Further Analysis of MISSE Polymeric Materials at MSFC

Miria M. Finckenor
Marshall Space Flight Center, AL 35812

Many different spacecraft materials were flown as part of the Materials on International Space Station Experiment (MISSE). MISSE was exposed to the low Earth orbital environment of atomic oxygen, ultraviolet radiation, thermal cycling, and hard vacuum. A number of polymer samples did not survive the atomic oxygen attack. Mass and thickness loss measurements indicate the durability of the remaining polymeric materials to withstand the space environment. Results from the one-year exposure on MISSE-3 and MISSE-4 are compared to those from the four-year exposure on MISSE-1 and MISSE-2. Solar absorptance and infrared emittance measurements are given for thermal control materials. Transmission measurements are given where appropriate.

A wide variety of polymeric materials were flown on MISSE, ranging from extremely thin films for solar sails to bulk materials. Some of the candidate solar sail materials were flown underneath magnesium fluoride windows to eliminate atomic oxygen effects and allow the study of ultraviolet radiation damage. Exposed seal materials include Viton®, silicone, and fluorosilicone. Multi-layer insulation materials were flown, including atomic oxygen-resistant polymers. Also flown were candidate inflatable materials for a High Altitude Airship or inflatable lunar habitat. Polymer materials being flown on MISSE-6 are discussed.

Further Analysis of

MISSE Polymeric Materials at MSFC

Miria M. Finckenor

NASA/Marshall Space Flight Center

Huntsville, AL

miria.finckenor@nasa.gov

National Space and Missile Materials Symposium
Henderson, NV
June 2009

- Acknowledgements
  - Special thanks to:
    - Rajib Dasgupta, system manager, and Dr. John Alred, deputy system manager for ISS M&P
    - Dr. Gary Pippin, Boeing Phantom Works
    - A.J. McDanal and Mark O'Neill of ENTECH
    - Dr. Garrett Poe and Brandon Farmer of NeXolve
    - Dr. Johnny Golden, Boeing Space Station
    - Karen Gibson, NASA/Langley for photographs

- Environment
- Results
  - DC93-500 films
  - CP1 films
  - Transhab candidate materials
  - Seal materials
  - Other polymeric materials
- Summary

Overview of Environmental Exposure

	Duration	**Atomic Oxygen ($atoms/cm^2$)**	**UV (ESH)**
MISSE-1	4 years	Ram ~9.5 $x10^{21}$ Wake 1.1 – 1.3 $x10^{20}$	Ram 5400 – 6400 Wake 4500 – 5600
MISSE-2	4 years	Ram 6.8 – 9.1 $x10^{21}$ Wake 1.4 – 2.0 $x10^{20}$	Ram 5000 – 6700 Wake 4800 – 6200
MISSE-3	1 year	Ram 1.2 – 1.3 $x10^{21}$ Wake ~1.9 $x10^{20}$	Ram 1695 – 1750 Wake 655 – 790
MISSE-4	1 year	Ram ~2.1 $x10^{21}$ Wake ~3.6 $x10^{20}$	Ram 1200 – 1600 Wake 825 – 1000

