MSFC Investigations on MISSE-8

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MSFC Investigations on MISSE-8

- Description
- Estimated environment
- Contamination
- ISS Vehicle Materials
- Discussion of MAPTIS database

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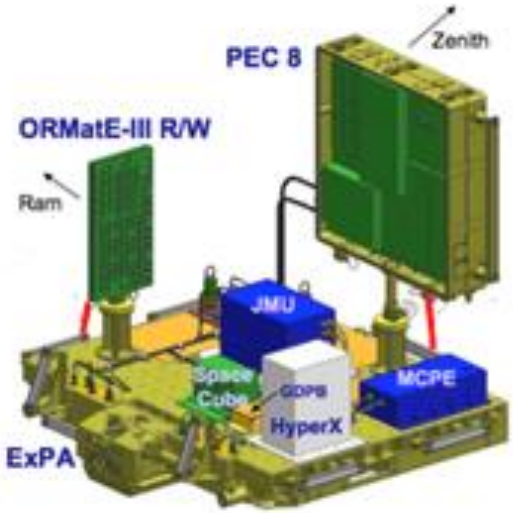
Materials International Space Station Experiment-8

- Deployed May 20, 2011 on STS-134
- Located on Express Logistics Carrier-2 (ELC-2)
- Retrieved July 9, 2013
- Returned to Earth May 2014 on SpaceX Dragon CRS-3

MSFC flew two passive sample trays on nadir side. Total of 96 samples.



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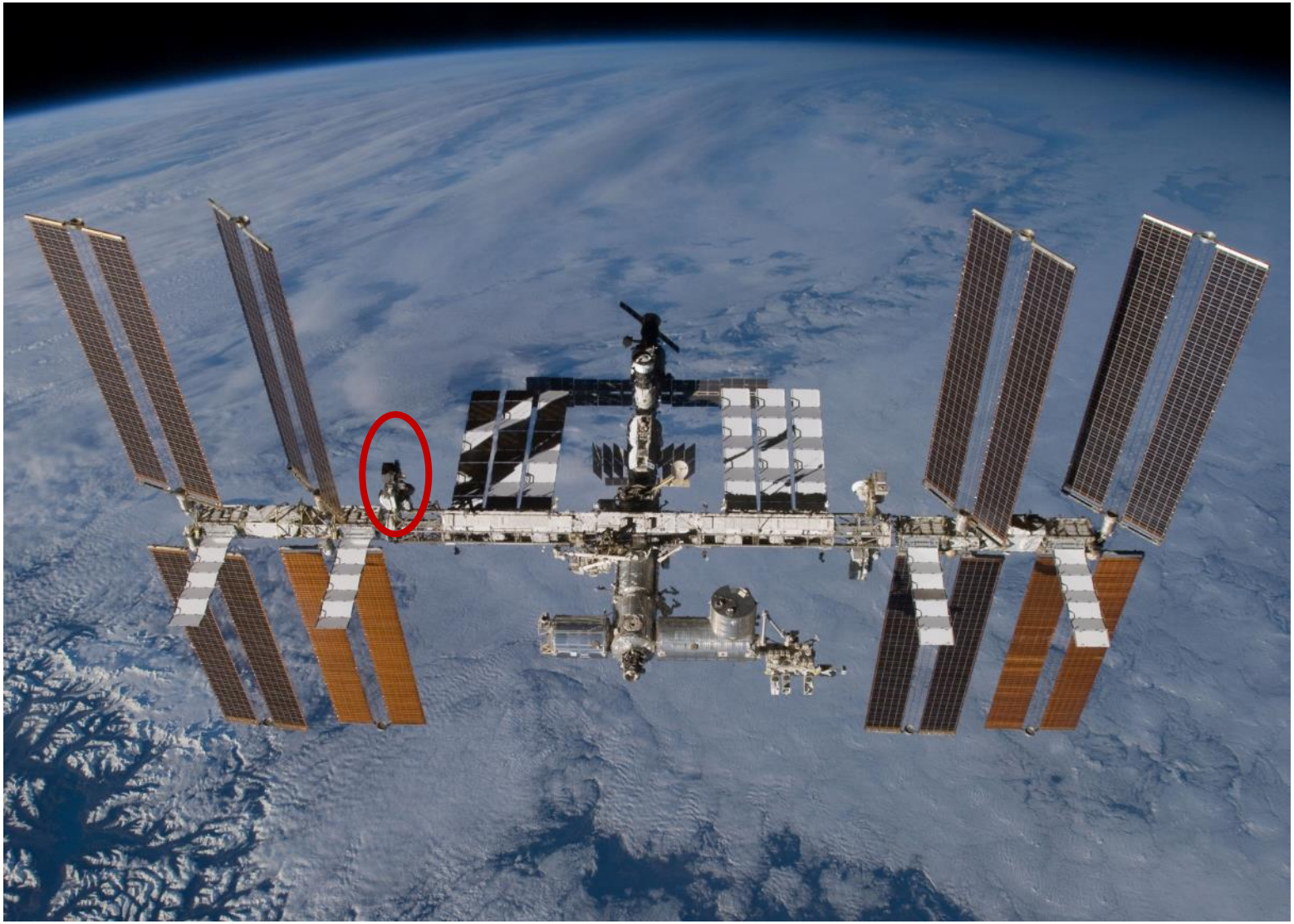

