MSFC-202_ABSTRACT

Optical Property Measurements on the Stardust Sample Return Capsule

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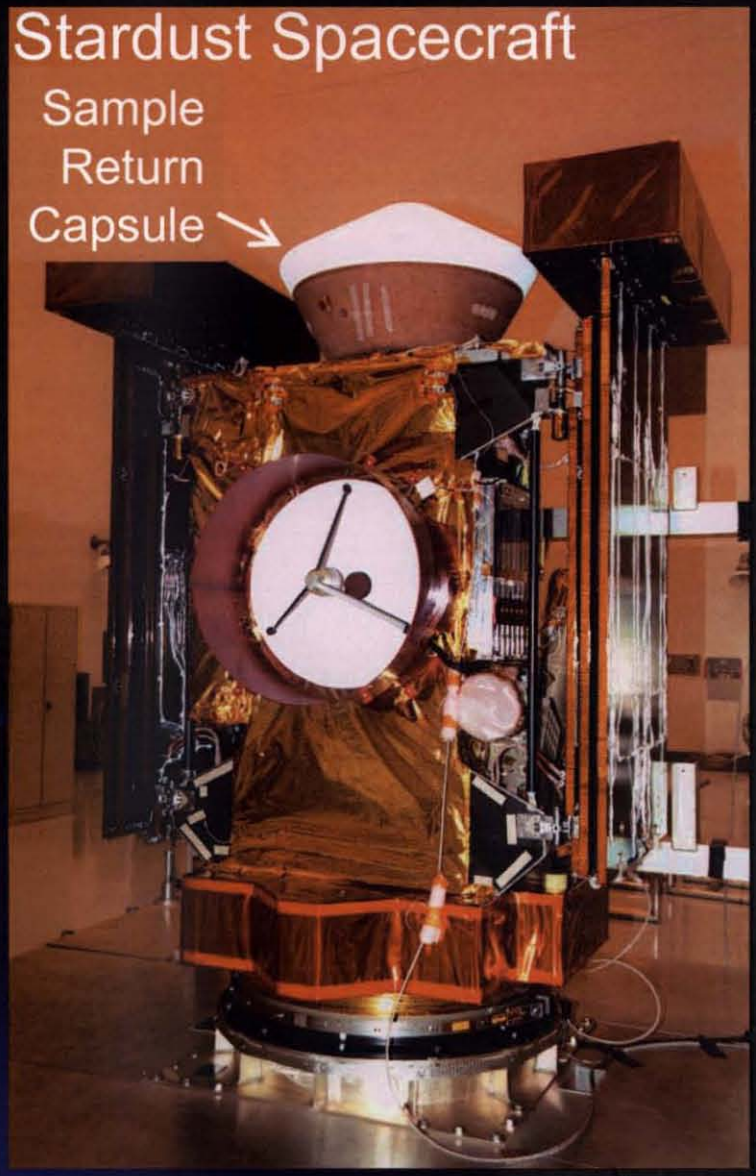
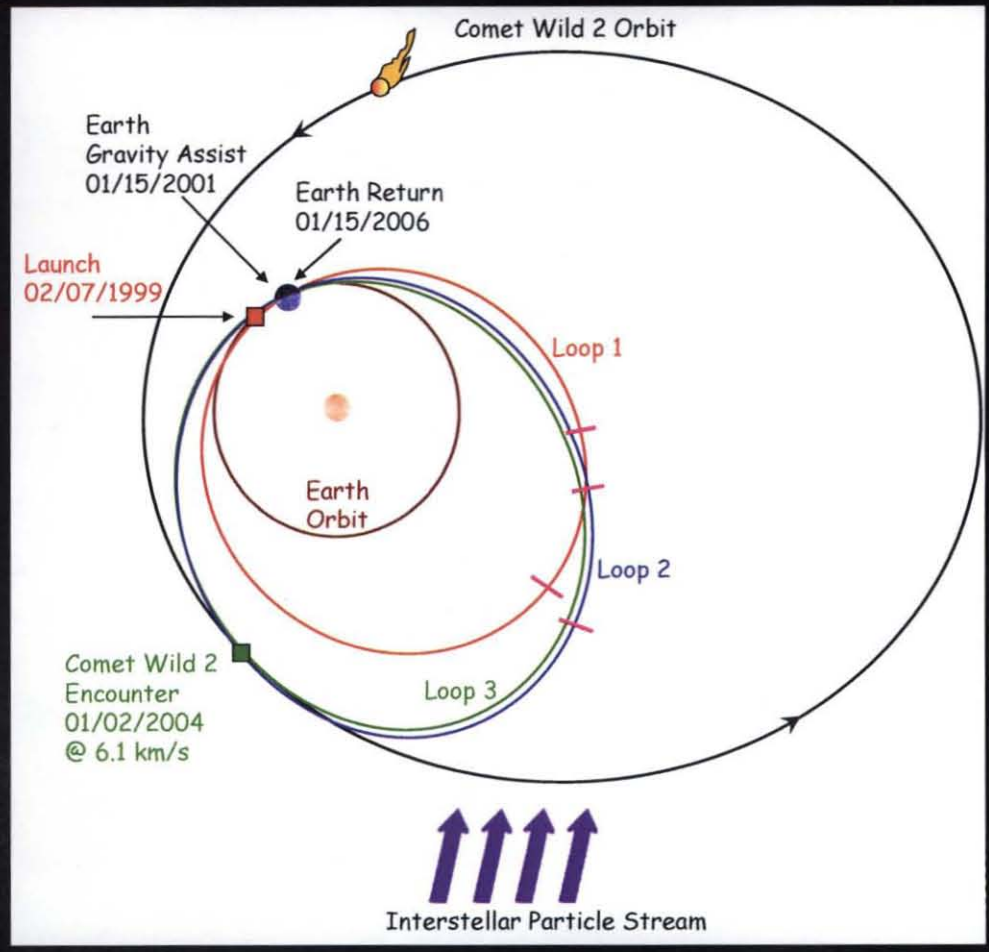
The Advanced Materials for Exploration (AME) task *Materials Analysis of Returned Hardware from Stardust* received funding to perform non-destructive analyses of the non-primary science hardware components of the Stardust sample return capsule. These components were (a) the blunt body reentry heatshield, encased in Phenolic Impregnated Carbon Ablator (PICA); (b) the backshell of Super Lightweight Ablator 561 (SLA-561) material handpacked into phenolic Flexcore and coated with CV-1100 silicone; (c) the rope seal used in between the heatshield and backshell; (d) the internal multi-layer insulation (MLI) blankets; and (e) parts of the Kevlar straps left attached to the backshell. These components were analyzed to determine the materials' durability in the space environment. The goals of the task were (a) to determine how the various materials from which the components were built weathered the extreme temperatures and harsh space environment during the capsule's nearly 7-year voyage to and from its rendezvous with Comet Wild 2 and (b) to provide lessons-learned data for designers of future missions.

