

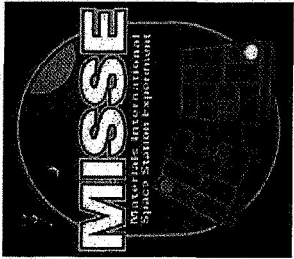
Optical Coatings and Surfaces in Space: MISSE

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West Hills, CA 91304-3232

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Environmental Effects Group
Mail Code EM50 Bldg. 4711 Room 100C
Marshall Space Flight Center, AL 35812

Abstract

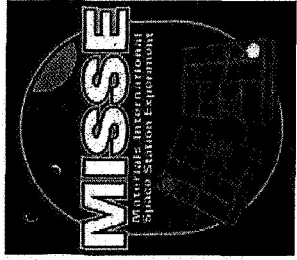
The space environment presents some unique problems for optics. Components must be designed to survive variations in temperature, exposure to ultraviolet, particle radiation, atomic oxygen and contamination from the immediate environment. To determine the importance of these phenomena, a series of passive exposure experiments have been conducted which included, among others, the Long Duration Exposure Facility (LDEF, 1985- 1990), the Passive Optical Sample Assembly (POSA, 1996-1997) and most recently, the Materials on the International Space Station Experiment (MISSE, 2001-2005). The MISSE program benefited greatly from past experience so that at the conclusion of this 4 year mission, samples which remained intact were in remarkable condition. This study will review data from different aspects of this experiment with emphasis on optical properties and performance.



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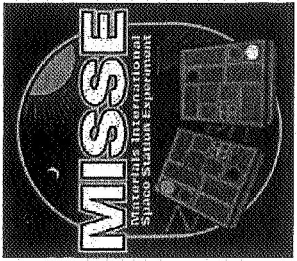
The MISSE Flight Experiment

MISSE - Materials on International Space Station Experiment

a project funded by AFRL and NASA

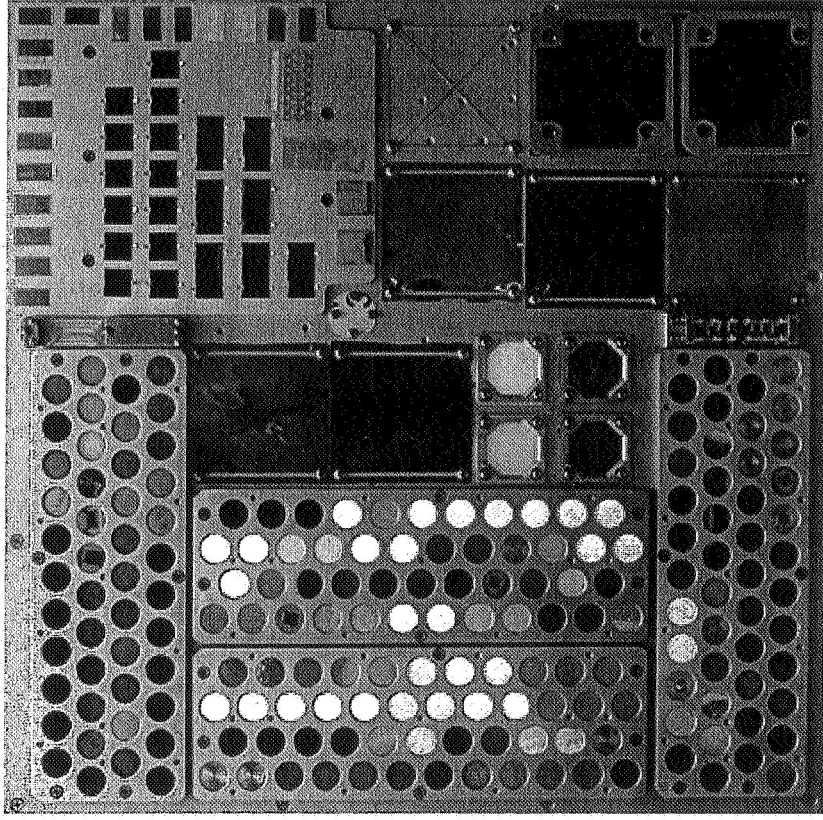
Project leads – Dr. Bill Kinard, NASA LARC
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- Samples placed on station 8-10-01
- Recovery 7-30-05

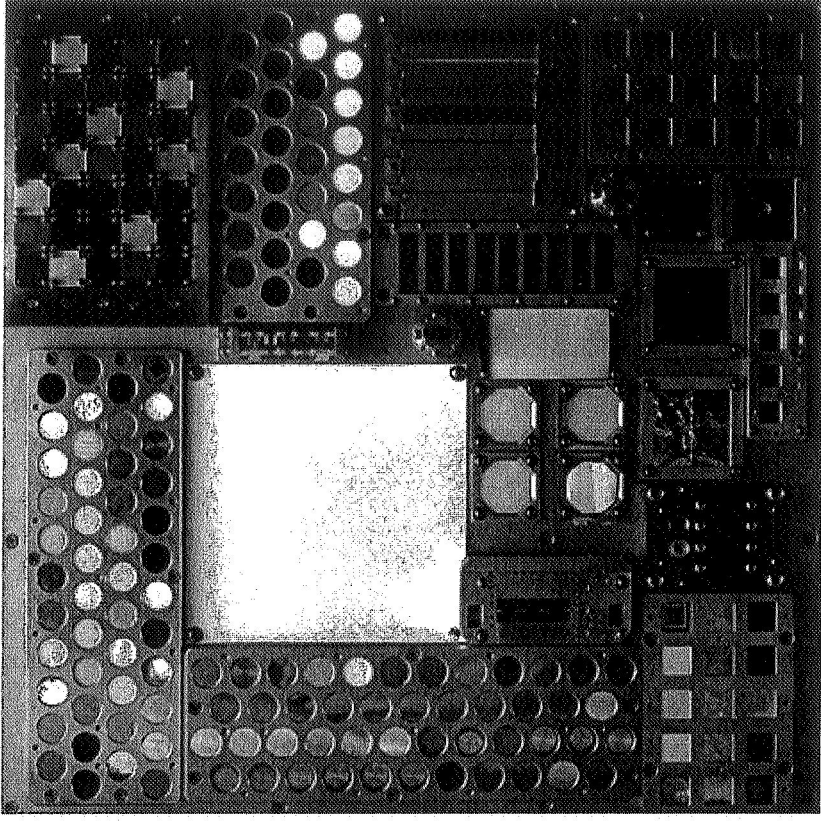



MISSE trays Prior to Deployment

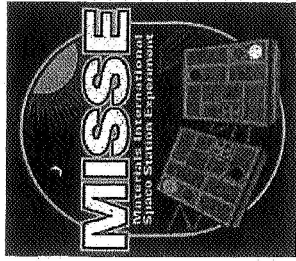
AO and Solar



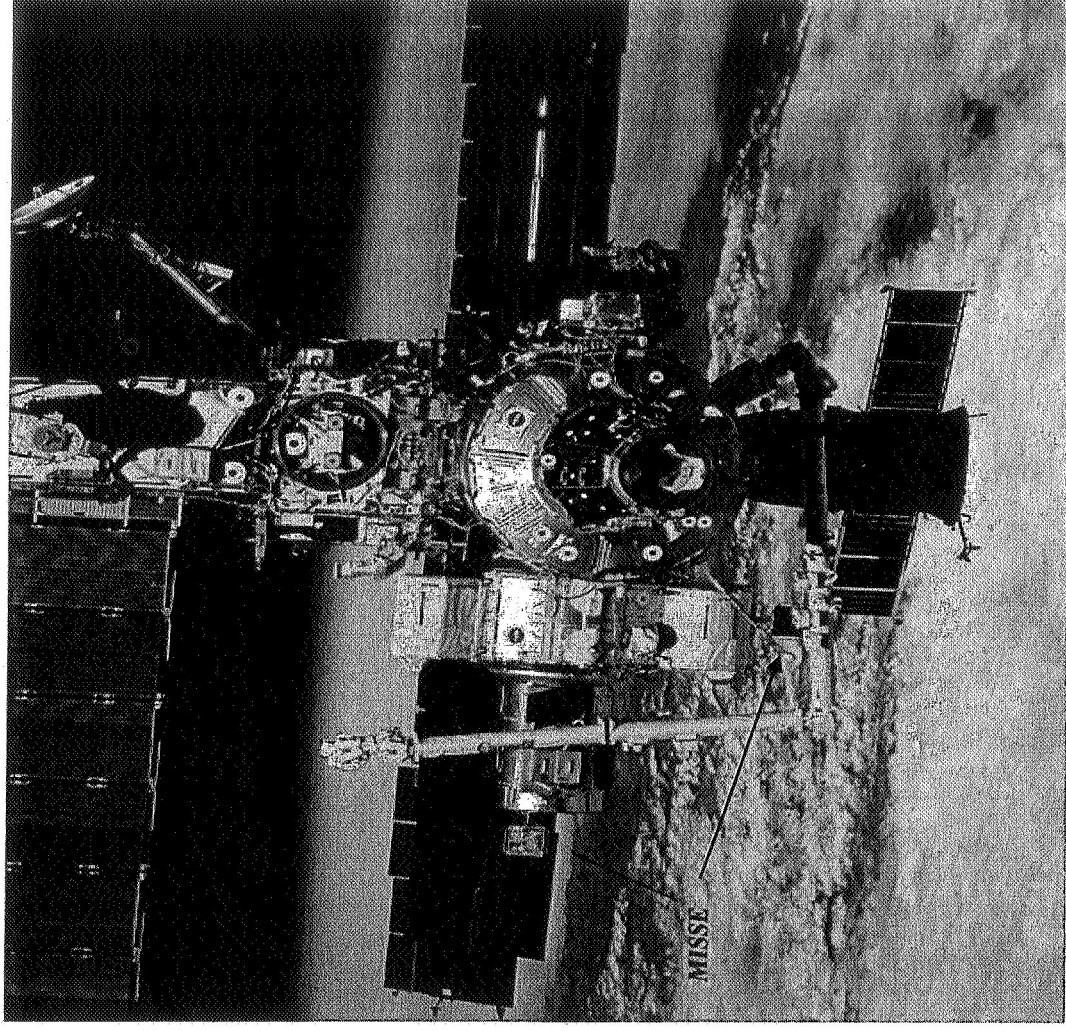
Solar exposure



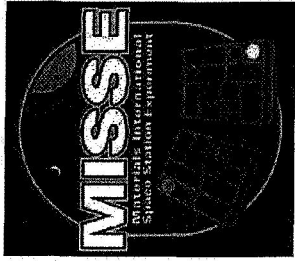
Passive experiment containers (PEC)  **BOEING**
DES



