NASA SBIR 2006 Phase I Solicitation

S2.03  Energy Conversion and Power Electronics for Deep Space Missions

Lead Center: GRC

 Participating Center(s): GSFC, JPL, JSC

Proposals are solicited to develop advanced energy conversion and power electronics to enable or enhance the capabilities of next decadal deep space missions, with potential missions to Europa, Venus, Titan, and primitive bodies. These missions require power systems with long life capability and high reliability and offering significant mass and volume savings and improved efficiency compared to the state of practice (SOP) devices. Other desired capabilities are high radiation tolerance, and ability to operate in extreme environments (high and low temperatures and over wide temperature ranges).

Extreme Photovoltaics Energy Conversion

NASA has an increasing interest in solar array technology for deep space missions. The science community is currently pushing for solar missions that go as far as Saturn. PV proposals are sought to develop advanced photovoltaic devices and systems that can operate in extreme environments and offer significant mass and volume savings over the SOP systems. Photovoltaic cell and array technologies should also have significant improvements in efficiency, specific power, cost, and ability to operate in high-radiation, extreme-temperature environments such as near sun (high-intensity, high-temperature - HIHT) environment or deep space (low-intensity, low-temperature - LILT) environments. Extreme Photovoltaic technologies of interest are:

- Solar cells that can function effectively under LILT conditions and high radiation environments for deep space missions beyond 4 AU;
- Solar cells that can operate high temperatures (up to 450°C) for near sun missions;
- Solar arrays with high specific power (> 250 W/kg) and low stowage volume for solar electric propulsion missions.

RPS Energy Conversion

Radioisotope power systems (RPS) are presently used in some planetary surface missions and deep space science missions that go beyond 4 AU. Proposals are sought to develop advanced RPS technologies that would contribute to a system with long life capability (> 14 years), high conversion efficiency (> 20%), and high specific power (> 8 - 10 W/kg). The radioisotope power conversion systems of interest are, Stirling, Thermoelectrics (TE),
and Thermophotovoltaics (TPV). All proposed energy conversion technologies must be able to operate in deep space environments with high radiation and wide-temperature operations (-200°C to >300°C). A high priority for NASA is the development of advanced static power conversion technologies (TPV or TE) that offer greater than 20% thermal-to-electric conversion efficiency for an RPS system, as well as power conversion approaches that can operate in the extreme environments of Venus and Europa.

Thermophotovoltaic technologies should focus on demonstrating converter component technologies that offer improved performance parameters:

- Photovoltaic devices capable of operating at high temperature (> 50°C) and high current density for extended durations (> 14 yr) while maintaining high performance;
- Optical filters that offer high spectral efficiency and high temperature survivability (> 150°C);
- Emitter materials that offer high efficiency as well as low evaporative losses suitable for extended (14 yr) operation;
- Solar concentrator based TPV systems with concepts for thermal energy storage and their integration with the emitter systems.

Thermoelectric technologies should focus on:

- High temperature and performance thermoelectric materials. NASA is interested in nanostructured thermoelectric materials with potential for \( ZT > 2 \) and ability to operate at temperatures and lifetimes compatible with RPS systems;
- Innovative packaging of thermoelectric elements in closed or compact arrays;
- Sublimation coatings or methods.

Stirling power conversion technologies should focus on:

- Novel methods or approaches for radiation-tolerant, sensorless, autonomous control of the Stirling converters with very low vibration and having low mass, size, and electromagnetic interference (EMI);
- Advanced regenerators with improved durability and high temperature capability while maintaining high performance;
- Lightweight, high-efficiency linear alternators with low EMI and capable of high-temperature operation;
- High temperature heater heads (> 850°C) and joining techniques.
Advanced Photovoltaics Energy Conversion

Photovoltaic cell and array technologies with significant improvements in efficiency, mass specific power, stowed volume, cost, radiation resistance, and wide operating conditions are solicited. Photovoltaic cell technologies for wide temperature operation and radiation environments are solicited. Potential array technologies of interest include:

- Rigid and deployable arrays;
- Concentrators (rigid or inflatable, primary or secondary);
- Ultra-lightweight arrays for lightweight, flexible;
- Thin-film photovoltaic cells;
- Electrostatically clean spacecraft solar arrays.

Energy Conversion Thermal Management

Thermal technology areas include heat rejection, composite materials, heat pipes, pumped loop systems, packaging and deployment, including integration with the power conversion technology. Highly integrated systems are sought that combine elements of the above subsystems to show system level benefits.