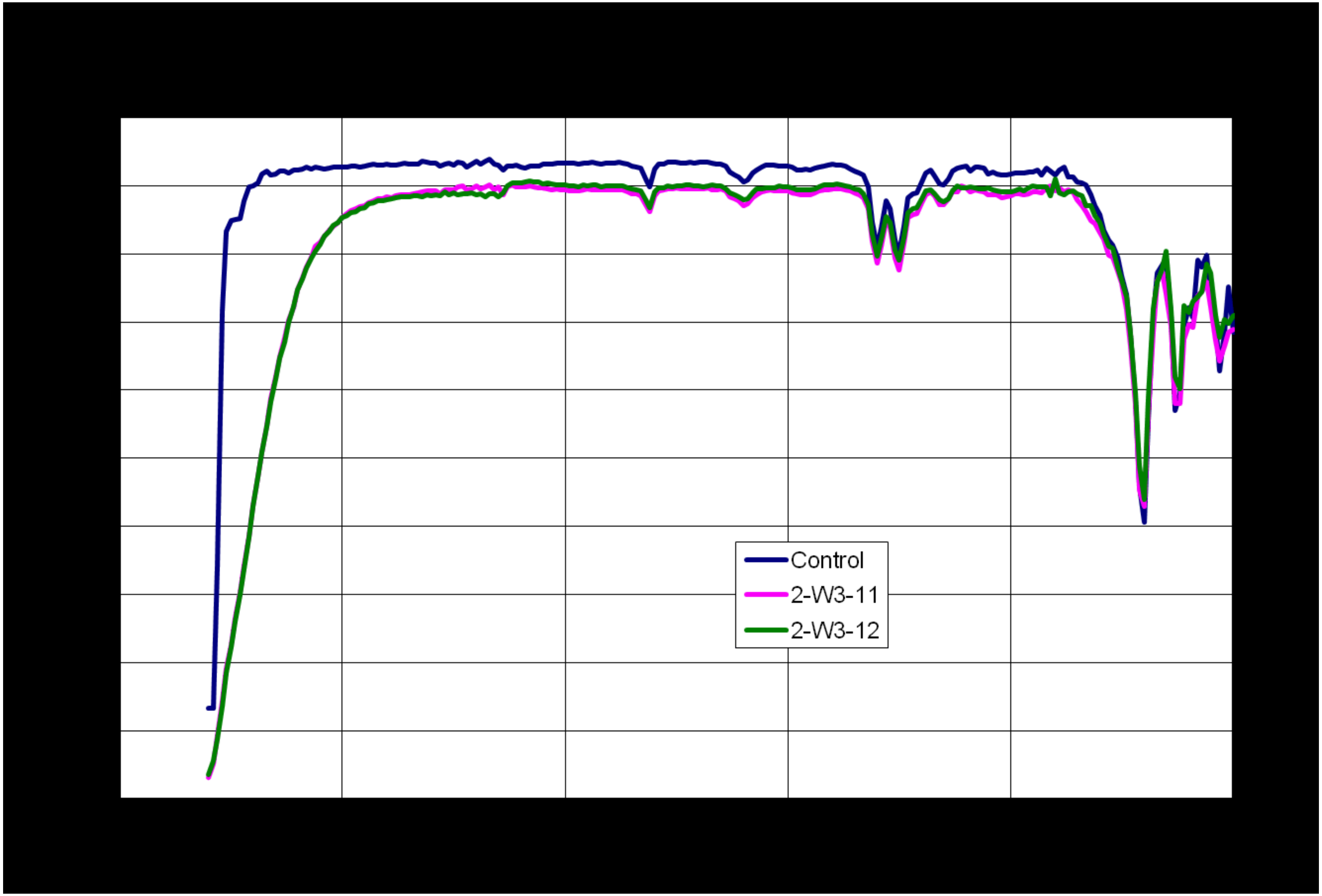
ENTECH DC93-500 Thin Silicone Films

- Used in refractive photovoltaic concentrator systems
- Four samples flown on MISSE-2 wake side
    - Two with UV-rejection coating
    - Two without coating
- Three samples flown on MISSE-4 wake side
    - Two with UV-rejection coating
    - One without coating
- Consistent results between flights
    - Samples without coating darkened
    - Samples with UV-rejection coating maintained similar transmission

