Silica Aerogel for Capturing Intact Interplanetary Dust Particles for the Tanpopo Experiment

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Highlights

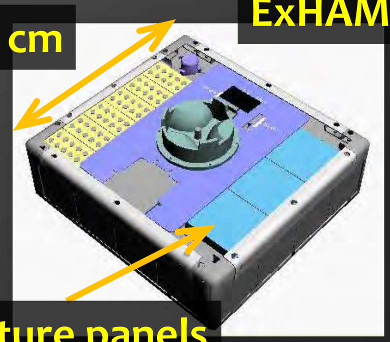
- We are developing a silica-aerogel-based cosmic dust collector for use in the Tanpopo mission.
- Box-framing aerogels with inner and outer densities of 0.01 and 0.03 g/cm^3, respectively, were designed and mass produced in a contamination-controlled environment.
- Tests to verify the performance of the aerogels were successfully performed.

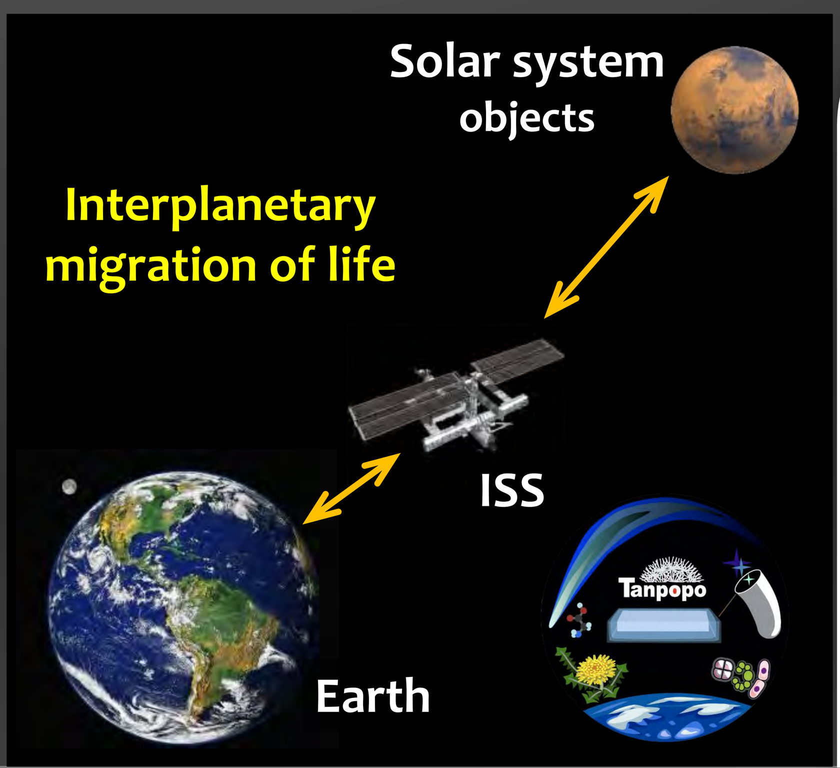
References

- A. Yamagishi *et al.*, *Trans. JSASS Space Tech. Japan* 7 (2009) Tk_49.
- M. Tabata *et al.*, *Trans. JSASS Space Tech. Japan* 12 (2014) in press.
- M. Tabata *et al.*, *Biol. Sci. Space* 25 (2011) 7.

