MSFC-293_ABSTRACT

Thermal Control Materials on MISSE-5 with Comparison to Earlier Flight Data

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A variety of thermal control materials were flown on the Materials on International Space Station Experiment (MISSE)-5. Several types of beta cloth, as used in multi-layer insulation blankets, were flown, including samples from the same batch as used on the International Space Station. Two candidate sunshade materials for the James Webb Space Telescope were also exposed on MISSE-5. The white thermal control coating AZ93 was applied to Kapton instead of aluminum; this sample maintained good solar absorptance and did not indicate any significant level of contamination to the MISSE-5 experiment. Marker coatings maintained their color. Thermo-optical properties are discussed, along with comparable data from MISSE-2 and the Passive Optical Sample Assembly (POSA) – I experiments.

MSFC-293_PRESENTATION

Thermal Control Materials on MISSE-5

With Comparison to Earlier Flight Data

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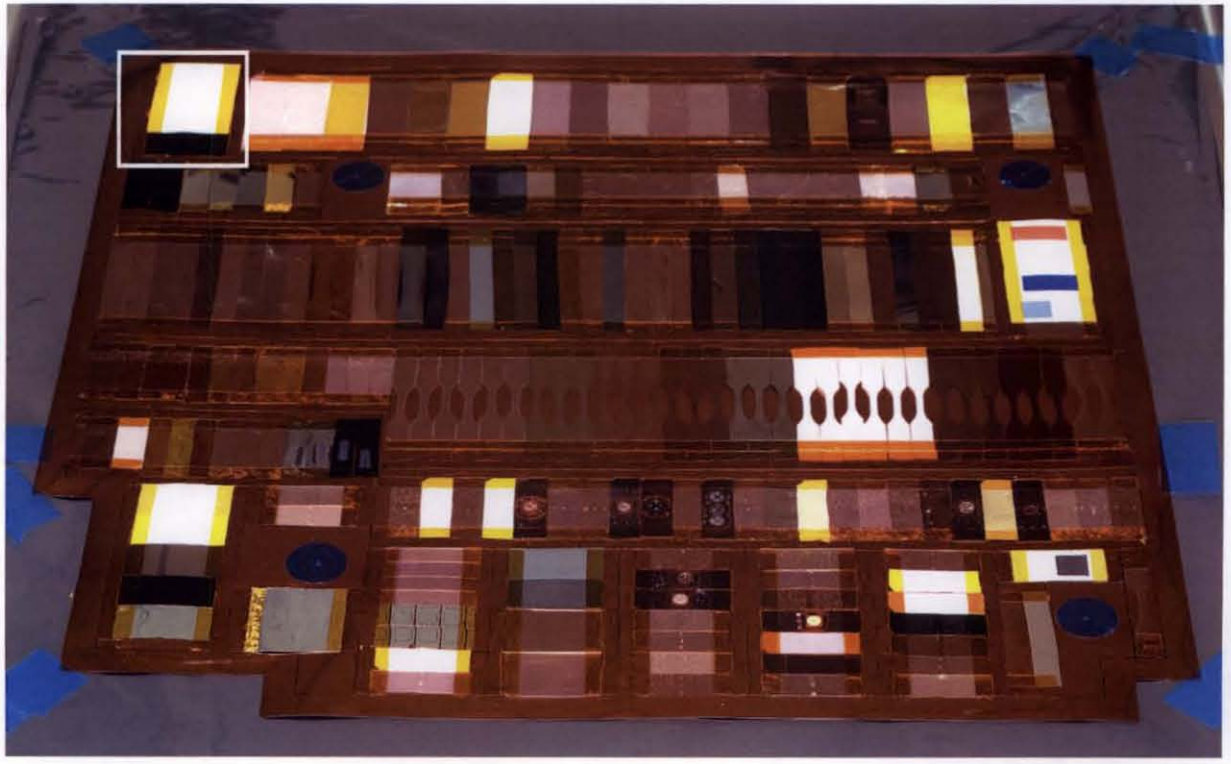
Materials on International Space Station Experiment (MISSE) - 5

Deployed: August 3, 2005 on STS-114
Retrieved: September 15, 2006 on STS-115

- Materials' Location on MISSE-5
- Environmental Exposure
- Effects on Coatings
  - Thermal Control Coatings
  - Marker / Astronaut Visual Aid Coatings
- Discussion and Conclusions