Optical Property Measurements on the Stardust Sample Return Capsule

Stardust Spacecraft



Mission Trajectory



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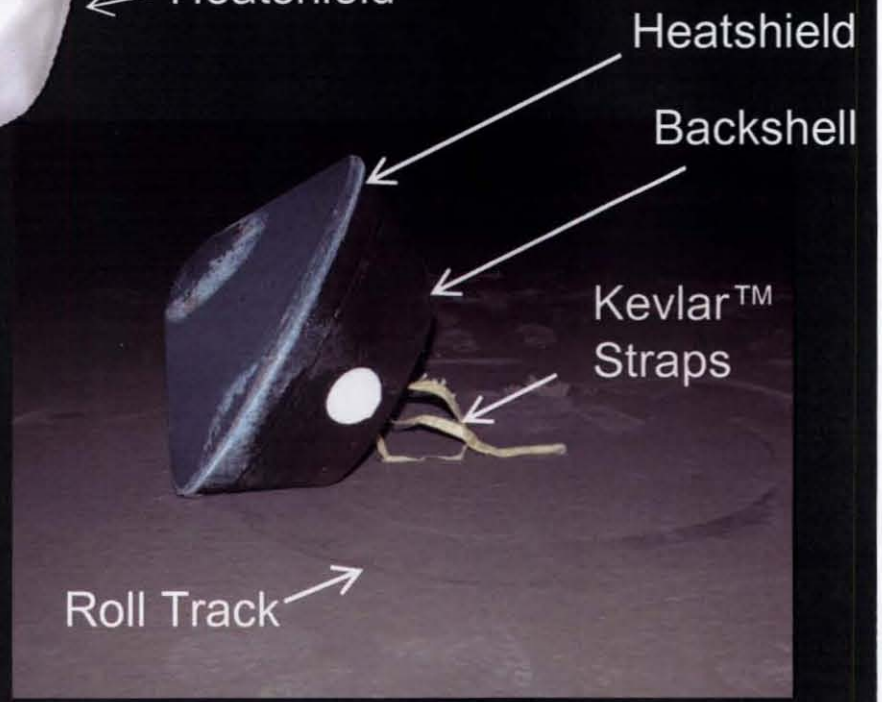

The Sample Return Capsule is the only part of Stardust that has been returned to Earth. The waffle grid with aerogel collectors is primary science. The non-primary science hardware (heatshield, backshell, etc.) was the focus of this research effort – to evaluate the materials' durability after 7 years in space plus re-entry heating, and provide useful information for aerocapture designers and thermal engineers.

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Stardust Components Studied

- Heatshield – Phenolic Impregnated Carbon Ablator (PICA)
- Back shell – Super Lightweight Ablator SLA-561V handpacked into phenolic Flexcore and sprayed with CV–1100 silicone
- Rope seal
- Multilayer insulation (MLI) blankets
- Kevlar™ straps
- Control samples of PICA and SLA-561V
- PICA tested in arcjet at Ames Research Center

Access to other non-primary science hardware, including avionics box, deployment/retraction mechanisms, and parachute, was denied.

NDE Methods used on Stardust

- Visual observations
- Black-light observations to detect contamination
- Solar absorptance measurements using Laboratory Portable Spectroreflectometer
- Infrared reflectance measurements by both TEMP 2000 [integrated infrared emittance (ε_{IR})] and Laboratory Portable Infrared Reflectometer (spectral reflectance between 2 and 20 microns)

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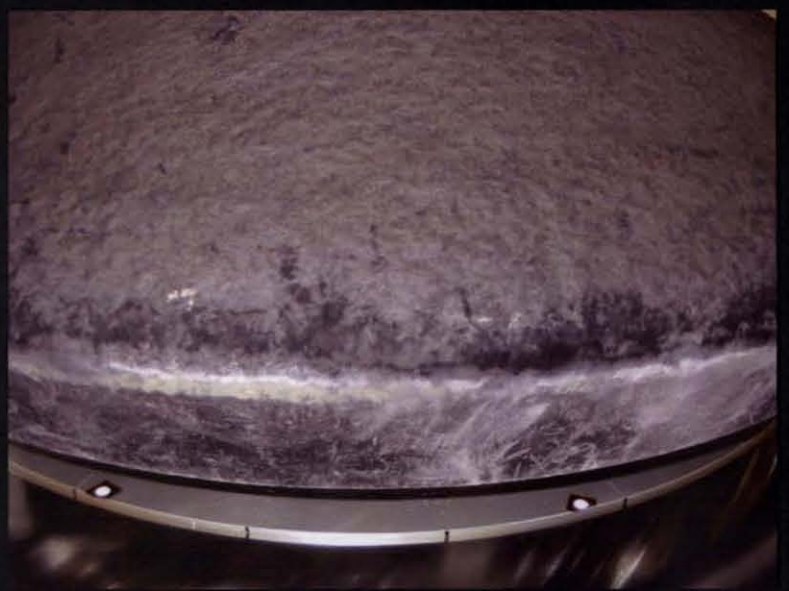
Heatshield

- PICA performed very well.
- Rim of blunt body design seemed to have been more affected than nose.
- Arcjet testing produced comparable results.
- May be very useful for lunar missions where the heat flux is greater than 400 W/cm^2
- TPS ablator used on Apollo (Avcoat 5026-39/HC-G) is no longer available.



