Effect of Concurrent UV Irradiation and Contamination on Silver Coated Teflon Radiator Surface

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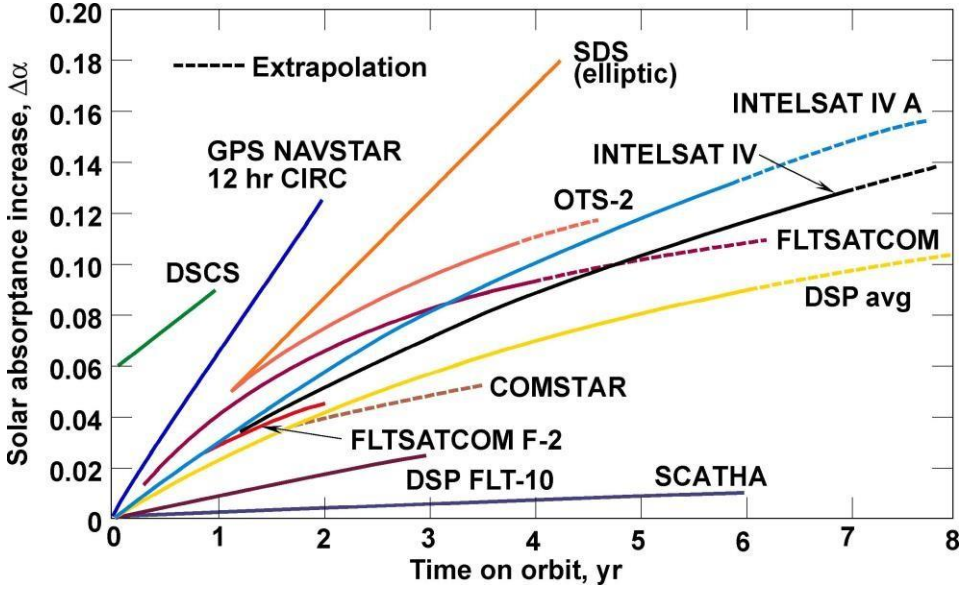
Introduction

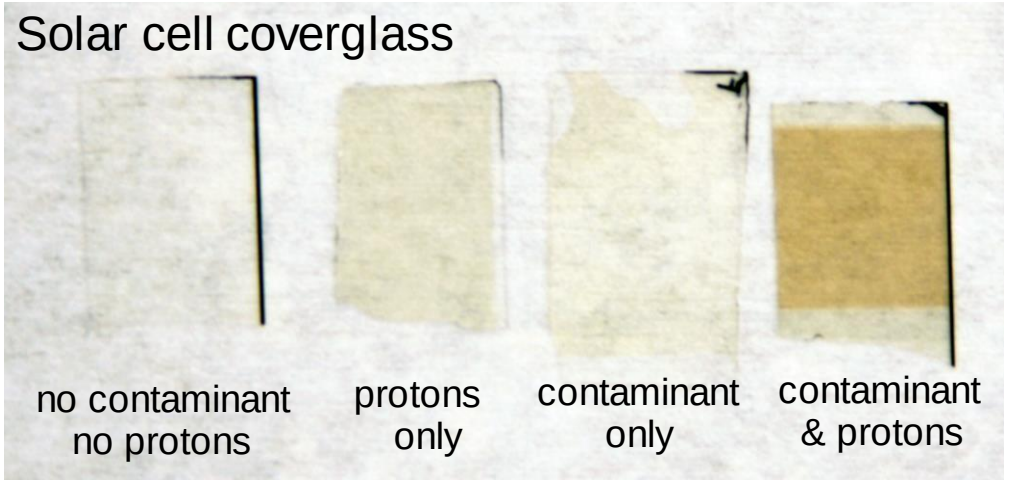
- Silver coated Teflon (SCT) has been used as a radiator material for spacecraft thermal control
- Roughening the smooth SCT surface is proposed to reduce the specular reflection
- Previous testing on solar cell coverglass samples show enhanced contaminant uptake on **rough** surface than on **smooth** surface
  - *Under identical simulated contamination/space radiation environment*
- It is speculated similar phenomenon may occur for smooth vs. rough (abraded) SCT surface
- The objective of this work is to collect lab testing data for assessing relative thermal performance degradation
  - *Solar absorptance (a) change*

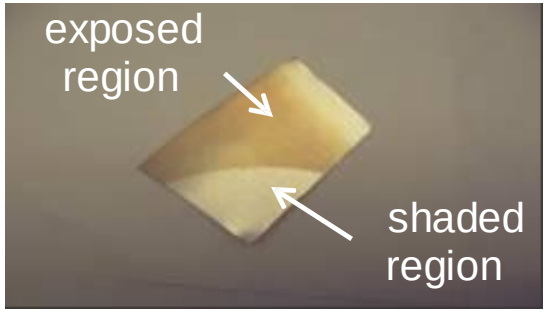
smooth SCT **abraded SCT**



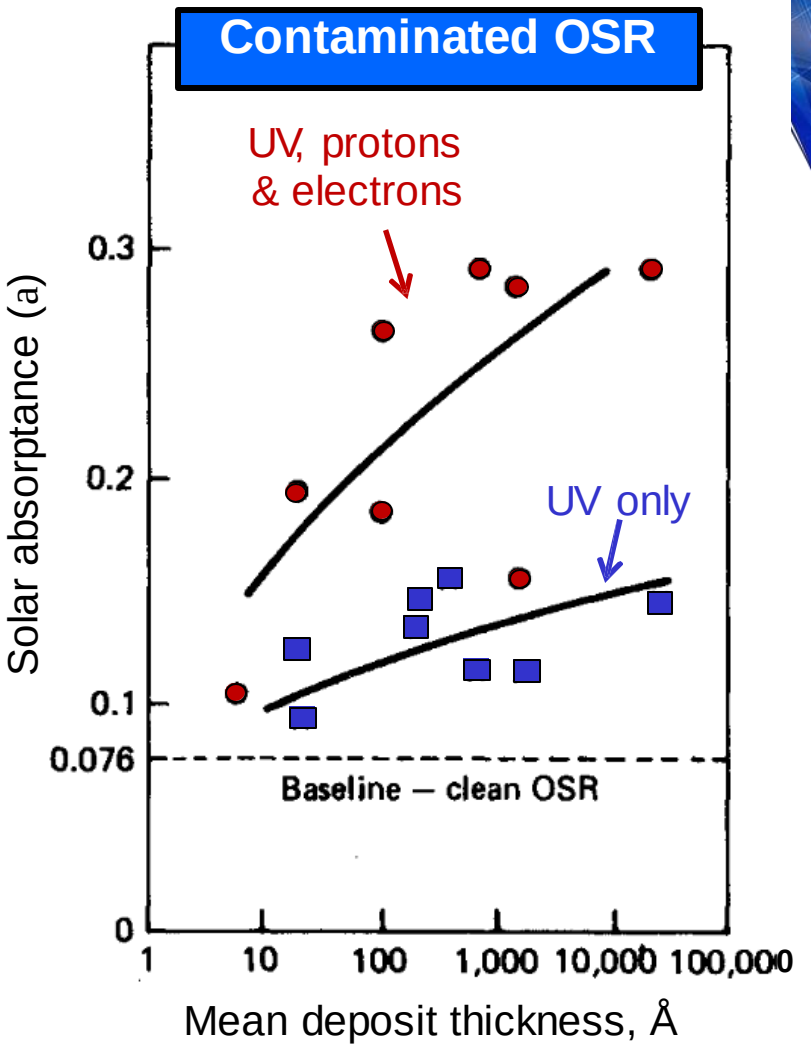
Surface roughness plays a role in contaminant deposition