Thermal Control Materials on MISSE-5
With Comparison to Earlier Flight Data



Aluminized beta cloth Chemfab 500F
"Super" beta cloth
Black beta cloth

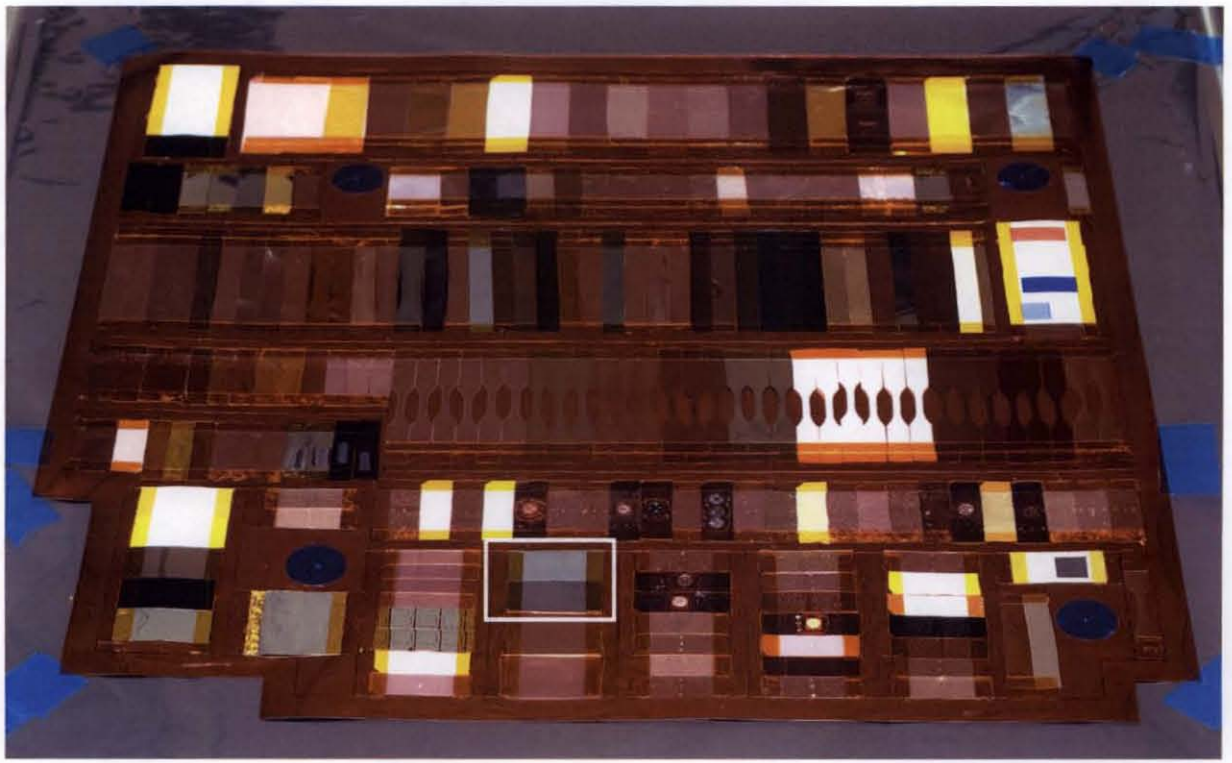
Photo courtesy of Glenn Research Center

Thermal Control Materials on MISSE-5
With Comparison to Earlier Flight Data

"Super" beta cloth
SiO/Kapton E/VDA
SiO/CP1/VDA

AZ93 on Kapton
Black beta cloth

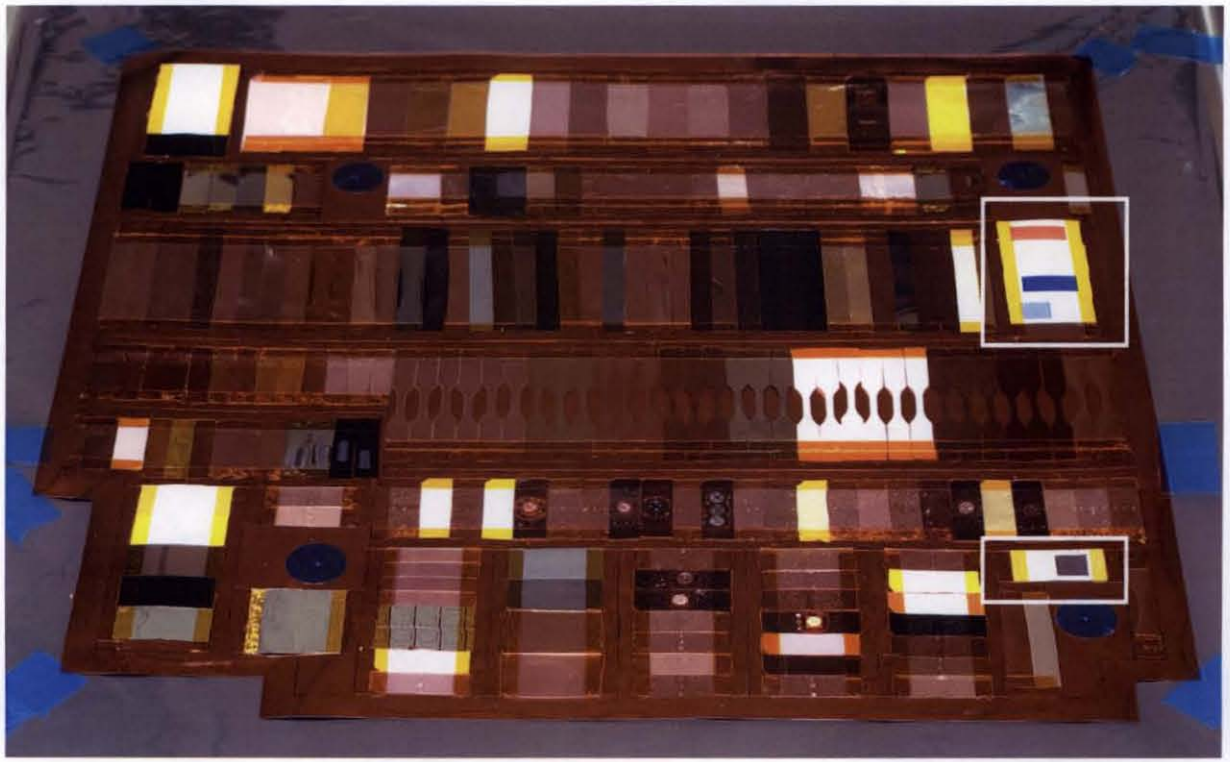
Photo courtesy of Glenn Research Center



Germanium on black Kapton
Germanium on Kapton HN

Photo courtesy of Glenn Research Center

Thermal Control Materials on MISSE-5
With Comparison to Earlier Flight Data

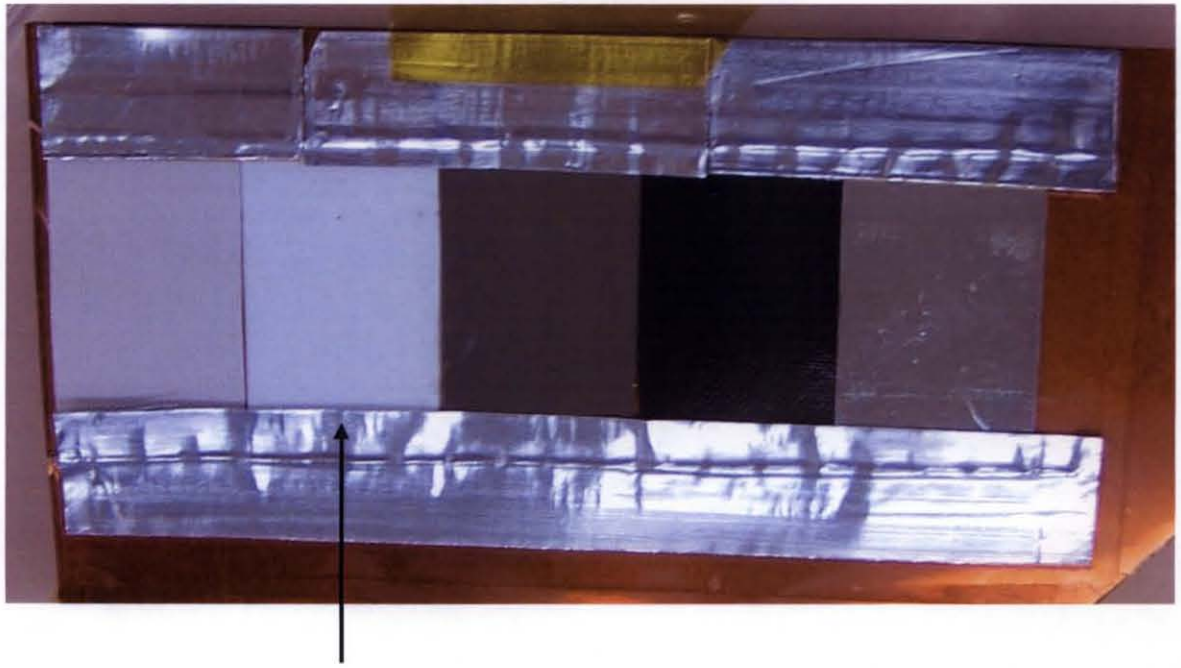


AZ93 on beta cloth
Marker coatings on beta cloth
Marker coatings on Dutch Space glass cloth

