placement of the DA. Later investigations have demonstrated that an excess of calcium and sulfate will cause precipitation at water recovery rates greater than 70%. The source of the excess calcium is likely physiological in nature, via crewmembers' bone loss, while the excess sulfate is primarily due to the sulfuric acid component of the urine pretreatment. To prevent gypsum precipitation in the UPA, the Precipitation Prevention Project (PPP) team has focused on removing the calcium ion from pretreated urine, using ion exchange resins as calcium removal agents. The selectivity and effectiveness of ion exchange resins are determined by such factors as the mobility of the liquid phase through the polymer matrix, the density of functional groups, type of functional groups bound to the matrix, and the chemical characteristics of the liquid phase (pH, oxidation potential, and ionic strength).

Previous experience with ion exchange resins has demonstrated that the most effective implementation for an ion exchange resin is a cartridge, or column, in which the resin is contained. Based on the results of equilibrium and sub-scale dynamic column testing, a possible solution for mitigating the calcium precipitation issue on the ISS has been identified. From an original pool of 13 ion exchange resins, two candidates have been identified that demonstrate substantial calcium removal on the sub-scale. The dramatic reduction in resin performance from published calcium uptake demonstrates the need for thorough evaluation of resins at the low pH and strong oxidizing environment present in the UPA. Chemical variations in the influent (calcium concentrations and pretreatment dosing) appear to have a noticeable impact on the calcium capacity of the resin. Low calcium concentrations and high pretreatment dosing will likely result in a decrease in calcium capacity. Conversely, low pretreatment dosing will likely result in an increase in calcium capacity. In contrast, investigations at a variety of flow rates, length-to-diameter ratios, resin volumes, and flow regimes (continuous versus pulsed) show that changes in physical parameters do not have substantial impacts on resin performance in the very low specific velocity ranges of interest. This result is particularly useful because most commercial applications at higher specific velocities do show a relatively strong relationship between flow and capacity. The lack of a strong relationship will allow more flexibility in the implementation of an ion exchange bed for flight. Verification of subscale tests with flight-scale resin beds is recommended prior to implementation in the on-orbit UPA.

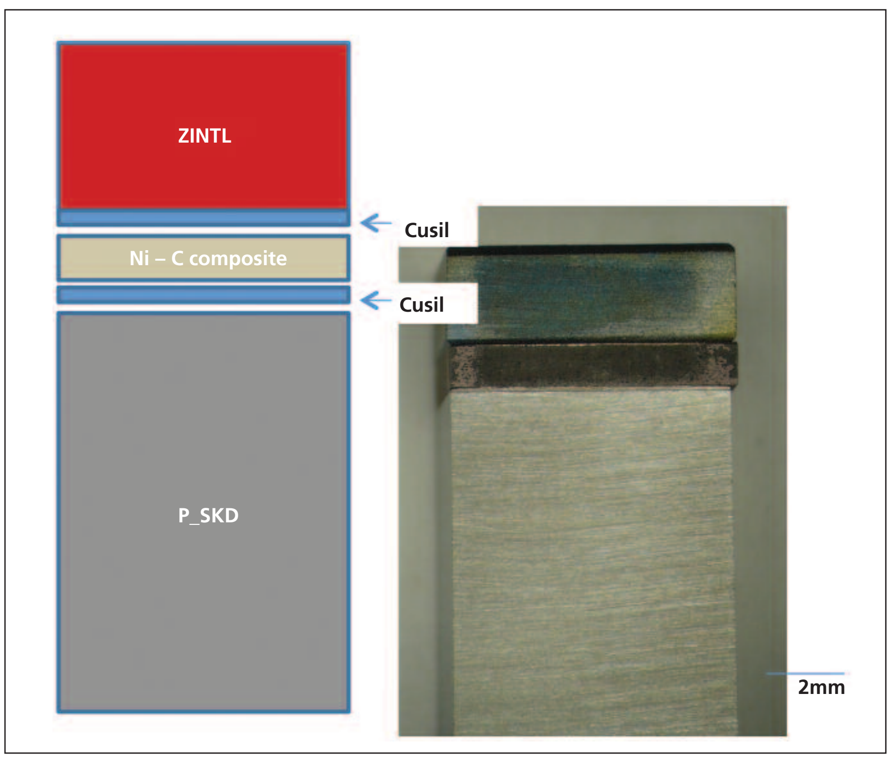
This work was done by Julie Mitchell, James Broyan, and Karen Pickering of Johnson Space Center. Further information is contained in a TSP (see page 1). MSC-25338-1

Nickel-Graphite Composite Compliant Interface and/or Hot Shoe Material

This innovation is a technique for joining various thermoelectric materials into segmented device architectures.

NASA's Jet Propulsion Laboratory, Pasadena, California

Next-generation high-temperature thermoelectric-power-generating devices will employ segmented architectures and will have to reliably withstand thermally induced mechanical stresses produced during component fabrication, device assembly, and operation. Thermoelectric materials have typically poor mechanical strength, exhibit brittle behavior, and possess a wide range of coefficient of thermal expansion (CTE) values. As a result, the direct bonding at elevated temperatures of these materials to each other to produce segmented leg components is difficult, and often results in localized microcracking at interfaces and mechanical failure due to the stresses that arise from the CTE mismatch between the various materials. Even in the absence of full mechanical failure, degraded interfaces can lead to increased electrical and thermal resistances, which adversely impact conversion efficiency and power output.



The freestanding segmented Zintl/skutterudite leg fabricated using a **Nickel-Graphite Composite-Based Compliant Layer** brazed to the metalized surfaces of the Zintl and skutterudite (SKD) segments.

The proposed solution is the insertion of a mechanically compliant layer, with high electrical and thermal conductivity, between the low- and high-temperature segments to relieve thermomechanical stresses during device fabrication and operation. This composite material can be used as a stress-relieving layer between the thermoelectric segments and/or between a thermoelectric segment and a hot- or cold-side interconnect material. The material also can be used as a compliant hot shoe.

Nickel-coated graphite powders were hot-pressed to form a nickel-graphite composite material. A freestanding thermoelectric segmented leg was fabricated by brazing the compliant pad layer between the high-temperature p-Zintl and low-temperature p-SKD TE segments using Cu-Ag braze foils. The segmented leg stack was heated in vacuum under a compressive load to achieve bonding.

The novelty of the innovation is the use of composite material that reduces the thermomechanical stresses encountered in the construction of high-efficiency, high-temperature thermo-electric devices. The compliant pad enables the bonding of dissimilar thermoelectric materials while maintaining the desired electrical and thermal properties essential for efficient device operation. The modulus, CTE, electrical, and thermal conductances of the composite can be controlled by varying the ratio of nickel to graphite.

This work was done by Samad A. Firdosy, Billy Chun-Yip Li, Vilupanur A. Ravi, Jean-Pierre Fleurial, Thierry Caillat, and Harut Anjunyan of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1).

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