Space Radiation Effects on Contamination





Aluminum thermal shield from NASA Genesis mission (courtesy of J. Allton, NASA Johnson Space Center)



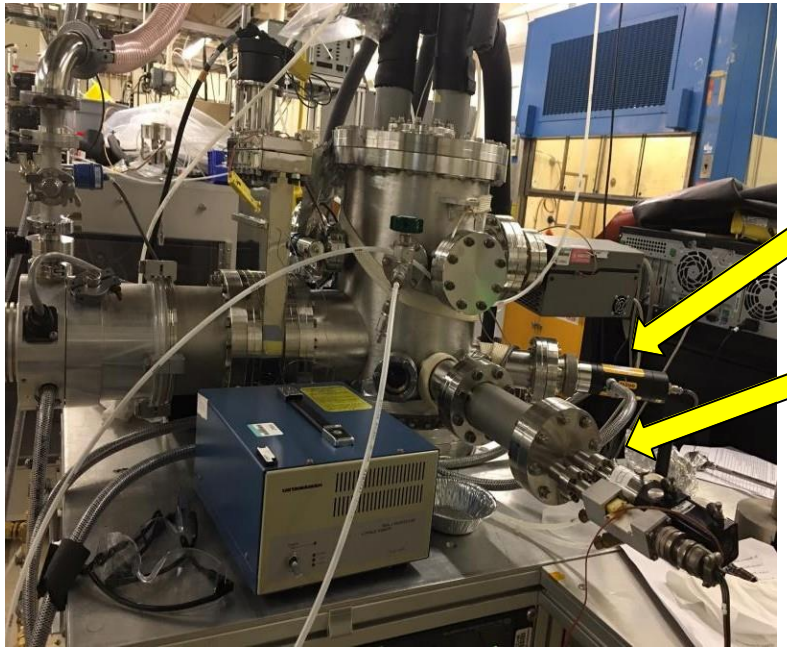
J.A. Neff, C.R. Mullen, L.B. Fogdall, J. Spacecraft & Rockets, **23**: 386-390,1986.

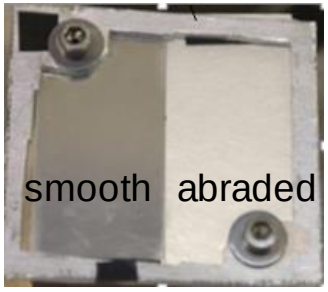
Space radiation exacerbates the degradation effects of contaminant films;

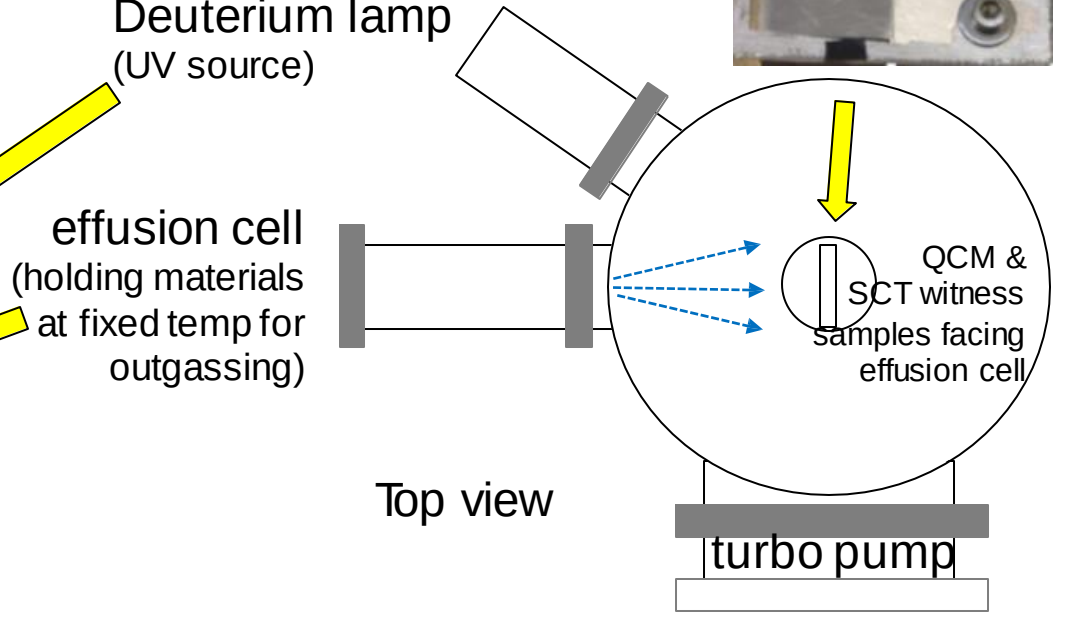
More degradation on rough surface (with AR coating) than smooth surface

Test Objective and Methodology

- Concurrent UV irradiation and contaminant deposition onto smooth and abraded SCT test coupons
- Characterize solar absorptance (a) before and after each iteration of deposition