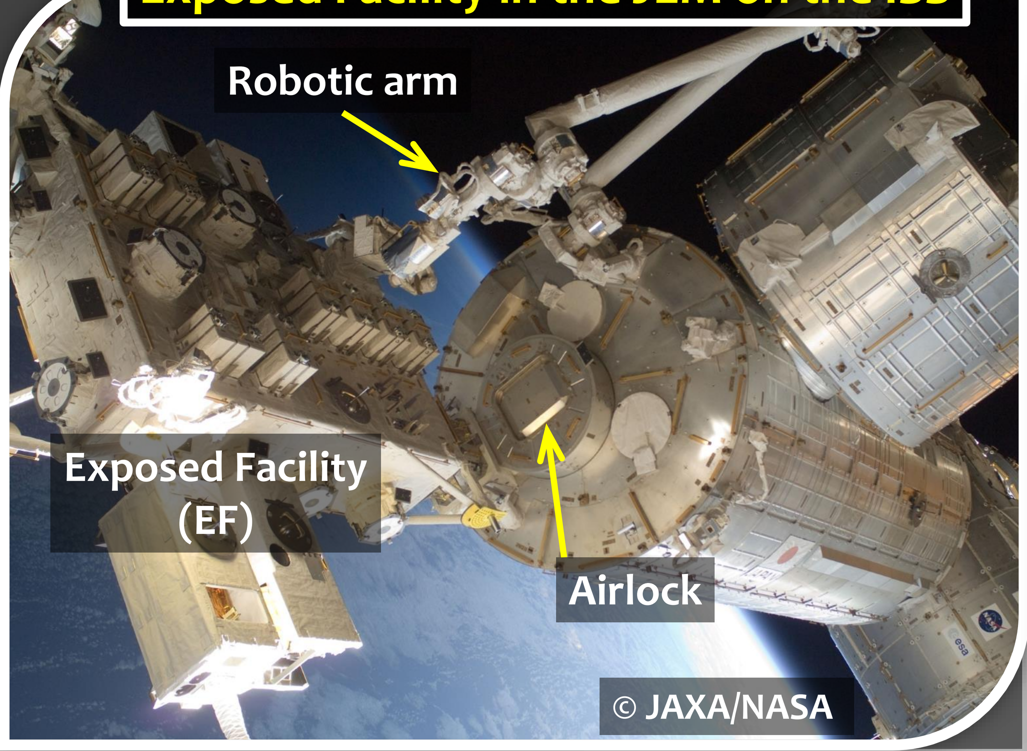
Introduction

- Tanpopo (dandelion) mission to be performed on the Japanese Experiment Module (JEM) on the International Space Station (ISS) from 2015
  - Astrobiological composite experiments (sample return)
    - Organic compound and microbe exposure to space
    - Cosmic (interplanetary, terrestrial, and artificial) dust capture
  - Analyzing the return samples in our ground laboratories
  - Verifying the hypothesis of panspermia
- Installing exposure and capture panels in the Exposed Experiment Handrail Attachment Mechanism (ExHAM; developed by JAXA)
  - ExHAM to be equipped to the Exposed Facility (EF) using a JEM airlock and robotic arm
- Using ultralow-density (0.01 g/cm^3) silica aerogel for cosmic dust capture in the capture panels
  - Three-time annual exposures of multiple aerogels to several sides of the ExHAM