Photo courtesy of Glenn Research Center

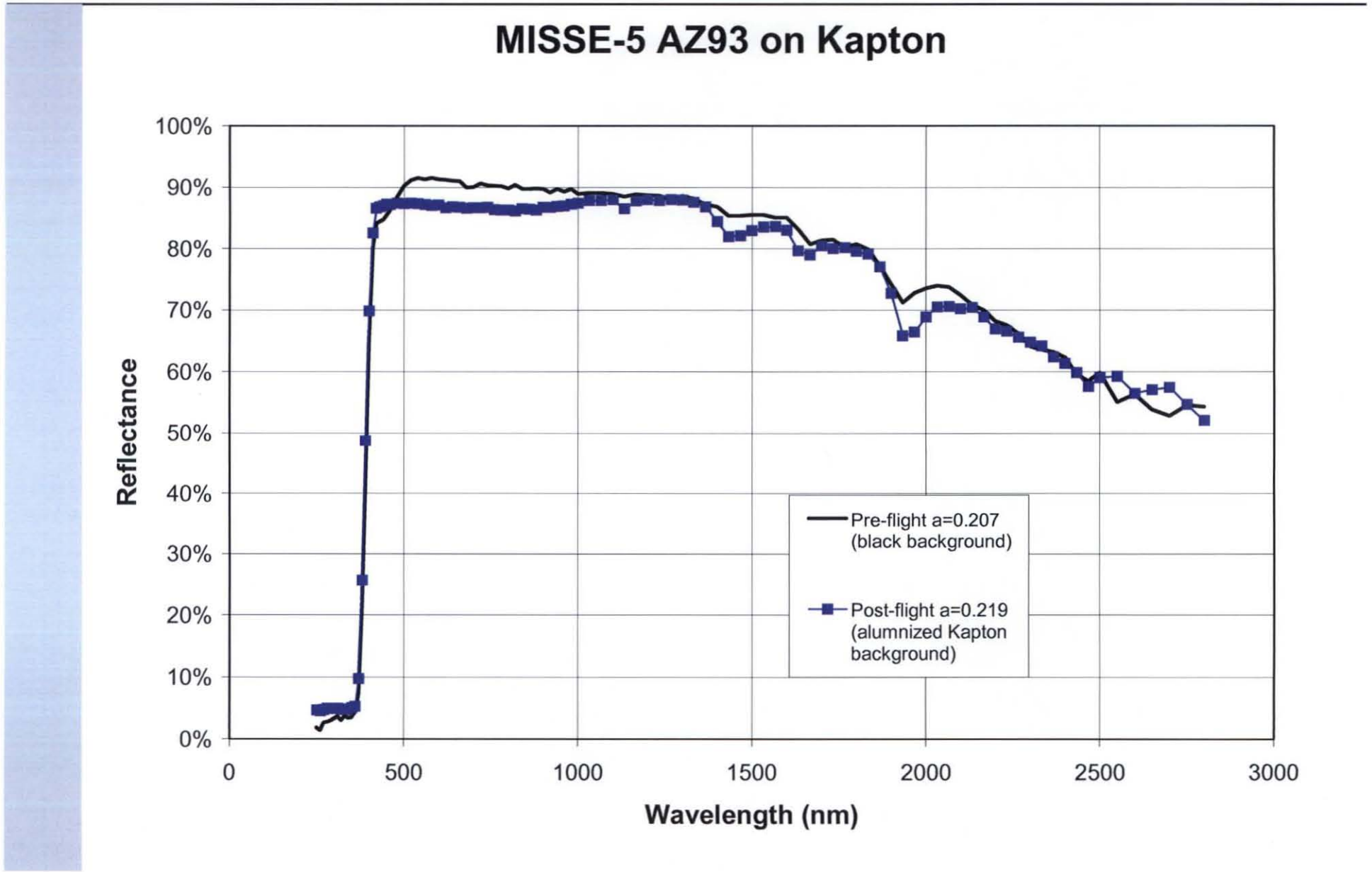
Environmental Exposure

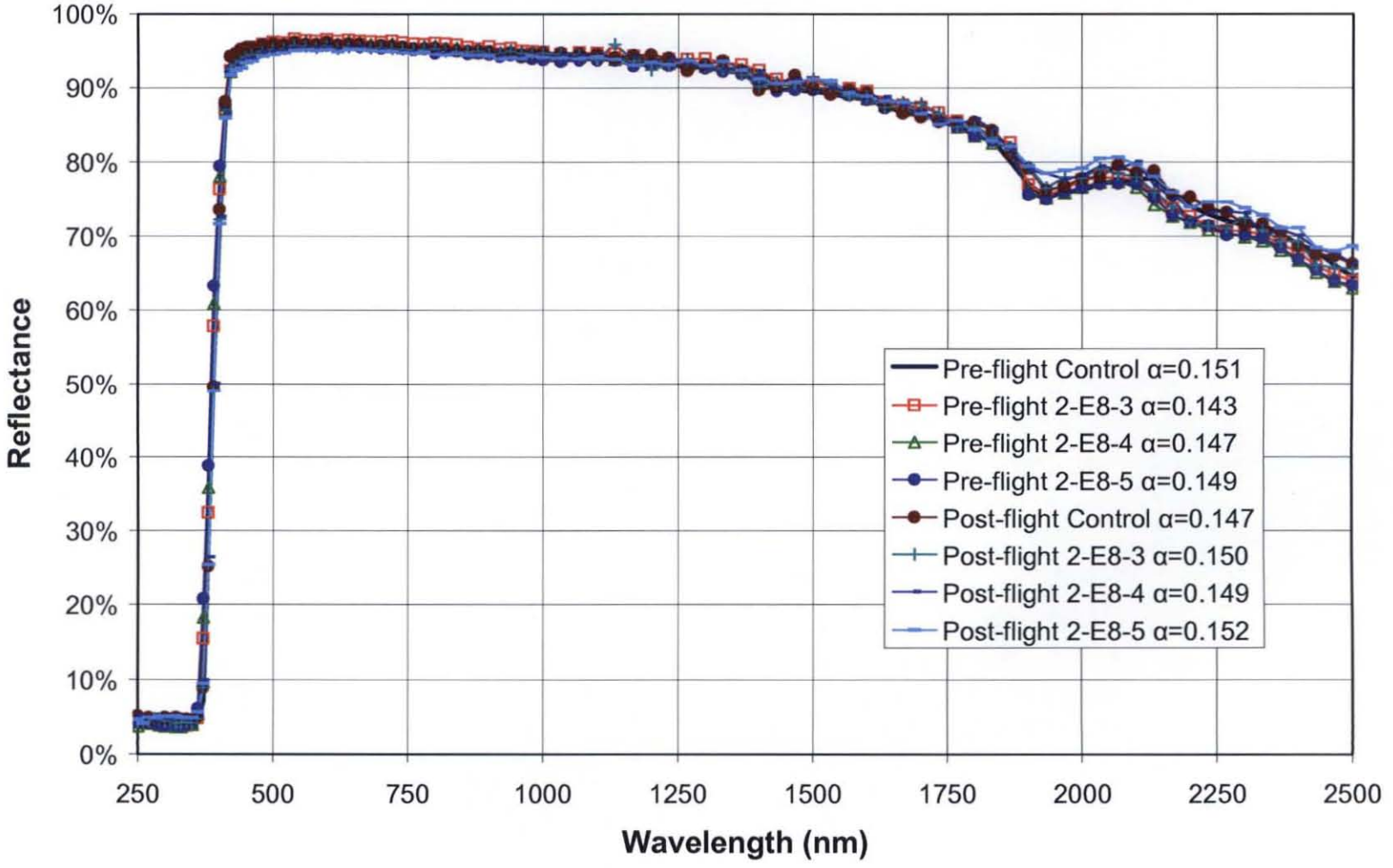
- ~1.8 x 10^{20} atoms/cm^2 atomic oxygen (Kapton erosion)
- ~ 525 equivalent sun-hours UV
- >6,500 thermal cycles of +40/-40 °C

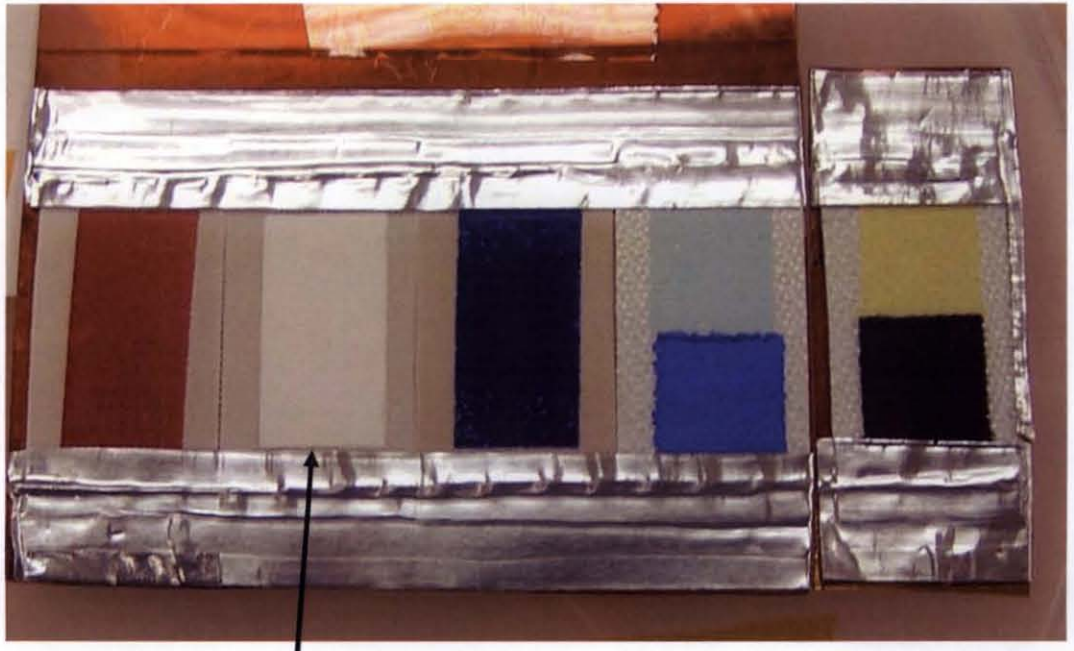


AZ93 on Kapton

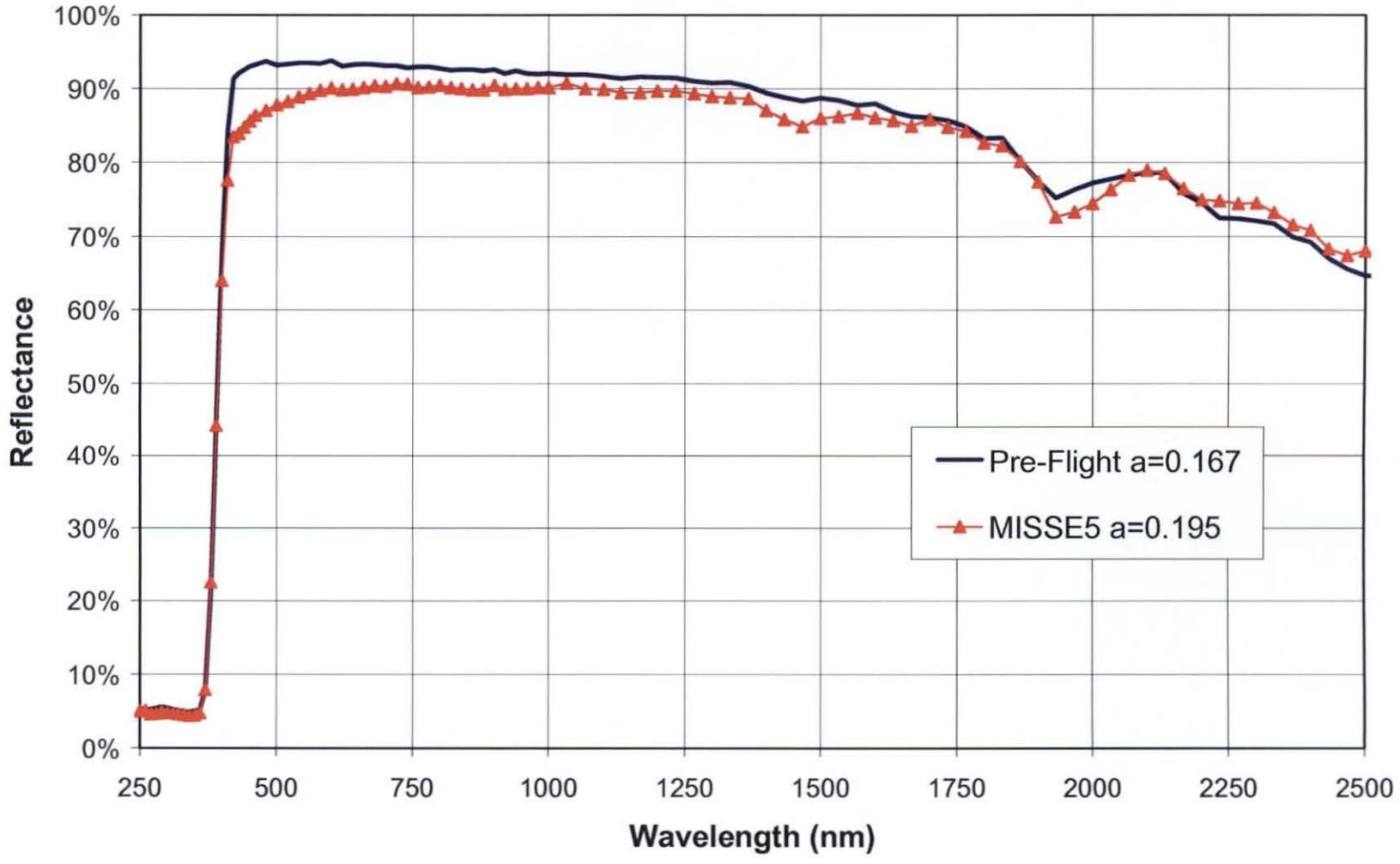
- Thinner layer than aluminum substrate
- No indication of contamination at 400 nm knee


MISSE-5 AZ93 on Kapton
Reflectance
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
500
1000
1500
2000
2500
3000
Wavelength (nm)
Pre-flight a=0.207
(black background)
Post-flight a=0.219
(alumnized Kapton
background)


MISSE-2 AZ93 Inorganic White Coating
Reflectance
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
250
500
750
1000
1250
1500
1750
2000
2250
2500
Wavelength (nm)
Pre-flight Control α=0.151
Pre-flight 2-E8-3 α=0.143
Pre-flight 2-E8-4 α=0.147
Pre-flight 2-E8-5 α=0.149
Post-flight Control α=0.147
Post-flight 2-E8-3 α=0.150
Post-flight 2-E8-4 α=0.149
Post-flight 2-E8-5 α=0.152