MISSE on the ISS



- Two Modules parked on the ISS for 3.9 years
- Two additional modules installed 7/06
 - 1 year exposure planned
- Locations selected for
 - min/max atomic oxygen
 - min/max solar
- EVA required for placement and retrieval
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Principal Mechanisms for Degradation of Optics in Space

Atomic oxygen
– 5 ev kinetic energy

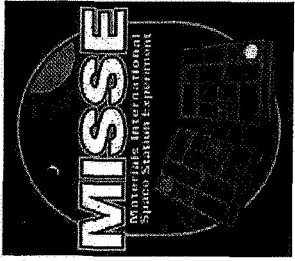
Solar UV exposure

Radiation

Micrometeoroids/Space Debris

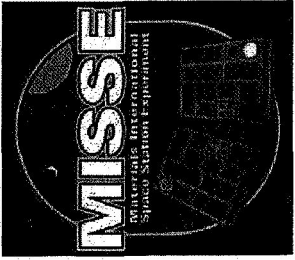
Contamination

- MISSE designed to try to isolate/control AO and solar UV exposure
- Contamination limited by material selection and placement on ISS



Optical Coatings and Windows on MISSE

- >100 samples from about 10 groups
- a broad range of wavelengths and potential applications
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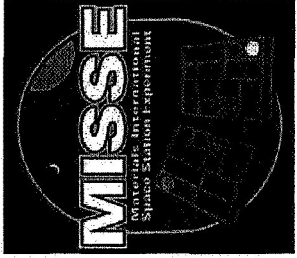
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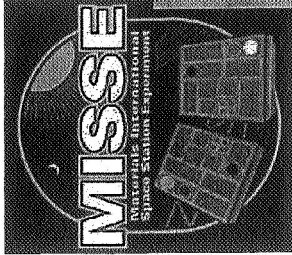
Dichromated gelatin



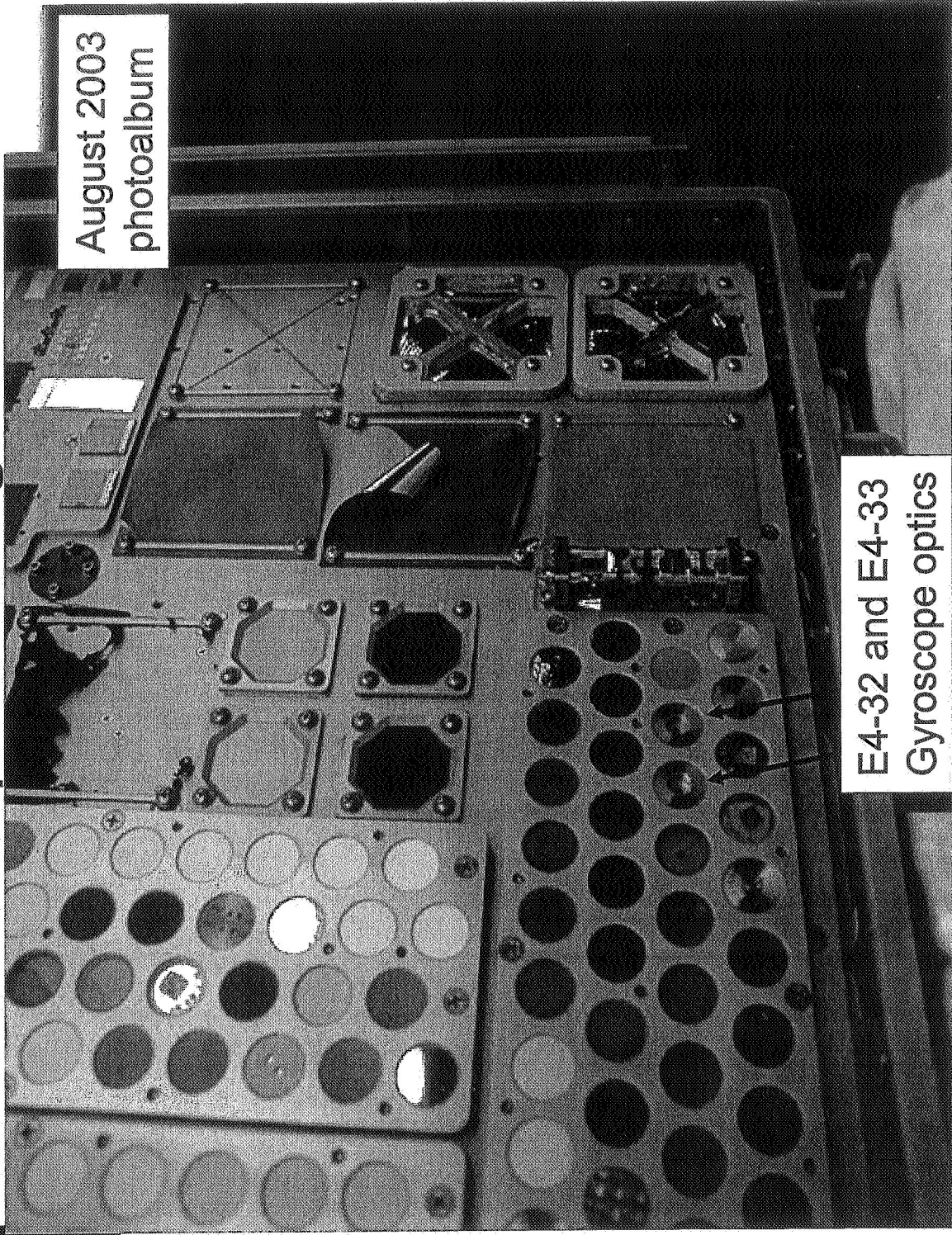
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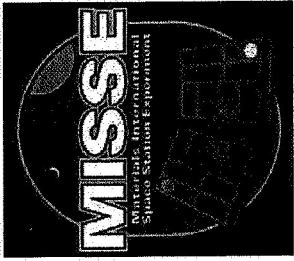


Samples in Flight



August 2003
photoalbum

E4-32 and E4-33
Gyroscope optics



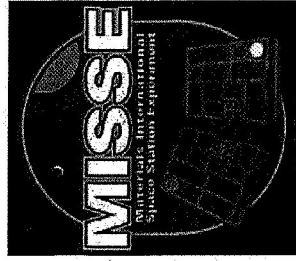
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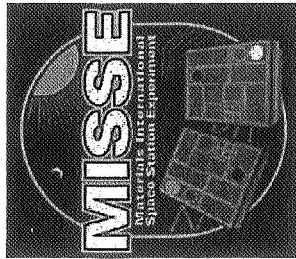


Test and Evaluation

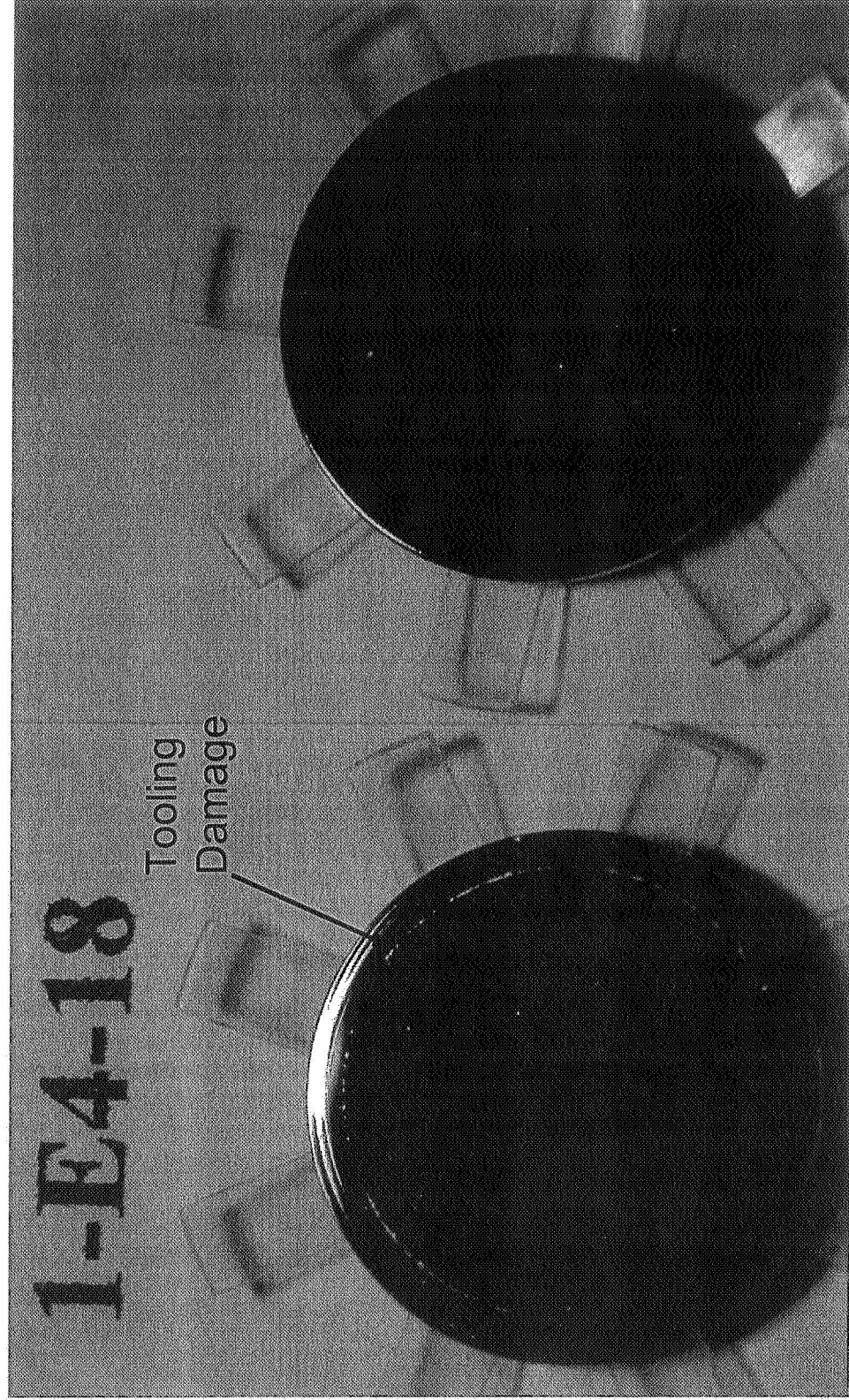
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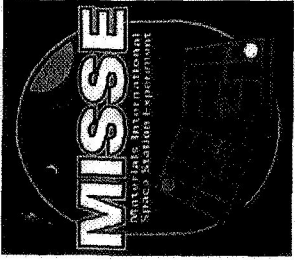
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- High purity DI water
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Flight Samples on the Bench

