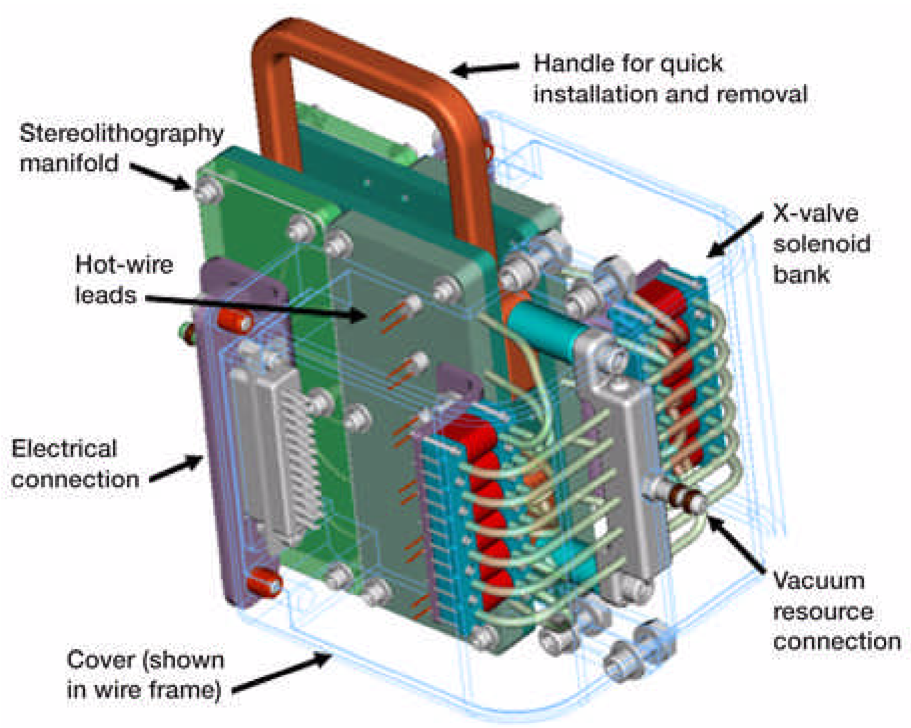
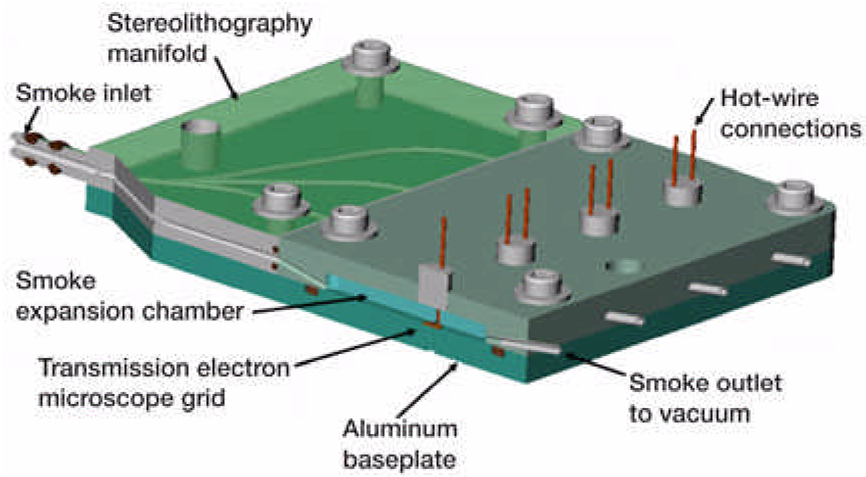
New Technologies Being Developed for the Thermophoretic Sampling of Smoke Particulates in Microgravity

The Characterization of Smoke Particulate for Spacecraft Fire Detection, or Smoke, microgravity experiment is planned to be performed in the Microgravity Science Glovebox Facility on the International Space Station (ISS). This investigation, which is being developed by the NASA Glenn Research Center, ZIN Technologies, and the National Institute of Standards and Technologies (NIST), is based on the results and experience gained from the successful Comparative Soot Diagnostics experiment, which was flown as part of the USMP-3 (United States Microgravity Payload 3) mission on space shuttle flight STS-75. The Smoke experiment is designed to determine the particle size distributions of the smokes generated from a variety of overheated spacecraft materials and from microgravity fires. The objective is to provide the data that spacecraft designers need to properly design and implement fire detection in spacecraft. This investigation will also evaluate the performance of the smoke detectors currently in use aboard the space shuttle and ISS for the test materials in a microgravity environment.



Smoke experiment-thermal precipitator.



Smoke experiment-cut through view of thermal precipitator.

As part of the suite of diagnostics required for the Smoke experiment, thermophoretic samplers, also called thermal precipitators, will be used to acquire representative samples of the smoke particulates generated when various materials (Teflon, silicon rubber, cellulose, and a liquid standard) are heated. These devices use a heated wire to drive the smoke onto a small collection grid (~1/8 in. in diameter) as it flows past. For each test point examined, a sample will be taken of the smoke within seconds of its generation, as well as another sample after a defined aging period, during which the sizes and geometries of the smoke particulates will have changed. These sample grids will be returned to Earth from the ISS after the completion of the experiment and examined under a transmission electron microscope.

Approximately 24 test points will be conducted for the Smoke investigation, with two samples required for each test. As conceptualized, each integrated thermal precipitator module will accommodate 12 thermophoretic samples. The experiment is being designed to require a minimum of ISS crew time for assembly and operation, and the current concept constitutes a significant improvement on the single sample design utilized for the Comparative Soot Diagnostics experiment.

To accommodate the large number of samples required for each thermal precipitator module, while minimizing the potential for cross-contamination of the samples, we incorporated separate flow paths for each sample grid into the design. These paths were sized (as small as 0.40 in. in diameter) to maintain a suitable flow velocity of 1 cm/s over the sample grids; and obstructions, which could impede particle flow, and potential leakage paths were minimized. This was accomplished through a manifold design within the unit that utilizes a unique fabrication technology called stereolithography. This technique, which takes a three-dimensional model and creates a part by solidifying a liquid polymer layer by layer, allows for a device to be formed without the restrictions imposed by more conventional molding or machining methods. Also, the semitransparent nature of the material allows for visual inspection of the internal flow paths as part of the verification process.

Another technology that makes this thermal precipitator design possible is the development of commercially available miniature valves that meet the flow control requirements of the Smoke experiment. Twelve such valves will be required for each thermal precipitator module. Finally, the individual transmission electron microscope grids will be installed in the sample modules by "sandwiching" them between two plates without the use of adhesives, which minimizes the potential of damage from handling and facilitates their removal from the unit upon return to Earth. The design of the thermal precipitator unit and the utilization of available technologies will result in a device that minimizes the use of valuable crew time aboard the ISS while maximizing science return.

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