NASA SBIR 2005 Phase I Solicitation

S2.02 Extreme High Temperature/High Pressure Environment

Lead Center: JPL

Participating Center(s): GRC

Proposals are sought for technologies to enable operation and survivability in high-temperature/high-pressure space environments. These technologies service the needs of the future in situ exploration of Venus as well as the atmospheric probes for giant planets.

Venus features a dense, CO₂ atmosphere completely covered by clouds with sulfuric acid aerosols, a surface temperature of 486°C, and a surface pressure of 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 (380°C) and high pressures (>100 bar) is also required for deep atmospheric probes to giant planets.

Technology needs for high-temperature and high-pressure environments include:

- Advanced passive and active thermal control for Venus missions, including lightweight (50 kg/m³), high strength/stiffness, high buckling stress resistant pressure vessels to protect the electronics and instruments for several hours; new lightweight thermal insulation materials with conductivity less than 0.1 W/mK at 486°C, thermal storage systems with 300-1000 kJ/kg energy density, thermal switches with a switching ratio of at least 100:1 between “On” and “Off” modes, and high temperature heat pipe systems operating over a temperature range of 25 to 500°C. Refrigeration systems capable of pumping heat from a 25 to 75°C source to the Venus sink temperature of 486°C;

- Science and engineering sensors able to operate at 486°C and 100 bar, including for example, high temperature imagers, hybrid imaging system that utilizes high temperature fiber optics, seismometers, and pressure sensors;

- High-temperature, low-power, and ultra low-power electronics and electronic packaging technology for sensor and actuator interfaces at 486°C, including low-noise (10 nV/sqHz) preamplifiers, power amplifiers and transmitters (S-band), temperature stable oscillators, drivers (with 0-100 V digital output for driving piezoelectric, electrostatic, or electromagnetic actuators), and high value (on the order of one to hundreds
of micro Farad) capacitors;

- Computer Aided Design (CAD) tools for predicting the performance, reliability, and life cycle for high-temperature electronic systems and components;

- High-temperature primary batteries (200 Whr/kg)) for operation at 380°C and 486°C;

- Actuators for sample handling and acquisition systems including high-temperature drills, motors, and actuators able to operate in the 486°C, 90 atmosphere surface environment of Venus; and

- Anticorrosive coatings to protect optical systems and spacecraft structures from corrosive agents present in the upper levels of Venus’ atmosphere (sulfuric acid clouds) or near surface (besides carbon oxide and nitrogen, the atmosphere contains sulfuric acid, hydrochloric acid, and hydrofluoric acid).

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 or software package for JPL testing at the completion of the Phase 2 contract.