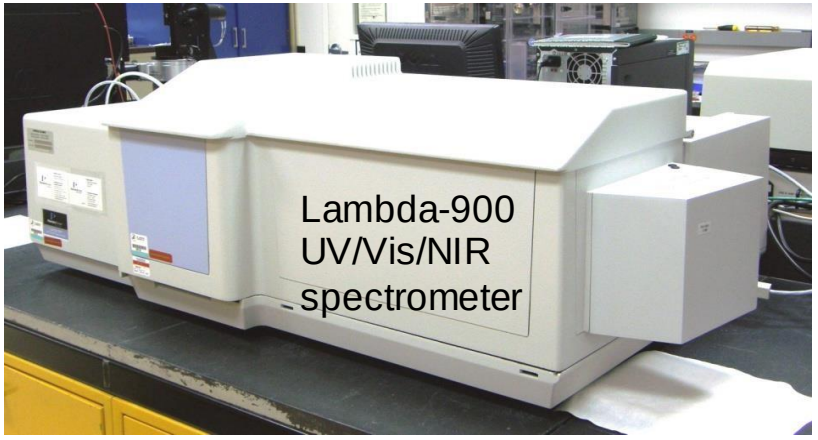




Characterize pre- and post-alpha values for thermal degradation assessment

Parameters in Testing

- Smooth vs. abraded SCT samples
- Contaminants simultaneously outgassed from 5 representative SV materials
  - *3M 966 tape adhesive, CV7-1142, amber Kapton, white Kapton, and white paint.*
- UV source by Deuterium lamp (Hamamatsu)
- Quartz crystal microbalance (QCM Research) for real-time in-situ monitoring
- Sample characterization
  - *Solar absorptance change (*Da*)*
    - Reflectance measurements by Lambda-900 UV/Vis/NIR spectrometer (Perkin Elmer)
    - Contaminant film thickness by atomic force microscope (AFM, Park NX20)



Characterizing Da and contaminant film thickness

Test Procedures

SCT pre-characterization
(a, SCT surface roughness)

Contaminant Deposition

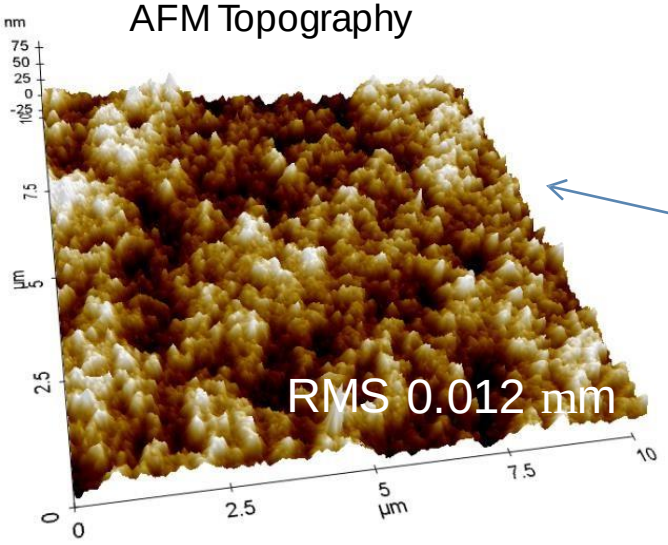
- Smooth/abraded SCT samples
- UV
- SV material outgassing
- QCM for monitoring contaminant accumulation

SCT post-characterization
(a, roughness, contaminant thickness)