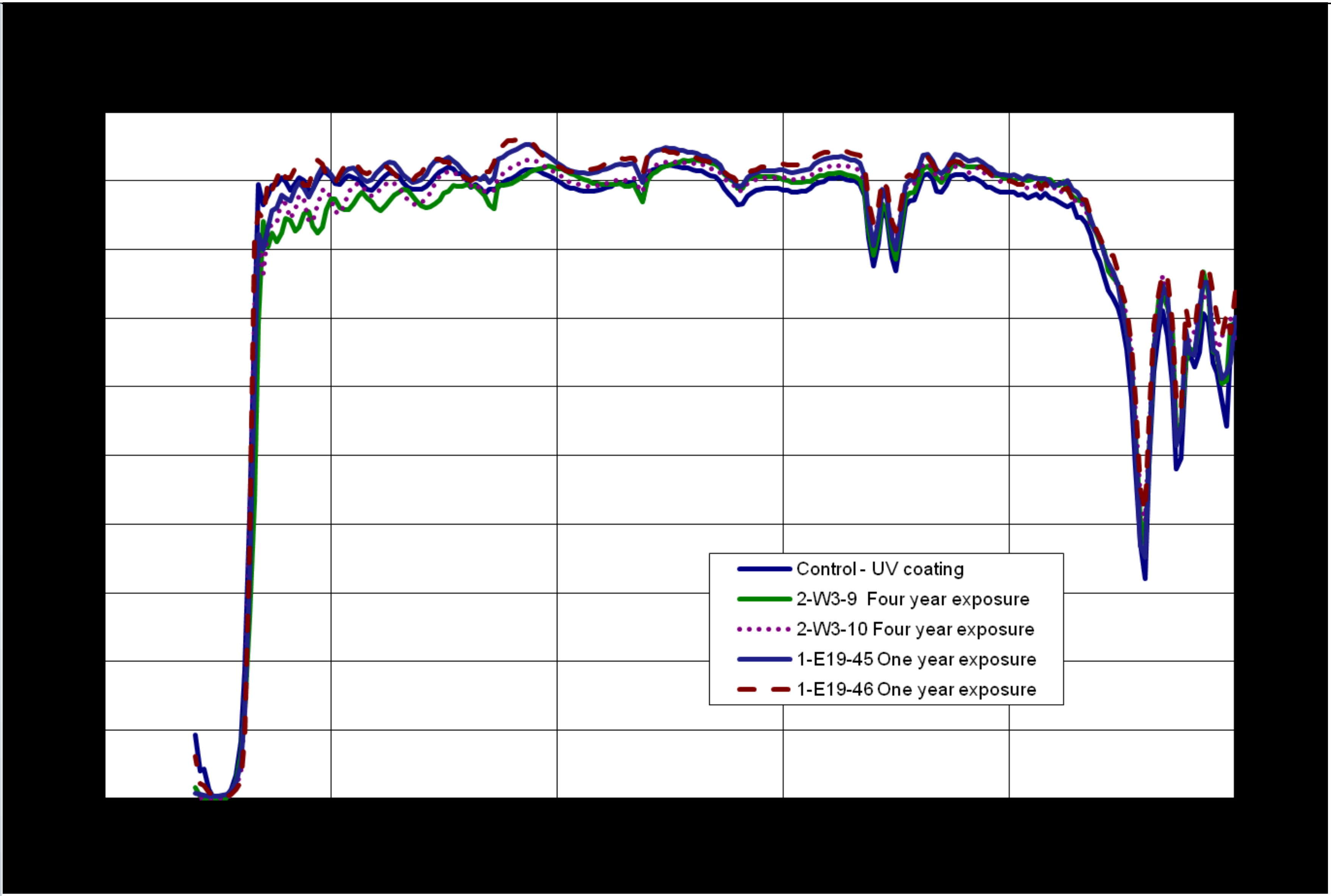
Typical coated sample

Typical uncoated sample

Further Analysis of MISSE Polymeric Materials at MSFC



Further Analysis of MISSE Polymeric Materials at MSFC

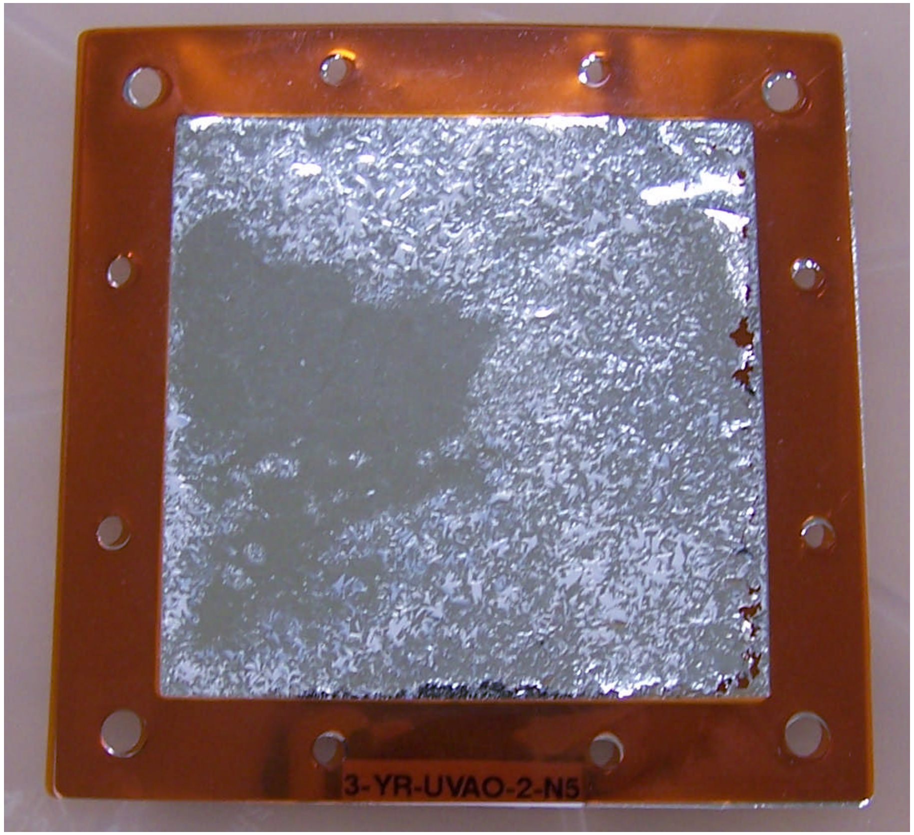


NeXolve Corporation CP1 Films

- Used in solar sails, solar concentrator systems, large antennas
- One sample exposed for one year on ram side
  - CP1 with aluminum and SiOx coating
- Four samples exposed for one year on wake side
  - CP1 with and without aluminum
  - CP1 with aluminum and SiOx coating and ripstop fiber
- Four samples exposed for four years on wake side
  - CP1 without aluminum, with butt joint and lap joint
  - CP1 with aluminum
  - CP1 with aluminum and SiOx coating and ripstop fiber

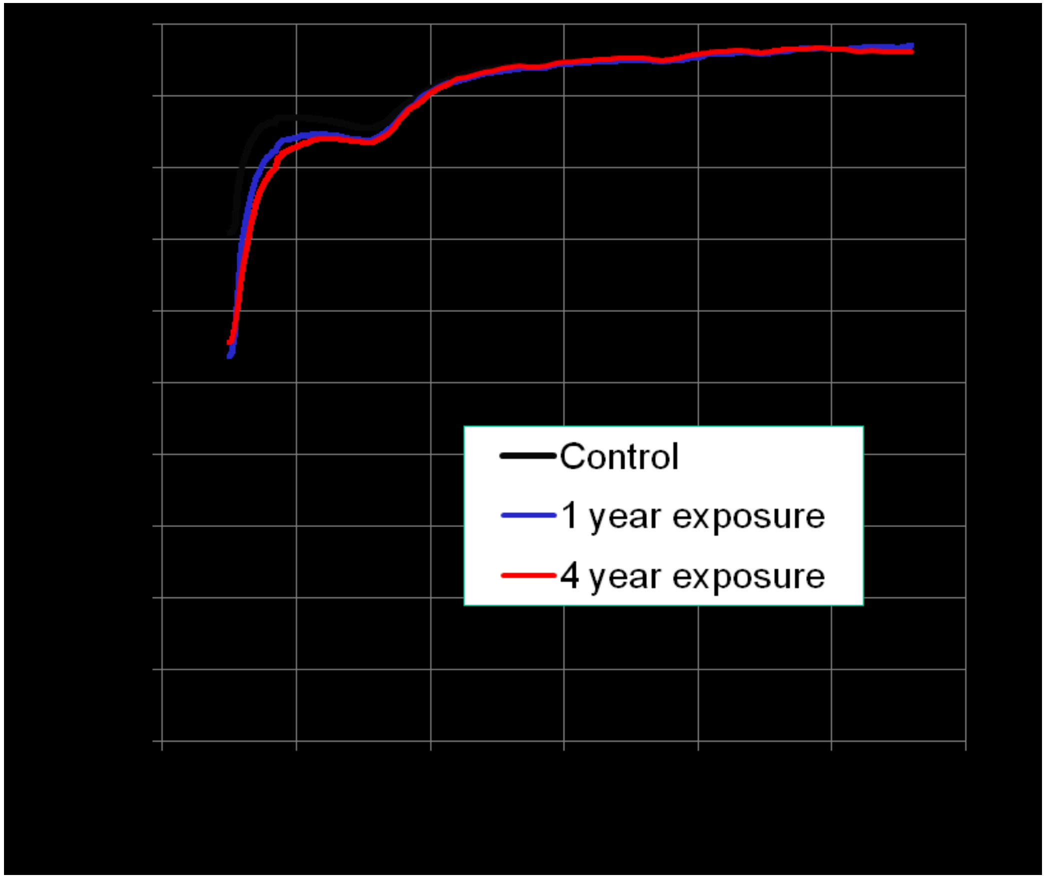
1 mil CP1 with aluminum and SiOx coating