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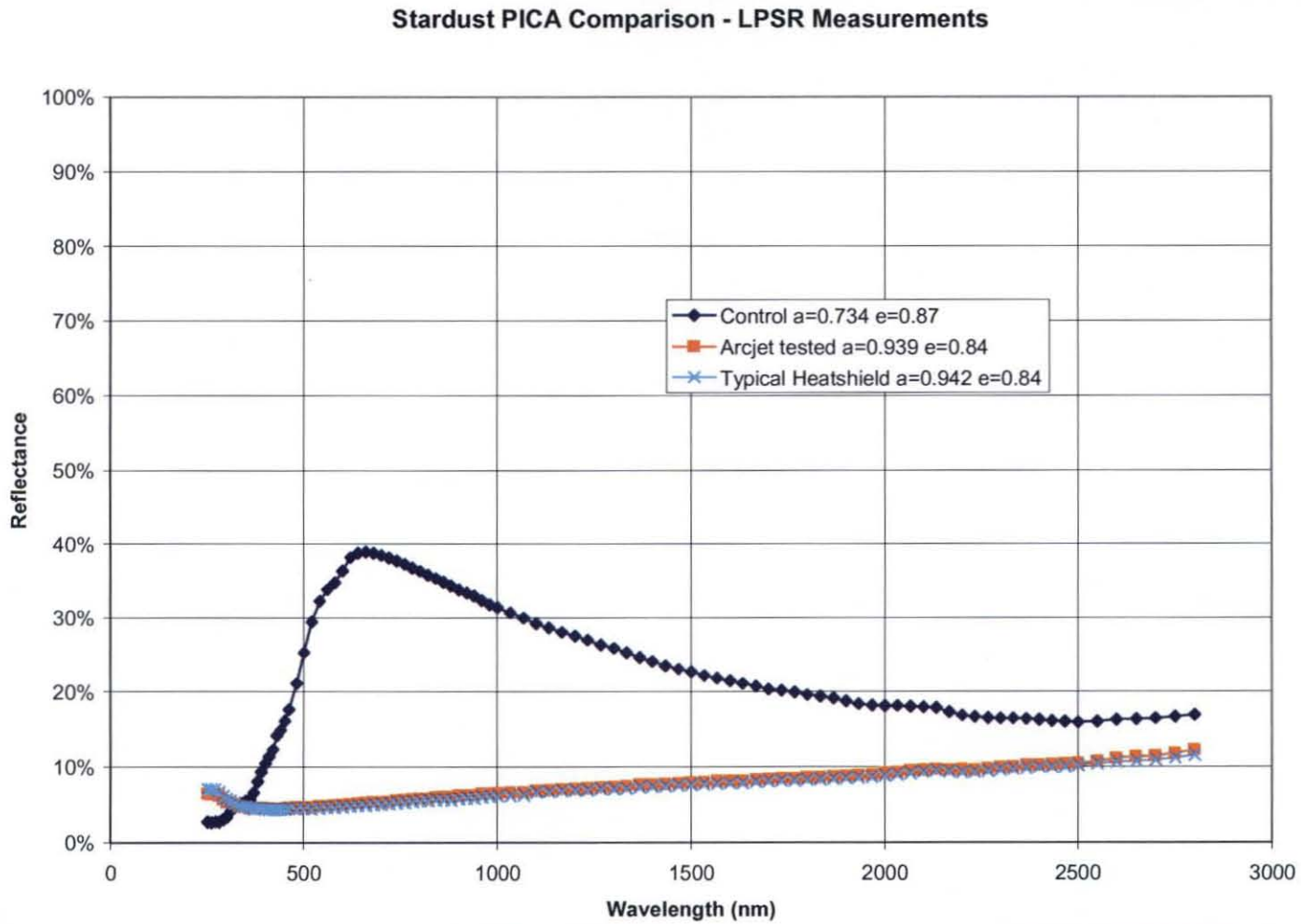
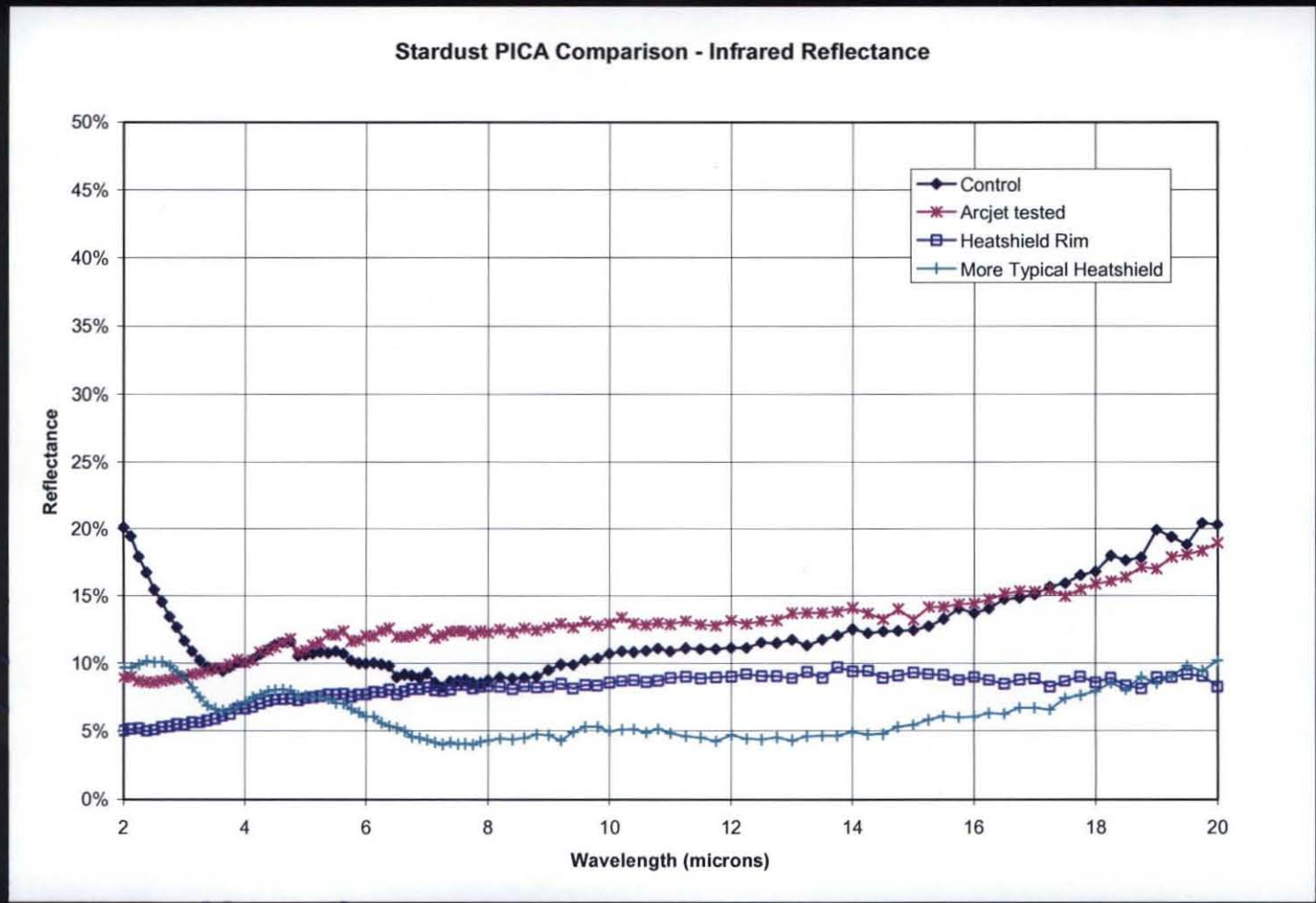
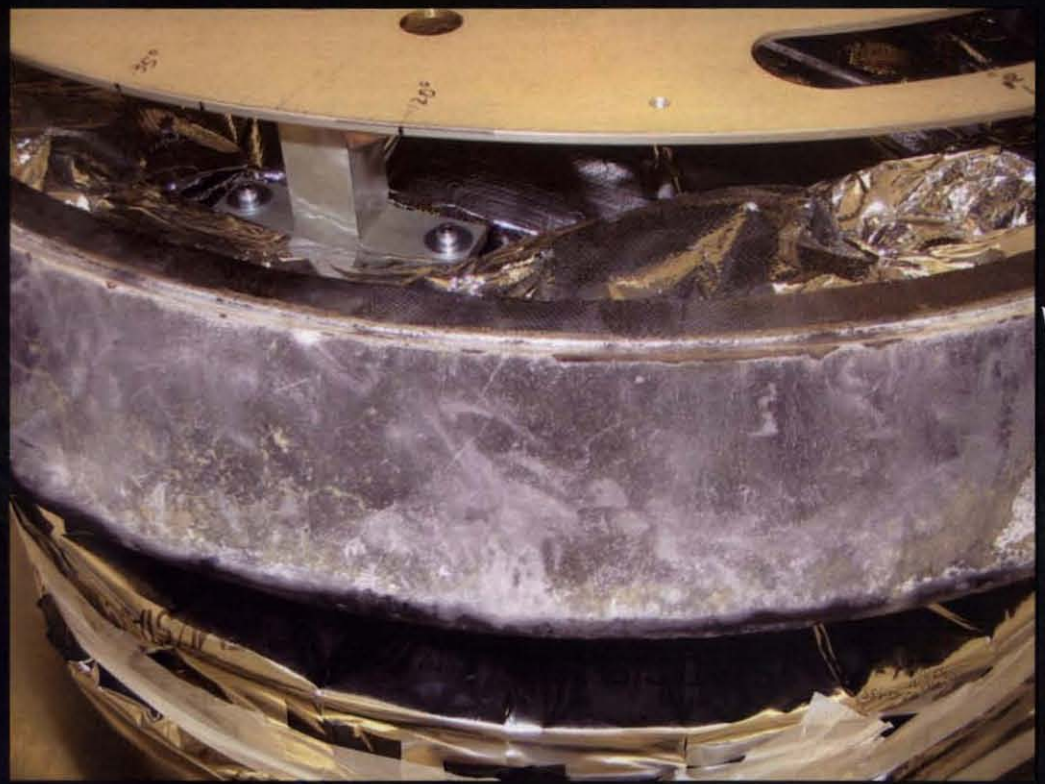