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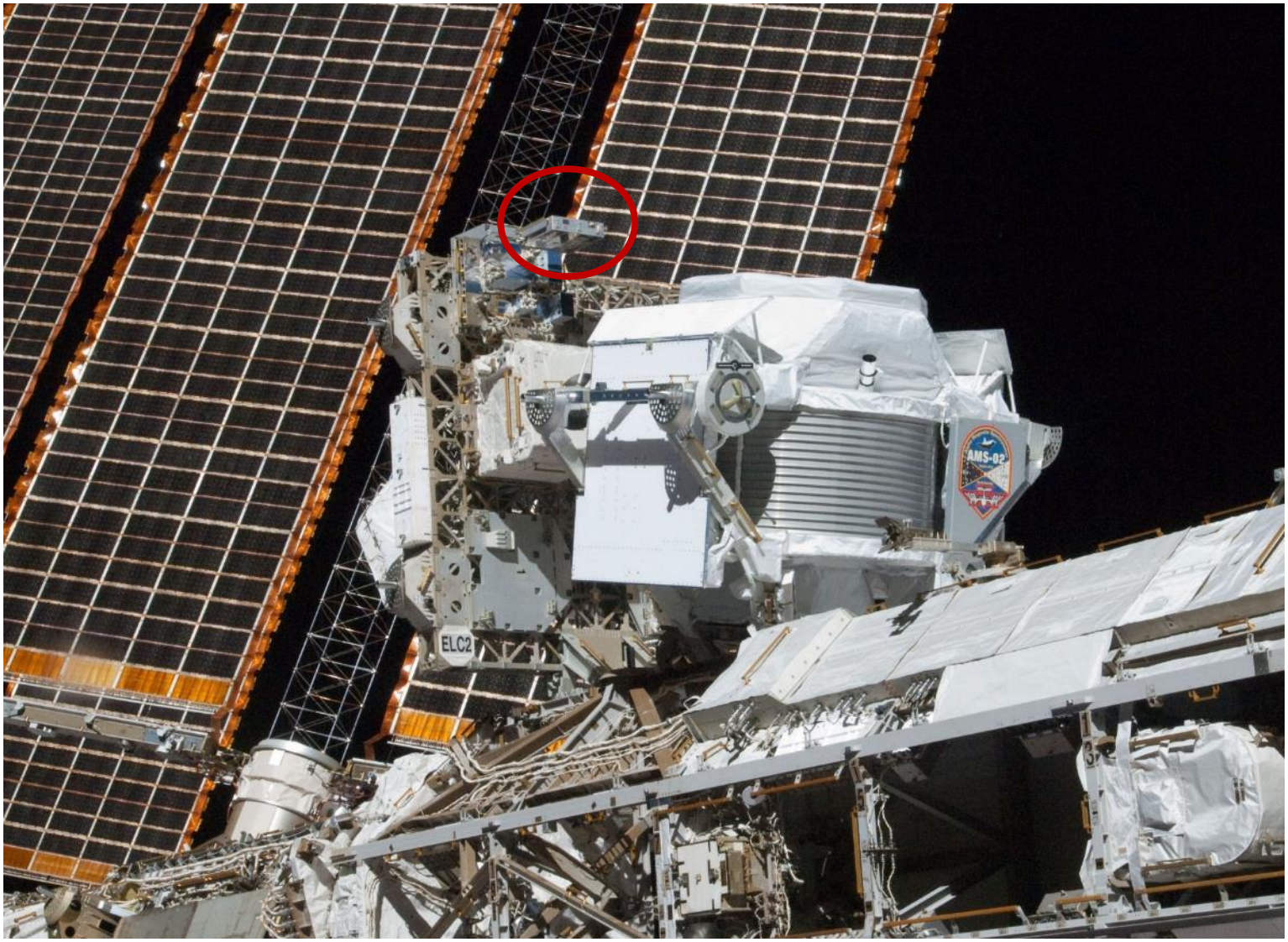

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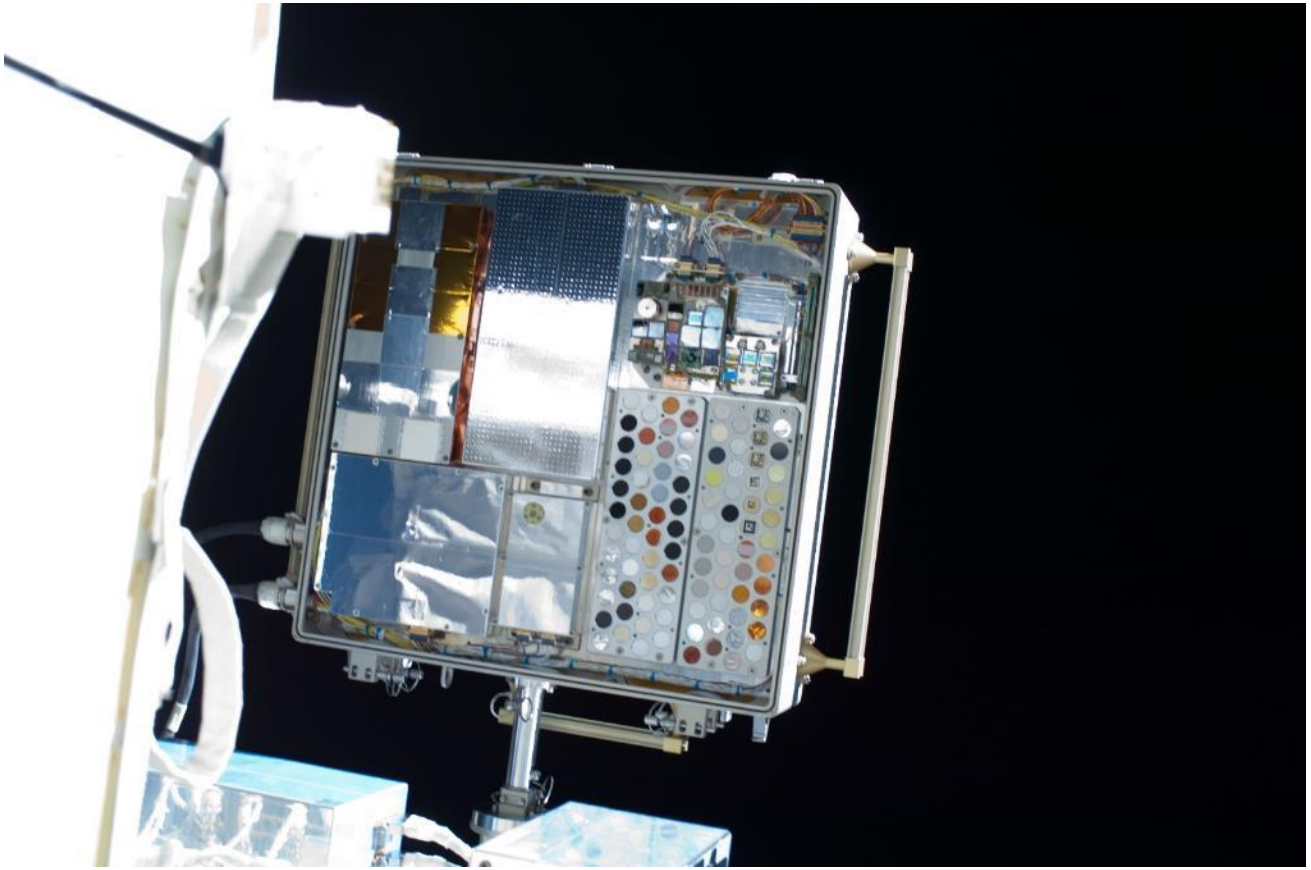

MISSE-8 nadir side with MSFC passive trays in lower right.