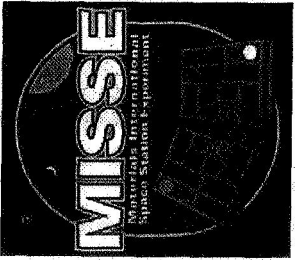




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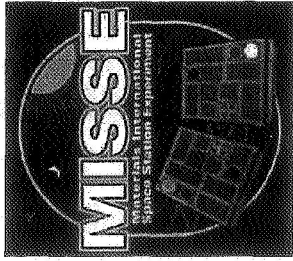
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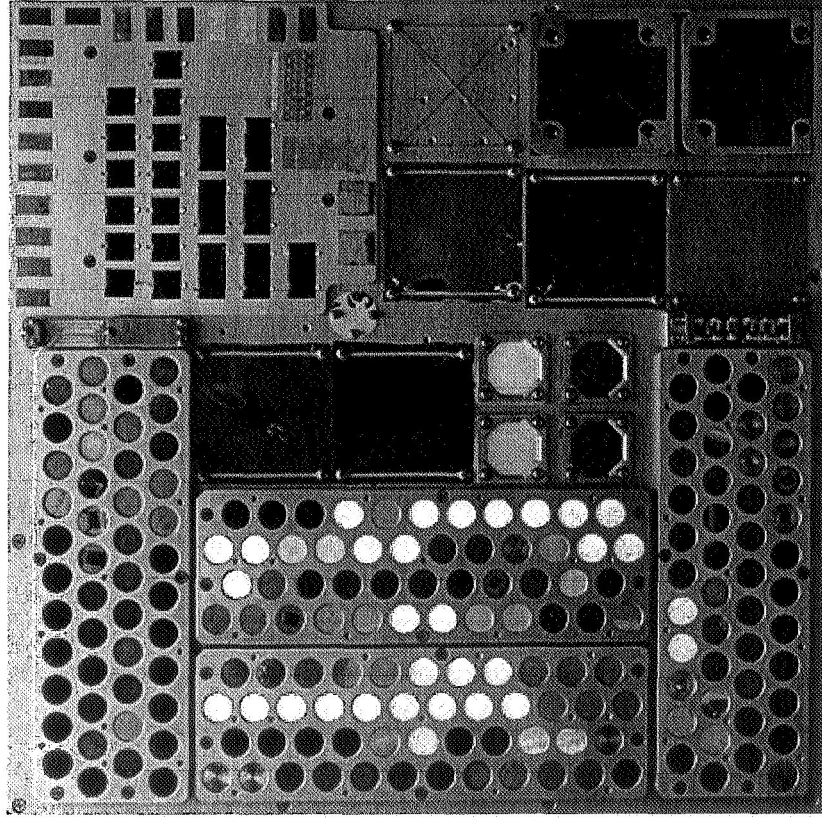
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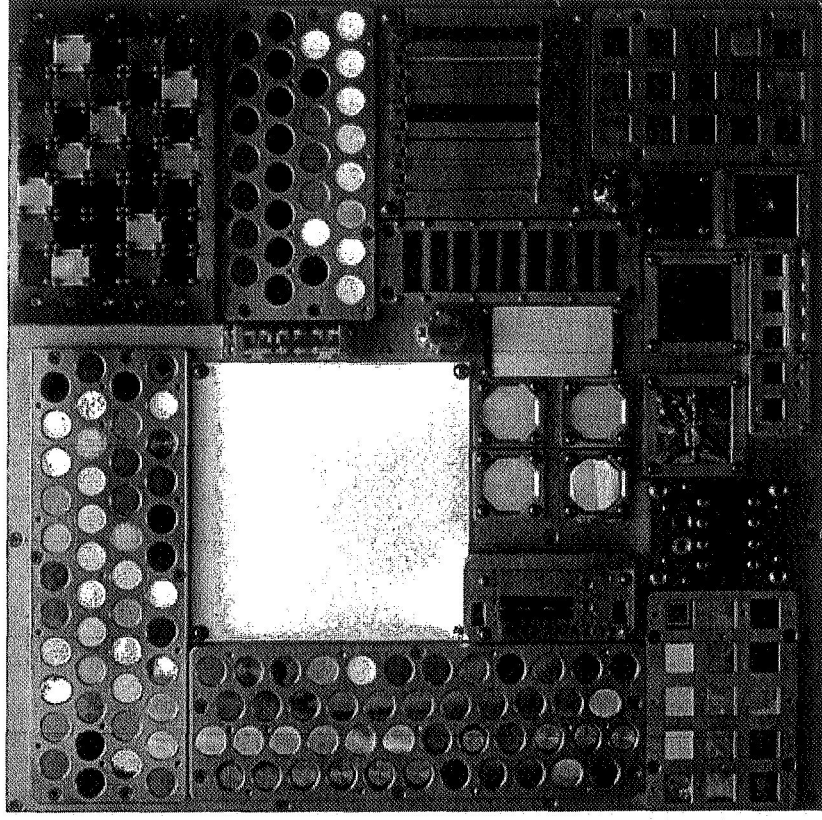


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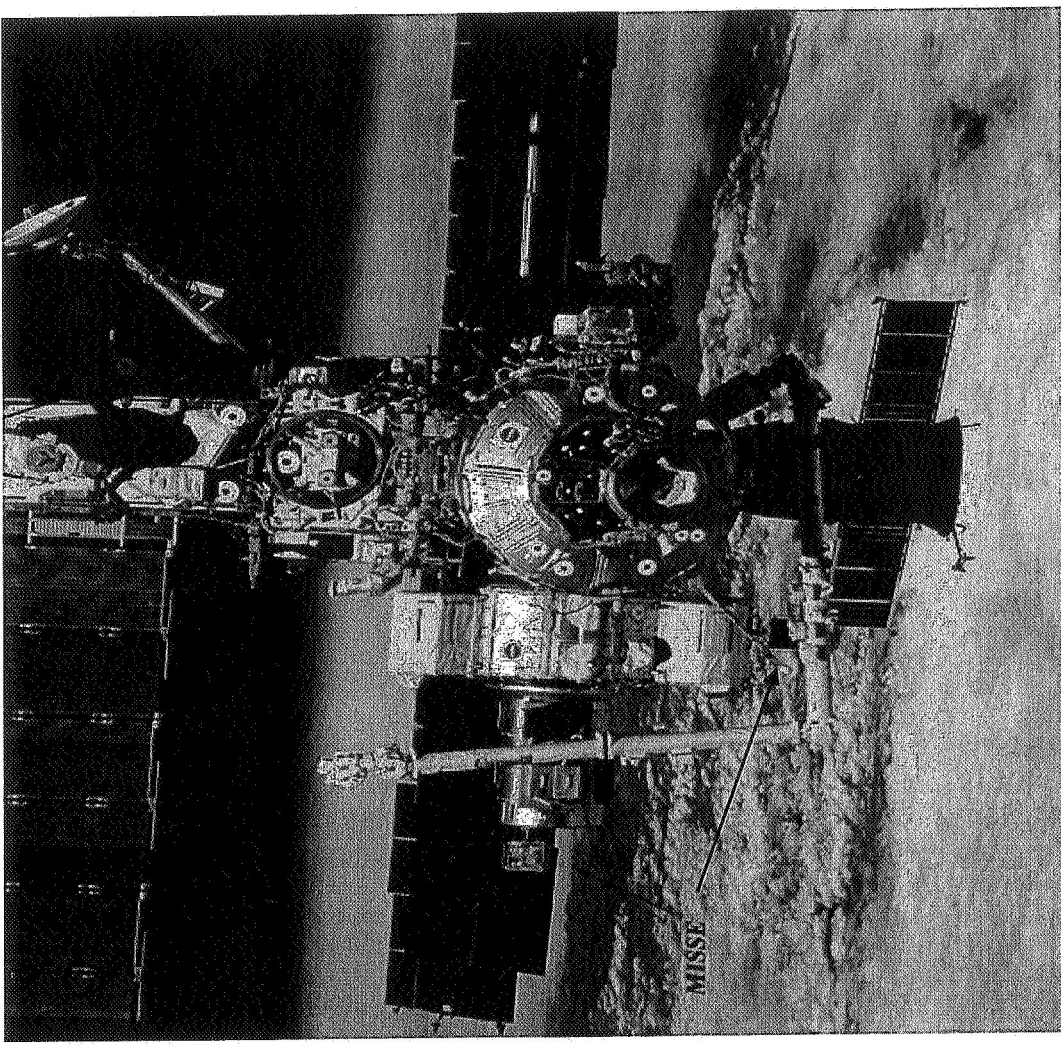
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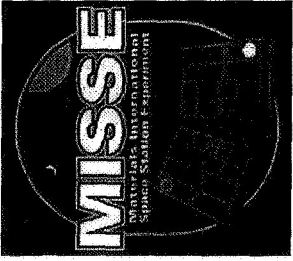
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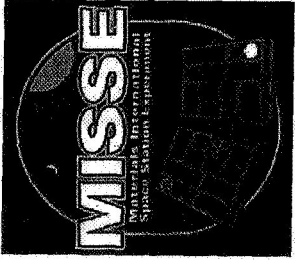
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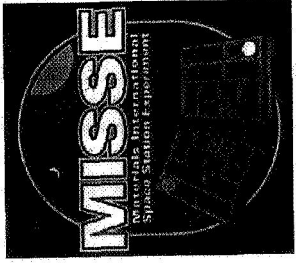
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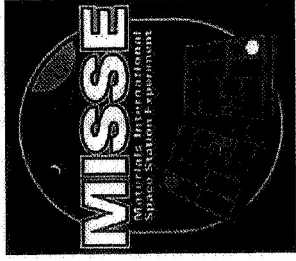
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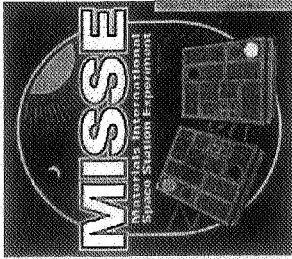
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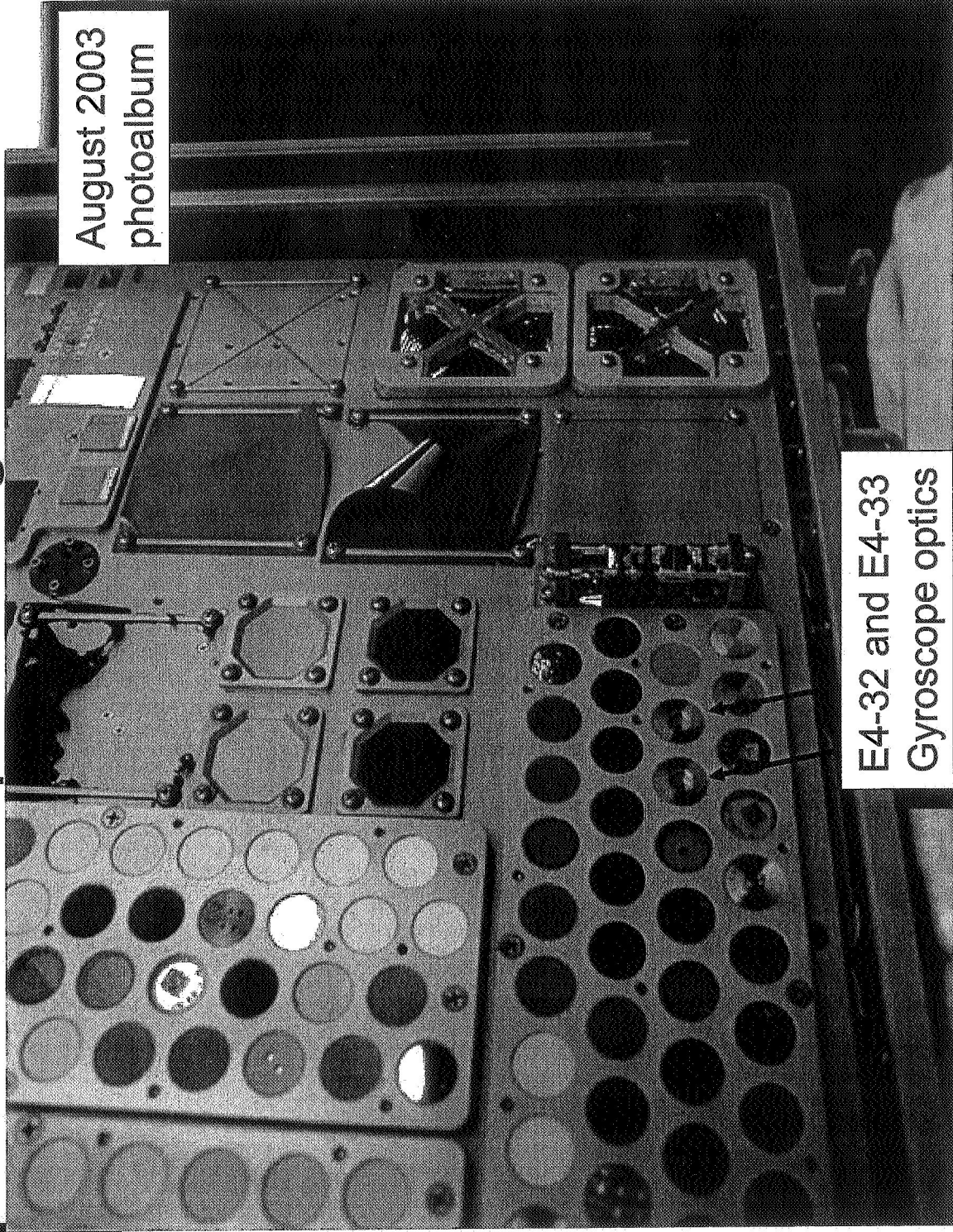
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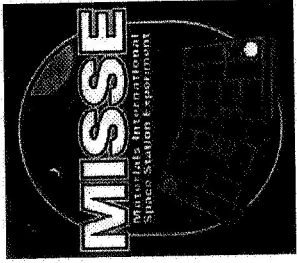