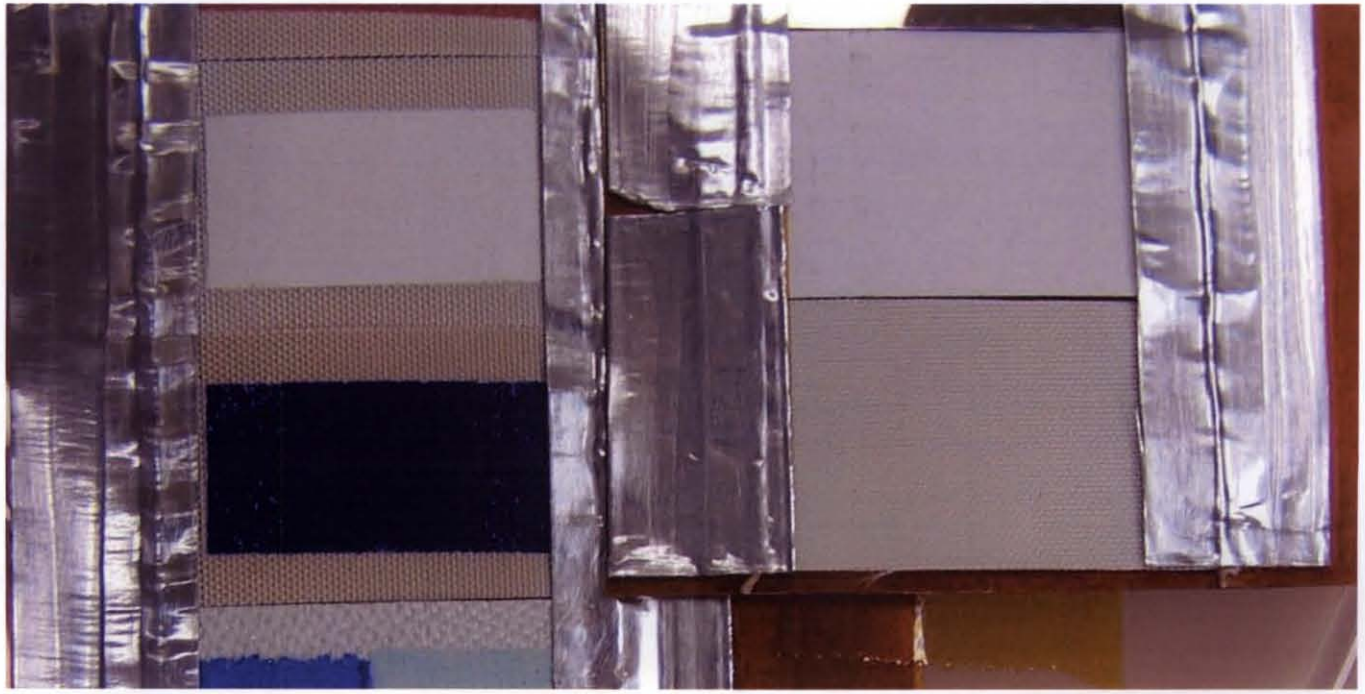
AZ93 on Beta Cloth looks white.
Change in reflectance spectra may indicate darkening of beta cloth underneath coating.


MISSE-5 AZ93 on Beta Cloth
No Aluminization
Reflectance
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
250
500
750
1000
1250
1500
1750
2000
2250
2500
Wavelength (nm)
Pre-Flight a=0.167
MISSE5 a=0.195

Thermal Control Materials on MISSE-5
With Comparison to Earlier Flight Data

AZ93 on Beta Cloth

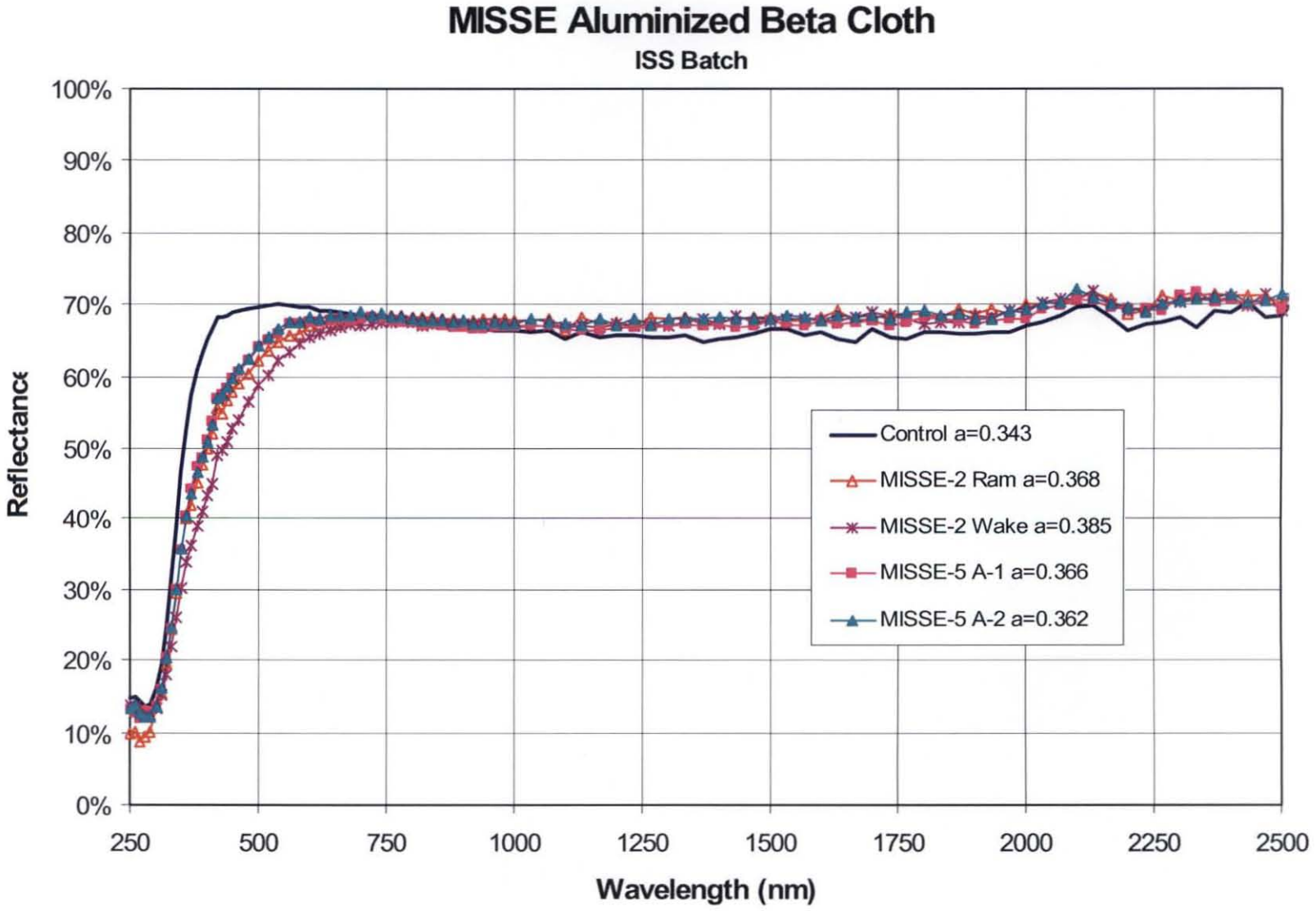
AZ93 on Kapton



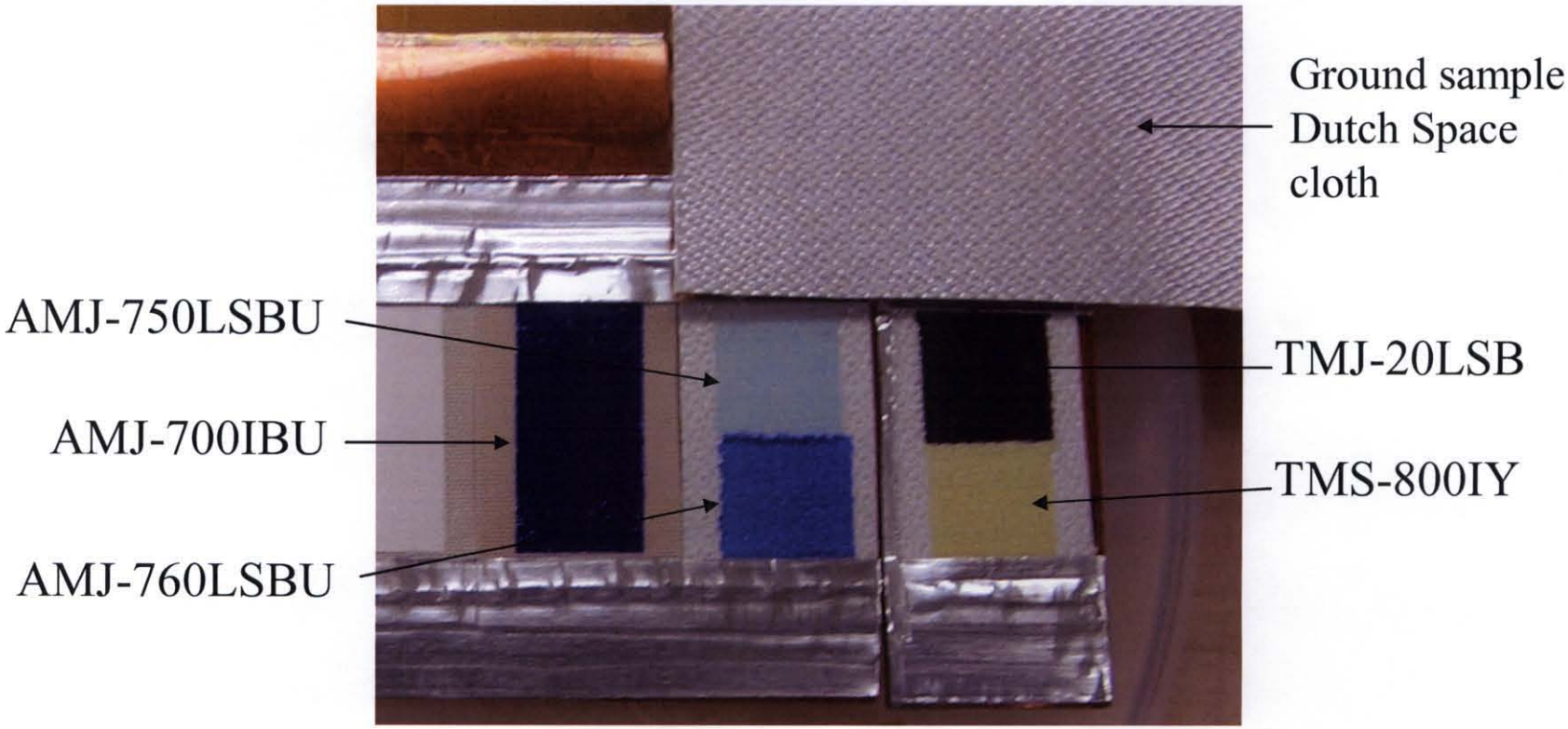
AMJ-700IBU on Beta Cloth

Aluminized Beta Cloth

Darkening of beta cloth without darkening of AZ93
indicates more UV radiation than expected.
Darkening of this level has been simulated with 500 – 800 ESH in lab.