Multiple iterations of concurrent contaminant deposition and UV irradiation

Surface Roughness

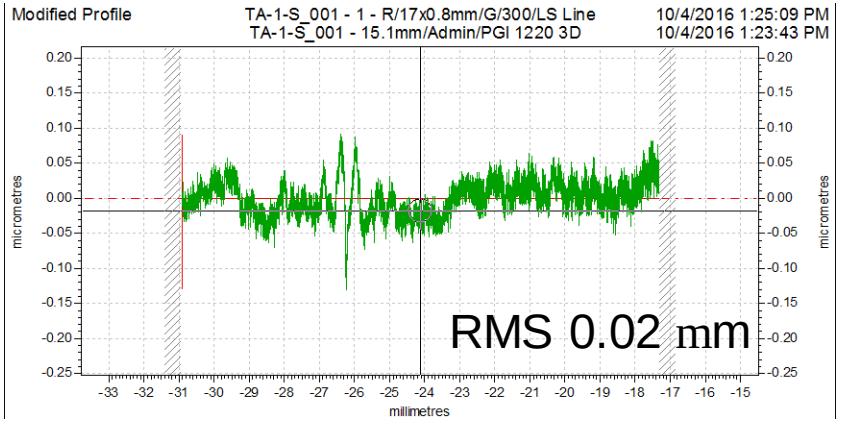
AFM Topography

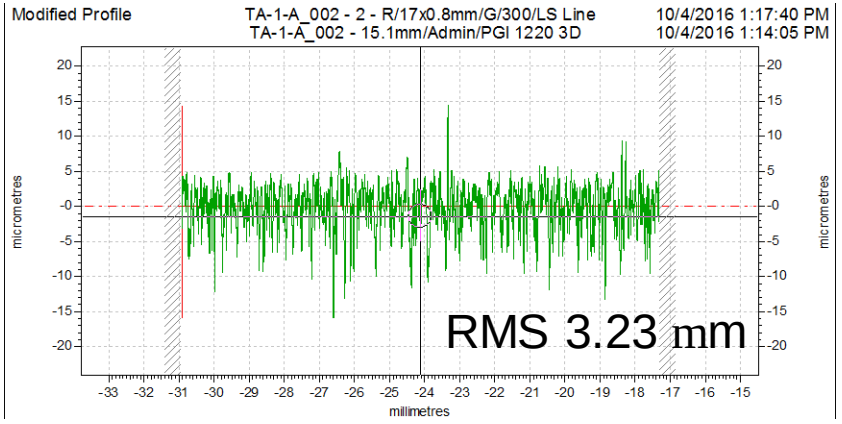


smooth SCT **abraded SCT**

Too rough for AFM

Surface Profilometry

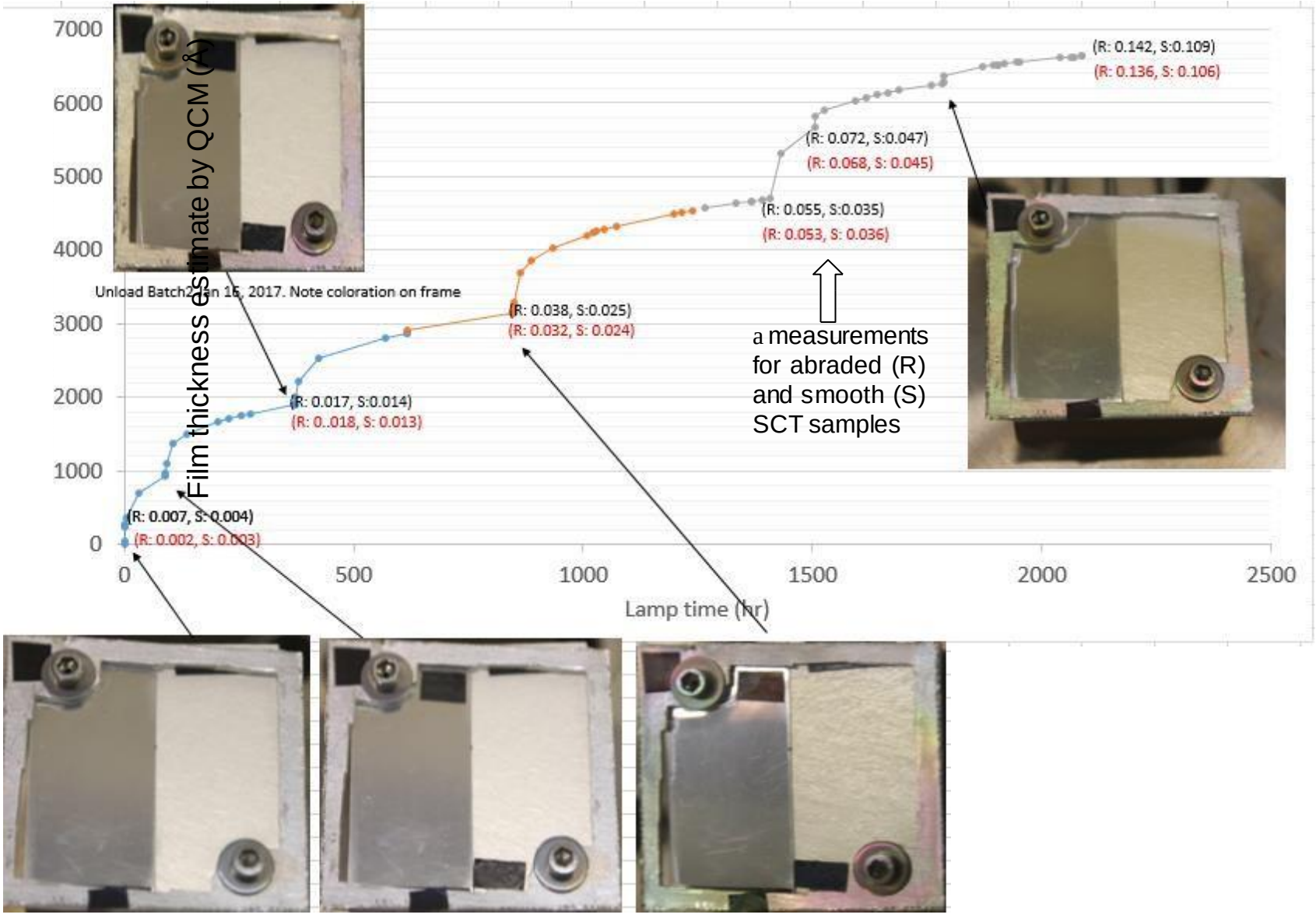




Abraded SCT roughness is 100X more than smooth SCT

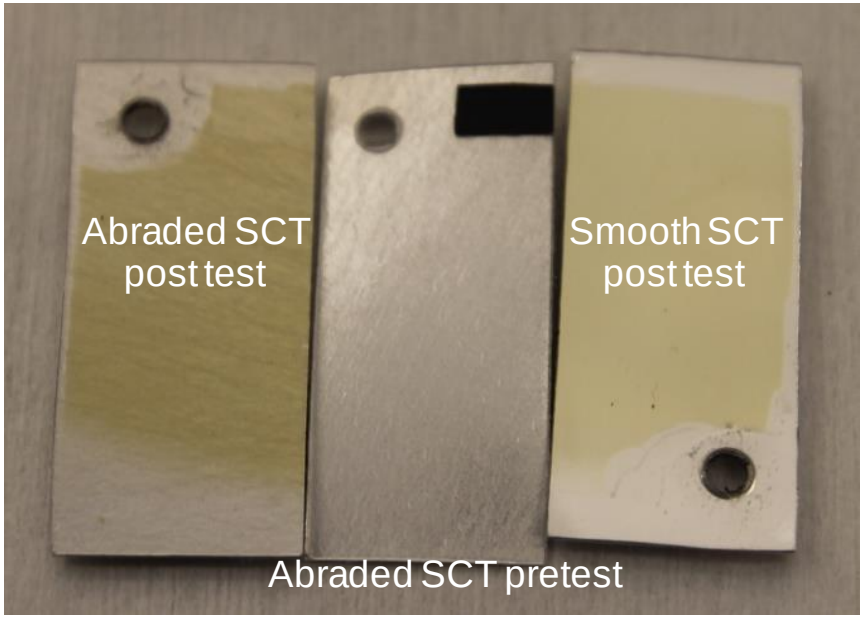
Contaminant Film Accumulation

Real-time accumulation monitoring provided by in-situ QCM data

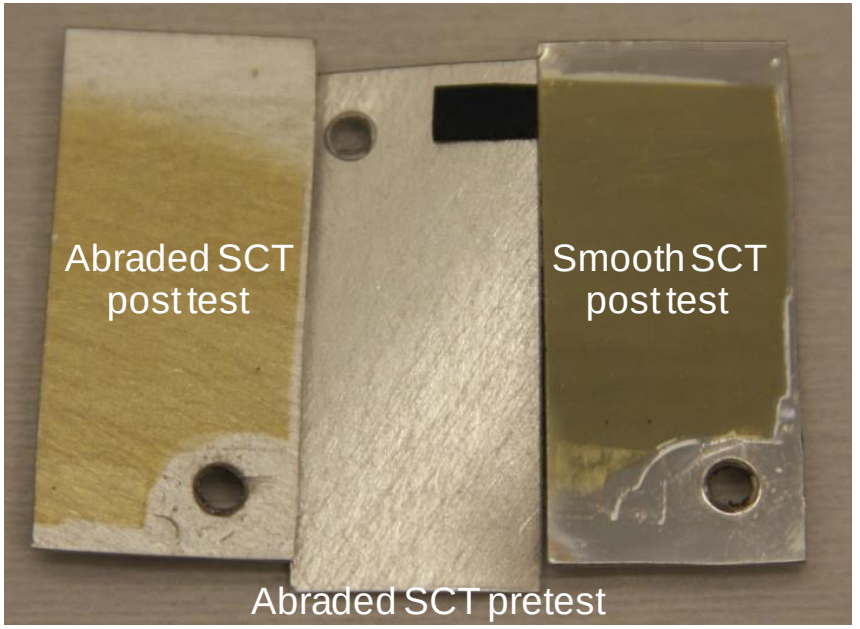


Incrementally visible contaminant film darkening on SCT surface

Darkening of SCT Samples



(after 10,547 eq. solar hours)