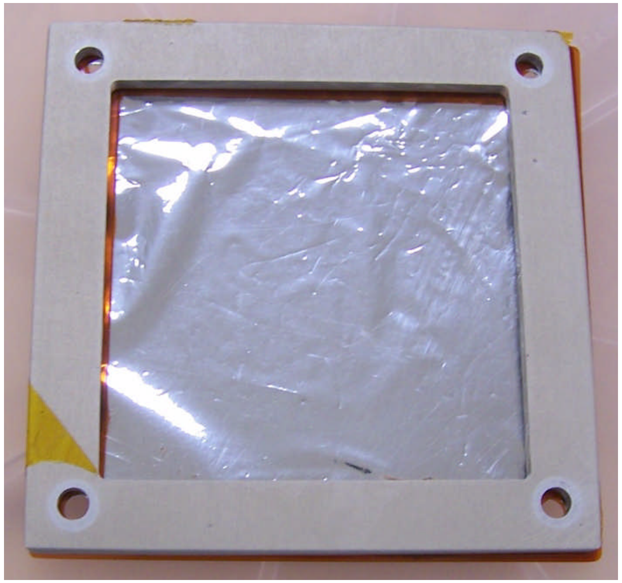
- Exposed to 1.3 x 10^{21} atoms/cm^2 AO
- Some erosion through film



1 mil CP1 with aluminum coating

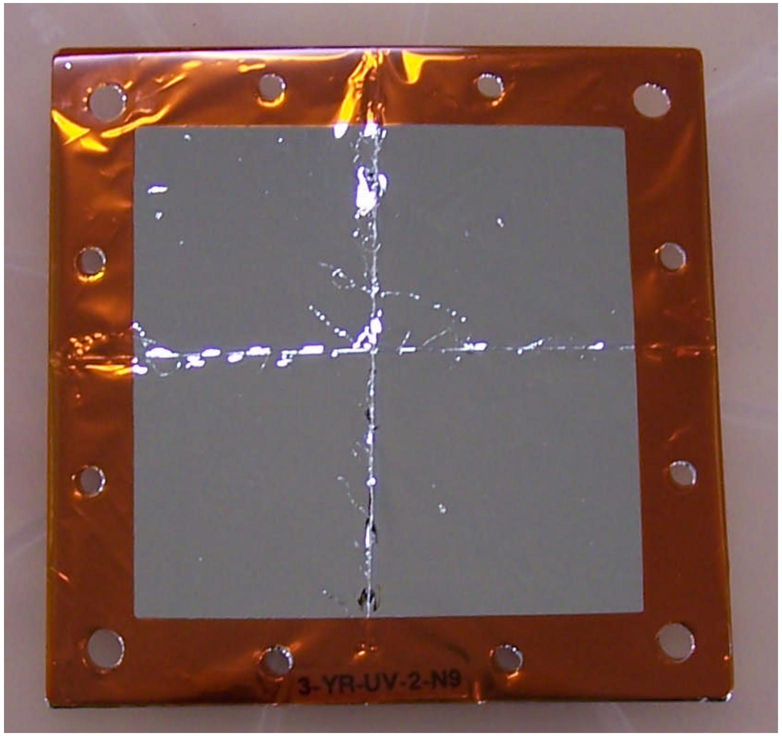
- Some oxidizing of aluminum coating noted





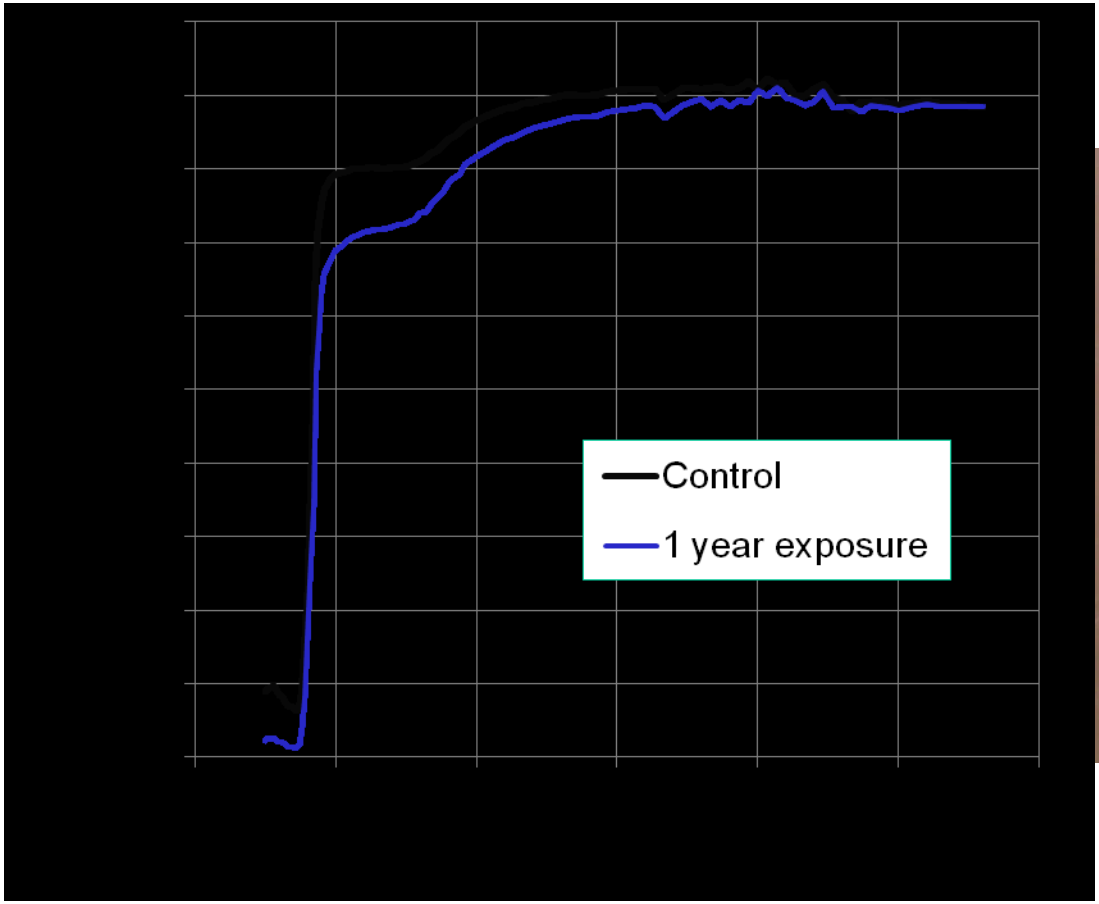
5 micron CP1 with Al and SiOx coating and ripstop

