Books & Reports

A Superfluid Pulse Tube Refrigerator Without Moving Parts for Sub-Kelvin Cooling

A report describes a pulse tube refrigerator that uses a mixture of ^{3}He and superfluid ^{4}He to cool to temperatures below 300 mK, while rejecting heat at temperatures up to 1.7 K. The refrigerator is driven by a novel thermodynamically reversible pump that is capable of pumping the ^{3}He–^{4}He mixture without the need for moving parts.

The refrigerator consists of a reversible thermal magnetic pump module, two warm heat exchangers, a recuperative heat exchanger, two cold heat exchangers, two pulse tubes, and an orifice. It is two superfluid pulse tubes that run 180° out of phase. All components of this machine except the reversible thermal pump have been demonstrated at least as proof-of-concept physical models in previous superfluid Stirling cycle machines. The pump consists of two canisters packed with pieces of gadolinium gallium garnet (GGG). The canisters are connected by a superleak (a porous piece of VYCOR® glass). A superconducting magnetic coil surrounds each of the canisters.

This work was done by Franklin K. Miller of for Goddard Space Flight Center. Further information is contained in a TSP (see page 1). GSC-15580-1

Sapphire Viewports for a Venus Probe

A document discusses the creation of a viewport suitable for use on the surface of Venus. These viewports are rated for 500 °C and 100 atm pressure with appropriate safety factors and reliability required for incorporation into a Venus Lander. Sapphire windows should easily withstand the chemical, pressure, and temperatures of the Venus surface. Novel fixture designs and seals appropriate to the environment are incorporated, as are materials compatible with exploration vessels. A test cell was fabricated, tested, and leak rate measured. The window features polish specification of the sides and corners, soft metal padding of the sapphire, and a metal C-ring seal. The system safety factor is greater than 2, and standard mechanical design theory was used to size the window, flange, and attachment bolts using available material property data. Maintenance involves simple cleaning of the window aperture surfaces. The only weakness of the system is its moderate rather than low leak rate for vacuum applications.

This work was done by Stephen Bates of Thoughtventions Unlimited for Goddard Space Flight Center. Further information is contained in a TSP (see page 1). GSC-16095-1

The Mobile Chamber

A document discusses a simulation chamber that represents a shift from the thermal-vacuum chamber stereotype. This innovation, currently in development, combines the capabilities of space simulation chambers, the user-friendliness of modern-day electronics, and the modularity of plug-and-play computing. The Mobile Chamber is a customized test chamber that can be deployed with great ease, and is capable of bringing payloads at temperatures down to 20 K, in high vacuum, and with the desired metrology instruments integrated to the systems control. Flexure plans to lease Mobile Chambers, making them affordable for smaller budgets and available to a larger customer base.

A key feature of this design will be an Apple iPad-like user interface that allows someone with minimal training to control the environment inside the chamber, and to simulate the required extreme environments. The feedback of thermal, pressure, and other measurements is delivered in a 3D CAD model of the chamber's payload and support hardware. This GUI will provide the user with a better understanding of the payload than any existing thermal-vacuum system.

This work was done by Gregory Scharfstein and Russell Cox of Flexure LLC for Goddard Space Flight Center. Further information is contained in a TSP (see page 1). GSC-16469-1

Electric Propulsion Induced Secondary Mass Spectroscopy

A document highlights a means to complement remote spectroscopy while also providing *in situ* surface samples without a landed system. Historically, most compositional analysis of small body surfaces has been done remotely by analyzing reflection or nuclear spectra. However, neither provides direct measurement that can unambiguously constrain the global surface composition and most importantly, the nature of trace composition and second-phase impurities.

Recently, missions such as Deep Space 1 and Dawn have utilized electric propulsion (EP) accelerated, high-energy collimated beam of Xe^+ ions to propel deep space missions to their target bodies. The energies of the Xe^+ are sufficient to cause sputtering interactions, which eject material from the top microns of a targeted surface. Using a mass spectrometer, the sputtered material can be determined. The sputtering properties of EP exhaust can be used to determine detailed surface composition of atmosphereless bodies by electric propulsion induced secondary mass spectroscopy (EPI-SMS).

EPI-SMS operation has three high-level requirements: EP system, mass spectrometer, and altitude of about 10 km. Approximately 1 keV Xe^+ has been studied and proven to generate high sputtering yields in metallic substrates. Using these yields, first-order calculations predict that EPI-SMS will yield high signal-to-noise at altitudes greater than 10 km with both electrostatic and Hall thrusters.

This work was done by Rashied Amini of Caltech and Geoffrey Landis of Glenn Research Center for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1). NPO-47798

Radiation-Tolerant DC-DC Converters

A document discusses power converters suitable for space use that meet the DSCC MIL-PRF-38534 Appendix G radiation hardness level P classification. A method for qualifying commercially produced electronic parts for DC-DC converters per the Defense Supply Center Columbus (DSCC) radiation hardened assurance requirements was developed.

Development and compliance testing of standard hybrid converters suitable for space use were completed for missions with total dose radiation requirements of up to 30 kRad. This innovation provides the same overall