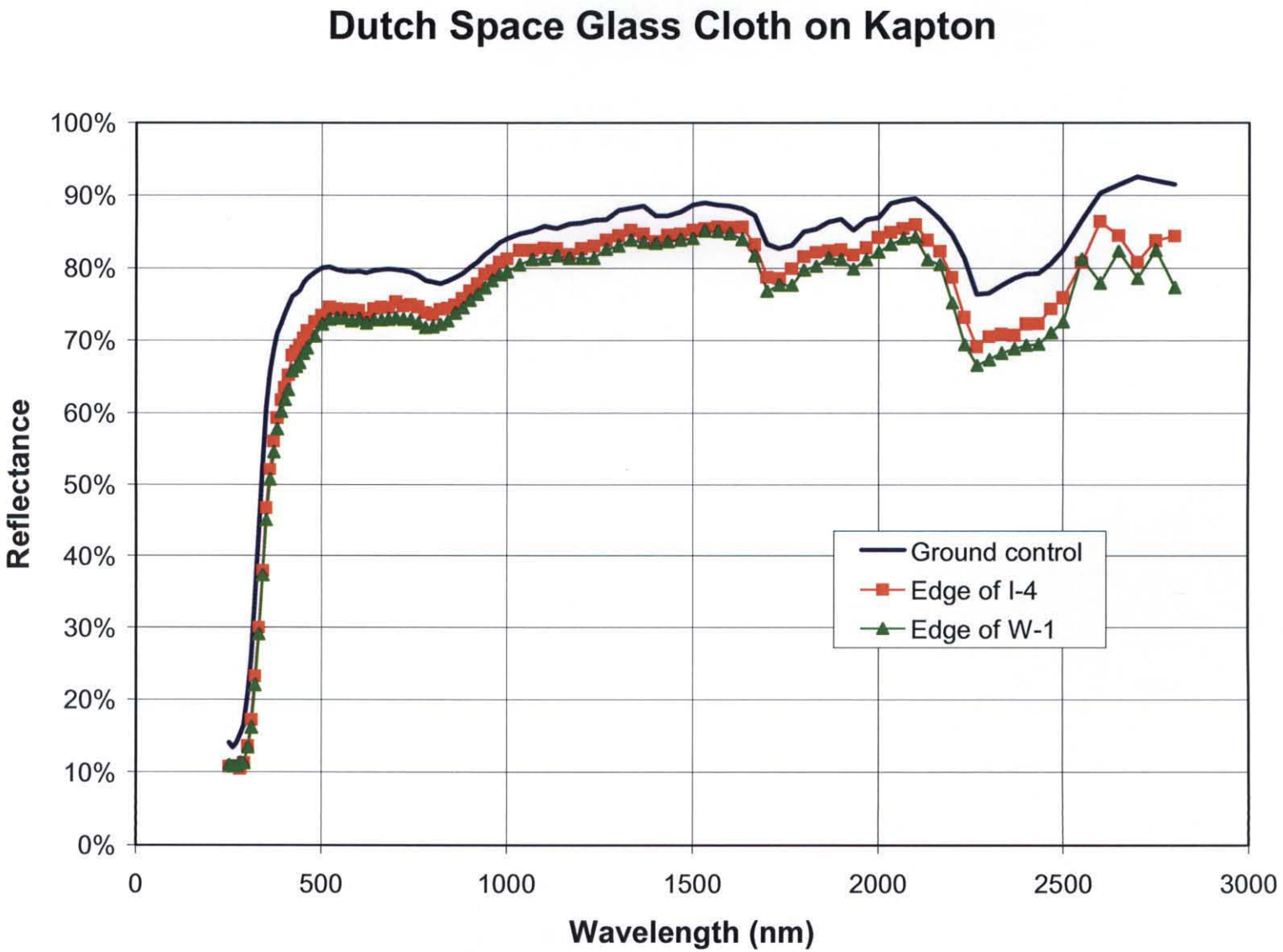

MISSE Aluminized Beta Cloth
ISS Batch
Reflectance
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
250
500
750
1000
1250
1500
1750
2000
2250
2500
Wavelength (nm)
Control a=0.343
MISSE-2 Ram a=0.368
MISSE-2 Wake a=0.385
MISSE-5 A-1 a=0.366
MISSE-5 A-2 a=0.362

Thermal Control Materials on MISSE-5
With Comparison to Earlier Flight Data

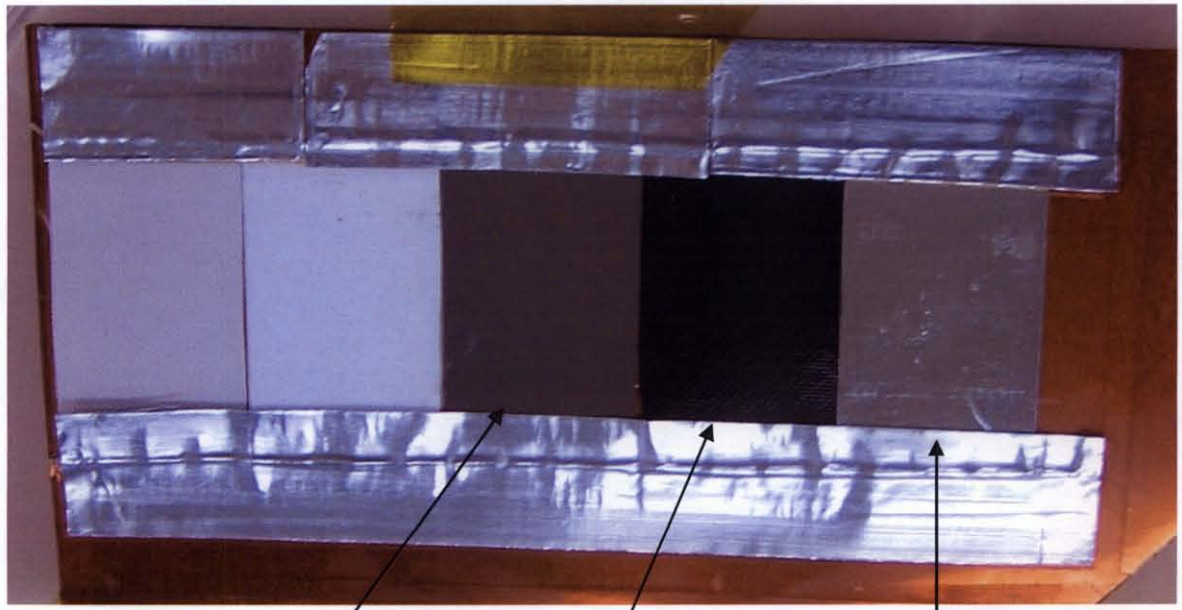


These coatings (on aluminum) also performed well on MISSE-1 and -2.

Some MISSE-5 marker coatings were screen printed on Dutch Space glass cloth/Kapton film


Dutch Space Glass Cloth on Kapton
Reflectance
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
500
1000
1500
2000
2500
3000
Wavelength (nm)
Ground control
Edge of I-4
Edge of W-1