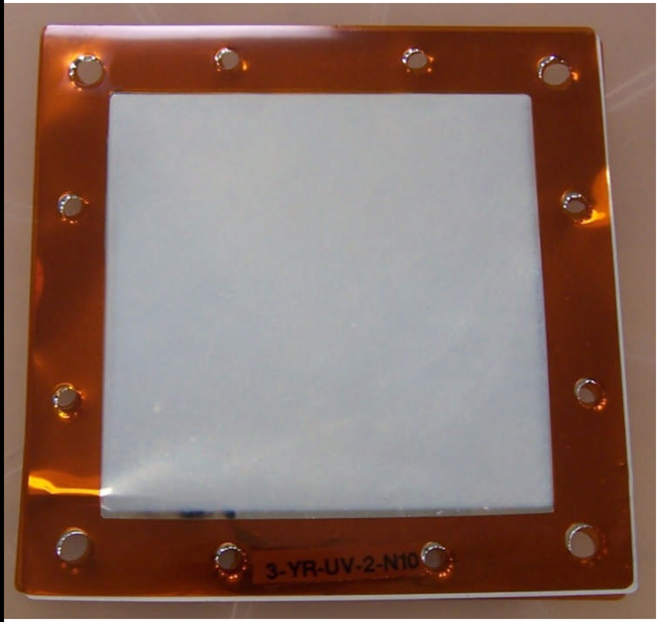
- Some oxidizing of aluminum coating noted
- Ripstop intact