Samples in Flight



August 2003
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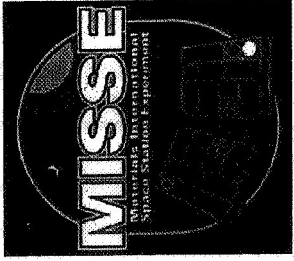
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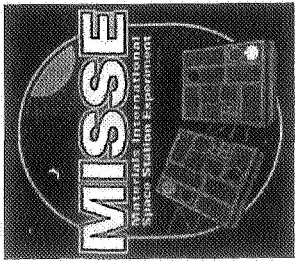


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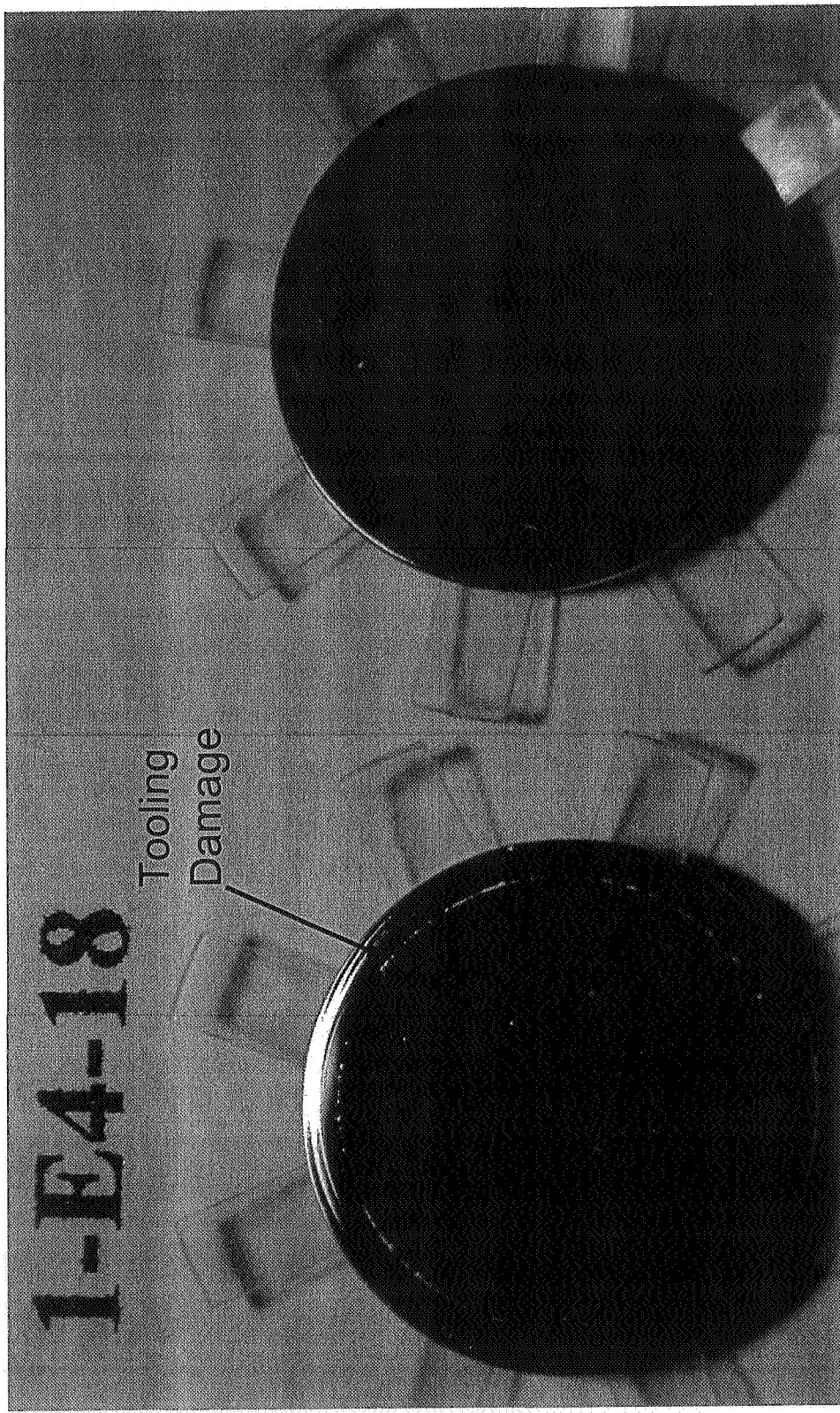
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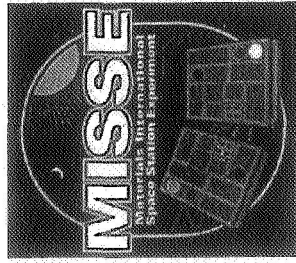
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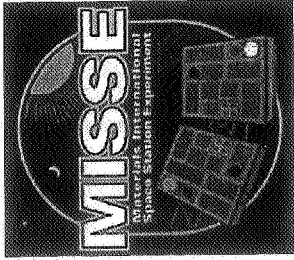
Flight Samples on the Bench



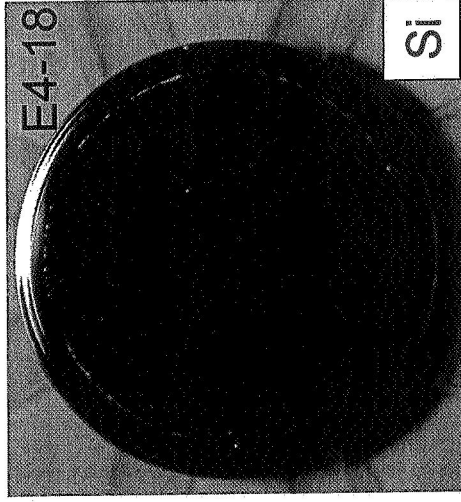


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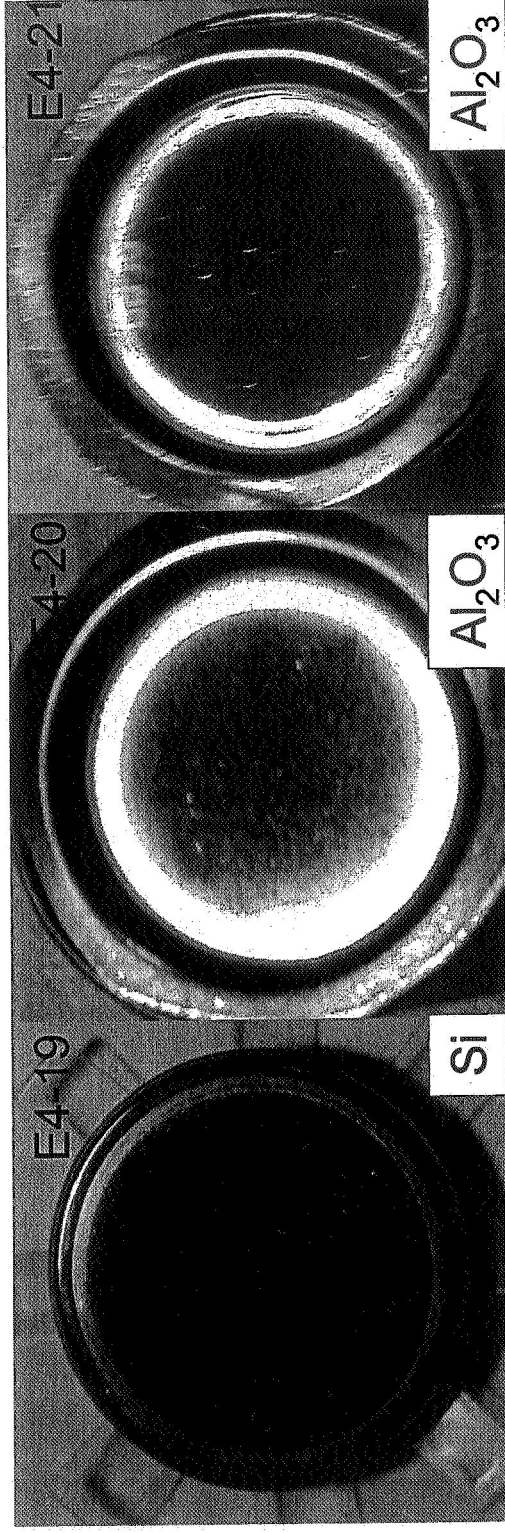




