the polymer electrolytes with carbon substrates, flow-cell stacks with membrane electrode assemblies (MEAs) may be configured much like with fuel cells with suitable flow-fields in biplates for an all-liquid rechargeable flow-battery.

There are several unique attributes of this flow cell, which is amongst the highest voltage flow batteries, with cell voltages higher than the prior non-aqueous 1.7 V vanadium acetylacetone redox flow battery. (1) The reaction involves the shuttling of lithium ions from the anolyte to catholyte, much like with traditional Li-ion cells; (2) The reactions involved at both electrodes are mostly chemical, with the oxidized or reduced lithium reacting with the liquid active materials; (3) Both the anolyte and catholyte are electronically conducting with some lithium, thus negating the need for ionic conduction through a lithium salt solution; and (4) The electrodes are only for current collection purposes, which precludes any morphological or interfacial changes at the electrode. All these features will, in principle, contribute to a long cycle life, calendar life, safety, and low self-discharge rates.

This work was done by Ratnakumar V. Bugga, William C. West, Andrew Kindler, and Marshall C. Smart of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1).

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to:

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Refer to NPO-48555, volume and number of this NASA Tech Briefs *issue, and the page number.*

Reliability of CCGA 1152 and CCGA 1272 Interconnect Packages for Extreme Thermal Environments

CCGA packages are used in logics and microprocessor functions, telecommunications, flight avionics, and payload electronics.

NASA's Jet Propulsion Laboratory, Pasadena, California

Ceramic column grid array (CCGA) packages have been increasing in use based on their advantages of high interconnect density, very good thermal and electrical performance, and compatibility with standard surface-mount packaging assembly processes. CCGA packages are used in space applications such as in logics and microprocessor functions, telecommunications, flight avionics, and payload electronics. As these packages tend to have less solder joint strain relief than leaded packages, the reliability of CCGA packages is very important for short- and long-term space missions.

Certain planetary satellites require operations of thermally uncontrolled hardware under extremely cold and hot temperatures with large diurnal temperature change from day to night. The planetary protection requires the hardware to be baked at +125 °C for 72 hours to kill microbugs to avoid any biological contamination, especially for sample return missions. Therefore, the present CCGA package reliability research study has encompassed the temperature range of –185 to +125 °C to cover various NASA deep space missions.

Advanced 1152 and 1272 CCGA packaging interconnects technology test hardware objects have been subjected to extreme temperature thermal cycles from –185 to +125 °C. X-ray inspections of CCGA packages have been made before thermal cycling. No anomalous behavior and process problems were observed in the x-ray images. The change in resistance of the daisy-chained CCGA interconnects was measured as a function of increasing number of thermal cycles. Electrical continuity measurements of daisy chains have shown no anomalies, even until 596 thermal cycles. Optical inspections of hardware have shown a significant fatigue for CCGA 1152 packages over CCGA 1272 packages.

No catastrophic failures have been observed yet in the results. Process qualification and assembly are required to optimize the CCGA assembly processes. Optical inspections of CCGA boards have been made after 258 and 596 thermal cycles. Corner columns have started showing significant fatigue per optical inspection results.

This work was done by Rajeshuni Ramesham of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1). NPO-48505

Using a Blender to Assess the Microbial Density of Encapsulated Organisms

This technology has applications in medical device manufacturing to ensure device sterility.

NASA's Jet Propulsion Laboratory, Pasadena, California

There are specific NASA requirements for source-specific encapsulated microbial density for encapsulated organisms in non-metallic materials. Projects such as the Mars Science Laboratory (MSL) that use large volumes of non-metallic materials of planetary protection concern pose a challenge to their bioburden budget. An optimized and adapted destructive hardware technology employing a commercial blender was developed to assess the embedded bioburden of thermal paint for the MSL project.

The main objective of this optimization was to blend the painted foil pieces in the smallest sizes possible without excessive heating. The small size increased the surface area of the paint and enabled the release of the maximum number of encapsulated microbes. During a trial run, a piece of foil was placed into a blender for 10 minutes. The outside of the blender was very hot to the touch. Thus, the grinding was reduced to five 2-minute periods with 2-minute cooling periods between cycles. However, almost 20% of the foil fraction was larger (>2 mm). Thus, the largest fractions were then put into the blender and reground, resulting in a 71% increase in particles less than 1 mm in size, and a 76% decrease in particles greater than 2 mm in size.

Because a repeatable process had been developed, a painted sample was processed with over 80% of the particles being <2 mm. It was not perceived that the properties (i.e. weight and rubber-like nature) of the painted/foil pieces would allow for a finer size distribution. With these constraints, each section would be ground for a total of 10 minutes with five cycles of a 2-minute pulse followed by a 2-minute pause. It was observed on several occasions that a larger blade affected the recovery of seeded spores by approximately half an order of magnitude.

In the standard approach, each piece of painted foil was aseptically removed from the bag and placed onto a sterile tray where they were sized, cut, and cleaned. Each section was then weighed and placed into a sterile Waring Laboratory Blender. Samples were processed on low speed. The ground-up samples were then transferred to a 500-mL bottle using a sterile 1-in. (≈2.5-cm) trim brush. To each of the bottles sterile planetary protection rinse solution was added and a modified NASA Standard Assay (NASA HBK 6022) was performed. Both vegetative and spore plates were analyzed.

This work was done by James N. Benardini, Robert C. Koukol, Gayane A. Kazarians, Wayne W. Schubert, and Fabian Morales of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1). NPO-48302