1 mil CP1 with aluminum coating

- CP1 side exposed
- AO erosion evident – emittance dropped from 0.65 to 0.61

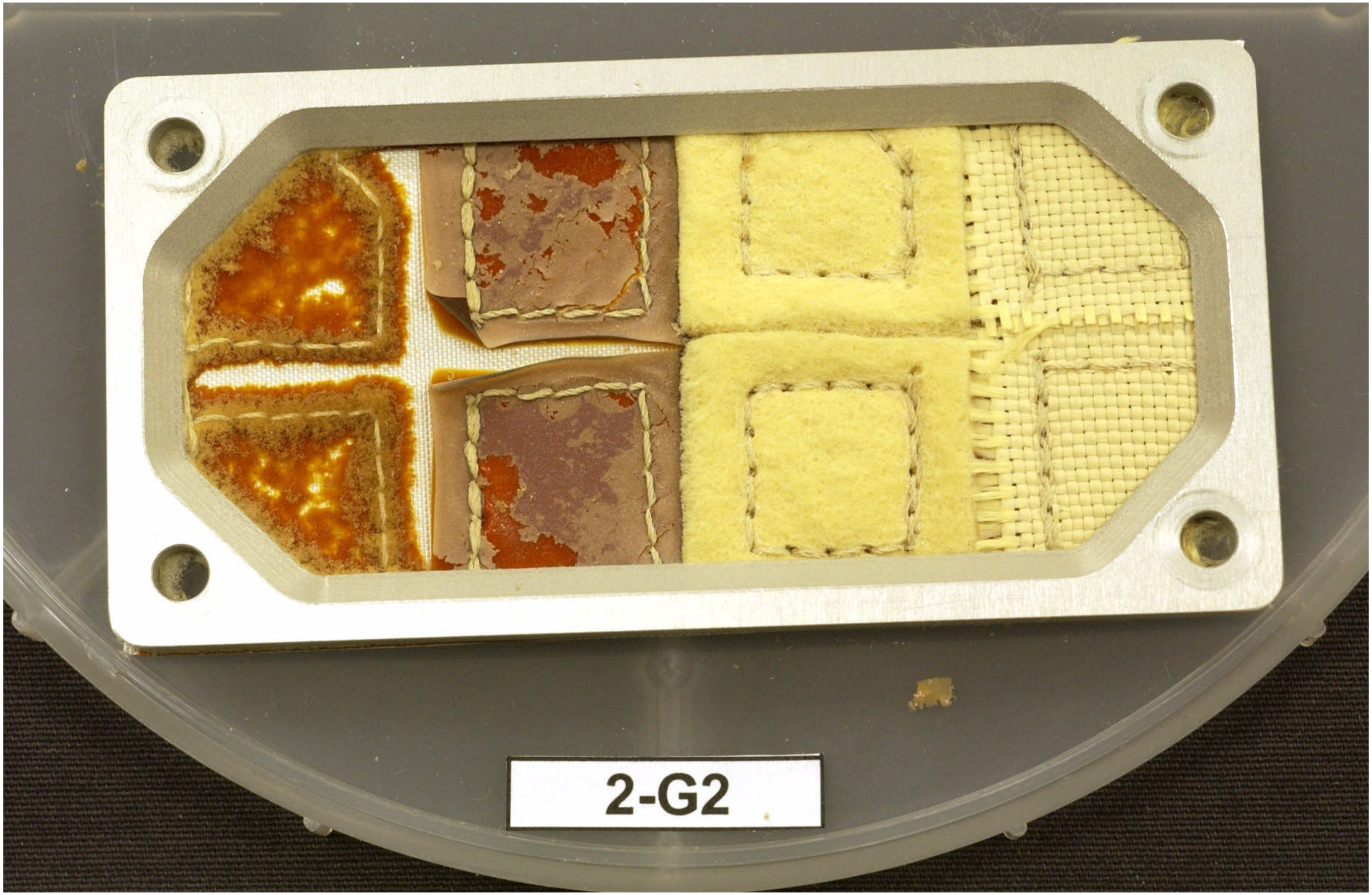




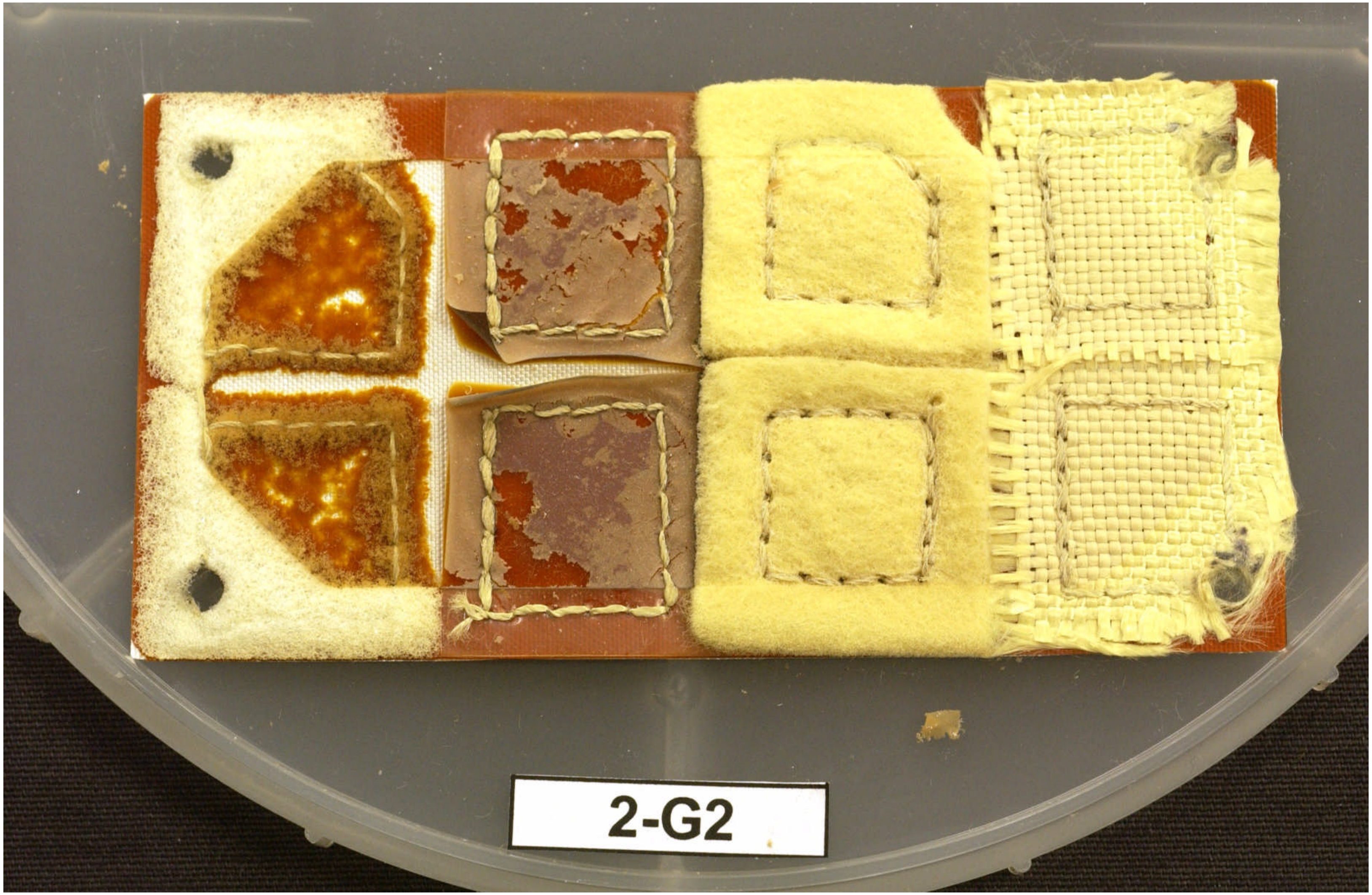
Transhab Materials

- Candidate materials for inflatable module
- Program cancelled, but development continued with Bigelow Aerospace Genesis and Nautilus spacecraft

