Low Temperature Compatible Low Power, Rad-Hard Electronics and Energy Storage

Technical Goal

1-Electronic packaging technology and materials that can survive -240^oC to +125^oC thermal cycling.

2-Localized heater and control electronics (total ionizing dose (TID) = 300 krad (Si), -240^oC operation).

3-Sense and control electronics capable of operating from +125 to -240^oC, under TID=300krad (Si), with noise levels of 6nV/ and power levels < 1 mW at -240^oC.

4-Primary batteries, capable of storage at -240^oC, with subsequent warm-up and operation at -140^oC (low rate) or -80^oC (high rate) with improved specific energy (>200Wh/kg). Batteries will be compatible with planetary protection bakeouts.

Mission Applications

Duty Cycled Lander or Probe for Ocean Worlds and Europa: Small mobility platforms and science instruments that can remain in sleep mode at -240^oC without sustained heating, relying on local heaters for "start up" and self-heating during operation, could reduce the required heater power by >95%. For a 1 meter diameter probe, this could result in 0.63kg/day mass savings for the mission from time of separation from the spacecraft (coast) to end of the landed mission. Alternatively, this stored energy could be used to increase probe lifetime or functionality.

Long life science crafts, aerial or small distributed probes: Surface missions to Ocean Worlds and Europa will require subsystems, arms, instruments, actuators, and appendages to operate at -240^oC. Cold-operational distributed electronics for these platforms can limit the number of wires and length of cables between electronics and their associated actuators/instruments. This will drastically reduce mass, power, signal losses and noise, while increasing redundancy. The use of distributed motor control could reduce actuator harness mass by 90%. Additional technologies needed for these probes include high specific energy -80^oC primary batteries that are able to meet the above technical goals. Such batteries can potentially extend mission life by 400%.

Technical Status

1-SOA for cold survivable electronics is defined by the *Mars Temperature Cycle Resistant Electronics* technology. This packaging technology is capable of +85 to -120^oC cycling for 2000 cycles (TRL 9).

2 and 3-NASA technology for lunar applications developed -180^oC SiGe based custom electronics and models on a presently obsolete 0.5μm SiGe BiCMOS technology (TRL 5). *Mars Focused Technology* (MFT) developed a custom Operational Amplifier on 0.35 μm SOI CMOS rated at -180^oC to +120^oC and 300krad (TRL 9). Teledyne and MIT Lincoln Lab have developed cryogenic capable custom ROICs and ASICs on an older generation CMOS technology (TRL 9).

4-DS-2 low rate micro-probe primary batteries, manufactured by Yardney Tech., capable of -80^oC operation (TRL 9). JPL RTD (346) investment in small lab scale cells with -120^oC operation (TRL3).

Development Cost and Schedule