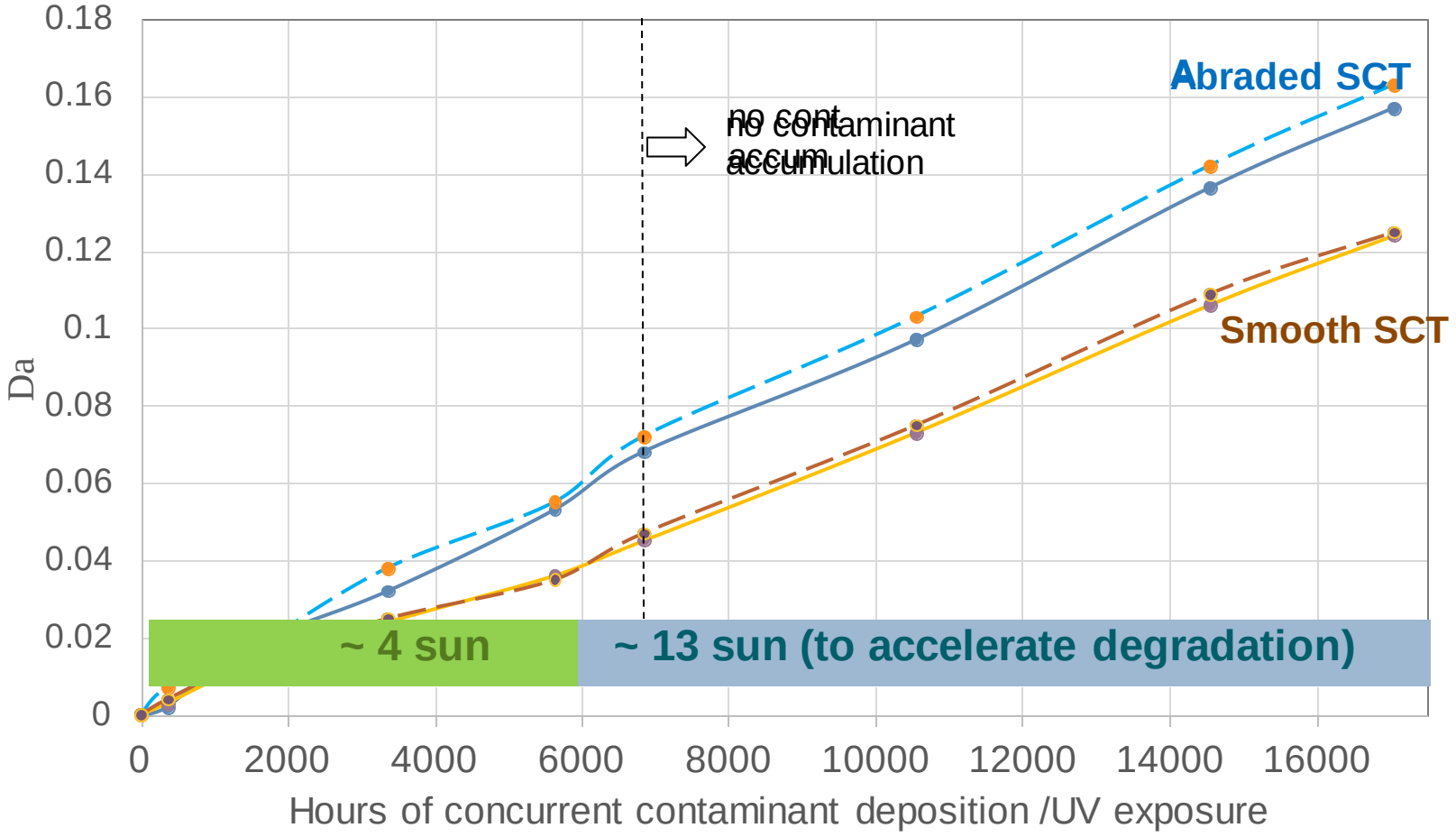
(after 14,547 eq. solar hours)

- GC-MS results indicates contaminants were primarily silicones and acrylics

Visible of contaminant film darkening

Comparison of Solar Absorptance Degradation (Da)

