Manufacturing & Prototyping

Low-Dead-Volume Inlet for Vacuum Chamber

John F. Kennedy Space Center, Florida

Gas introduction from near-ambient pressures to high vacuum traditionally is accomplished either by multi-stage differential pumping that allows for very rapid response, or by a capillary method that allows for a simple, single-stage introduction, but which often has a delayed response. Another means to introduce the gas sample is to use the multi-stage design with only a single stage. This is accomplished by using a very small conductance limit. The problem with this method is that a small conductance limit will amplify issues associated with dead-volume.

As a result, a high-vacuum gas inlet was developed with low dead-volume, allowing the use of a very low conductance limit interface. Gas flows through the ConFlat flange at a relatively high flow rate at orders of magnitude greater than through the conductance limit. The small flow goes through a conductance limit that is a double-sided ConFlat.

This work was done by Guy Naylor and C. Arkin of ASRC Aerospace Corporation for Kennedy Space Center. For further information, contact the Kennedy Innovative Partnerships Program Office at (321) 861-7158. KSC-13317

Thermal Control Method for High-Current Wire Bundles by Injecting a Thermally Conductive Filler

Goddard Space Flight Center, Greenbelt, Maryland

A procedure was developed to inject thermal filler material (a paste-like substance) inside the power wire bundle coming from solar arrays. This substance fills in voids between wires, which enhances the heat path and reduces wire temperature. This leads to a reduced amount of heat generated. This technique is especially helpful for current and future generation high-power spacecraft (1 kW or more), because the heat generated by the power wires is significant enough to cause unacceptable overheating to critical components that are in close contact with the bundle.

Powered test results in thermal vacuum showed a significant decrease in temperature with filler of ≈50 °C. Without filler, the bulk wire temperature was around 100 °C, whereas with filler, it was around 50 °C. The heat generated by the bundle was reduced by ≈15 percent. The procedure generated the development of an injection manifold for simultaneous injection around the perimeter of the bundle, which is unique. This manifold ensures a consistent and thorough fill of gaps between wires.

The unique or novel features are twofold. This is the first instance where thermal filler material was used to fill in voids in between wires to enhance thermal path, and reduce wire temperatures and heat generated. The injection manifold designed for the procedure is also unique. A thermal test was performed in order to evaluate the advantages of the use of this procedure. In the test with 2.5 A running through the wires, an approximately 50 °C temperature reduction was measured after the filler injection procedure. Heat conduction path improved by up to a factor of 11, and waste heat generated was reduced by 15 percent.

This work was done by Juan Rodriguez-Ruiz, Russell Rowles, and Greg Greer of Goddard Space Flight Center. Further information is contained in a TSP (see page 1). GSC-15987-1

Method for Selective Cleaning of Mold Release From Composite Honeycomb Surfaces

A simple, EPA-friendly approach solves a long-standing problem in heat-formed composite manufacturing.

Goddard Space Flight Center, Greenbelt, Maryland

Honeycomb structures are commonly employed as load- and force-bearing structures as they are structurally strong and lightweight. These structures include many aircraft and spacecraft surfaces, including aircraft wings and fuselages, spacecraft pressure vessels, and heat-shield materials. Many other processes in other areas of transportation and defense, as well as the pharmaceutical and construction industries, employ pressure vessels with similar heat-formed composite structures.

Manufacturing processes for heat-molded composite honeycomb structures commence with the placement of pre-impregnated composite layups over metal mandrels. To prevent permanent bonding between the composite layup and the metal mandrels, an agent, known as a mold release agent, is used. Mold release agents allow the molded composite material to be removed from mandrels after a heat-forming process. Without a specific removal process, mold release agents may continue to adhere to the surface of the composite material, thereby affecting the bonding of other materials that may come into contact with the composite surface in later stages of processing.

Mold release agents have a unique chemistry that, upon heating, requires a unique chemical method for removal. Prior art includes immersion solvent cleaning (trichloroethylene, hexane, limonene), vapor degreasing, and plasma cleaning. Many of the solvent and vapor degreasing techniques, such as Freon and trichloroethylene, can no longer be used per EPA standards. Plasma cleaning has limited use in structures that have a deep channel or high aspect ratio, as the plasma penetrates diffusively and thus, may result in incomplete cleaning for the full depth of the structure.

A constituent common to commercially available household cleaning agents is employed for the removal of mold release agents common to the manufacturing of heat-formed composite materials. The reliability of the solvent has been proven by the longevity and reliability of commercial household cleaners. At the time of this reporting, no one has attempted using constituent for this purpose. The material to be cleaned is immersed in the solution, vertically removed so that the solution is allowed to drain along cell walls and into a solvent bath, and then placed on a compressed airflow table for drying. Non-destructive evaluation techniques [see "Non-Destructive Evaluation of Materials via Ultraviolet Spectroscopy" (GSC-15338), *NASA Tech Briefs,* Vol. 32, No. 6 (June 2008) p. 81] are employed to detect mold release residue and evaluate the degree of cleanliness. The cleaning process is repeated until non-destructive evaluation shows minimal detection limits for mold release residue.

This work was done by Diane Pugel of Goddard Space Flight Center. Further information is contained in a TSP (see page 1). GSC-15902-1

Infrared-Bolometer Arrays With Reflective Backshorts

Operational wavelengths can be tailored by adjusting a few process steps.

Goddard Space Flight Center, Greenbelt, Maryland

Integrated circuits that incorporate square arrays of superconducting-transition-edge bolometers with optically reflective backshorts are being developed for use in image sensors in the spectral range from far infrared to millimeter wavelengths. To maximize the optical efficiency (and, thus, sensitivity) of such a sensor at a specific wavelength, resonant optical structures are created by placing the backshorts at a quarter wavelength behind the bolometer plane. The bolometer and backshort arrays are fabricated separately, then integrated to form a single unit denoted a backshort-under-grid (BUG) bolometer array. In a subsequent fabrication step, the BUG bolometer array is connected, by use of single-sided indium bump bonding, to a readout device that comprises mostly a superconducting quantum interference device (SQUID) multiplexer circuit. The resulting sensor unit comprising the BUG bolometer array and the readout device is operated at a temperature below 1 K.

The concept of increasing optical efficiency by use of backshorts at a quarter wavelength behind the bolometers is not new. Instead, the novelty of the present development lies mainly in several features of the design of the BUG bolometer array and the fabrication sequence used to implement the design. Prior to joining with the backshort array, the bolometer array comprises, more specifically, a square grid of free-standing molybdenum/gold superconducting-transition-edge bolometer elements on a 1.4-μm-thick top layer of silicon that is part of a silicon support frame made from a silicon-on-insulator wafer. The backshort array is fabricated separately as a frame structure that includes support beams and contains a corresponding grid of optically reflective patches on a single-crystal silicon substrate.

The process used to fabricate the bolometer array includes standard patterning and etching steps that result in the formation of deep notches in the silicon support frame. These notches are designed to interlock with the support beams on the backshort-array structure to provide structural support and precise relative positioning. The backshort-array structure is inserted in the silicon support frame behind the bolometer array, and the notches in the frame serve to receive the support beams of the backshort-array structure and thus determine the distance between the backshort and bolometer planes. The depth of the notches and, thus, the distance between the backshort and bolometer planes, can be tailored to a value between 25 to 300 μm adjusting only a few process steps. The backshort array is designed so as not to interfere with the placement of indium bumps for subsequent indium bump-bonding to the multiplexing readout circuitry.

This work was done by Timothy M. Miller, John Abrahams, and Christine A. Allen of Goddard Space Flight Center. Further information is contained in a TSP (see page 1). GSC-15104-1