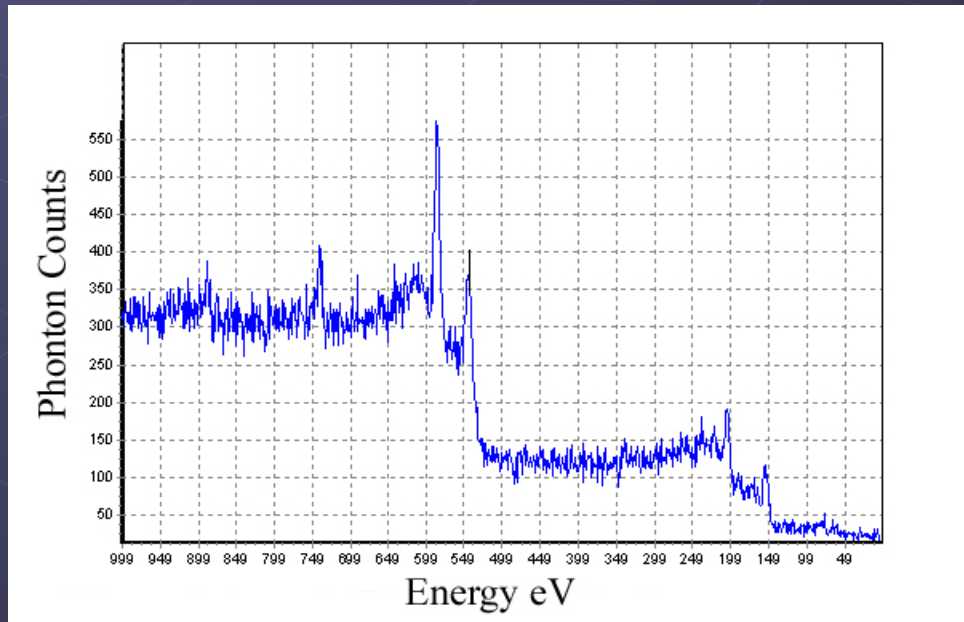


- Atomic oxygen in the plasma readily reacts with the surface contaminants, breaking them up into smaller and more volatile pieces which easily evaporate.

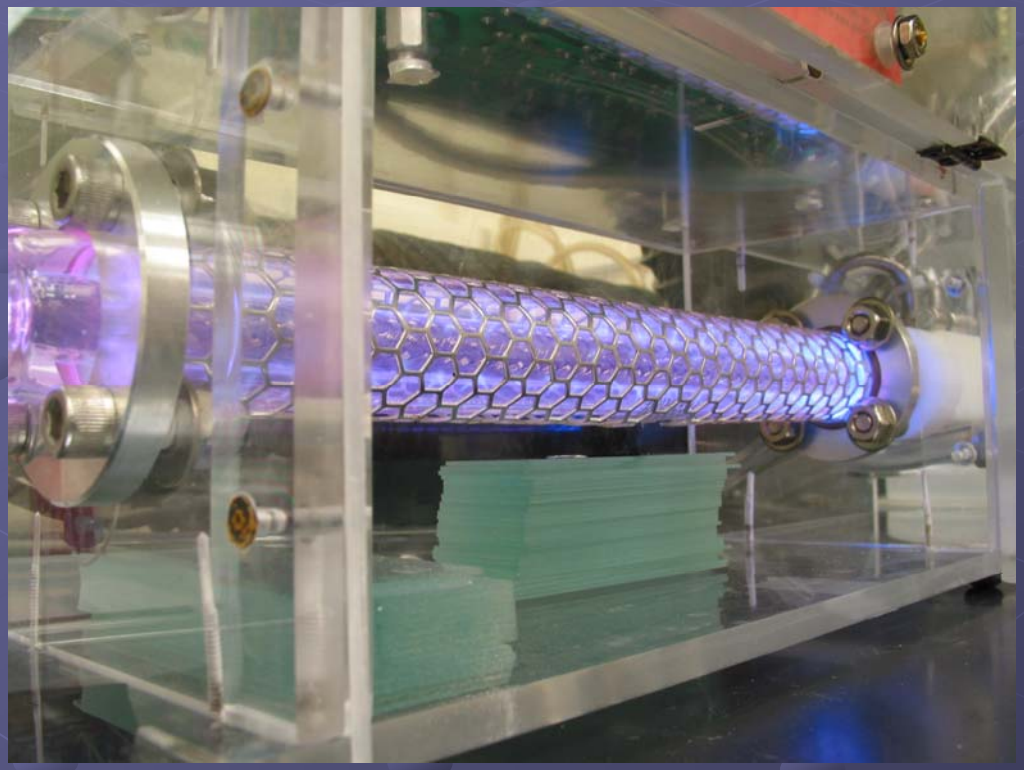
Oxygen Plasma Results

- Contaminants are removed rapidly.
- Concerns:
  - Top graph indicates increase in thickness over time… oxidation
  - Bottom graph confirms growing layer is NOT hydrocarbons. There is no XPS carbon peak.