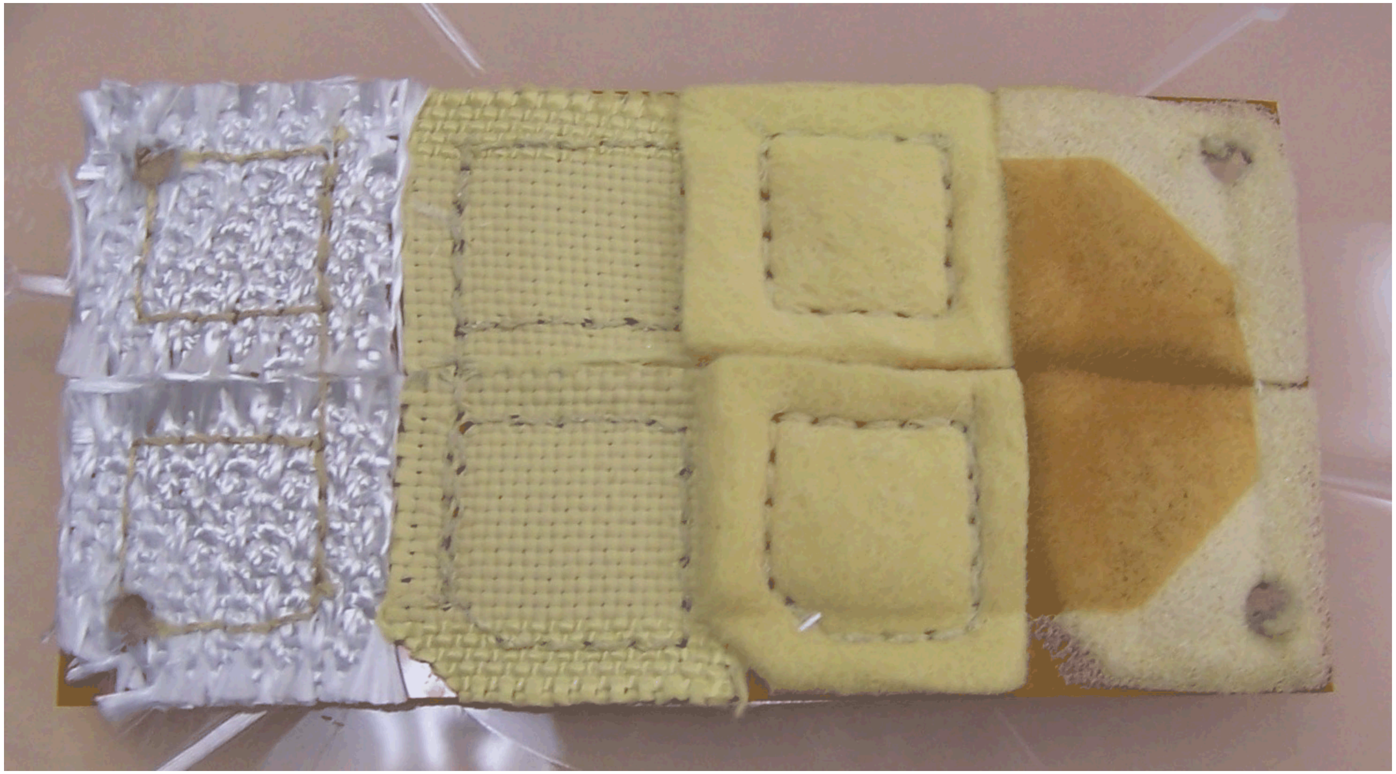
Polyurethane foam, Combitherm bladder material, Kevlar felt, Kevlar webbing



Polyurethane foam, Combitherm bladder material, Kevlar felt, Kevlar webbing



Nextel cloth, Kevlar webbing, Kevlar felt, polyurethane foam



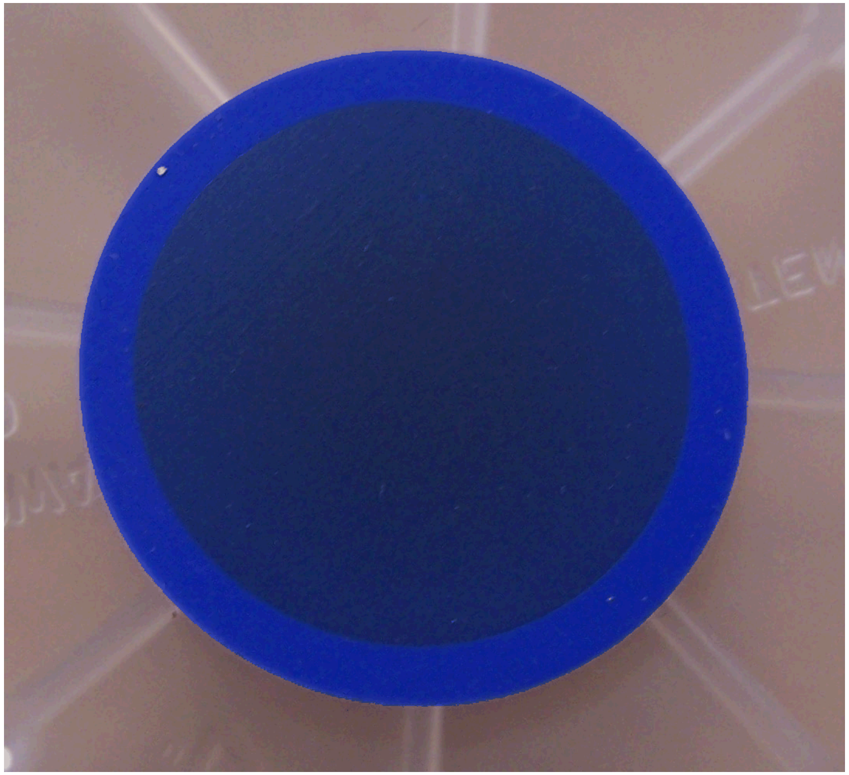
Transhab Materials

- Foam and bladder materials heavily eroded
  - No AO reactivity calculated
- Kevlar materials, including thread intact, after four years
- Nextel intact (one year exposure)
- Sizing appears to be removed