ZnSe/ThF₄ Coatings on Silicon and Sapphire



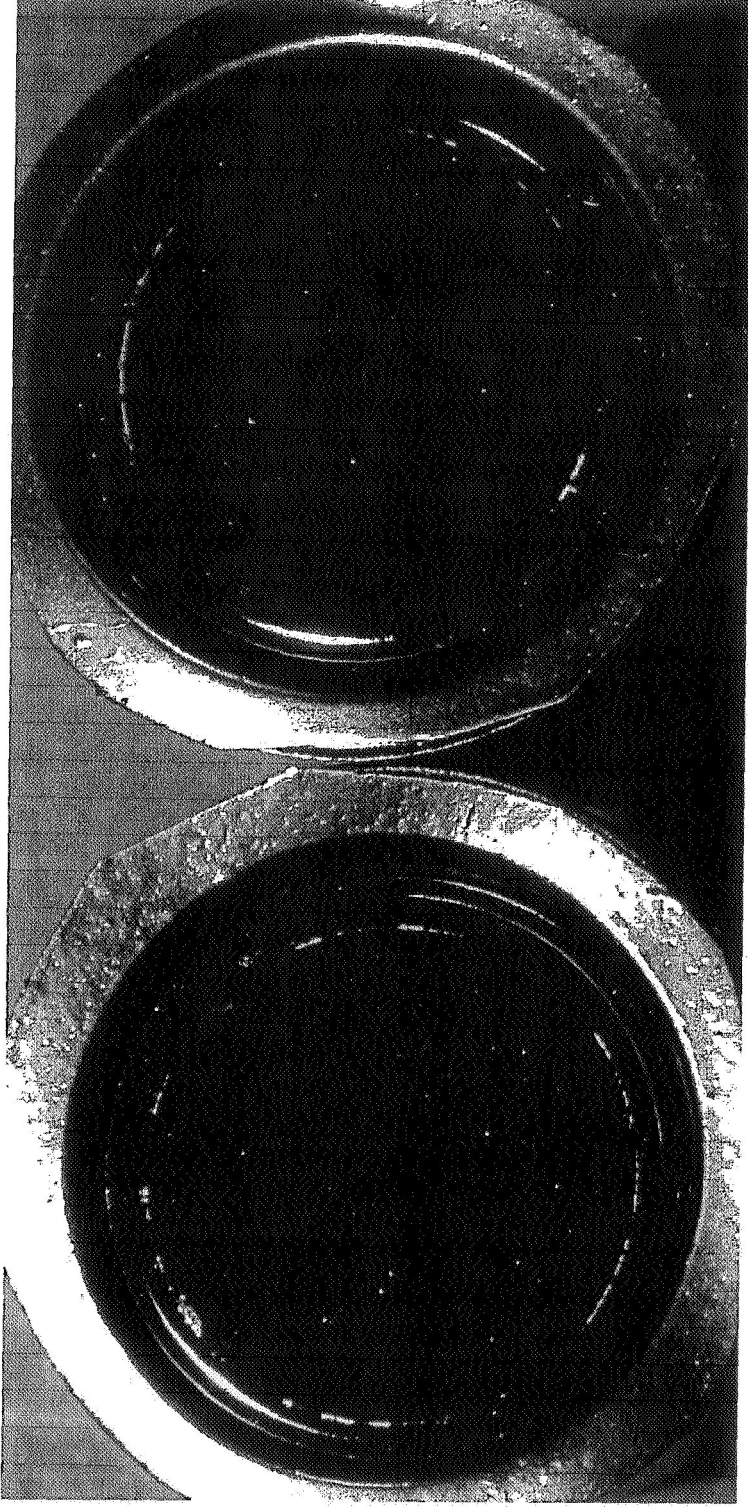
ZnSe/ThF₄ stack with Al₂O₃ overcoat
Showing resistance to abrasion at
contact to sample mount and debris



ZnSe/ThF₄ stacks showing abrasion at contact to sample mount and debris



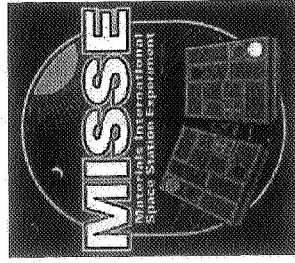
Si/Al₂O₃/SiO₂ Mirrors



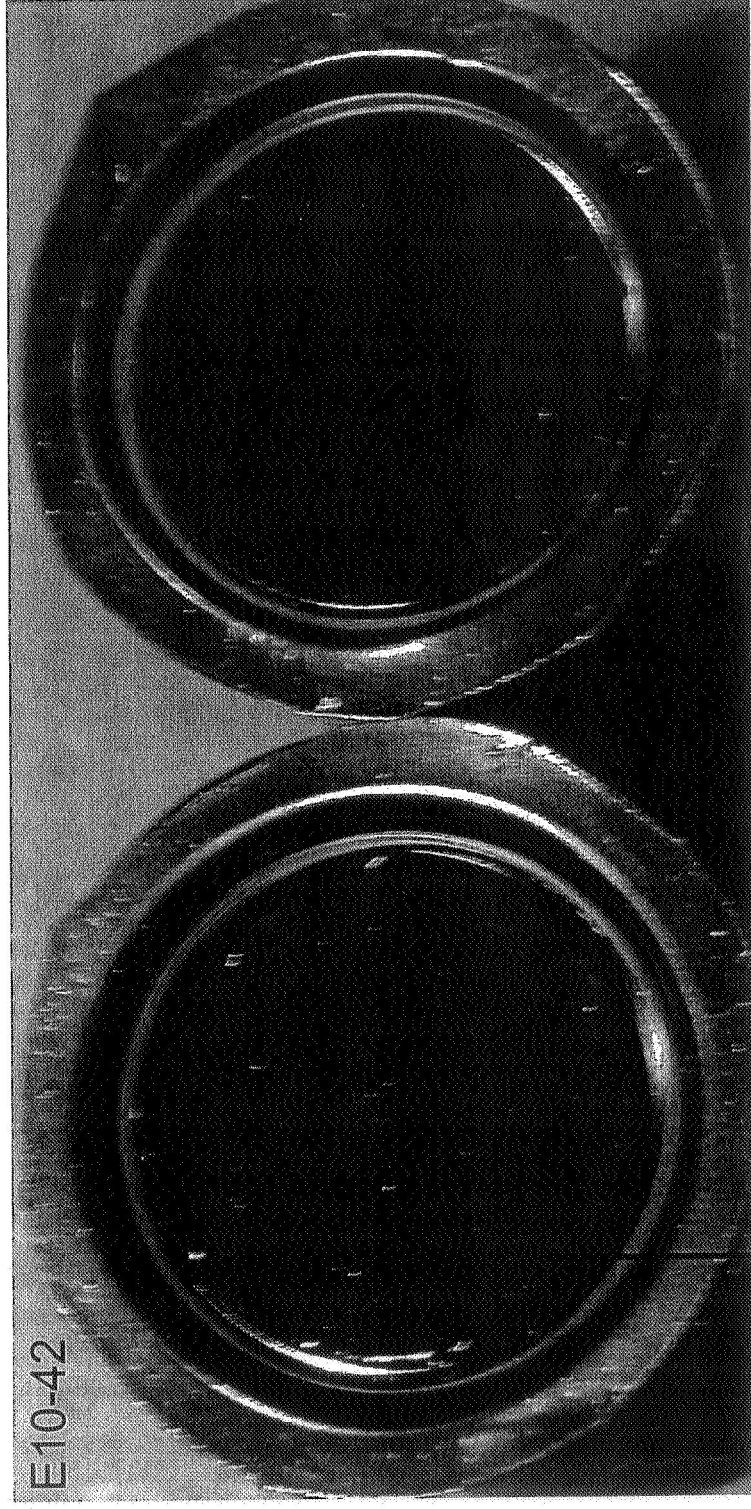
E4-22

E4-23

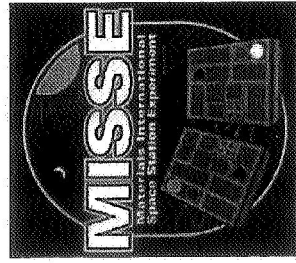
Some tooling damage is evident in the contact area for the sample holder.



Si/Al₂O₃/SiO₂ Mirror Shows Contamination



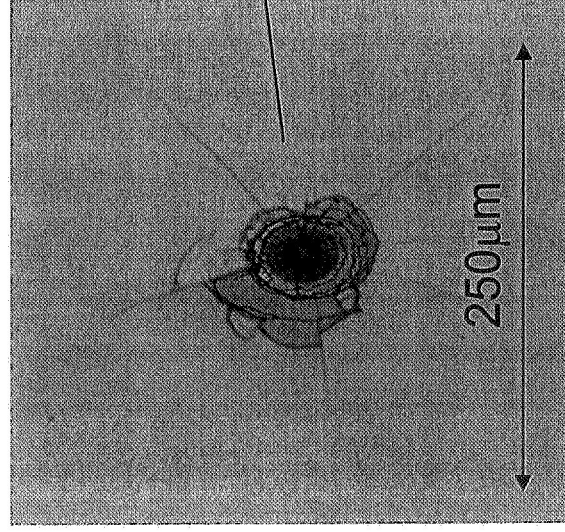
Contamination layer is lighter in color than unexposed coating



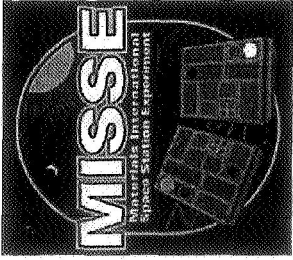
Micrometeorite Impact!