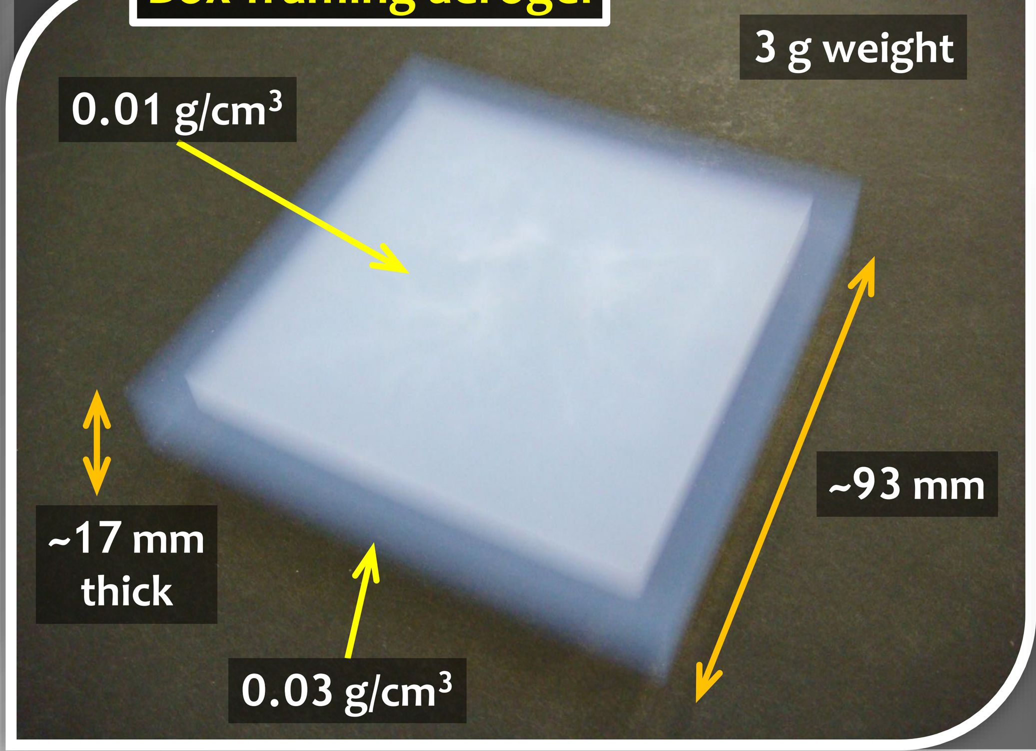
Exposed Facility in the JEM on the ISS



Silica Aerogel

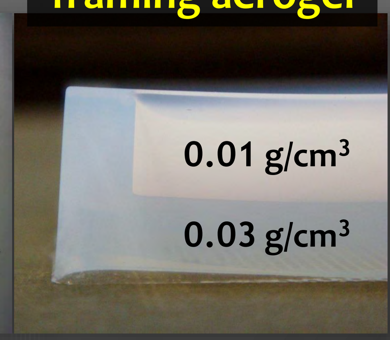
- Silica aerogel as a cosmic dust capture medium
  - Low bulk density (tunable), ρ
    - ρ = 0.01–1.0 g/cm^3 (by our production method)
    - Suitable medium for intact capturing hypervelocity (~ km/s) dusts
  - Optical transparency
    - High visibility of impact cavity and captured dusts (~10 μm)
  - Hydrophobic material (by our production method)
    - Suppressing age-related degradation caused by moisture absorption
- Mass production at Chiba University
  - Produced in a contamination-controlled environment
    - No DNA and low amino acid contamination
  - Using a custom-made mold for synthesizing a wet gel
  - A total of 60 tiles including spares