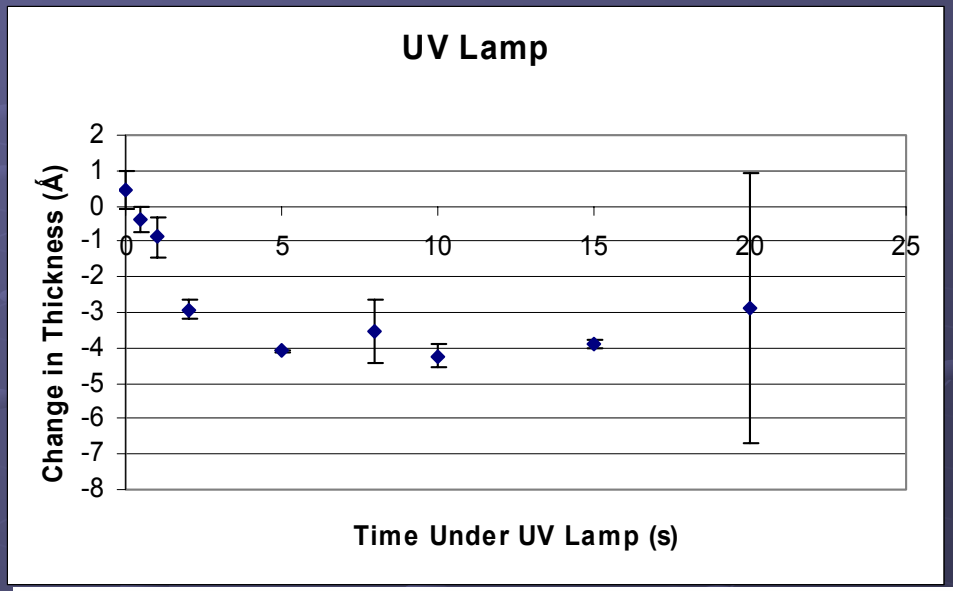
UV Lamp Theory

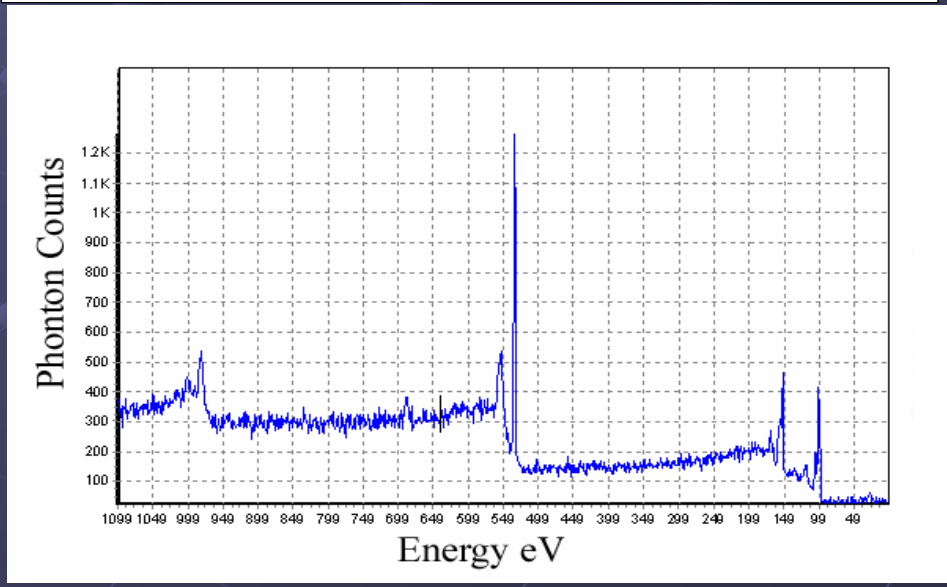


- High energy photons break up hydrocarbon bonds. Volatile fragments leave the surface.
- UV produces oxygen radicals which react with oxygen gas to form ozone. The reactive ozone oxidizes contaminants and they evaporate.

UV Results

- 4.5 Å DADMAC layer eliminated rapidly, followed by slow oxidation.
- XPS shows no carbon peak.
- Concern: silicon doesn't appear to oxidize, but mirror coatings such as U and Ni do.





Opticlean® + Plasma

- Very effective: Removes both large and small particles.
- Drawback: Procedure is long and specialized equipment required.

Acknowledgements

- Ross Robinson
- Luke Bissell
- Richard Sandberg
- Mike Newey
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Conclusions

1. For rigorous cleaning, Opticlean® + Plasma is most effective
2. UV Lamp shows potential for ease and quickness, but heavy oxidation can ruin surfaces
3. Further Study: Which surfaces will oxidize (from UV) and how much?