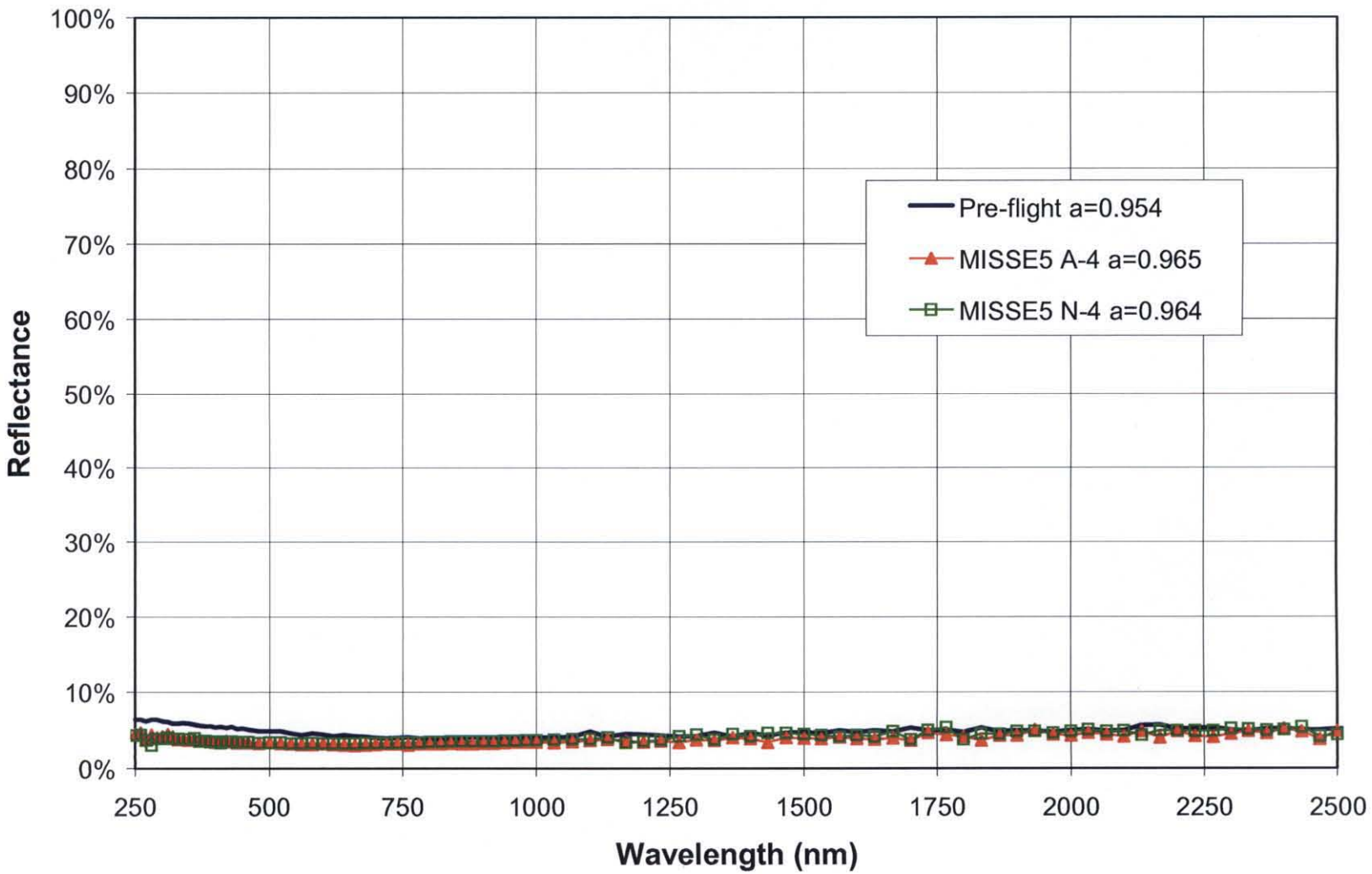
Thermal Control Materials on MISSE-5
With Comparison to Earlier Flight Data