Box-framing aerogel



Custom-made polystyrene mold

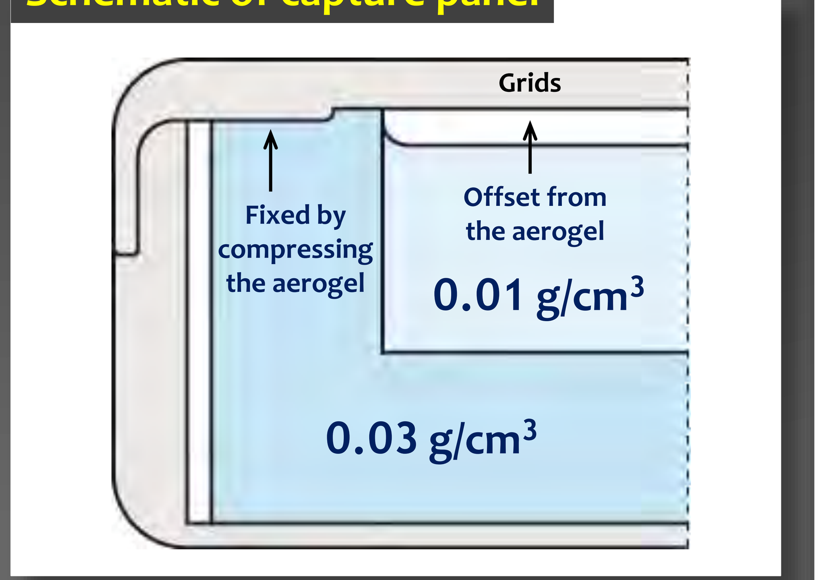
Side view of box-framing aerogel



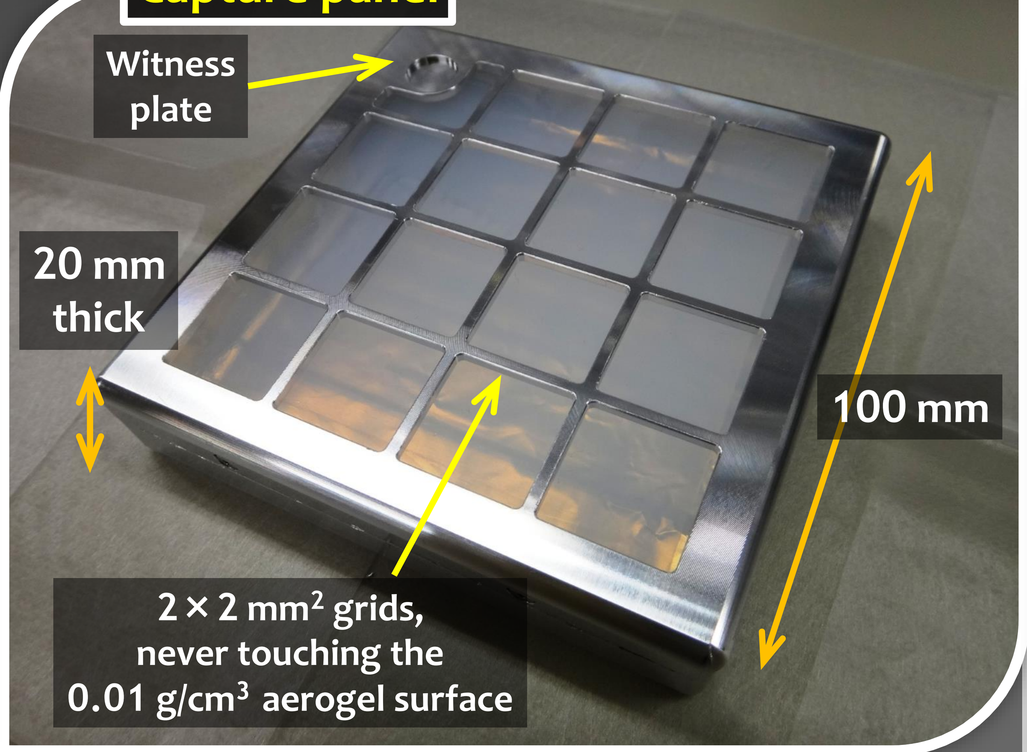
Clean booth for aerogel production

Capture Panel Design

Schematic of capture panel

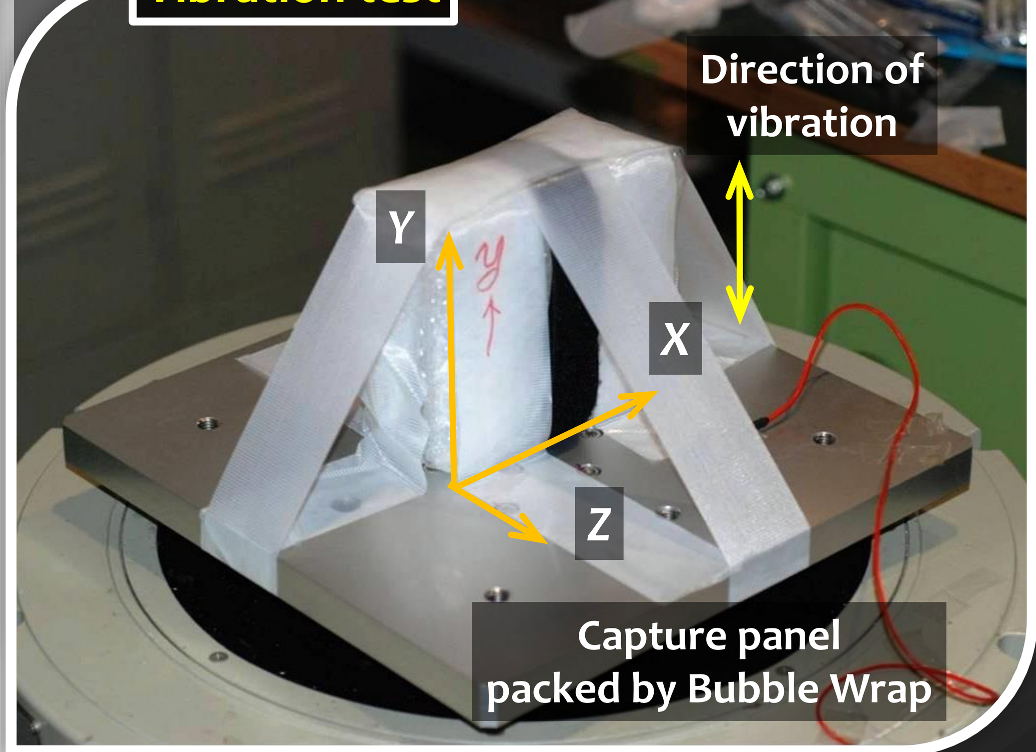


Capture panel



- Designing an aerogel holder for interfacing with the ExHAM
  - Body case and gridded lid (with cover plate): "Capture panel (CP)"
- Requirements
  - Outer Panel dimensions: 100 × 100 × 20 mm^3
    → Aerogel dimensions: ~93 × 93 × 17 mm^3
  - Ensuring scientific outputs (aerogel protection)
    - Retaining the aerogel within the CP if it disintegrates by vibrations
    - Minimizing damage to the aerogel when the ISS crews handle the CP
      → "Box-framing" aerogel
      - Protecting 0.01 g/cm^3 aerogel layer by robust 0.03 g/cm^3 layer
  - Ensuring safety of the ISS crews
    - Preventing aerogel chips from being scattered aboard the ISS
      → Grids on the lid of the CP
- Specifications
  - Exposure area per panel: 56 cm^2
  - Effective aerogel thickness: 8 mm (0.01 g/cm^3) + 7 mm (0.03 g/cm^3)
  - Grids on the lid
    - Cross section: 2 × 2 mm^2 (ensuring adequate strength)
    - Never touching the 0.01 g/cm^3 inner aerogel surface to prevent the aerogel from cracking by vibrations
  - Fabricated from aluminum alloy A7075

Vibration test



Performance Tests

- Random vibration tests of the box-framing aerogel tile mounted in the capture panel
  - Vibration conditions
    - Level: Qualification test (QT)
    - Direction: *X* (=*Y*), *Z* (*Z* = thickness direction)
    - Shock-absorbing foam: 0.5 in. Bubble Wrap
    - Launching vehicle: H-II Transfer Vehicle (HTV) or Russian Progress/Soyuz
    - Landing vehicle: Russian Soyuz
    - Duration: 60 s
  - Results: No serious damage and no fragmentation of the aerogel
- Depressurization and repressurization tests
  - Rate of air out-take and intake: 5 kPa/s
  - Results: No serious damage and no serious shrinkage
- Hypervelocity impact experiments
  - Laboratory simulation using a two-stage light-gas gun
    - Projectile material: Soda lime glass beads with 2.44-g/cm^3 density
    - Projectile diameter: 30 μm
    - Impact velocity: 5.97 km/s
  - Result: Successful capture of projectiles with no serious damage

Two-stage light-gas gun

Impact cavity under microscope