Abraded SCT shows more degradation than smooth SCT

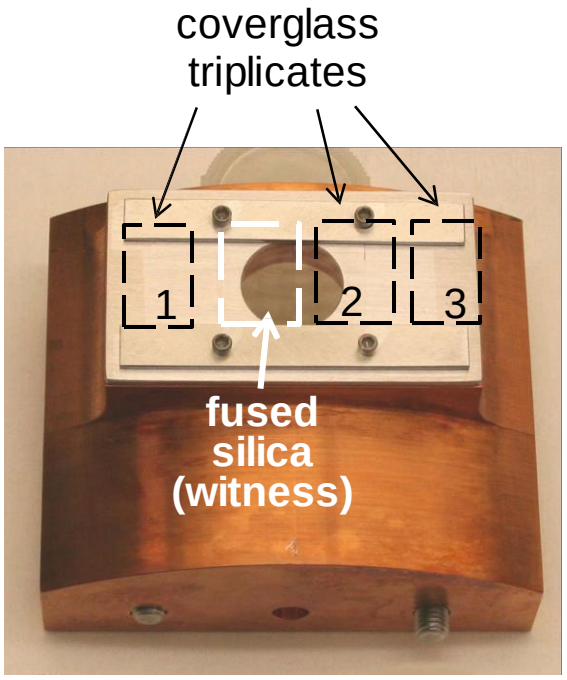


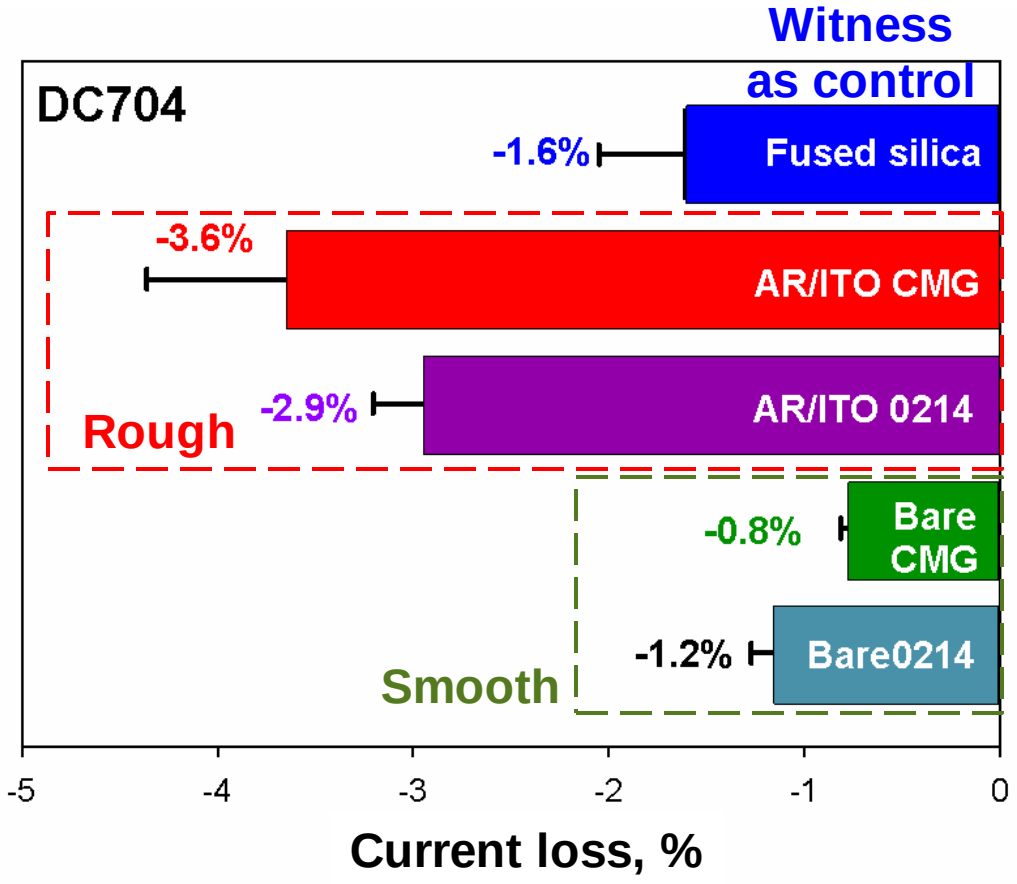
* The alpha measurements are based on two methods calibrated via VDA (vapor deposition aluminum) in solid lines and IS (integrating sphere) in dash lines

Distinct difference in Da between smooth vs. abraded SCT

We have seen this before in prior coverglass work

- **All samples exposed to nearly identical photo-deposition conditions**



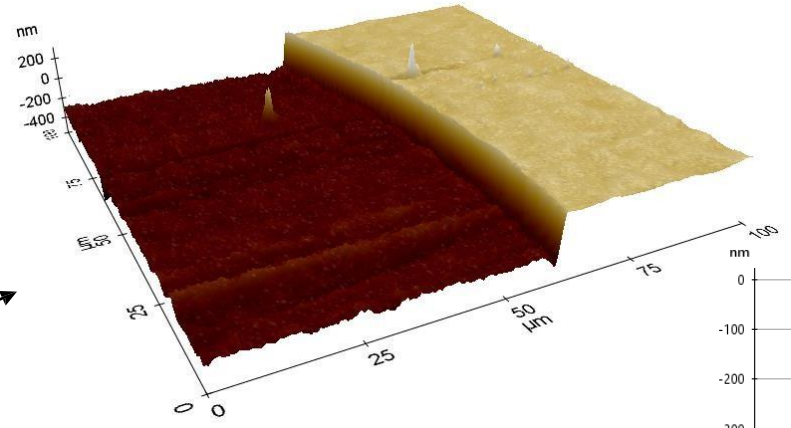


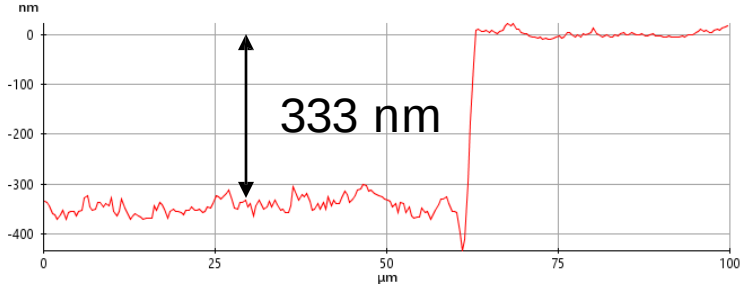
Enhanced contamination (thus degradation) due to surface roughness

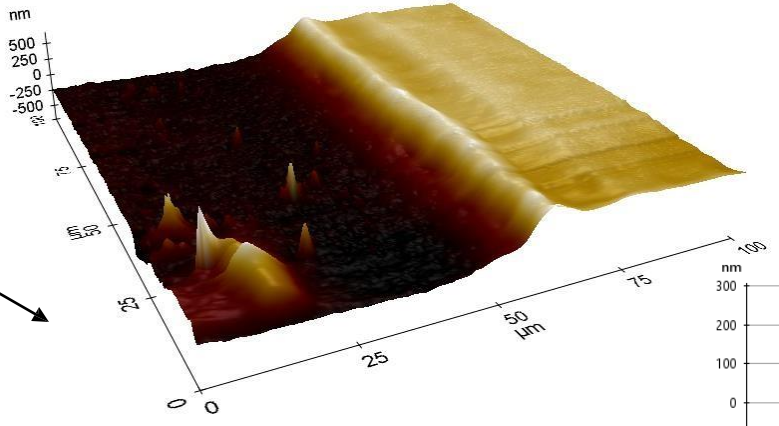
Contaminant Film Thickness Estimate by AFM