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Pre-flight

Post-flight

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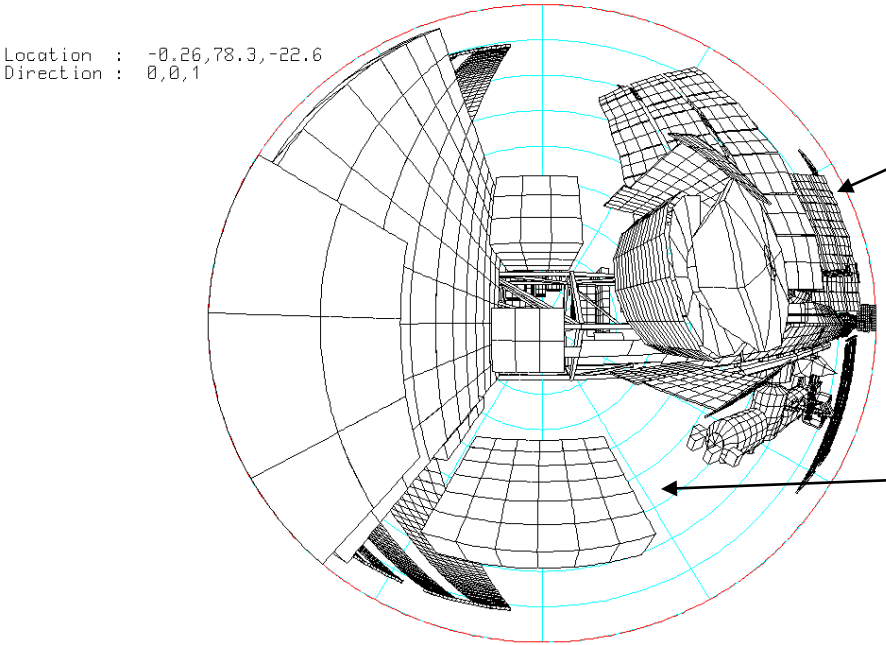
Atomic Oxygen Fluence 3.6 ± 0.1 x 10^{19} atoms/cm^2

Determined by mass loss and thickness loss of Kapton HN

Very low fluence due to nadir location and ISS shielding

MISSE-8 Nadir Samples Hemispherical View



AMS-2

MISSE Ram/Wake element
MISSE-7 shown
OrMATe on orbit

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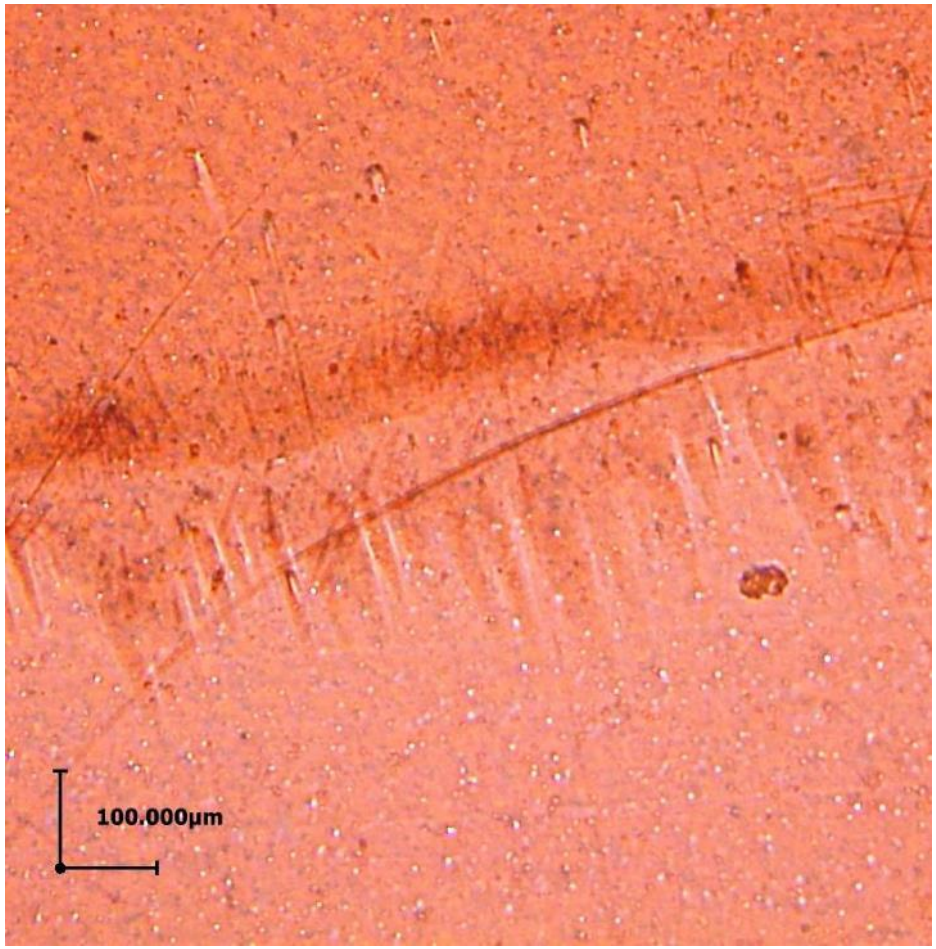
Grazing Atomic Oxygen Erosion



Exposed Area

Protected by holder

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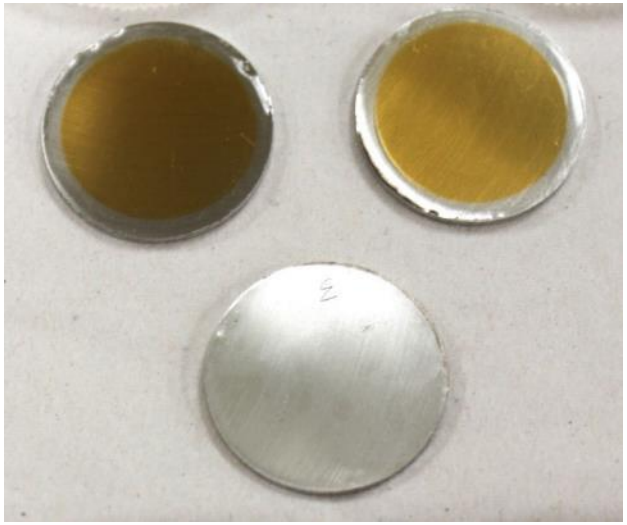
Ultraviolet Radiation Exposure – exact dose unknown at this time

UV darkening observed on beta cloth, ionic liquid epoxy samples, part markings, and others

This suggests a minimum of 500 equivalent sun hours (ESH).