Optical Property Measurements on the Stardust Sample Return Capsule



Z93 Thermal Control Coating



Mostly burned off; some left near mating edge

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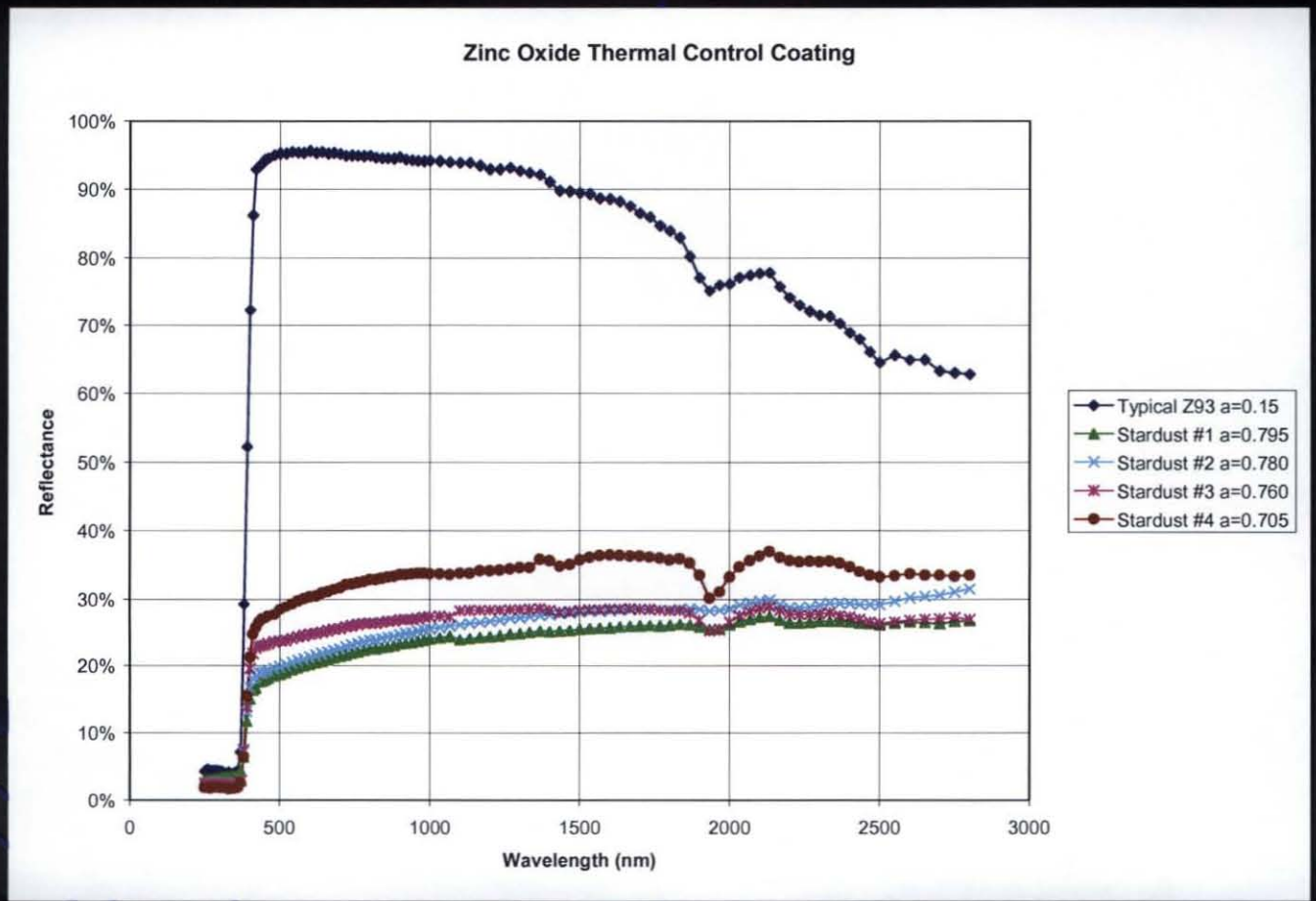

These data differentiate between the Z93 and the Utah dirt and confirm what Betsy Pugel (GSFC) observed in her photoluminescence studies.

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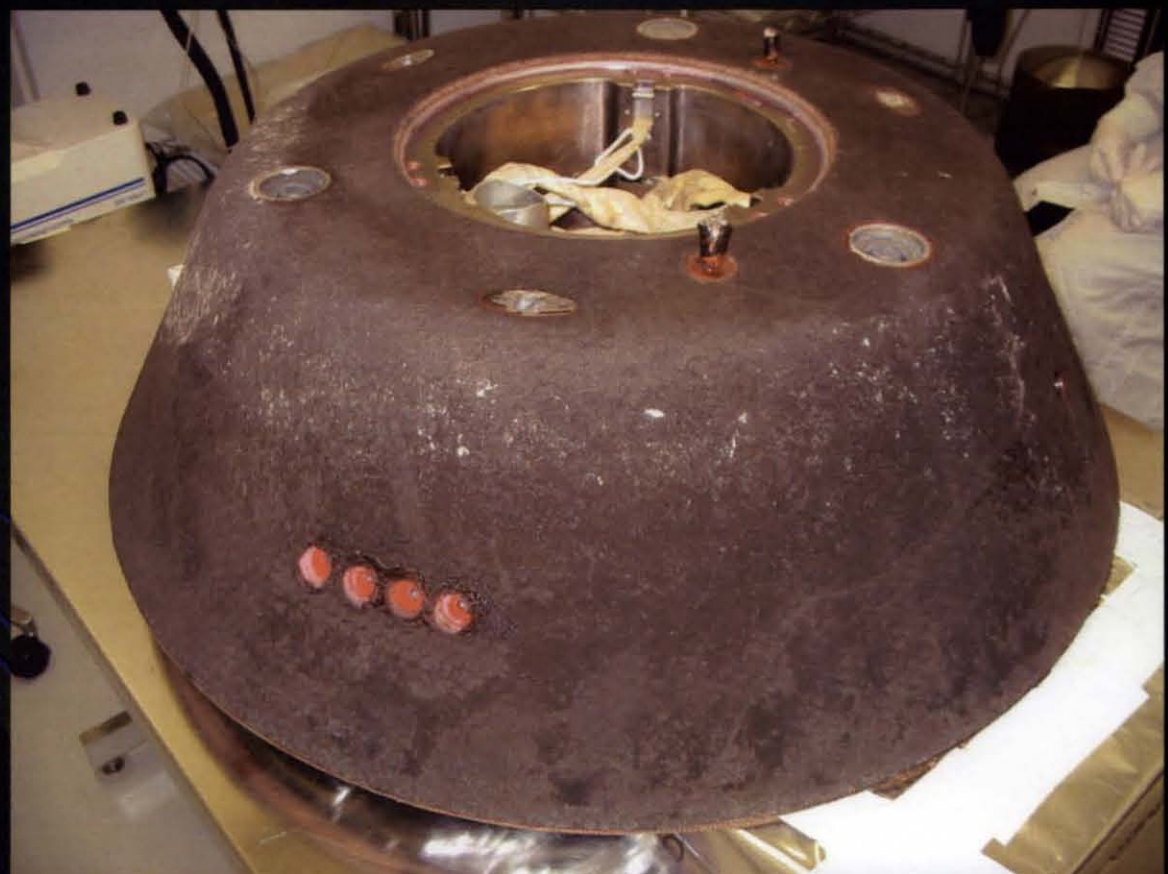
Backshell

- SLA-561V still had strong burnt odor after 6 months in atmosphere.
- Many more features visible under black light



