NASA SBIR 2007 Phase I Solicitation

S5.01 Extreme Environments Technology

Lead Center: JPL

Participating Center(s): ARC, GRC, GSFC, MSFC

High temperature, high pressure, and chemically corrosive environments:

Proposals are sought for technologies that enable the in situ exploration of the surface and deep atmosphere of Venus and the deep atmospheres of Jupiter or Saturn for future NASA missions. Venus features a dense, CO₂ atmosphere completely covered by sulfuric acid clouds at about 55 km above the surface, a surface temperature of about 486°C and a surface pressure of about 90 atmospheres. Although already explored by various orbiters and short-lived atmospheric probes and landers, Venus retains many secrets pertaining to its formation and evolution. NASA is interested in expanding its ability to explore the deep atmosphere and surface of Venus through the use of long-lived (days or weeks) balloons and landers. Survivability in extreme high temperatures and high pressures is also required for deep atmospheric probes to giant planets. Technology advancements to permit operation and survivability in high-temperature/high-pressure planetary environments are sought in the following areas:

Thermal Control Systems: Survivability of electronic components in high temperature environments relies on three basic areas of thermal control: isolation, thermal capacitance and/or refrigeration. Specific improvements in are sought in the development of:

- Thermal energy storage systems with 300 - 1000 kJ/kg energy density through either phase changes or chemical heat absorption;
- High performance, low mass refrigeration cooling systems capable of pumping on the order of 100 Watts of heat from a 100°C source to the Venus sink temperature of 486°C. In this area, particular attention must be paid to the power source for such a system. A total systems approach must be considered as opposed to development of a particular component.

Pressure Vessel Components:
• Optical Window systems that are transparent in IR, Visible and UV wavelengths at Venus surface temperatures that remain sealed under expected mission temperature variations from -50°C to 486°C and from external pressure variation from 0 to 90 atmospheres.

• Pressure vessel flange seal technology compatible with materials such as stainless steels, titanium and beryllium. Seals shall exhibit leakage rates lower than 10⁻¹⁵ cc He/sec over the expected mission temperature variations from -50°C to 486°C and from external pressure variation from 0 to 90 atmospheres. Clamping loads for the seals shall be less than 1500 pounds per linear inch.

Low temperature environments:

Moon equatorial regions experience wide temperature swings from -180°C to +130°C during the lunar day/night cycle, and the sustained temperature at the shadowed regions of lunar poles can be as low as -230°C. Mars diurnal temperature changes from about -120°C to +20°C. Low temperature survivability is also required for missions to Titan, surface of Europa and comets. Proposals are sought in the following specific areas:

• Wide temperature (-180°C to +130°C) and low-temperature (-230°C), radiation-tolerant and SEL immune, low power, mixed-signal circuits including analog-to-digital converters, digital-to-analog converters, low-noise pre-amplifiers, voltage and current references, multiplexers, power switches, microcontrollers, and integrated command/control/drive electronics for sensors, actuators, and communications transponders.

• Computer Aided Design (CAD) tools for predicting the electrical performance, reliability, and life cycle for low-temperature electronic systems and components.

• Physics-based transistor device models valid at temperature ranging from -230°C to +130°C to enable design, verification and fabrication of custom low power mixed-signal and analog circuits.

• Low-temperature (-230°C) circuit design methodologies facilitating novel layout designs for integrated mixed-signal and analog circuits.

• Selected hardware and support technologies for motors, drive systems and related mechanisms that will operate in low temperature environments. Specific areas of interest include gear boxes, suspension systems, material components (i.e., wiring, harnesses, insulating materials, and jackets/covers) that can operate in cryogenic environments; advanced lubricants and lubrication technology.

Research should be conducted to demonstrate technical feasibility during Phase 1 and show a path toward a Phase 2 hardware/software demonstration, and when possible, deliver a demonstration unit for functional and environmental testing at the completion of the Phase 2 contract.