Ionic liquid epoxy – Flight

Control



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Ultraviolet Radiation Exposure

Atomic oxygen erosion rate of Teflon related to UV ESH

From "Analysis of Metallized Teflon™ Thin Film Materials Performance on Satellites" by Gary Pippin, Eugene Normand, Suzanne Woll, and Rachel Kamenetzky, Journal of Spacecraft and Rockets vol. 41, no. 3, pp 322-325, May 2004

Erosion yield (10^{-24} cm^3/atom) = 0.0532 * ln (ESH) – 0.165

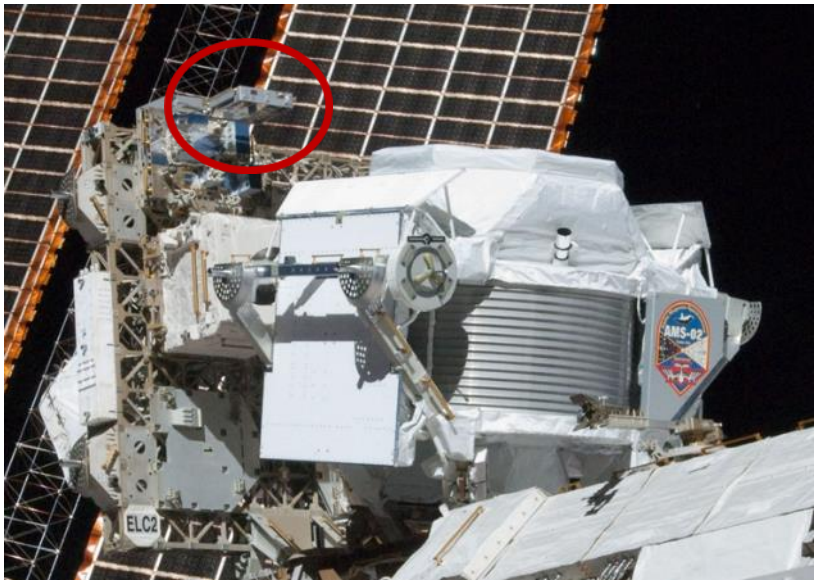
MISSE-8 erosion yield was calculated by using the mass loss of silverized Teflon samples and the AO fluence of 3.6 x 10^{19} atoms/cm^2

This gives 800 ± 300 ESH.

The majority of the solar UV exposure on the MISSE-8 nadir was likely Earth-reflected, with less short wavelength UV. If we assume similar parameters as MISSE-5 nadir, this gives 320 direct solar ESH and a total of 1050 ESH (direct plus Earth-reflected).

Contamination

- Concern prior to the STS-134 flight that the Alpha Magnetic Spectrometer AMS-2 would significantly outgas onto MISSE-8 and other line-of-sight hardware.
  - White silicone paint, unbaked composites, polypropylene fleece
- Predicted deposition on MISSE-8 nadir and wake-facing experimental sample trays was 40-100 Angstroms per year in addition to normal ISS background of 130 Å/yr.



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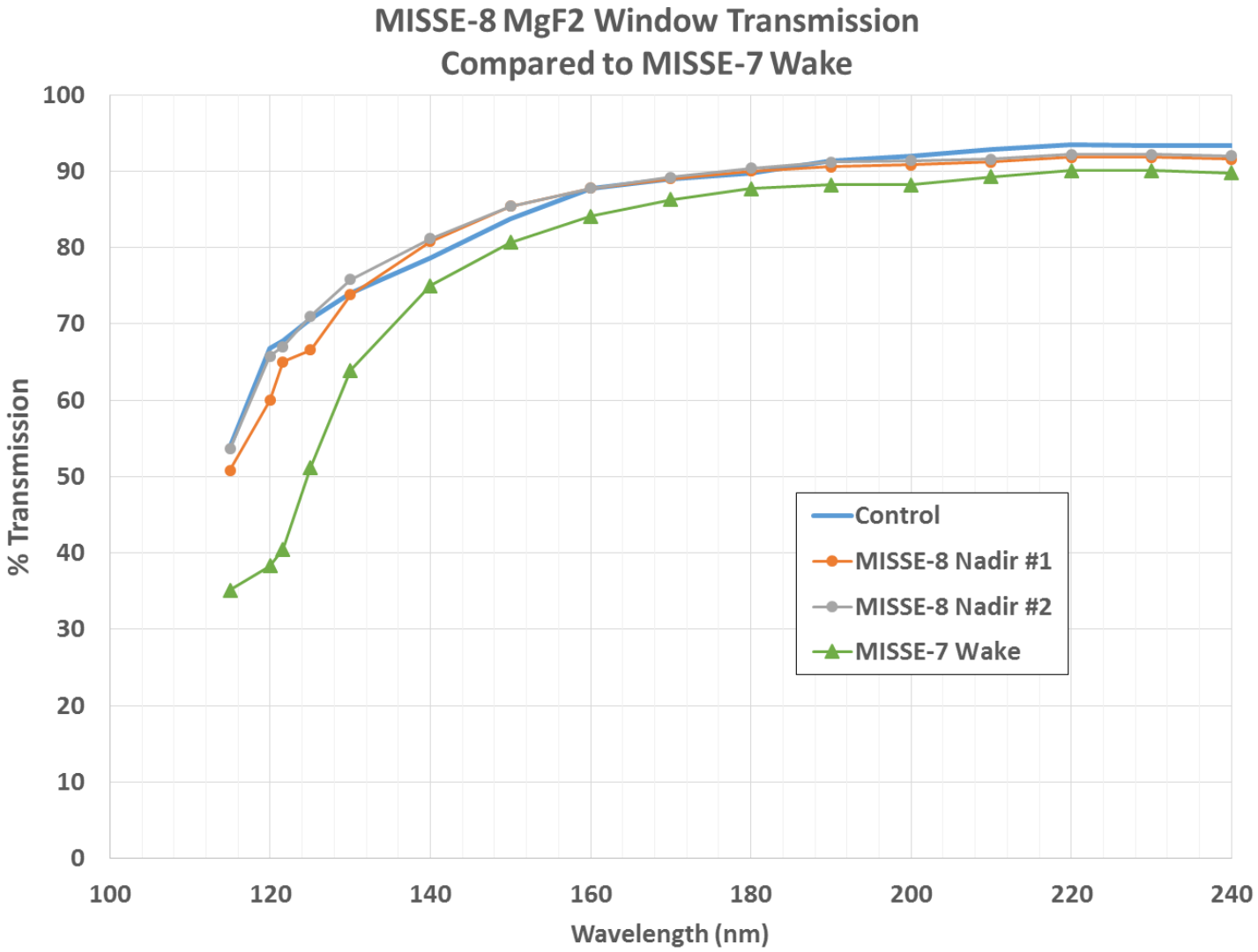

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Contamination

- Very little observed on MgF2 and fused silica windows, certainly less than 250 Å
- Glenn Research Center's analysis of Second Single Events Upset Xilinx-Sandia Experiment (SEUXSE) hardware in agreement
- "Comparison of Spacecraft Contamination Models with Well-Defined Flight Experiment" by Gary Pippin, NASA/CR-1998-208800
  - ESCA analysis of Long Duration Exposure Facility trays E10 (ram), A4 (wake), and C6 (in between, some AO exposure)
  - Contaminant fixing on aluminum strongly dependent on AO fluence

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Contamination

- On the other hand, MISSE-8 AZ93 slightly increased in solar absorptance from 0.17 to 0.18.
  - Coating was thinner than specification; ordinarily AZ93 solar absorptance is 0.15
- Surface morphology may affect contaminant fixing, as the smooth optical windows and silver/Teflon film did not have any contamination.
- Optical properties not a significant factor since AZ93 α/ε = 0.198 compared to silver/Teflon α/ε = 0.103, so silver/Teflon would have been a cooler surface.