E10-41

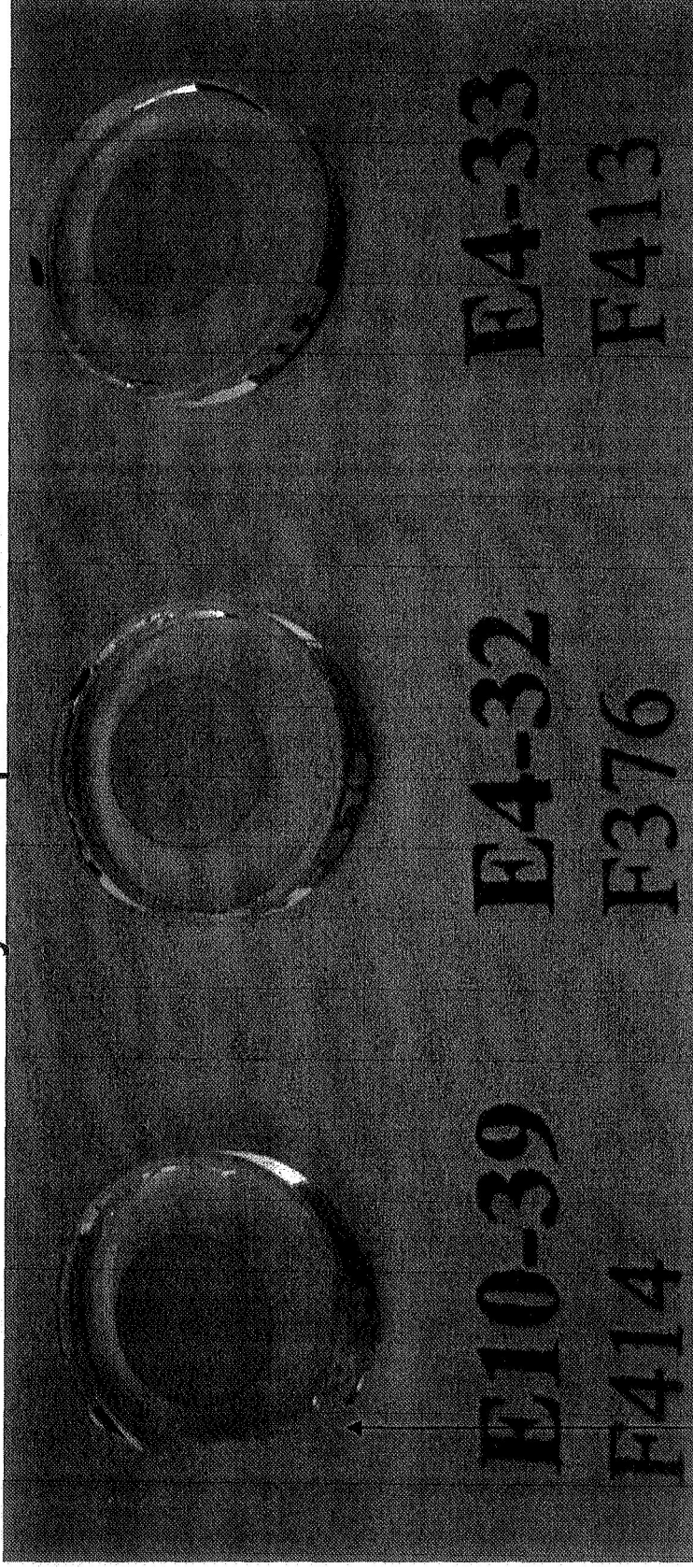


ZnSe/ThF₄ coating on sapphire

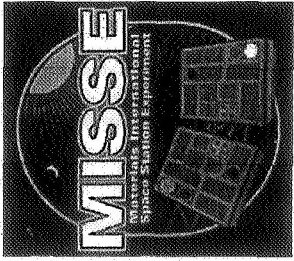


Flight Samples on the Bench

Laser Gyroscope Mirrors

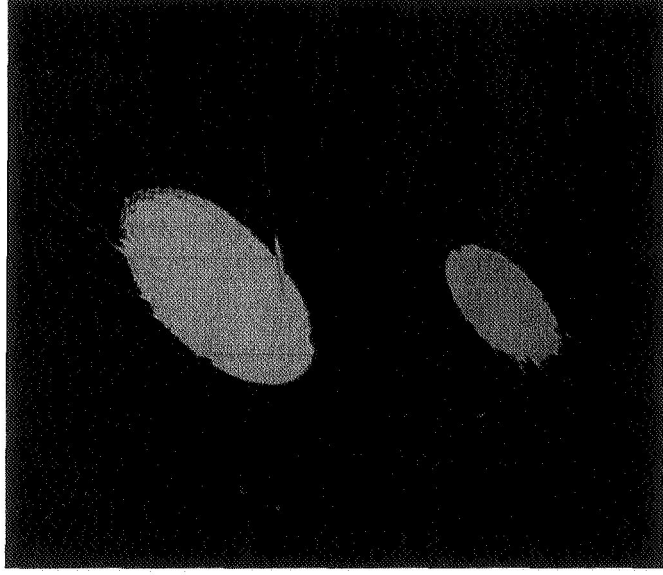
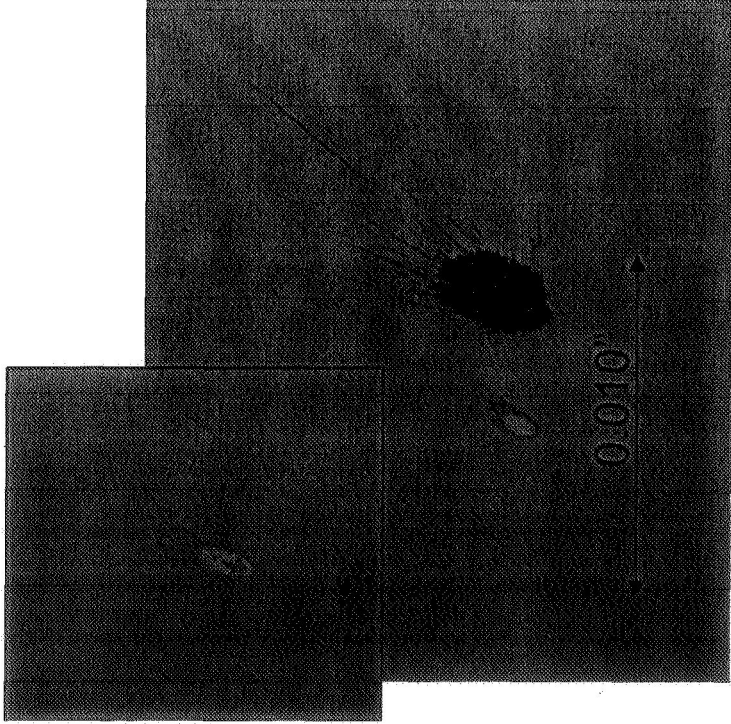


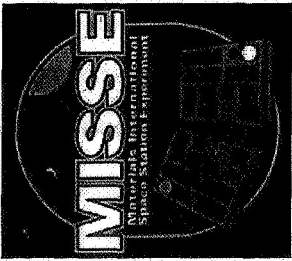
Serious tooling damage!



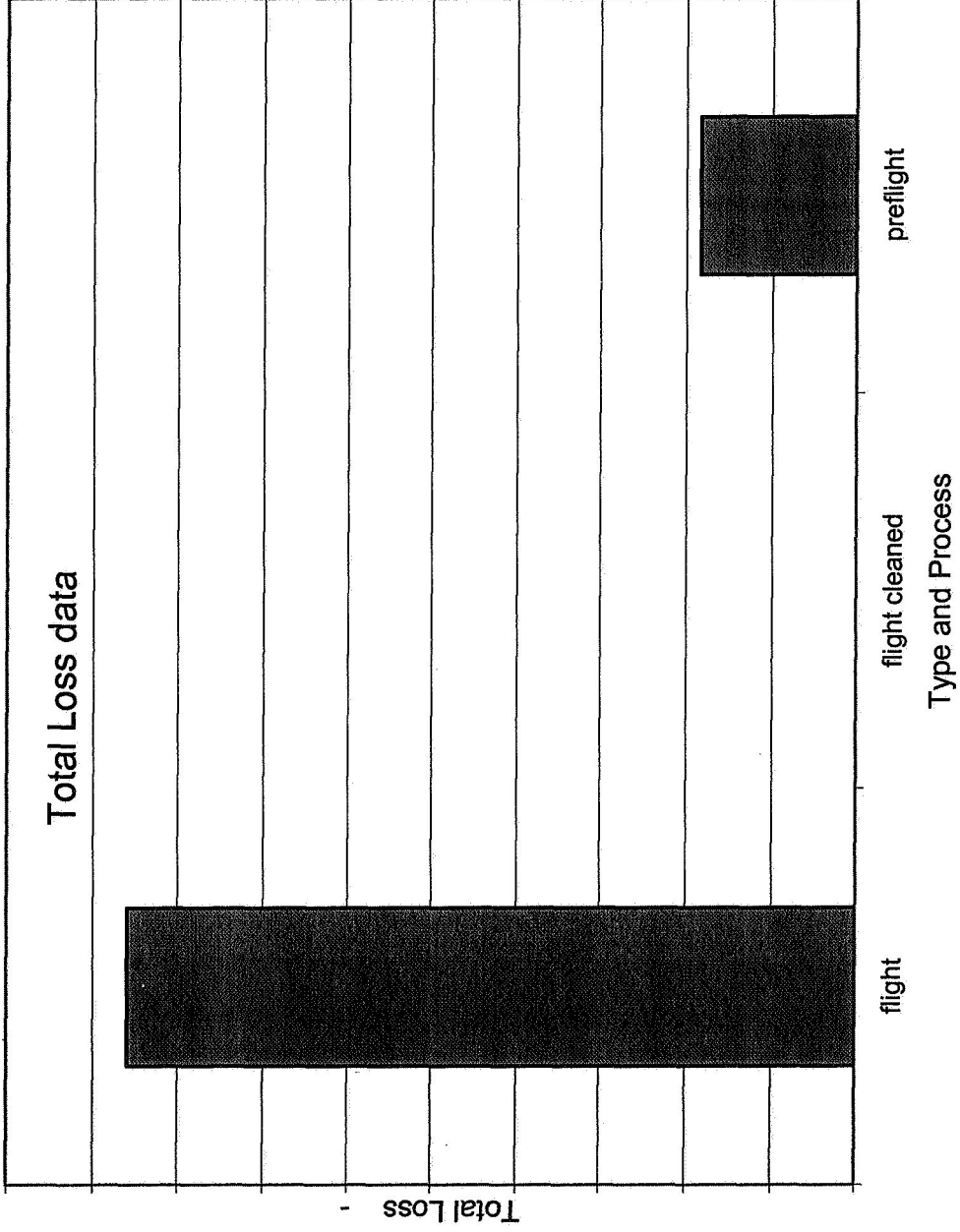
Laser Gyroscope Mirrors Showed "Liquid" Contamination

Surface contamination observed on
Flight samples showing:
Liquid nature of particle
Highly directional emission



