

Editorial

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Electronic subsystems (avionics), radio subsystems (telecom), payload elements on the Mars Exploration Rovers (MER) or Nanorovers to Asteroid, Mars Science Laboratory (MSL), or other NASA missions should be maintained at a nearly constant temperature with heating elements installed to control the temperature as a part of the microelectronic package. Heating of the electronic package boards consumes valuable power resources. Reliable operation of the above subsystems under ambient conditions experienced on Mars or an asteroid can result in the elimination of temperature controls, thereby providing added flexibility in the overall design of future rovers. Most research in the area of low-temperature electronics has been limited to work near the boiling points of liquid nitrogen (77 K) and liquid helium (4.2 K). Rover electronics and packages would be exposed to ambient temperatures on Mars ranging from -130 to $+85^{\circ}\text{C}$ and on the asteroid ranging from -180 to -100°C . Most silicon, germanium, and gallium arsenide (GaAs) devices exhibit enhanced performance at reduced temperatures. Perhaps the most vital issue in addressing effects of temperature on spacecraft electronic packages is the thermal cycling associated with exposure to the ambient conditions on the surface of Mars and the asteroid during the day and night operations and non-operations. Much of the work to date has been focused only on a limited number of thermal cycles related to routine maintenance of electronic components. Understanding the effects of extended thermal cycling, therefore, is crucial to the evaluation of new systems for future space missions in the context of the stringent safety and reliability requirements of all spacecraft modules. The circuits must also function over a wide temperature range in order to infuse such technology in future space missions.

The part, package, module, subassembly, system, etc. shall be designed to survive at least three times the total number of expected temperature cycles resulting from all environmental and operational exposures occurring over the life of the flight hardware (including all relevant manufacturing, ground operations, transportation, power cycling, and thermal testing) and mission phases, such as launching, cruising, and landing. Specifically, it shall be demonstrated that subjecting flight-like hardware to environmental temperature extremes (levels or temperature limits and thermal cycles) will not result in structural failures or electrical performance degradations due to either overstress or low thermal cycle fatigue.

We have organized a single-session workshop to address the reliability of devices and electronic packages under extreme temperatures. The gathering of more than 70 people from around the world at the International Microelectronics and Packaging Society's (IMAPS) Second Advanced Technology Workshop on "Reliability of Advanced Electronic Packages and Devices in Extreme Cold Environments" was held at the Embassy Suites Hotel, Arcadia, CA, USA, from February 27 to March 1, 2007, and has further intensified the interest of the scientific, technical, and industrial communities in the cold electronics package reliability area.

The four papers included in this special issue are chosen from the extended versions of the 31 papers in the *Proceedings of the IMAPS ATW* reporting new results. The four papers are as follows:

- Flight Qualification and Circuit Development of Sensor Front-End Electronics for PACS/Herschel at Liquid Helium Temperature
- Development and Manufacture of a Linear 16-Pixel FIR Array—The PACS Module
- Testing of the Mars Exploration Rovers to Survive the Extreme Thermal Environments
- Reliability Assessment of Advanced Flip-Chip Interconnect Electronic Package Assemblies under Extreme Cold Temperatures (-190 and -120°C)

We are confident that this special issue will attract the attention of many more cold electronics packaging reliability, device reliability, and system-level reliability experts to the new field of advanced technology reliability under extreme cold temperatures. We hope that a good understanding of the reliability of electronic packages will be achieved in the future by prominent technology developers and researchers around the world.