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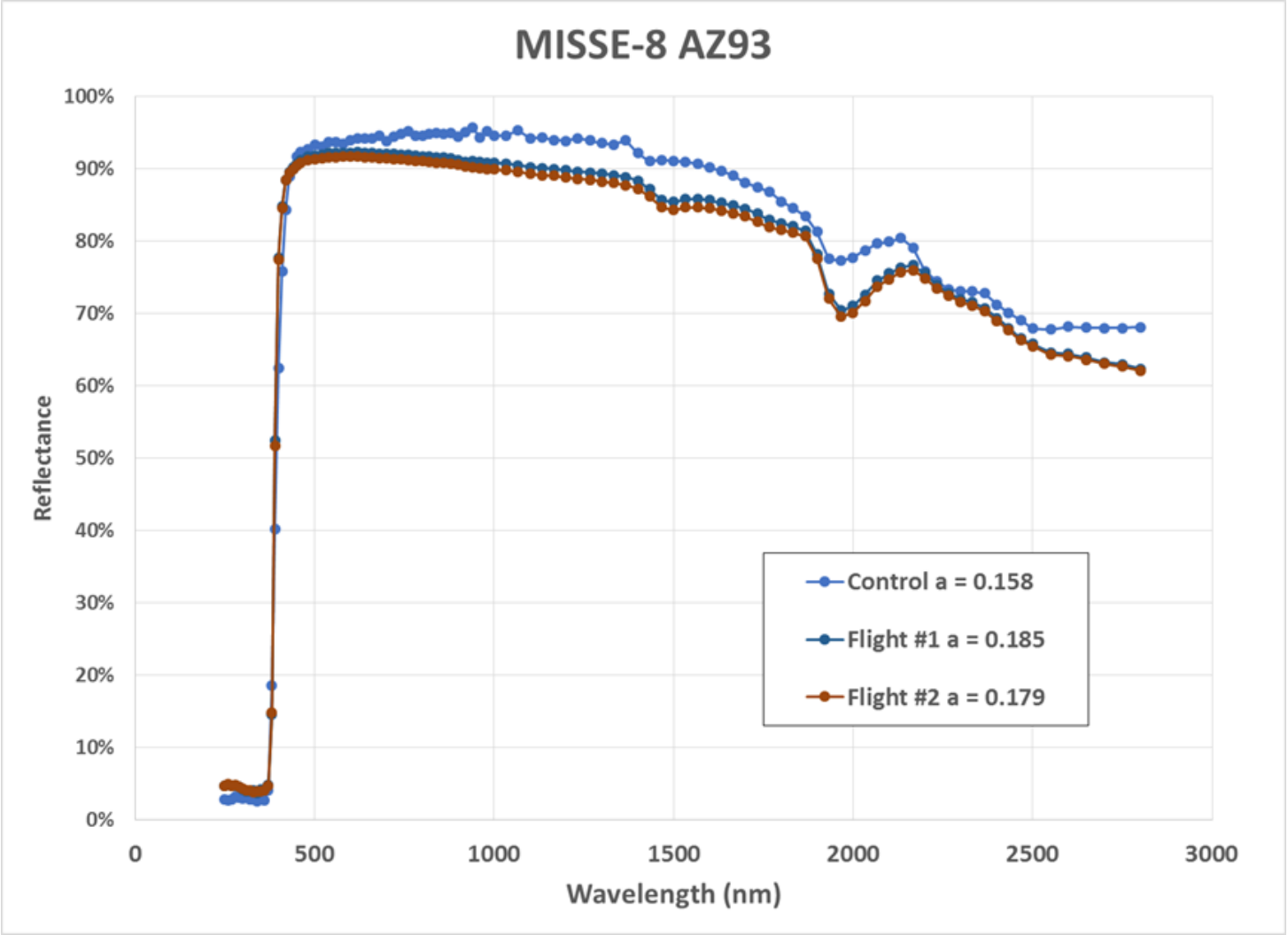

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ISS Vehicle Materials

- Beta cloth, from ISS batch and from Sheldahl
- Davlyn fiberglass sleeve
- Permacel and Intertape
- Solar array scrimcloth
- Thermal control and static dissipative coatings
- Indium tin oxide / Kapton

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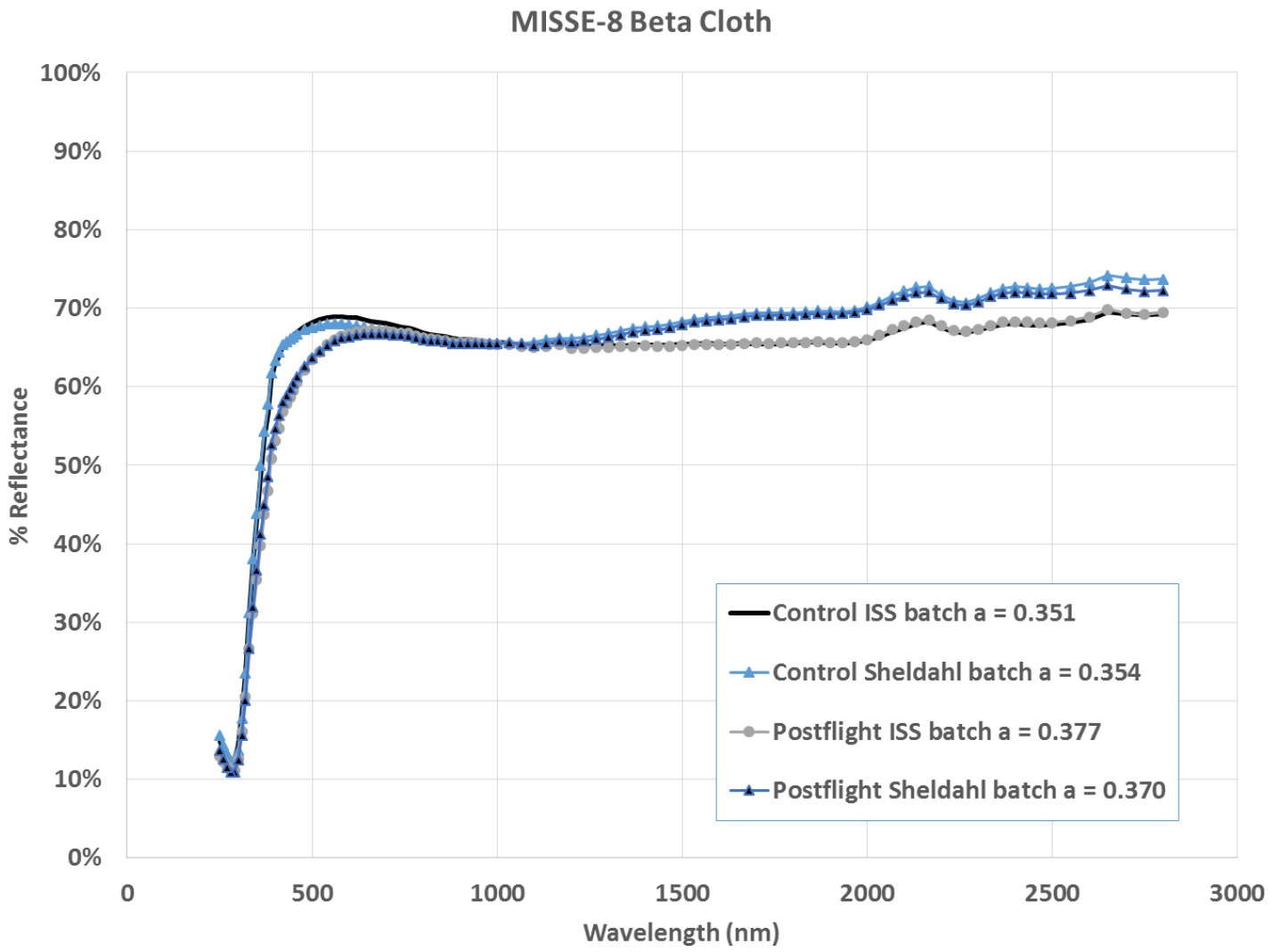