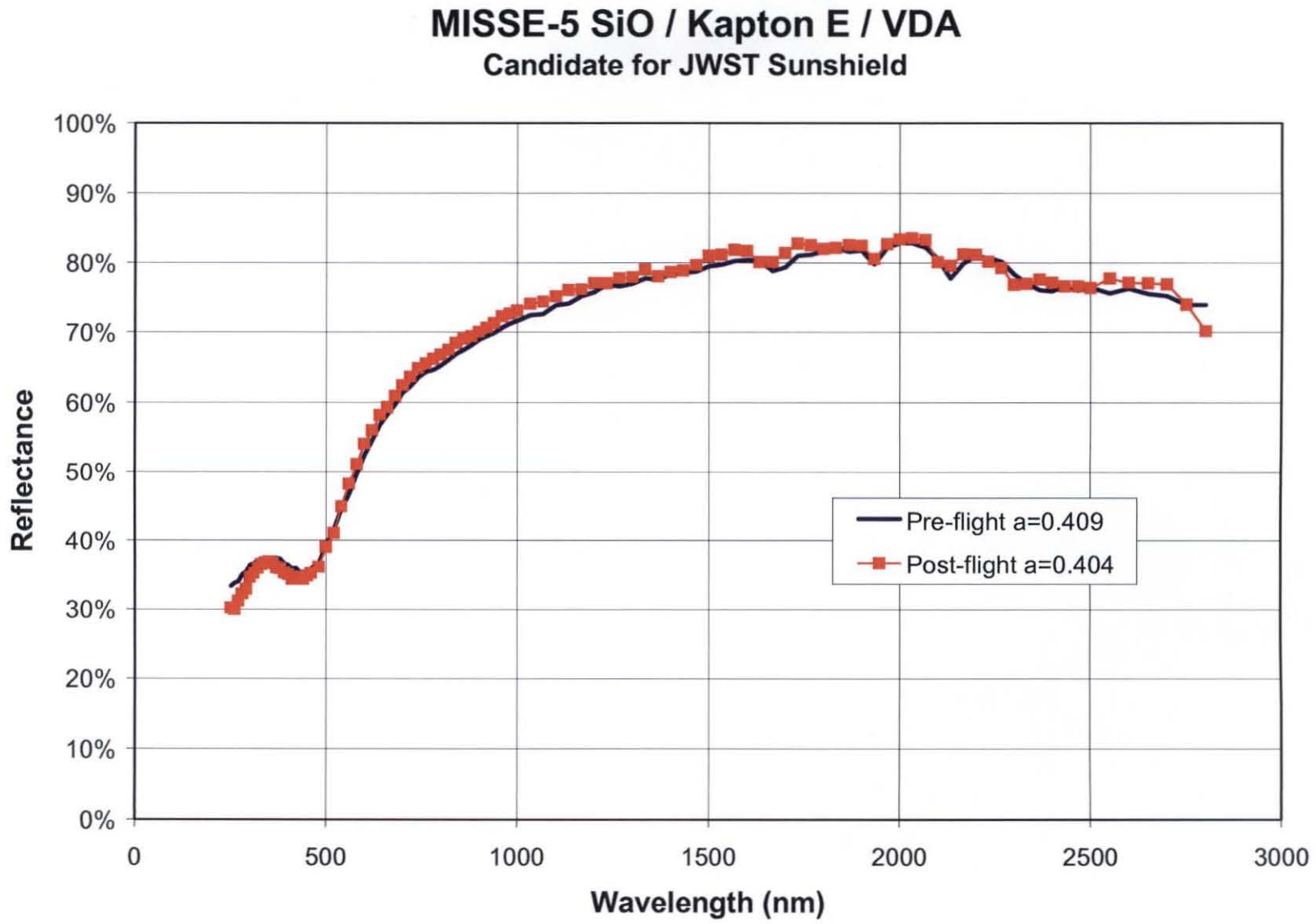


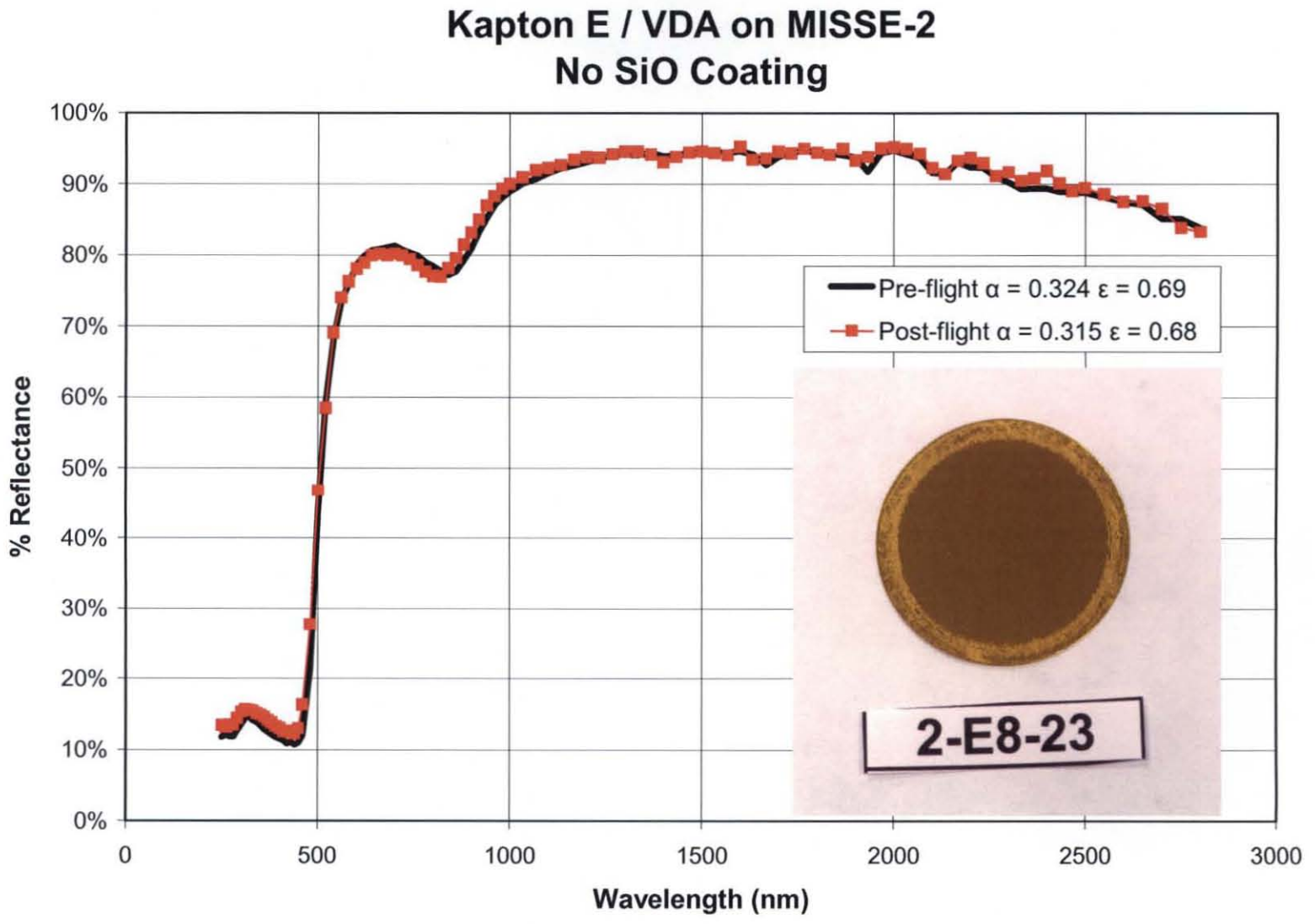
SiO/Kapton E/VDA

Black beta cloth

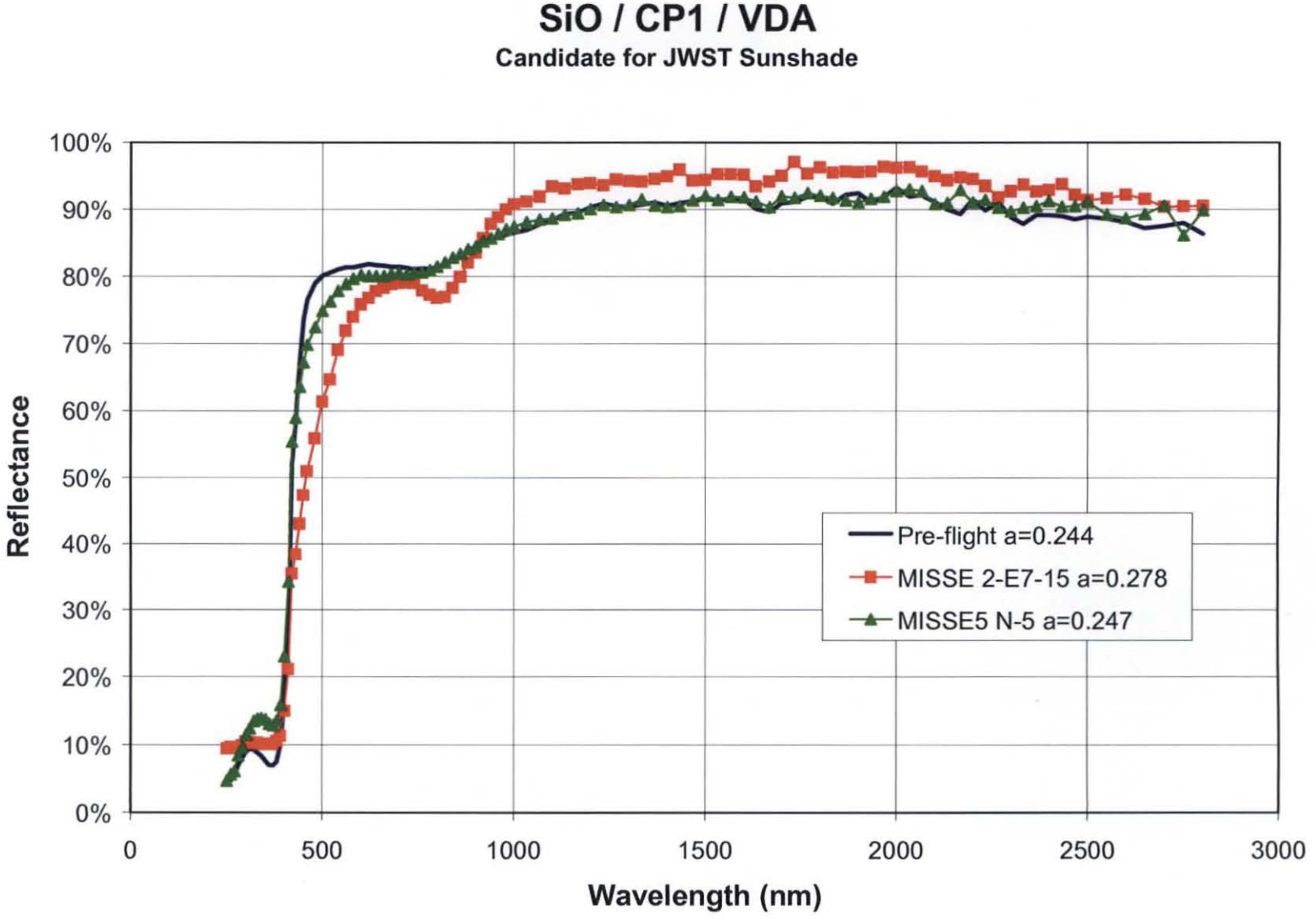
SiO/CP1/VDA

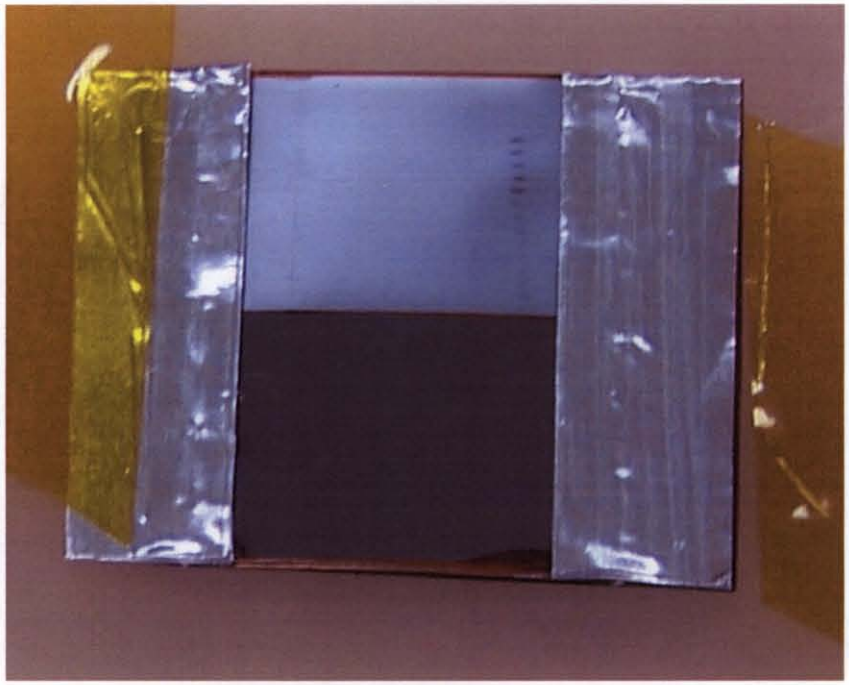

MISSE Black Beta Cloth
Reflectance
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
250
500
750
1000
1250
1500
1750
2000
2250
2500
Wavelength (nm)
Pre-flight a=0.954
MISSE5 A-4 a=0.965
MISSE5 N-4 a=0.964


MISSE-5 SiO / Kapton E / VDA
Candidate for JWST Sunshield
Reflectance
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
500
1000
1500
2000
2500
3000
Wavelength (nm)
Pre-flight a=0.409
Post-flight a=0.404

