



## Electronics/Computers

### **Cryogenic Quenching Process for Electronic Part Screening**

**This process can be used in medical or industrial application of electronics at cryogenic temperatures.**

*NASA's Jet Propulsion Laboratory, Pasadena, California*

The use of electronic parts at cryogenic temperatures ( $\leq -100$  °C) for extreme environments is not well controlled or developed from a product quality and reliability point of view. This is in contrast to the very rigorous and well-documented procedures to qualify electronic parts for mission use in the  $-55$  to  $125$  °C temperature range. A similarly rigorous methodology for screening and evaluating electronic parts needs to be developed so that mission planners can expect the same level of high reliability performance for parts operated at cryogenic temperatures.

A formal methodology for screening and qualifying electronic parts at cryogenic temperatures has been proposed. The methodology focuses on the base physics of failure of the devices at cryogenic temperatures. All electronic part reliability is based on the "bathtub" curve, high amounts of initial failures (infant mortals), a long period of nor-

mal use (random failures), and then an increasing number of failures (end of life). Unique to this is the development of custom screening procedures to eliminate early failures at cold temperatures. The ability to screen out defects will specifically impact reliability at cold temperatures.

Cryogenic reliability is limited by electron trap creation in the oxide and defect sites at conductor interfaces. Non-uniform conduction processes due to process marginalities will be magnified at cryogenic temperatures. Carrier mobilities change by orders of magnitude at cryogenic temperatures, significantly enhancing the effects of electric field. Marginal contacts, impurities in oxides, and defects in conductor/conductor interfaces can all be magnified at low temperatures.

The novelty is the use of an ultra-low-temperature, short-duration quenching process for defect screening. The quenching process is designed to identify those defects that will precisely

(and negatively) affect long-term, cryogenic part operation. This quenching process occurs at a temperature that is at least  $25$  °C colder than the coldest expected operating temperature. This quenching process is the opposite of the standard "burn-in" procedure. Normal burn-in raises the temperature (and voltage) to activate quickly any possible manufacturing defects remaining in the device that were not already rejected at a functional test step. The proposed "inverse burn-in" or quenching process is custom-tailored to the electronic device being used. The doping profiles, materials, minimum dimensions, interfaces, and thermal expansion coefficients are all taken into account in determining the ramp rate, dwell time, and temperature.

*This work was done by Douglas J. Sheldon of Caltech and John Cressler of Georgia Tech University for NASA's Jet Propulsion Laboratory. For more information, contact [iaoffice@jpl.nasa.gov](mailto:iaoffice@jpl.nasa.gov). NPO-47933*

### **Broadband Via-Less Microwave Crossover Using Microstrip-CPW Transitions**

**Potential applications include high-frequency probe interfaces, phased-array antennas, and beam-forming networks.**

*Goddard Space Flight Center, Greenbelt, Maryland*

The front-to-back interface between microstrip and CPW (coplanar waveguide) typically requires complex fabrication or has high radiation loss. The microwave crossover typically requires a complex fabrication step. The prior art in microstrip-CPW transition requires a physical vias connection between the microstrip and CPW line on a separate layer. The via-less version of this transition was designed empirically and does not have a close form solution. The prior art of the microwave crossover requires either additional substrate or wire bond as an air bridge to isolate two

microwave lines at the crossing junction. The disadvantages are high radiation loss, no analytical solution to the problem, lengthy simulation time, and complex fabrication procedures to generate air bridges or via. The disadvantage of the prior crossover is a complex fabrication procedure, which also affects the device reliability and yield.

This microstrip-CPW transition is visualized as two microstrip-slotline transitions combined in a way that the radiation from two slotlines cancels each other out. The invention is designed based on analytical methods; thus, it sig-

nificantly reduces the development time. The crossover requires no extra layer to cross two microwave signals and has low radiation loss. The invention is simple to fabricate and design. It produces low radiation loss and can be designed with low insertion loss, with some tradeoff with signal isolation.

The microstrip-CPW transition is used as an interface to connect between the device and the circuit outside the package. The via-less microwave crossover is used to allow two signals to cross without using an extra layer or fabrication processing step to enable this function. This