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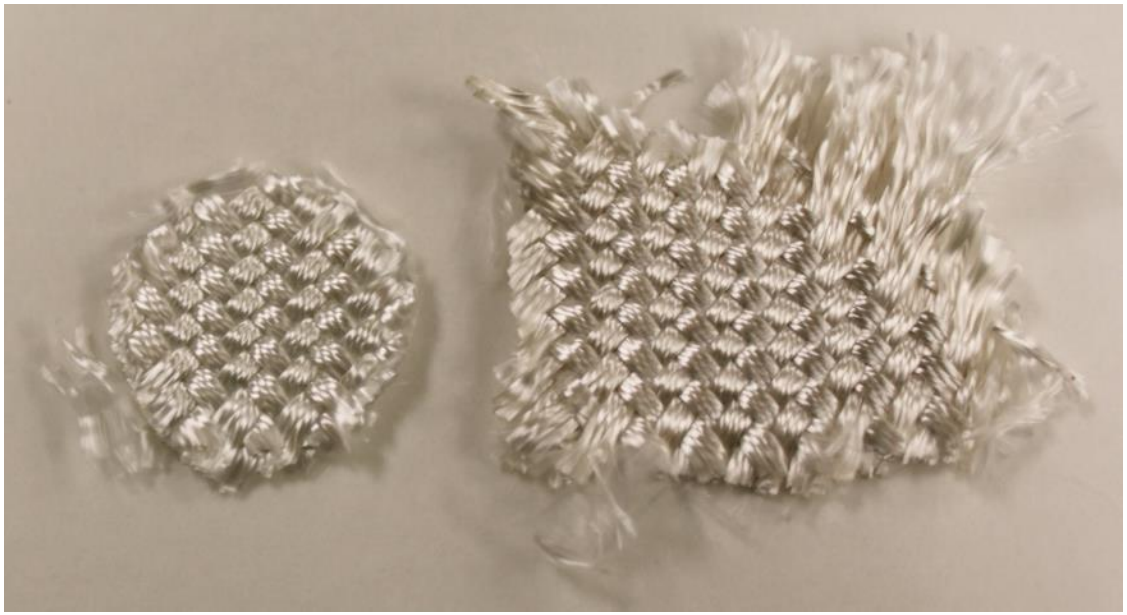
Davlyn fiberglass sleeve

- Some bleaching noted in reflectance curves, not really apparent by visual inspection
- Mass loss indicates possible erosion of sizing

Flight



Control

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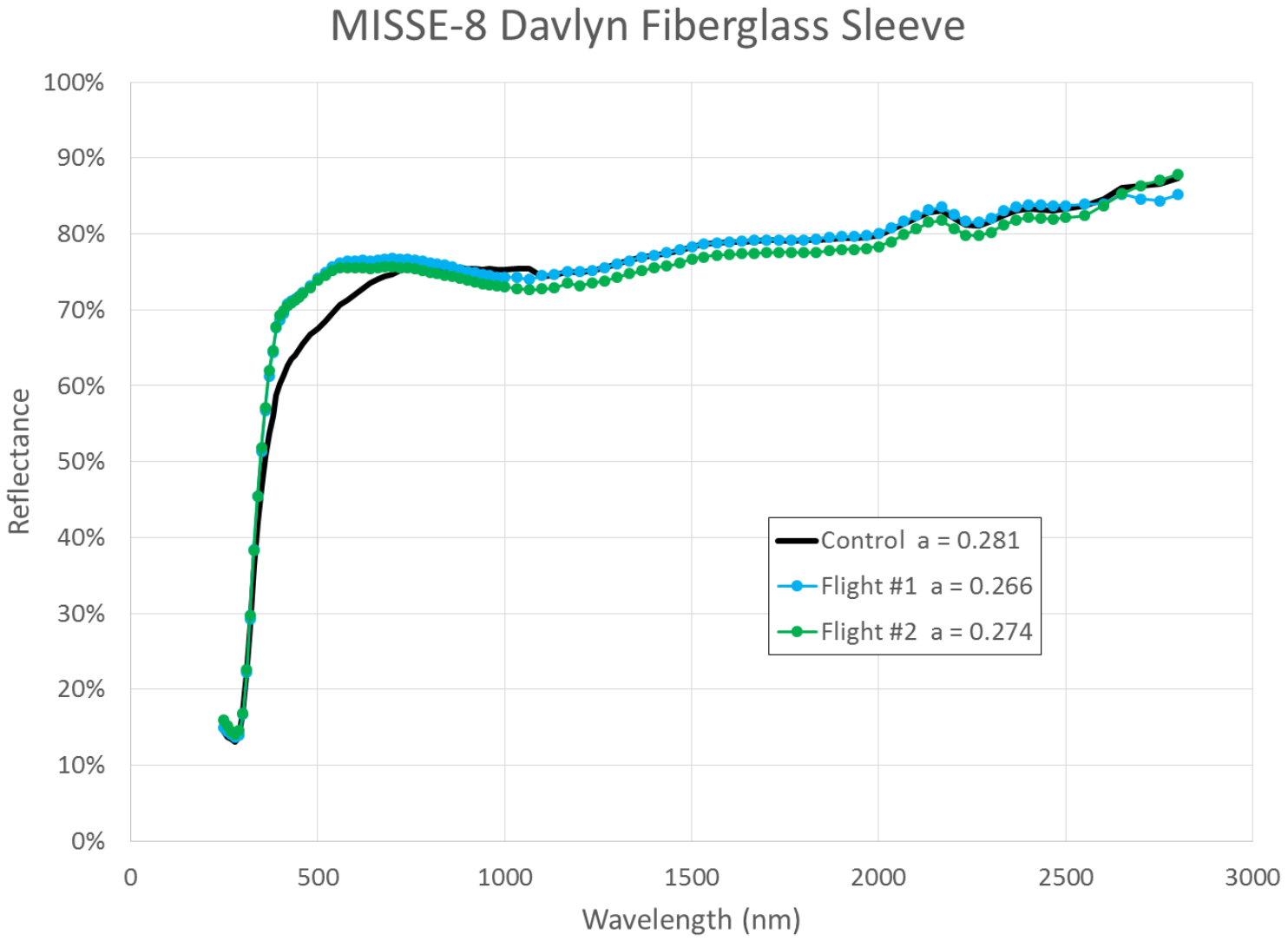

