Issue 60

In This Issue

Materials in Space


Astronaut Andrew Feustel Installing a PEC
Courtesy NASA – Images in public domain

Launched in 1998, the International Space Station is a research laboratory that enables the study of many scientific disciplines under the unique conditions of the space environment. The station is a shared project between five space agencies: the National Aeronautics and Space Administration (USA) (NASA), the Russian Federal Space Agency (Roscosmos), the Japan Aerospace Exploration Agency (JAXA), the European Space agency (ESA), and the Canadian Space Agency (CSA).

Among the many scientific disciplines studied is, of course, materials science.

Space offers scientists a unique environment in which to examine their field of interest. The orbiting space station offers a very low gravity, or microgravity, work domain. Moreover, the rarified atmosphere of the low earth orbit presents unusual conditions that are not encountered on earth.

For the materials scientist, there are two main aims:

- Expose materials and components made on earth to the conditions of the space environment and then test them to identify changes resulting from that exposure.
- Test materials that are formed or processed in space to compare them with the same materials similarly formed or processed on earth.

Material Exposure

The space environment is surprisingly harsh. Atomic oxygen (O1), a free radical, is prevalent in the atmosphere of the low earth orbit and is highly corrosive to many polymers and some metals. Ultraviolet radiation deteriorates many polymers and thin film coatings. The vacuum in space can also alter the properties of many materials and the operation of components. Impacts from dust, meteoroids, solar wind particles, and man-made debris can, of course, damage materials and components.

To investigate the long-term effects of the space environment on materials is the aim of MISSE - the Materials International Space Station Experiment. MISSE evaluates the performance, stability, and long-term survivability of materials and components (switches, mirrors, and so on) for NASA, the Department of Defense (DOD), and commercial companies that have interests in space missions, both in earth's orbit and beyond.

The materials and components to be tested are packed into Passive Experiment Containers (PECs). These containers, the size of a small suitcase, are secured to rails on the outside of the space station during an astronaut's extra-vehicular activity (EVA) or space walk. Once installed, the container lid is opened, exposing the various items inside to the space environment. The PECs are left in place for varying periods of time and then removed on a subsequent EVA and returned to earth for testing and evaluation. These experiments help materials scientists develop products, components, and coatings that can meet the requirements of the space environment.

Material Formation and Processing

Many of the industrial processes that produce or process materials involve one or more liquid phases. Materials processes in which a liquid component is present include crystal growth, casting, welding, and atomization. Because these industrial processes involve some liquid component it means that they are also heavily influenced by gravity. Therefore, the International Space Station offers a unique opportunity to study materials in conditions of microgravity. Researchers benefit from studying materials in space because they can isolate the fundamental heat and mass transfer processes involved that are frequently masked by gravity on the ground.

These experiments and processes are carried out in Materials Science Research Racks (MSRRs). Development of the rack was a cooperative effort between NASA and the European Space Agency. Each rack is the size of a large kitchen refrigerator. They let researchers study a variety of materials, including metals, alloys, semiconductors, ceramics, and glasses, to see how the materials form and learn how to control their properties. Each rack is an automated facility with furnace inserts in which sample cartridges are processed to temperatures up to 2,500 degrees Fahrenheit. Once a cartridge is in place, the experiment is run by automatic command or conducted via telemetry commands from the ground. Processed samples are returned to Earth for evaluation and comparison of their properties to samples that have been similarly processed on the ground.

Performing unique experiments and industrial processes in reduced gravity lets researchers obtain a much better understanding of materials development and production with the aim of increasing the accuracy of sought-after material properties such as improved crystal growth, longer and more stable polymer chains, and purer alloys.

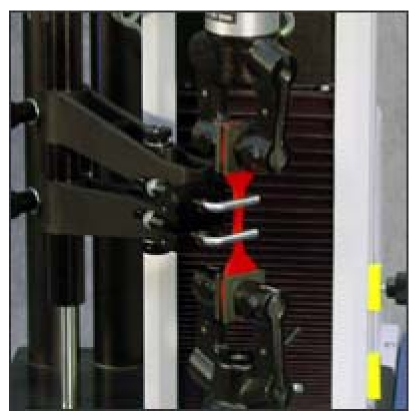
Don’t Let Your Standards Slip

You most likely understand the importance of regularly calibrating your testing and measuring equipment and making sure it is maintained to the highest standards to ensure the data that you capture is as accurate as possible. But do you regularly review your testing standards?

ASTM and other standards are continuously improved and amended. Email notification of changes and update subscription services can help you make sure that you stay current. However, it’s important to occasionally review the standards that you work with and examine your test methods and testing practices and procedures against those standards. Particularly for those signing their name to a test report or certification, it's important to question the assumptions and methods used to obtain results and to make sure that you are still fully meeting the standard’s requirements.

Q. Why is strain rate important?

A. Strain rate is the speed at which a material is deformed and different strain rates can have a big effect on the tensile properties of some materials.



Take silly putty as an example. If you slowly pull on a piece of silly putty, it will stretch an enormous amount before it breaks. But if you pull on it quickly, it breaks almost immediately. This is known as strain-rate sensitivity. Many plastics and polymers and some steels are strain rate sensitive.

So it’s important to remember that stress/strain data captured at lower strain rates may not produce accurate predictions for the properties of that material at high strain rates. Using that data to analyze and design parts and structures can result in those parts and structures being perfectly able to withstand predicted day-to-day forces. However, when subject to sudden high strain rates such as those found in a collision, those parts and structures could shatter rather than absorb the energy of that collision.

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