Seal Materials

Fluorosilicone

- Little mass loss
  - 1.5 mg (0.13%) for four-year exposure
- Darkened due to UV
- Some glassification



Seal Materials

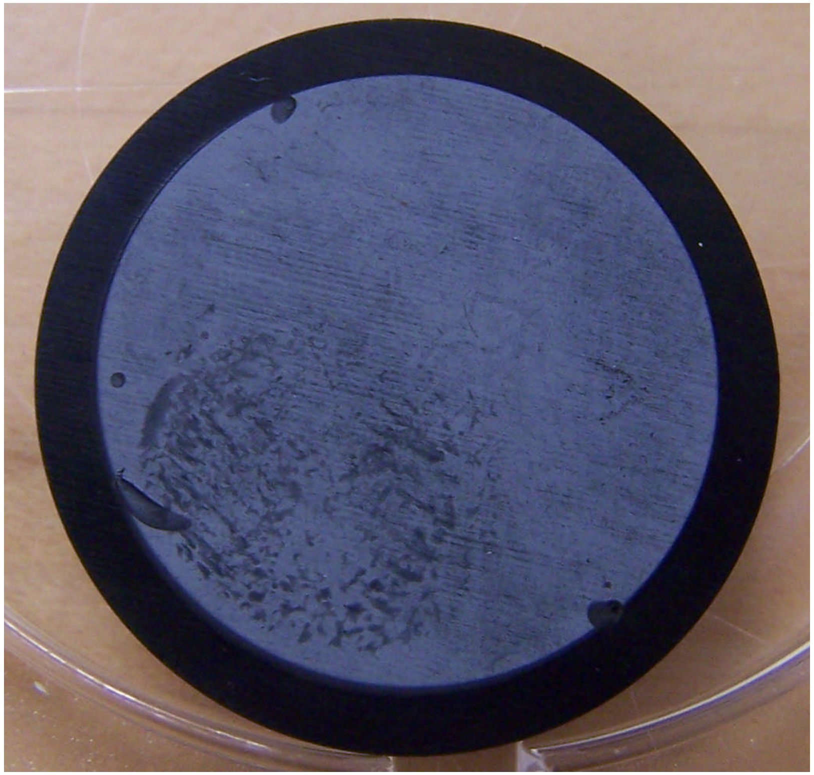
Silicone S383

- Mass increase with the formation of SiOx
- Cracking evident

Seal Materials

Viton 835

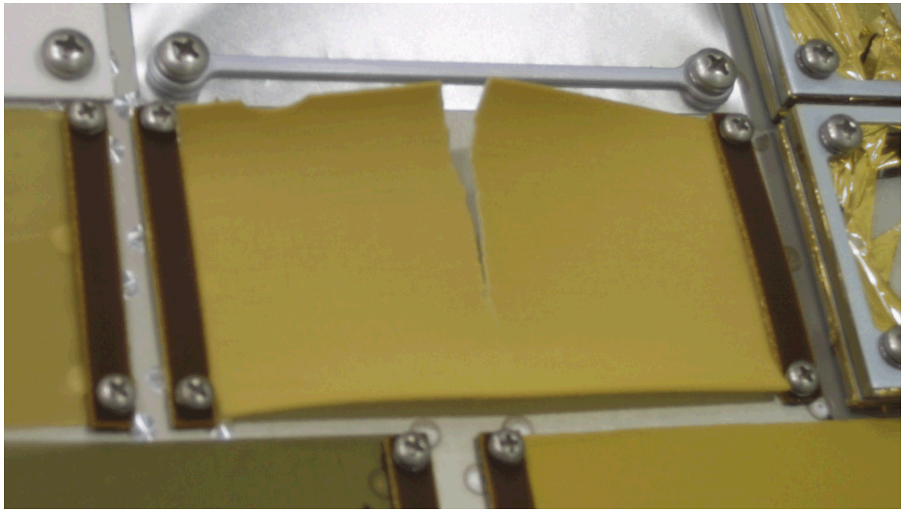
- Some mass loss
  - 3.7 mg (0.32%) for one-year exposure
- Calculated AO reactivity
  0.26×10^{-24} cm^{-3}/atom

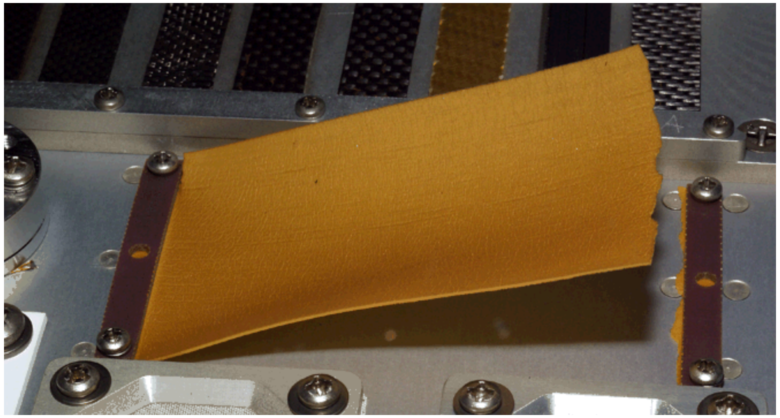


Other Polymeric Materials

Boeing Dielectric Film

Withstood AO attack, too brittle for much analysis





Conclusions and Future Research

- UV-rejection coatings worked as intended
- CP1 films performed better on wake side
- Transhab foam and bladder materials heavily eroded by AO
- Kevlar and Nextel performed as expected
- Seal samples should be evaluated for permeability
- MISSE-6 returning on STS-128
  - Germanium/Kapton
  - L'Garde materials incl. ripstop and grounding patch
  - Ballute materials Upilex and PBO
  - NeXolve CORIN, EP2550, conductive CP1