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Permacel and Intertape Glass Cloth Tapes

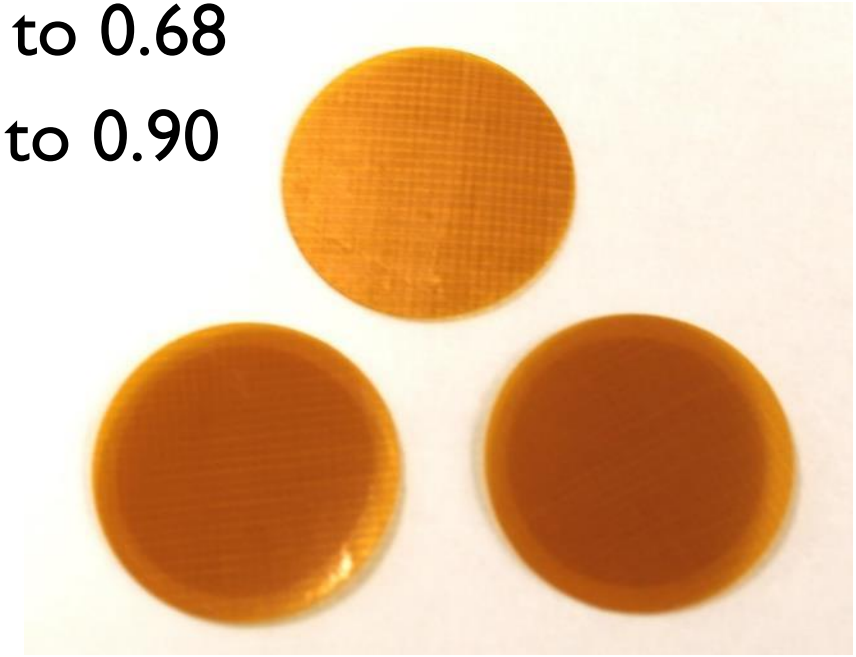
- Permacel P-213 tape is obsolete, Intertape 4617 is substitute for sharp edge mitigation and other protective uses on ISS hardware.
- Even though MISSE-8 had low AO fluence, mass loss indicates same level of protection for Kapton underneath.
- Permacel solar absorptance slightly increased from 0.48 to 0.51
- Intertape solar absorptance negligible change from 0.62 to 0.63.

Solar array scrim cloth

- Higher than expected erosion rate
  - ~6 x 10^{-24} cm^3/atom
- Slightly higher optical properties

  α increased from 0.65 to 0.68

  ε increased from 0.88 to 0.90



Thermal Control Coatings

MISSE-8		Preflight	Postflight	Δ
AZ400 white, low outgassing silicone	α	0.17	0.17	-
	ε	0.87	0.88	+0.01
AZ-2000-ICW white, inorganic, conductive	α	0.26	0.25	-0.01
	ε	0.92	0.92	-
AZ-2000-LSW white, low outgas silicone, static-dissipative	α	0.28	0.30	+0.02
	ε	0.90	0.90	-
AZ-2100-IECW white, inorganic, conductive	α	0.25	0.27	+0.02
	ε	0.91	0.91	-
AZ-3700 on Kapton with 966 adhesive	α	0.28	0.25	-0.03
	ε	0.31	0.36	+0.05

White coatings did not change or had slight increase in absorptance similar to AZ93 due to contamination. AZ-3700 similar to MISSE-7 results.

Thermal Control Coatings

MISSE-8		Preflight	Postflight	Δ
MLS-85-SB-C, black, low outgassing silicone, conductive	α	0.97	0.96	-0.01
	ε	0.91	0.91	-
RM-550-LSB, black, low outgassing silicone, nonconductive	α	0.97	0.96	-0.01
	ε	0.90	0.90	-
RM-550-LSB-H, black, low outgassing silicone, high gloss	α	0.97	0.96	-0.01
	ε	0.91	0.91	-
RM-550-LSB-C, black, low outgassing silicone, conductive	α	0.96	0.95	-0.01
	ε	0.89	0.89	-
RM-550-IB black, inorganic, non-conductive	α	0.97	0.97	-
	ε	0.90	0.90	-

Black coatings did not change significantly.

Indium tin oxide on Kapton

- PN146635-001 "1500 Ω/sq." sample and Multek ITO/SiO_2/Kapton unaffected
  - Control and flight PN 146635-001 was 1300 - 1400 Ω/sq
  - Control and flight ITO/SiO_2/Kapton 10 - 20 KΩ/sq
- Control newer Multek ITO/Kapton was 20 - 30 KΩ/sq, flight was 60 KΩ/sq., no visible change in appearance
- Older PN146635-003 "20 KΩ/sq." sample had same appearance of scratches, same degradation in conductivity, same degradation in solar absorptance as on MISSE-7