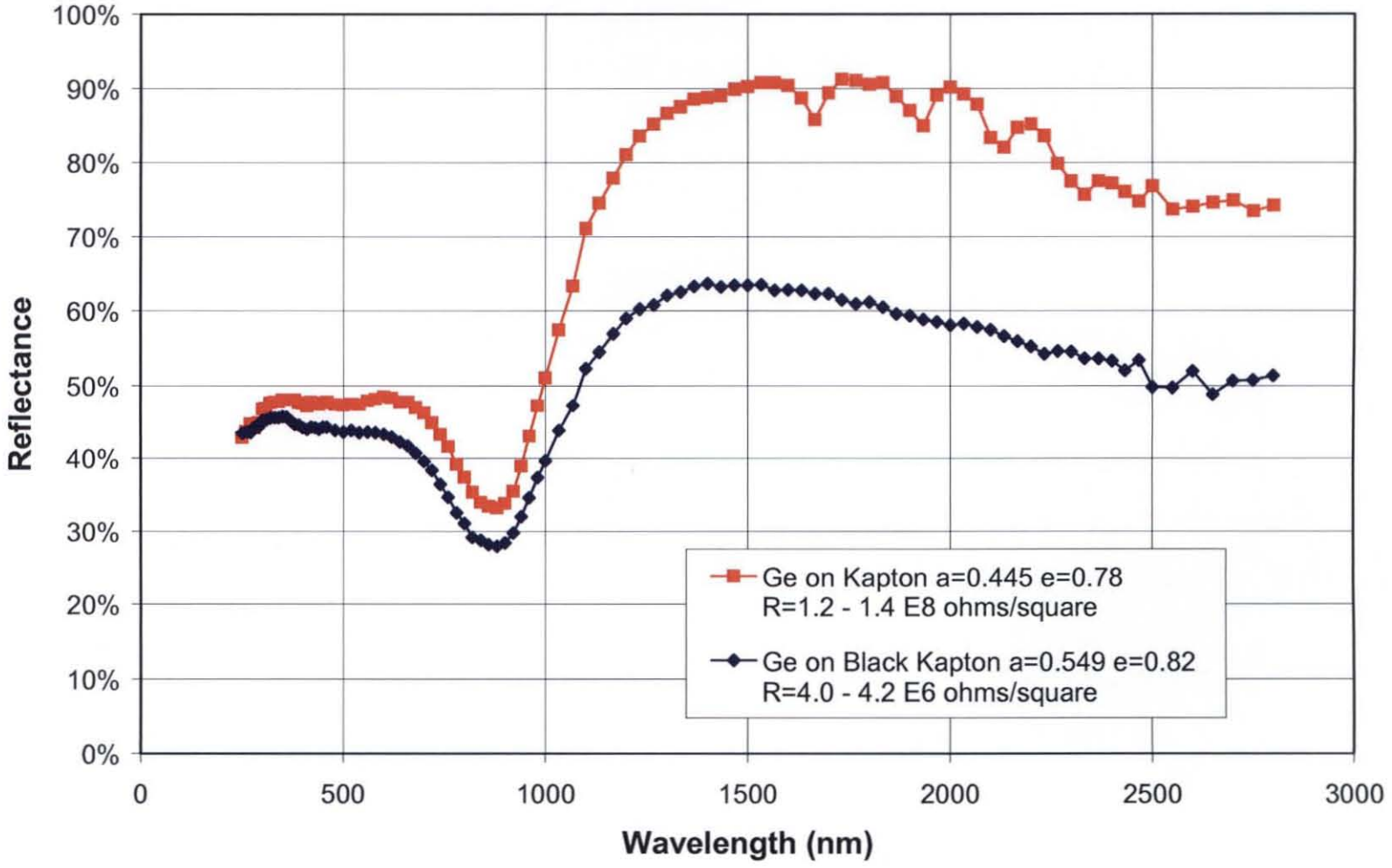


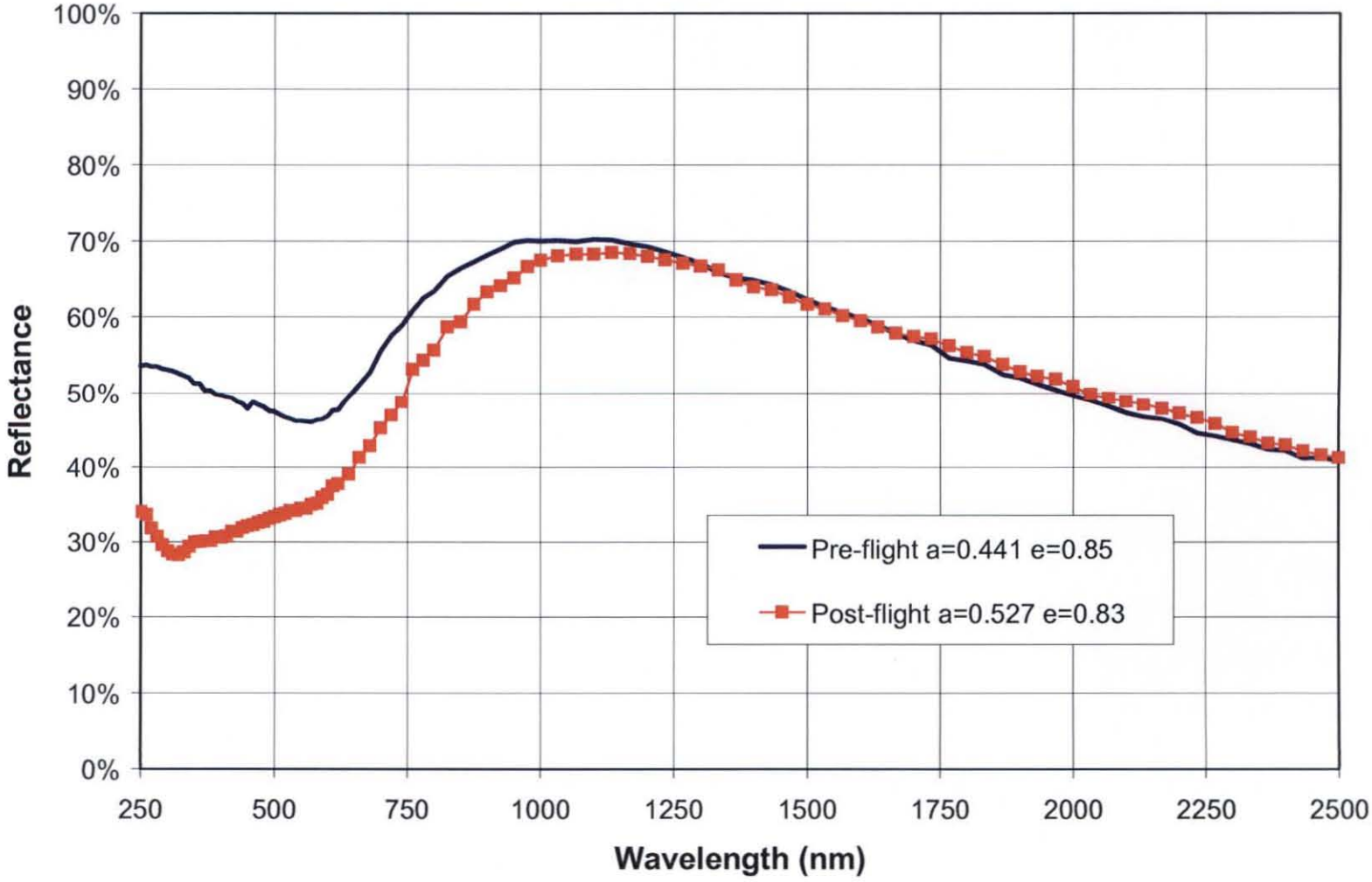
Note: sample was exposed to UV and no AO through magnesium fluoride window


SiO / CP1 / VDA
Candidate for JWST Sunshade
Reflectance
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
500
1000
1500
2000
2500
3000
Wavelength (nm)
Pre-flight a=0.244
MISSE 2-E7-15 a=0.278
MISSE5 N-5 a=0.247

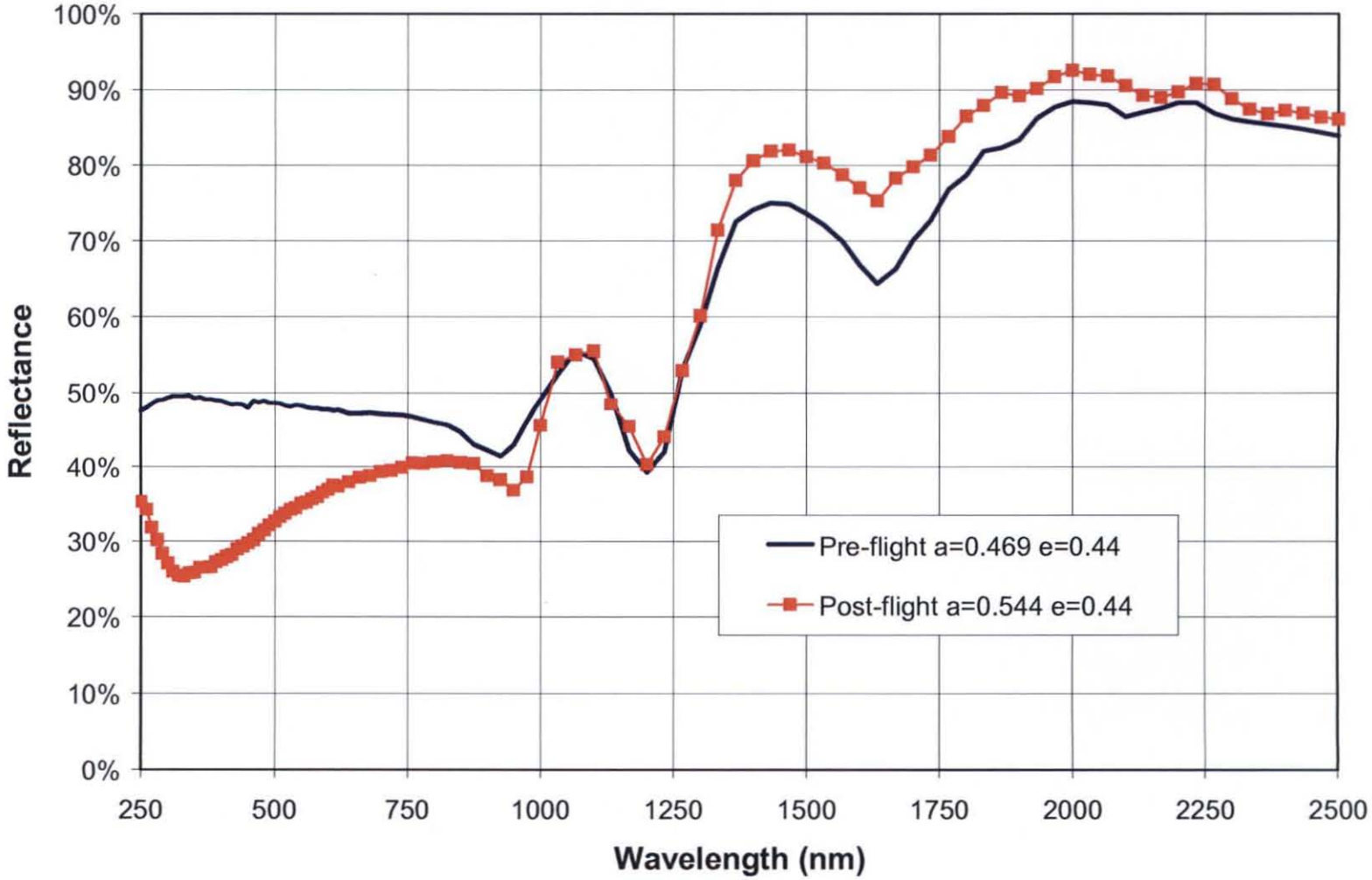


Germanium on Kapton and black Kapton
Similar materials flown on Passive Optical Sample Assembly


MISSE-5 Germanium/Kapton Post-flight
Reflectance
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
500
1000
1500
2000
2500
3000
Wavelength (nm)
Ge on Kapton a=0.445 e=0.78
R=1.2 - 1.4 E8 ohms/square
Ge on Black Kapton a=0.549 e=0.82
R=4.0 - 4.2 E6 ohms/square


POSA-I Germanium on Black Kapton
Reflectance
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
250
500
750
1000
1250
1500
1750
2000
2250
2500
Wavelength (nm)
Pre-flight a=0.441 e=0.85
Post-flight a=0.527 e=0.83

POSA-I Germanium on Kapton



Conclusions

- Coatings, particularly AZ93 zinc oxide pigment with inorganic binder, held up well in LEO {AO+UV} environment.
- No evidence of significant contamination.
- Marker / Label coatings maintained their color.
- Beta cloth darkened due to UV exposure. Solar absorptance was in agreement with previous MISSE exposure.
- Candidate JWST sunshade materials held up well.
- Germanium-coated Kapton maintained better than 1×10^9 Ω/□ surface resistivity.