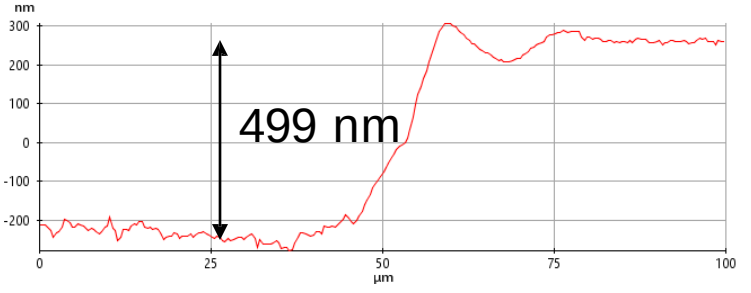
Tape 1

Tape 2



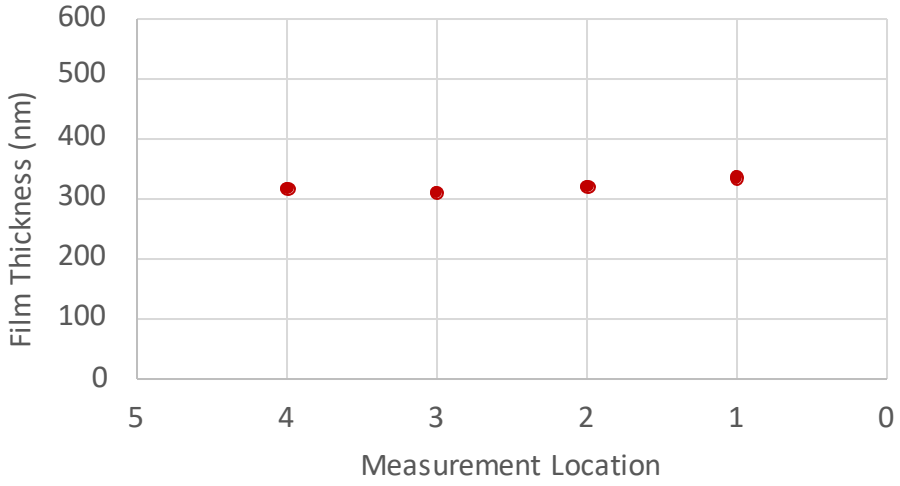


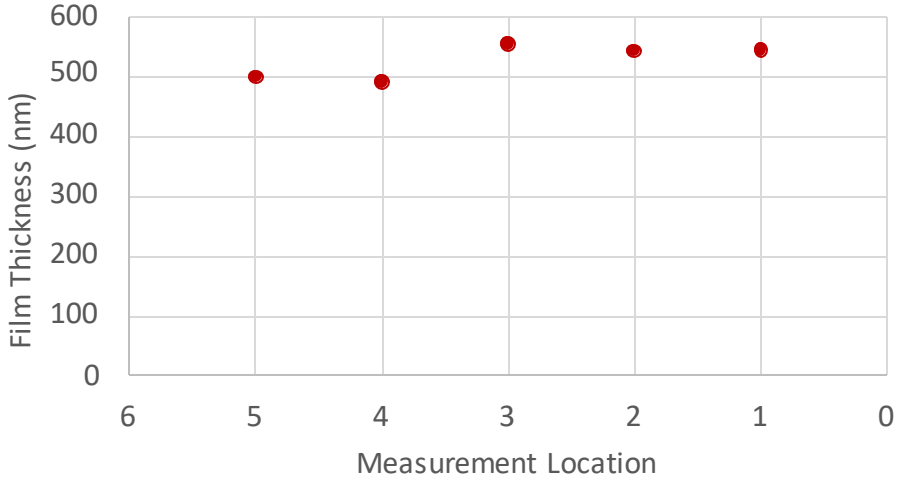




Film thickness estimated by comparing exposed vs. unexposed area (masking tape)

Film Thickness Profiles Across the Taped Lines (by AFM)