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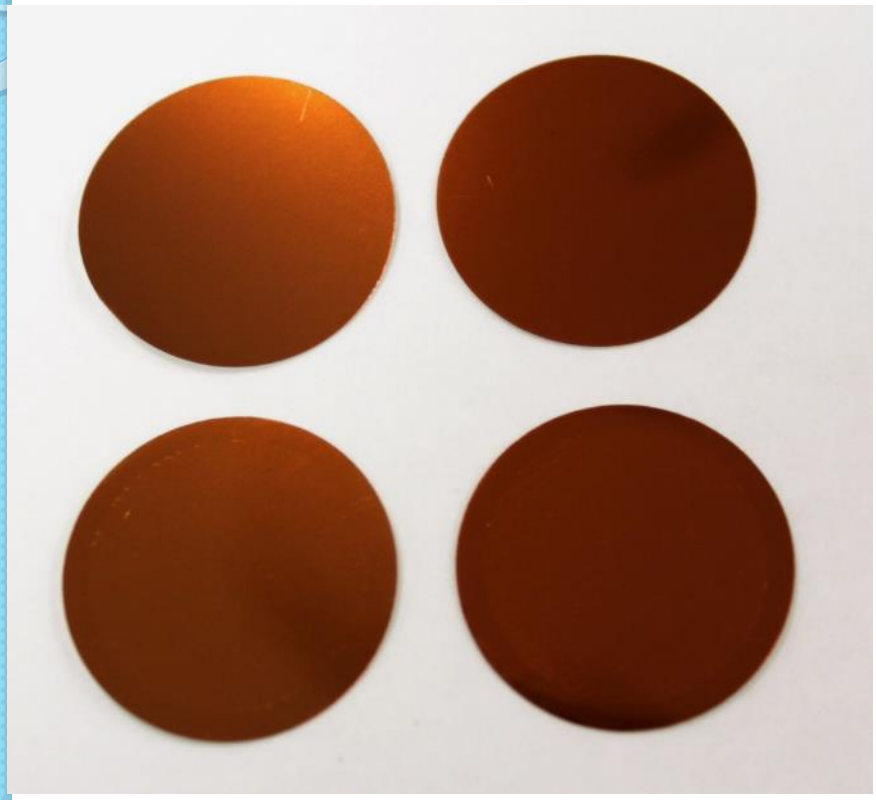
Control Samples



Flight Samples

ITO/SiOx/Kapton, newer ITO/Kapton, ITO/Kapton 1500 Ω/sq., ITO/Kapton 20K Ω/sq.

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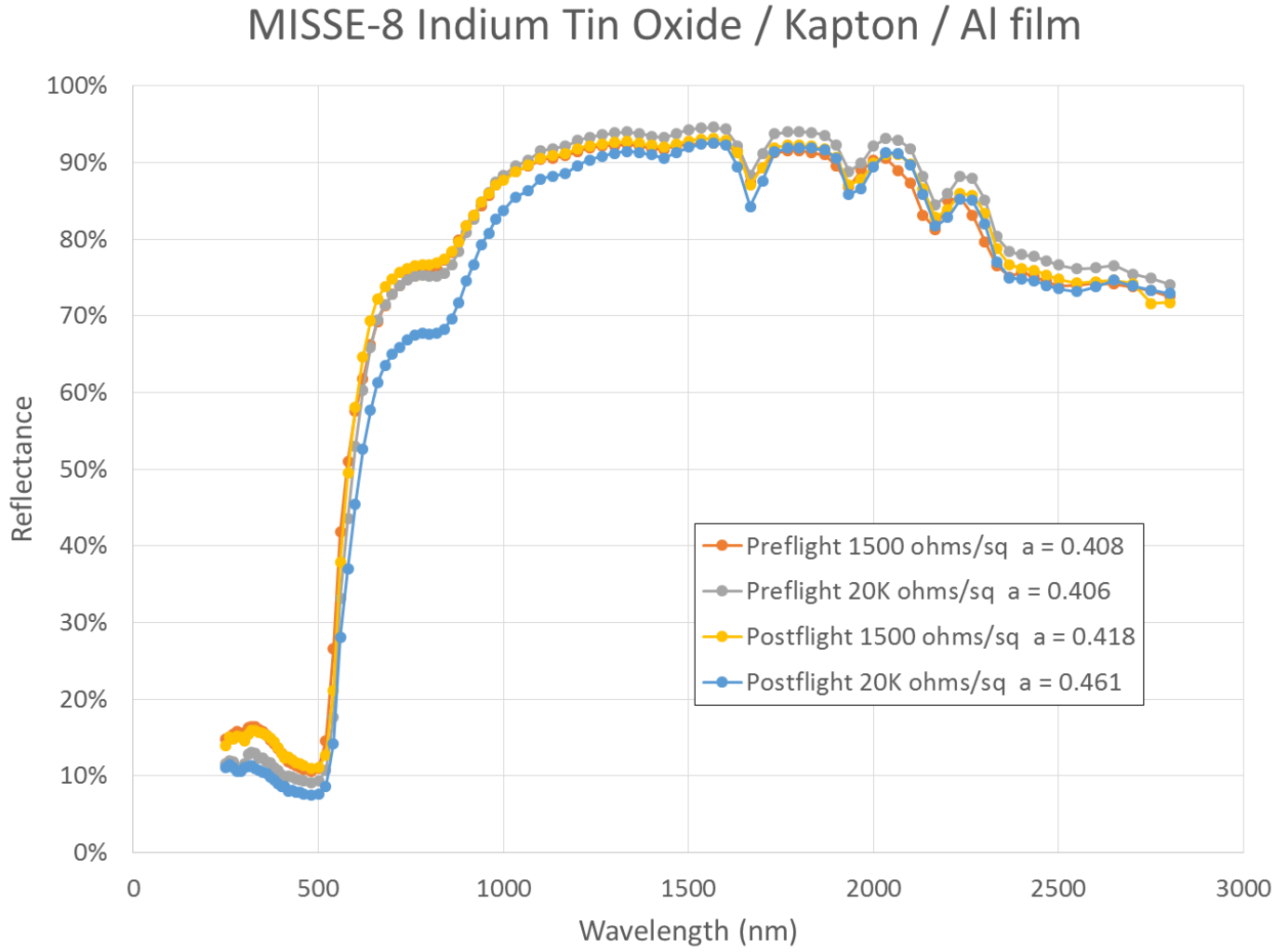

STATUS OF THE MISSE DATA BASE

- Data base contains in excess of 3200 records, with information on individual materials specimens and hardware.
  - Each individual record indicates if the individual specimen did or did not survive the flight.
  - Over 800 records with erosion yield, optical properties, or other specific data
- Records include environmental exposure estimates and pre-flight, on-orbit, and post-flight NASA-provided images.
- Several hundred documents, or references to specific documents, are included in the data base.
- Access to documents containing SBU or ITAR designated information is restricted. (Such information is not included in individual records.)

More MISSE on MAPTIS

- Will make improvements based on user responses/ comments/metrics
  - Metrics include what programs are using MAPTIS, so please don't be shy if you log in and get the query screen.
- Will continue to work with organizations to obtain more MISSE data.

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For access to MAPTIS

http://maptis.nasa.gov/Request.aspx

and fill out the form.

To add MISSE data to MAPTIS – miria.finckenor@nasa.gov

or MAPTISsupport@mail.nasa.gov

Be sure to specify whether your information is unlimited access or ITAR-restricted/proprietary/ export-controlled.

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Acknowledgments

- NRL/Rob Walters, Phil Jenkins, and Susie LaCava for MISSE-8 integration
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