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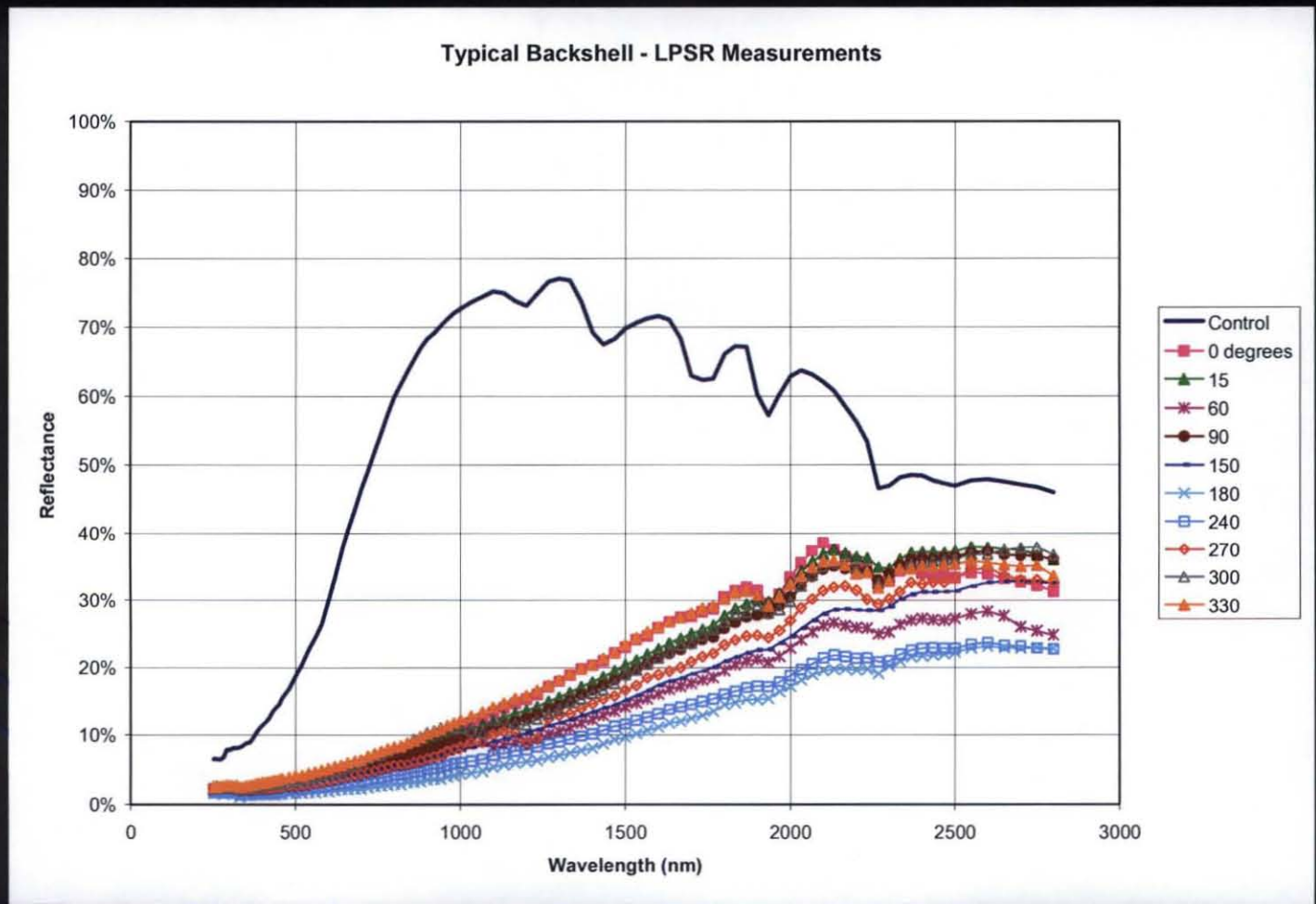

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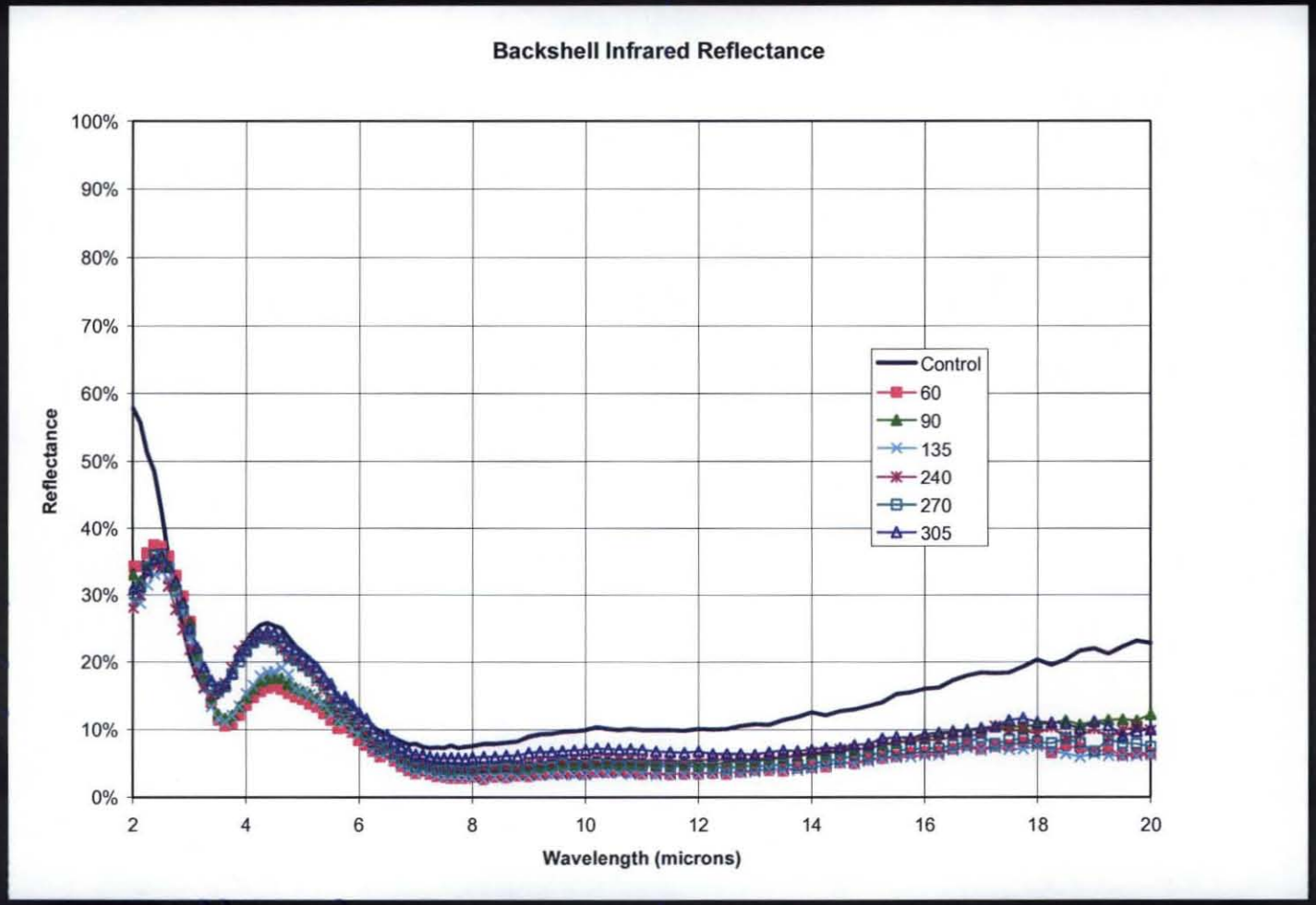