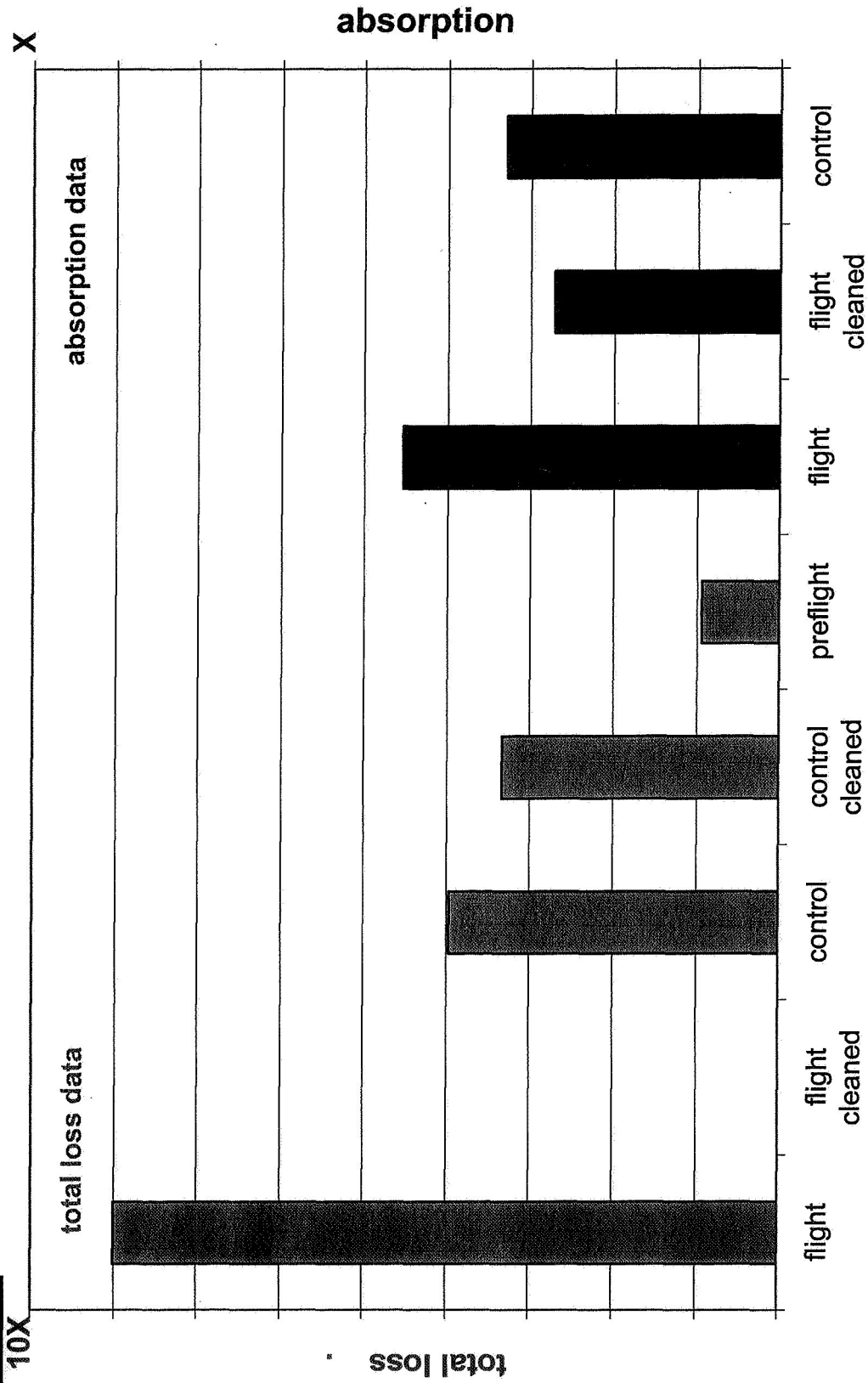


633nm Laser Gyro Mirrors



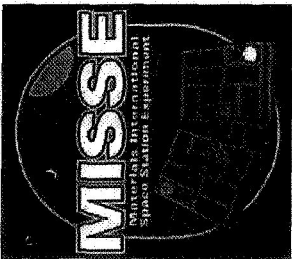


Total Loss and Calorimetry at 1319nm

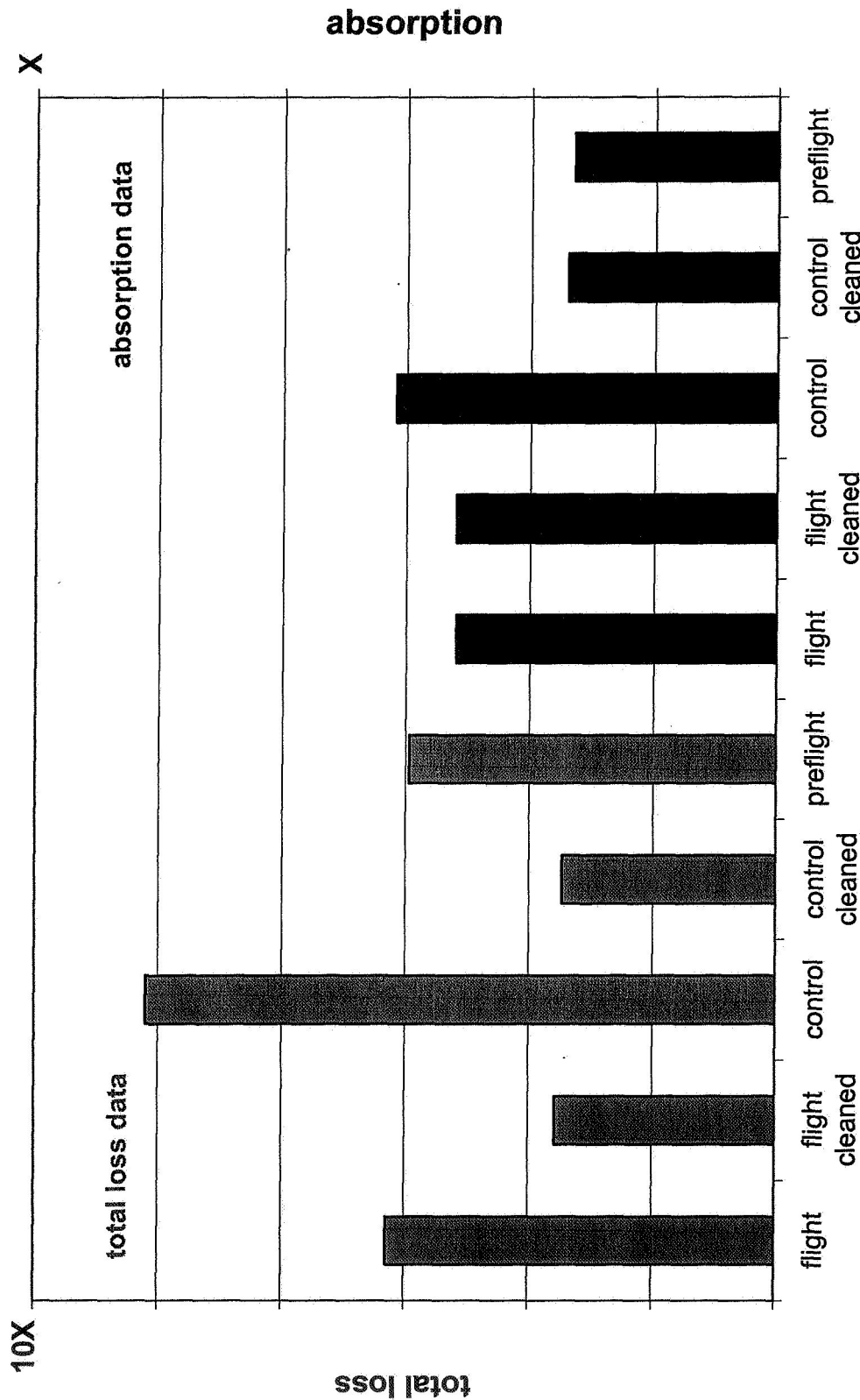


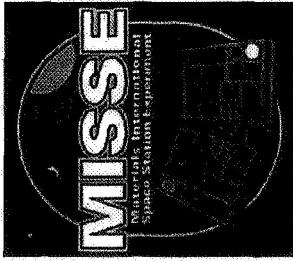
Type or Process
21



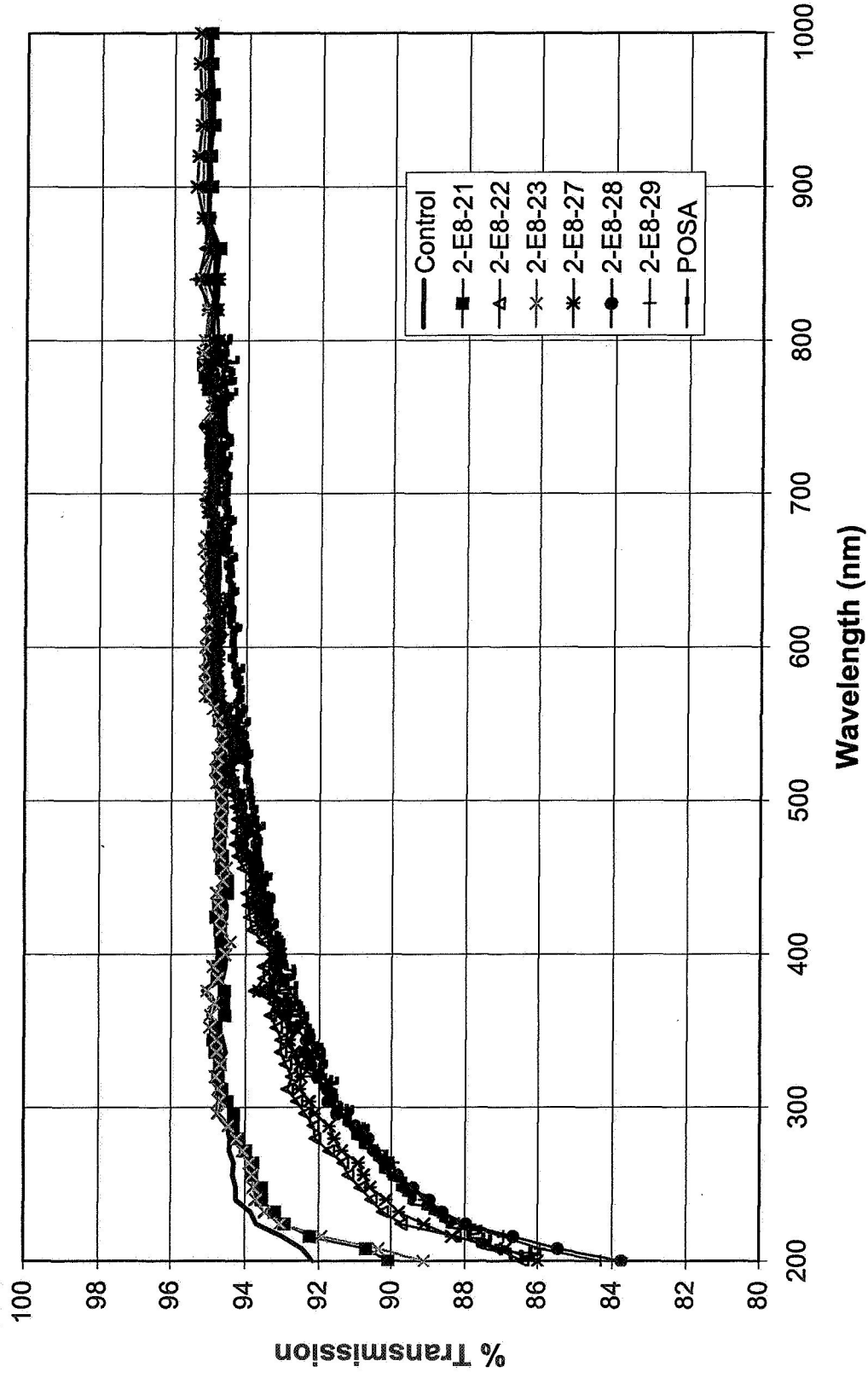


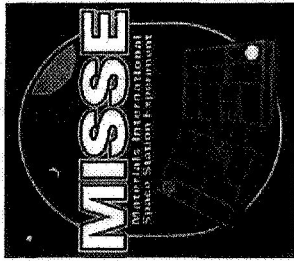
Total Loss and Calorimetry at 1064nm



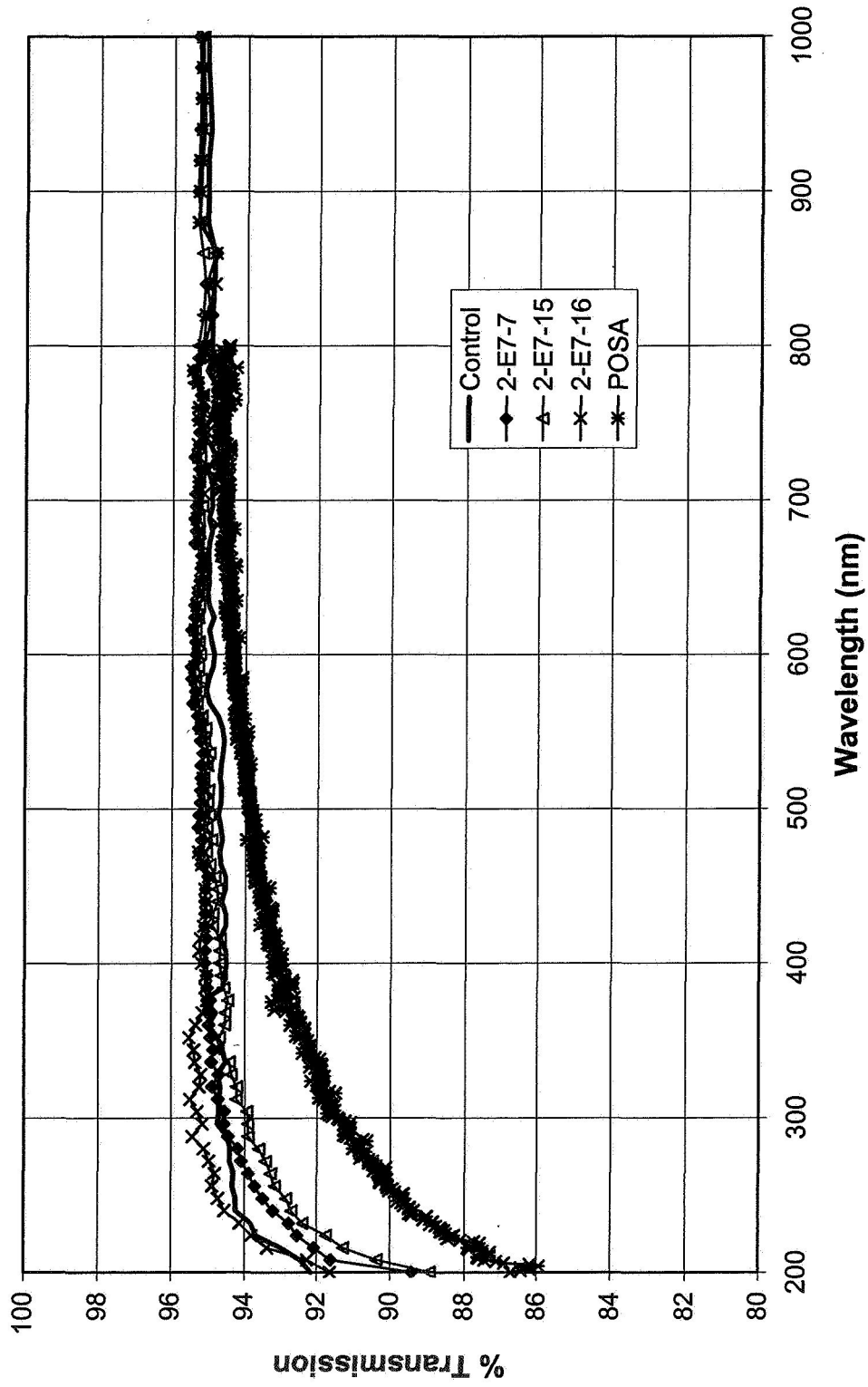


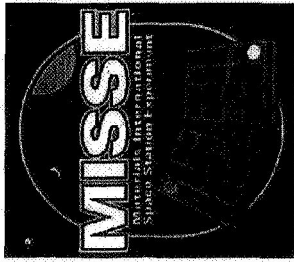
MgF₂ Windows Show Effects of Space



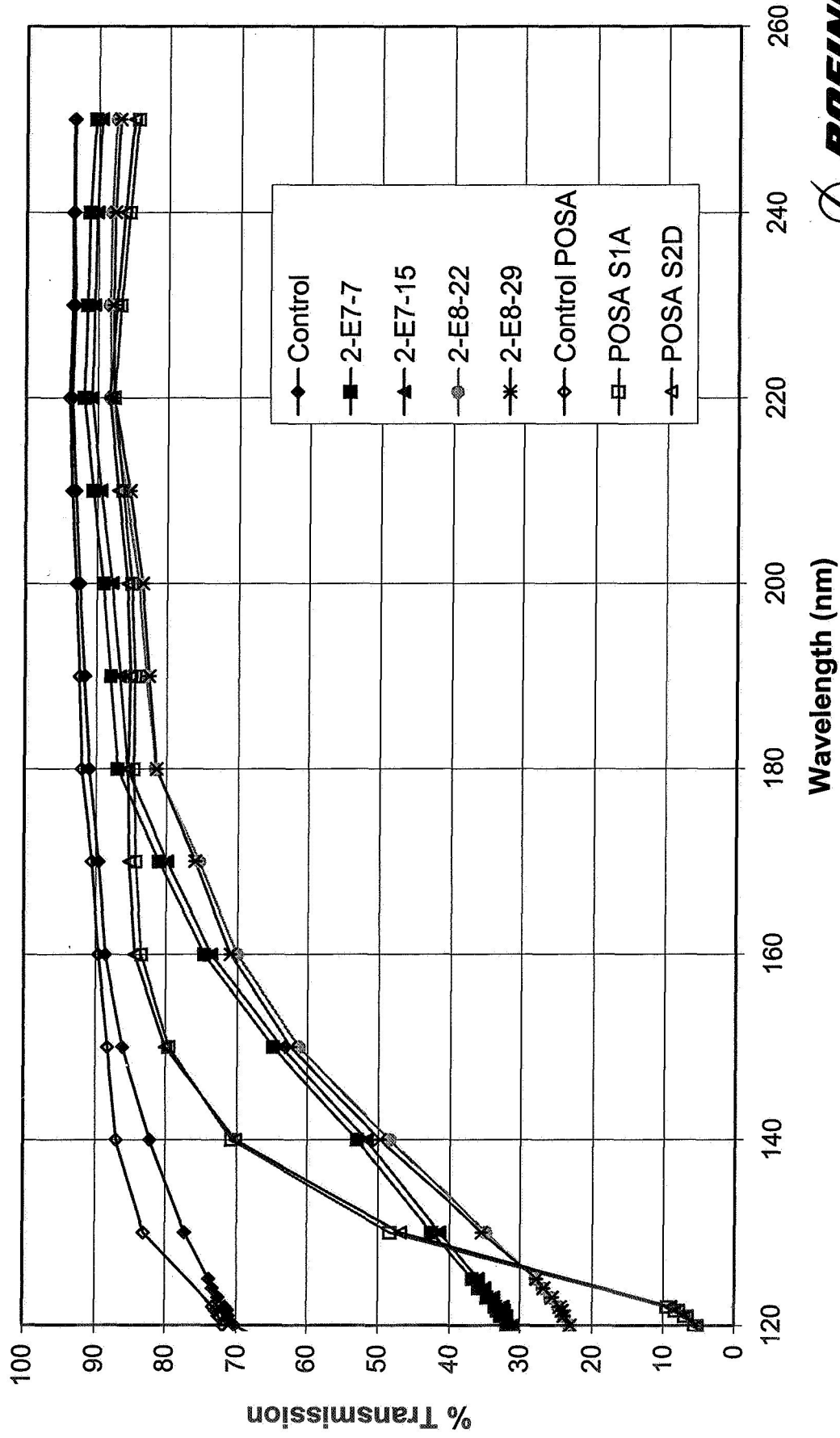


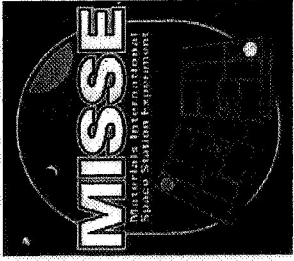
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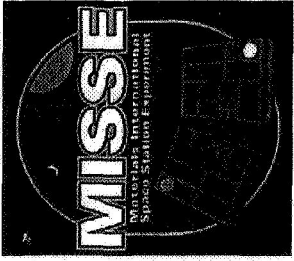
MISSE MgF₂ Windows Comparison with POSA





Summary

- Flight samples experienced some mechanical damage from contact with the surface of the tray.
- Contamination was present on all samples
 - Increased total loss
 - Light scatter
 - Haze
 - Particulate or isolated defects were present on all samples
- Absorption increased on flight samples by factor > 2x
- Total loss increased on Flight samples by factor > 3x
- Overall sample performance better than was hoped for



MISSE has a Bright Future !

Continuing study of samples on the ground

- Evaluation of contamination layer and surfaces
- Scatter maps to show distribution and magnitude of “defects”

- MISSE 3,4 deployed July 06 (1 yr)
- MISSE 6 in integration
- MISSE 7 in planning stages