Electronic Packaging for Extreme Environments

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Almost all Solar System Exploration/Earth Orbiting missions NASA is planning to pursue in the next ten years (including those to Mars) incorporate an element of mobility (external appendages and/or external electronics) and will be required to operate under extreme conditions. Electronic parts and standard packaged components, however, are not designed for and may not operate at the extremely low temperatures (up to –196 °C) required for such missions. In addition, attempting to design for extremely low temperature operation at late stages in the design cycle is costly and inefficient, requiring a dedicated development effort much earlier. To address this issue, we propose to develop a set of technologies that will enable the construction of systems capable of (1) operating under extremely cold environments and (2) surviving cold temperature cycling (see examples in the table below). Our packaging approach looks at the root causes of failures of the traditional packaging technologies for cold temperatures. It accents the choice of materials and components that can ensure reliable operation under extremely cold temperatures, as well as providing a vehicle to explore innovative engineering solutions. Furthermore, it concentrates on the use of embedded passives and flip-chip attachment technology in the packaging as a means for increasing the packaging density and enhancing cold temperature reliability. Although a range of environmental extremes exist (e.g., pressure, impact, dust, corrosive atmospheres, radiation, extreme temperatures etc.) limitations on resources compel us to focus our efforts on critical thrusts in the areas of ultra low temperature operation/survivability of electronics and radiation effects. When combined, the elements of this investigation will significantly reduce the size, weight and complexity of the mobility avionics system by employing a high-density packaging approach and by reducing the need for a warm electronics box (WEB), while simplifying its design.

Environment	Geosynchronous earth orbit (GEO)	Lunar surface	Martian surface
Temperature cycles:	90 cycles/y @ - 196 C to 128 C	13 cycles/y, altitude dependent @ -171 C to 111C	356 cycles/y, altitude dependent @ -143 C to 27 C
Electromagnetic radiation:	8760 ESH/y	8760 ESH/y	1656 ESH/y
Particulate radiation:	protons, electrons, alpha-particles	protons, electrons, alpha-particles	n/a