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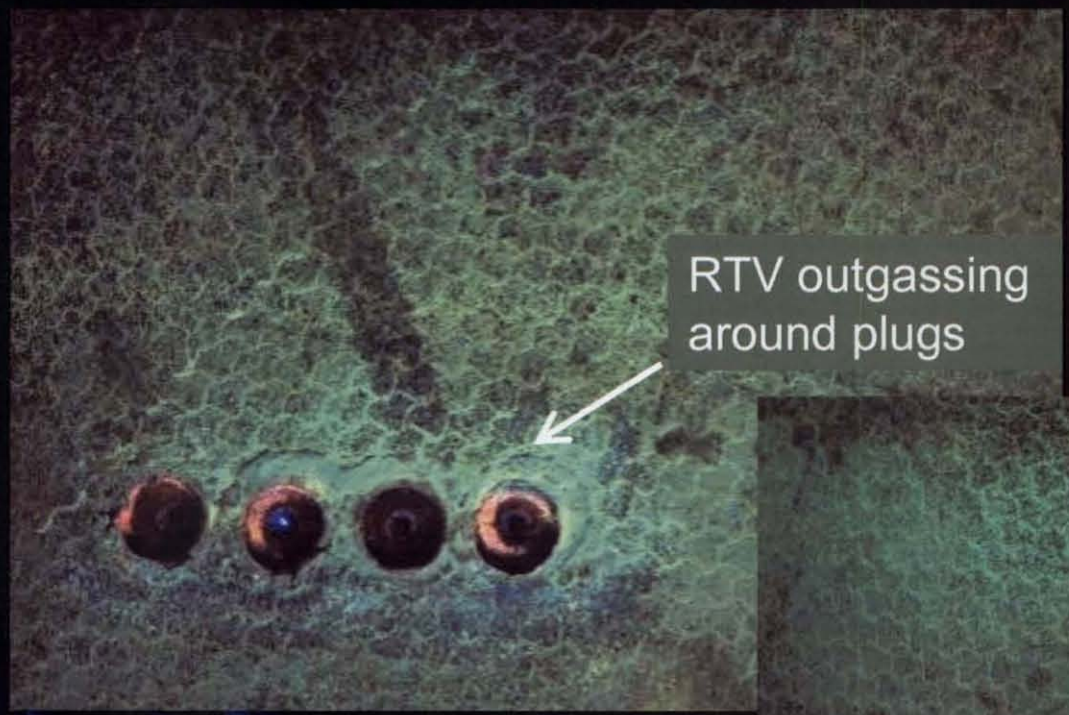
Black-light photos



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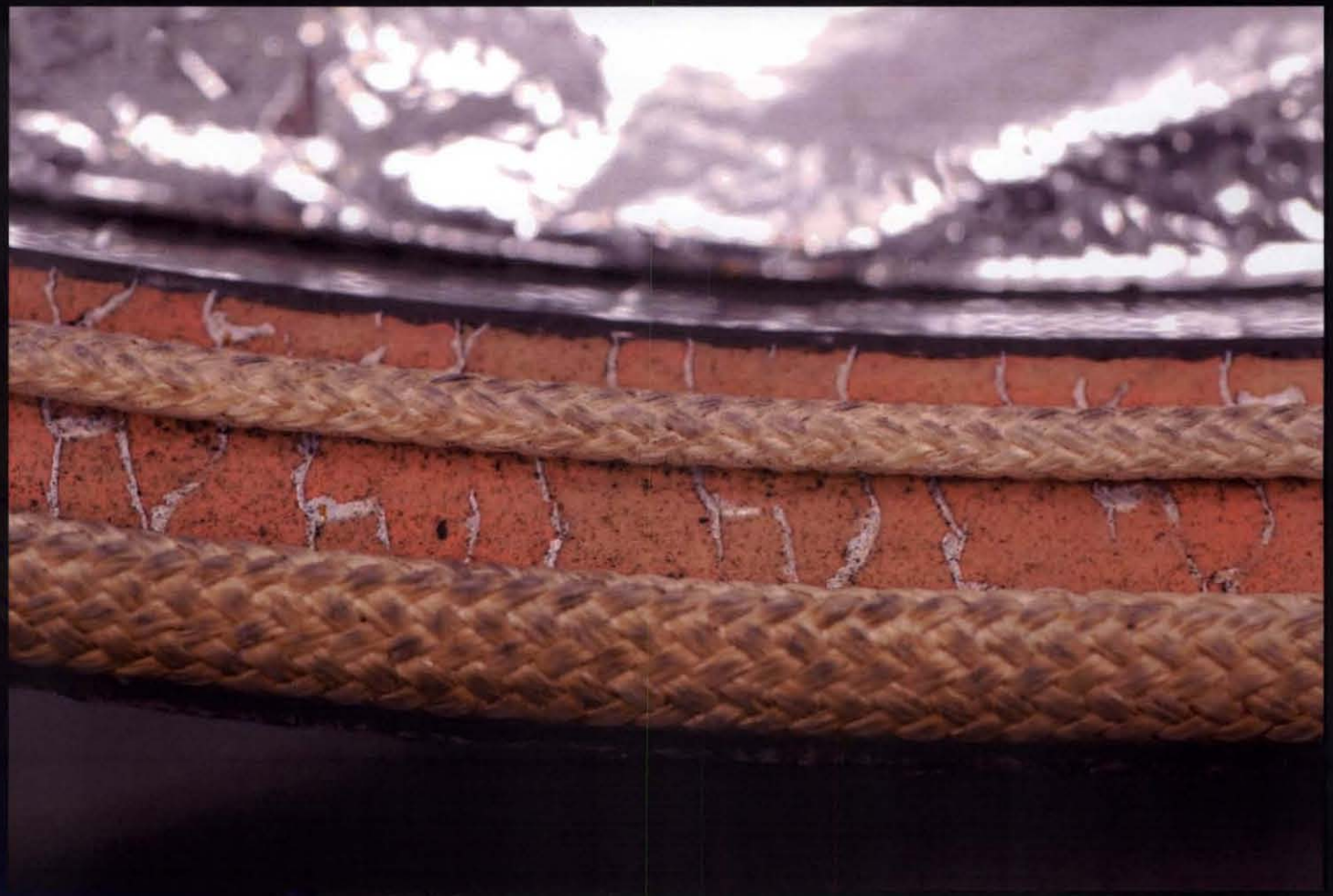
Rope Seal