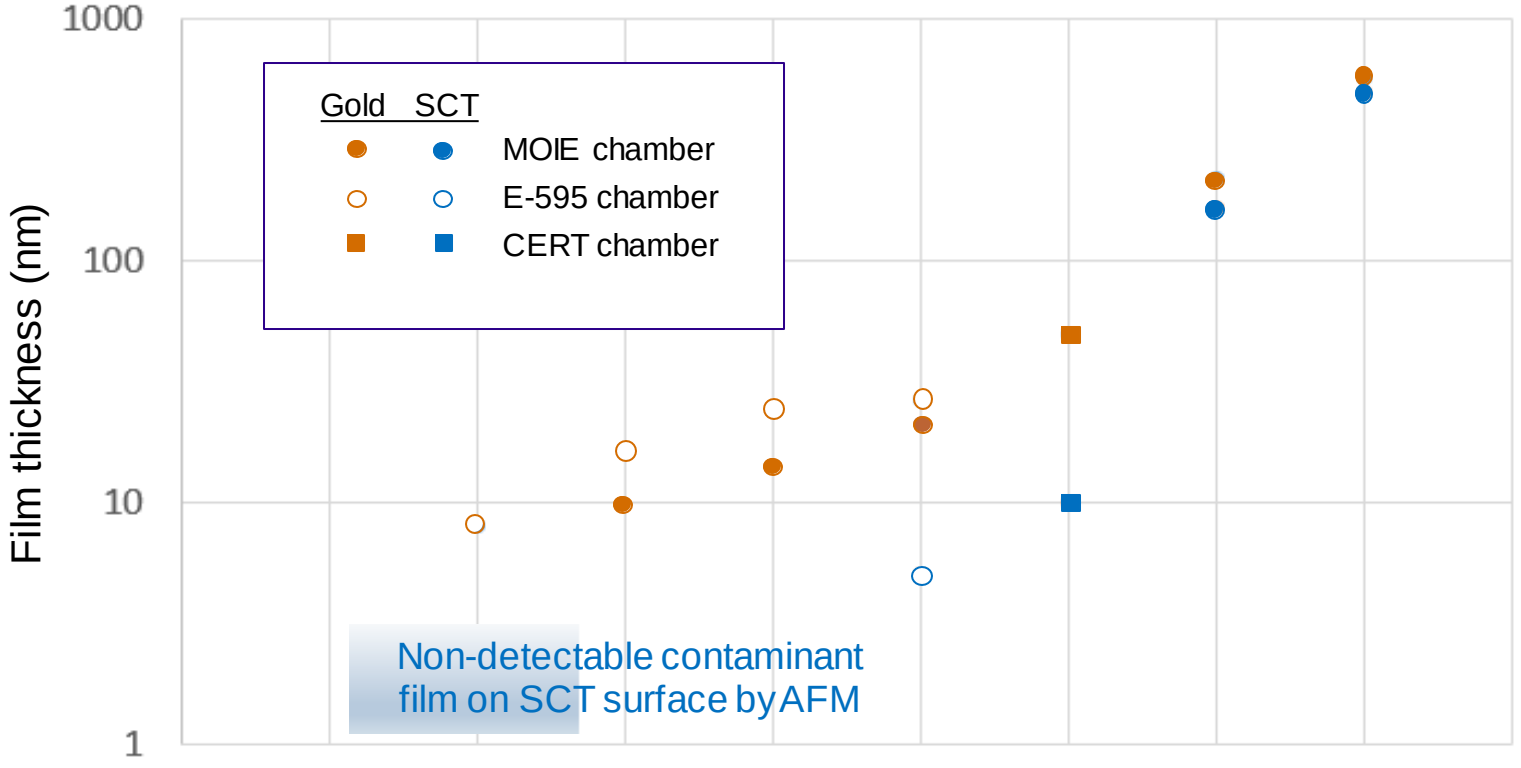




Comparing Contaminant Film Accumulation

Simultaneous Deposition on Gold and SCT (Teflon)

- Significant slower contaminant accumulation rate on SCT vs. gold surface in early deposition phase
- Film thickness appears to converge between gold and SCT after certain film thickness



Observed different contaminants deposition rate on SCT and gold surfaces

Conclusions

What we have learned

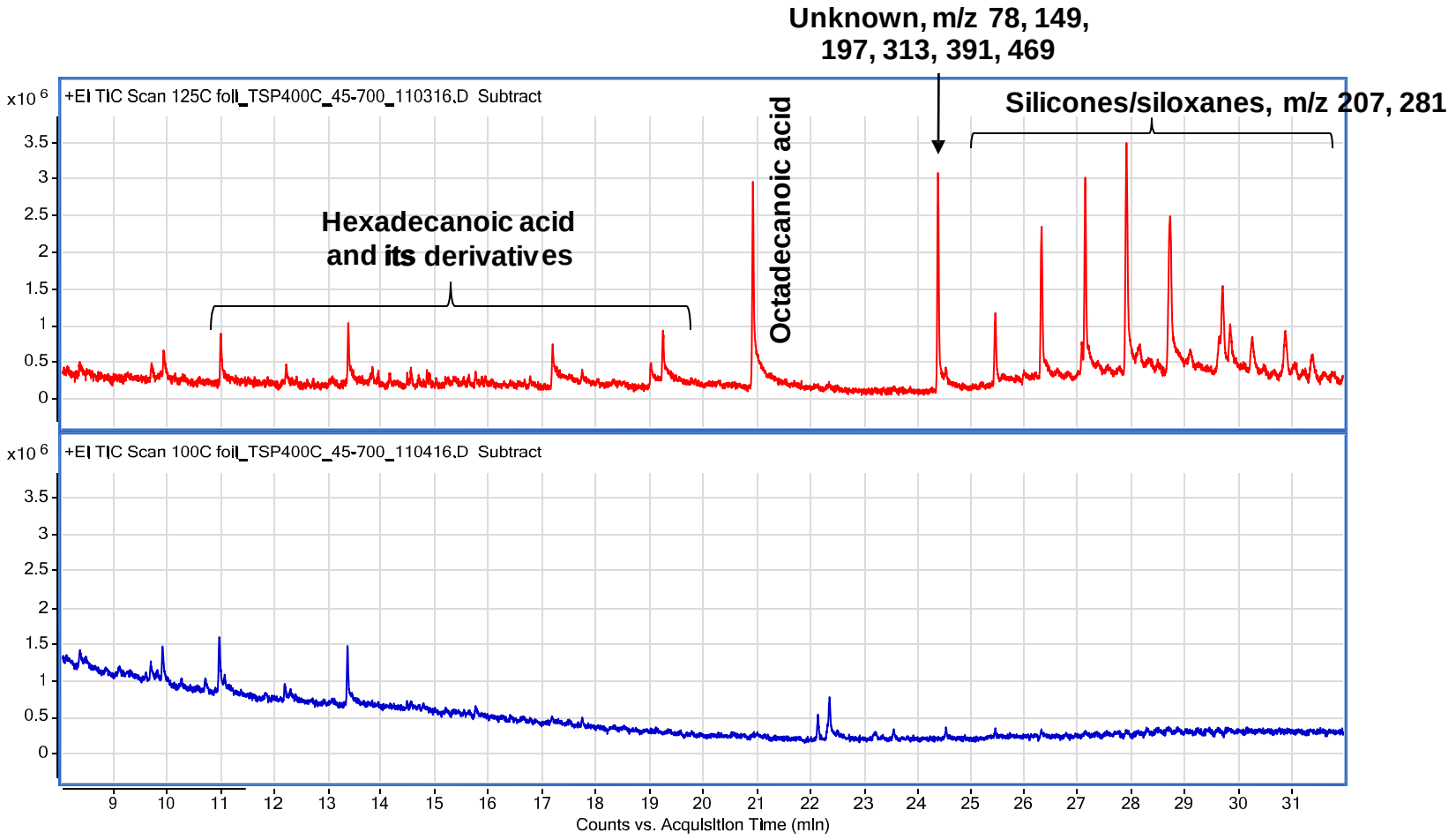
- The extent of contaminant accumulation on surface can be affected by
  - *Surface roughness*
    - Thermal property degradation (Da) used for indicating contamination level
    - Abraded silver coated Teflon (SCT) showed faster degradation than the smooth counterpart
    - Increased surface area available to collect contaminants
  - *Type of substrate (Teflon vs. gold)*
    - Contaminants preferentially stick to gold than to Teflon
    - The difference in substrate becomes less pronounced after the surface is covered mostly by contaminants

More research is needed to advance understanding of contaminant/surface interaction

Backup

GC-MS of Outgassed Contaminants

100°C and 125°C source temp



Different chemical species when SV materials outgassed at 100 and 125 C for 24 hours