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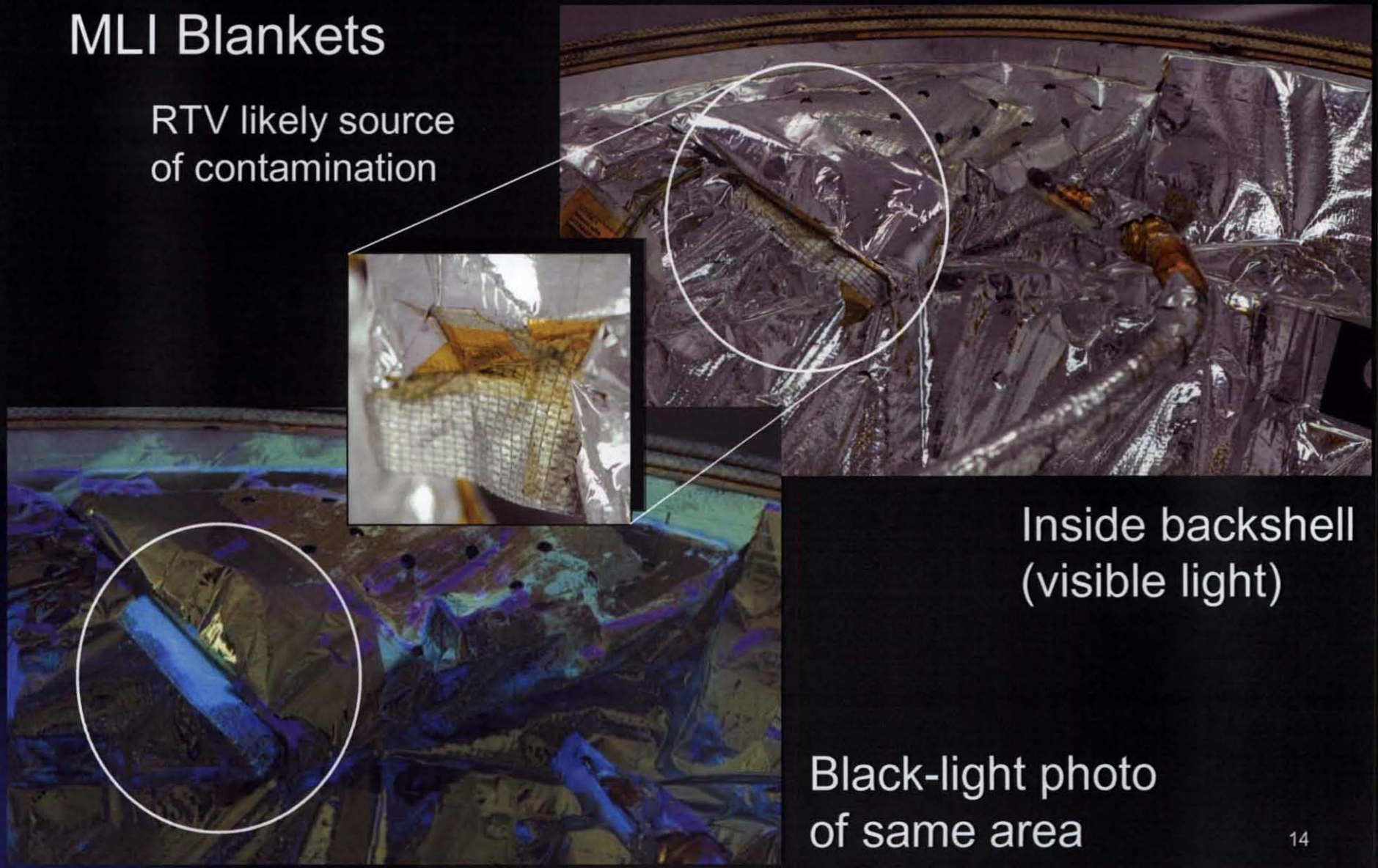
MLI Blankets

RTV likely source of contamination



Inside backshell (visible light)

Black-light photo of same area

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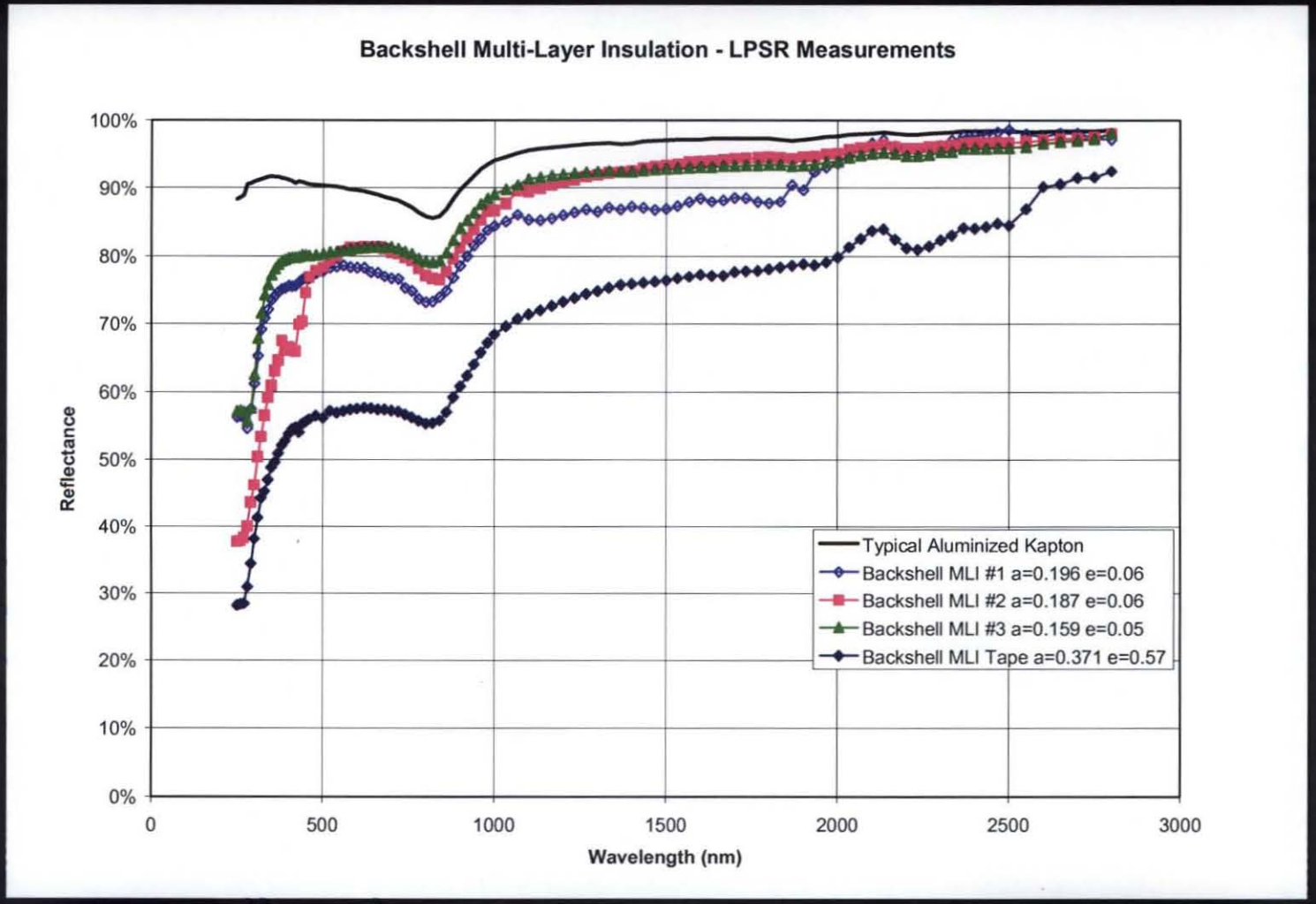

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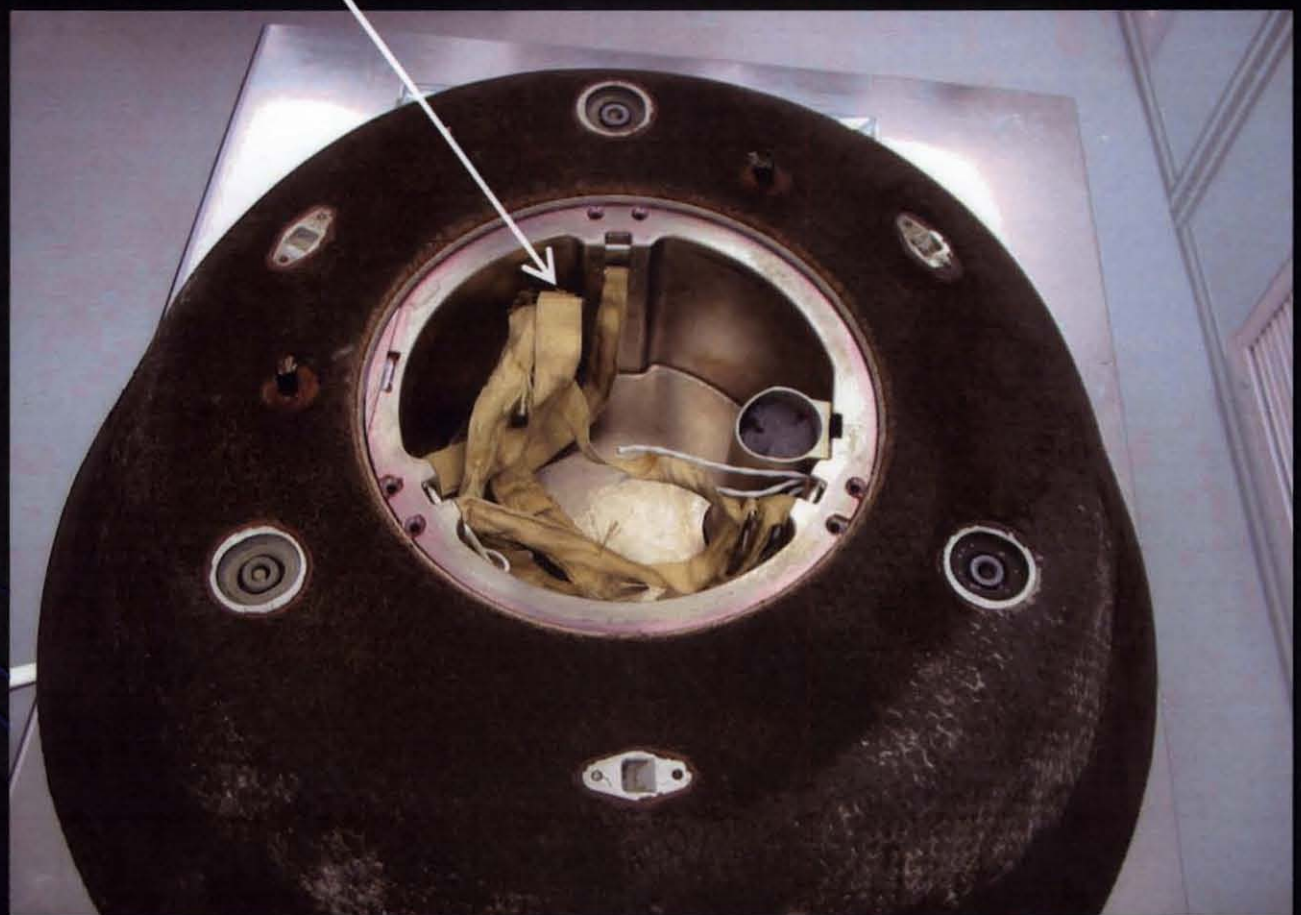
Kevlar™ Straps



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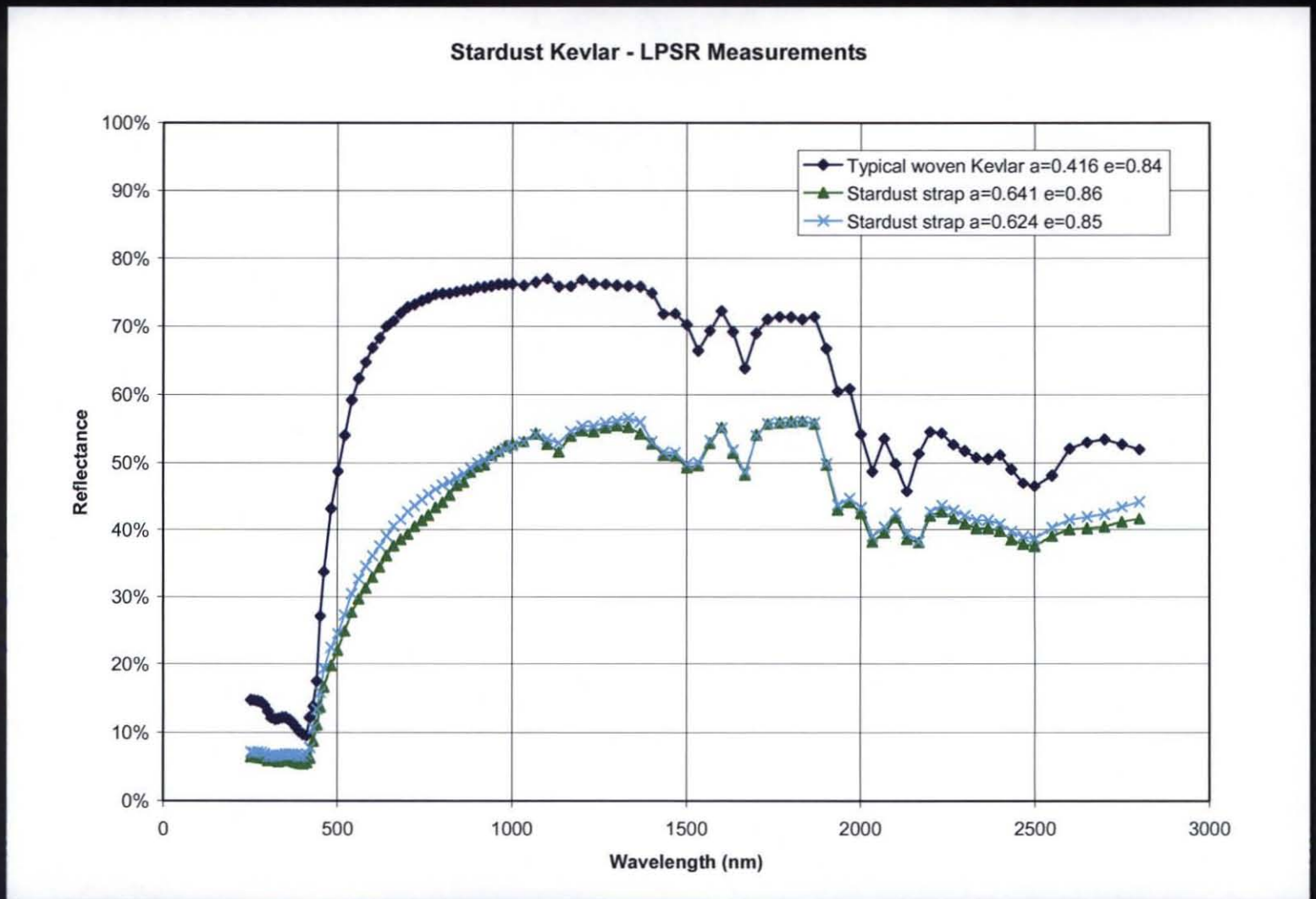

Future activities

- Coring of the heatshield and backshell to determine pyrolysis zone depth (Ames).
- FTIR analysis of the cored PICA to study radiation effects
- Further investigation into contaminant film on the MLI blankets
- Understand contaminant's effect on optical properties
- Assist science team members who are analyzing organic compounds in the cometary and interstellar material

Acknowledgments

- Dr. Carlton Allen, Dr. Karen McNamara, and Dr. Michael Zolensky of the Astromaterials Acquisition and Curation Office at JSC for access to Stardust
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