Electronics/Computers

Cryogenic Quenching Process for Electronic Part Screening

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

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The use of electronic parts at cryogenic temperatures (<–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 normal 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.

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Broadband Via-Less Microwave Crossover Using Microstrip-CPW Transitions

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

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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 significantly 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 design allows the solution to be determined entirely though analytical techniques. In addition, a planar via-less microwave crossover using this technique was proposed. The experimental results show that the proposed crossover at 5 GHz has a minimum isolation of 32 dB. It also has low in-band insertion loss and return loss of 1.2 dB and 18 dB, respectively, over more than 44 percent of bandwidth at room temperature.

This microstrip-CPW transition requires the microstrip line to be split into two sections. Each section is connected to a microstrip quarter-wavelength open-ended stub. A slotline is also placed perpendicular to the microstrip section. The slot is connected to a grounded-end quarter-wavelength slotline and generates a microstrip-slotline transition. When two of these sections are placed in parallel and with the microstrip section combined at transition, a microstrip-CPW transition is formed. The slotline radiation is suppressed as two slots are excited with the electric field in an opposite direction, which cancels the radiation in far field. The invention on the crossover consists of the invented microstrip-CPW transitions combined back-to-back and a microstrip low-pass filter. One signal is crossed through to the microstrip layer, while the other signal is crossed through the CPW line located on the ground plane of the microstrip line. The microstrip low-pass filter produces a narrow line at the crossing point to enhance the system isolation. It also produces broadband response in the operating frequency band.

The microstrip-CPW transition allows a microwave signal to travel from microstrip line to CPW line with low radiation loss. The crossover allows two microwave signals to cross with minimal parasitic coupling.

This work was done by Thomas Stevenson, Kongpop U-Yen, Edward Wollack, Samuel Moseley, and Wen-Ting Hsieh of Goddard Space Flight Center. Further information is contained in a TSP (see page 1). GSC-15705-1

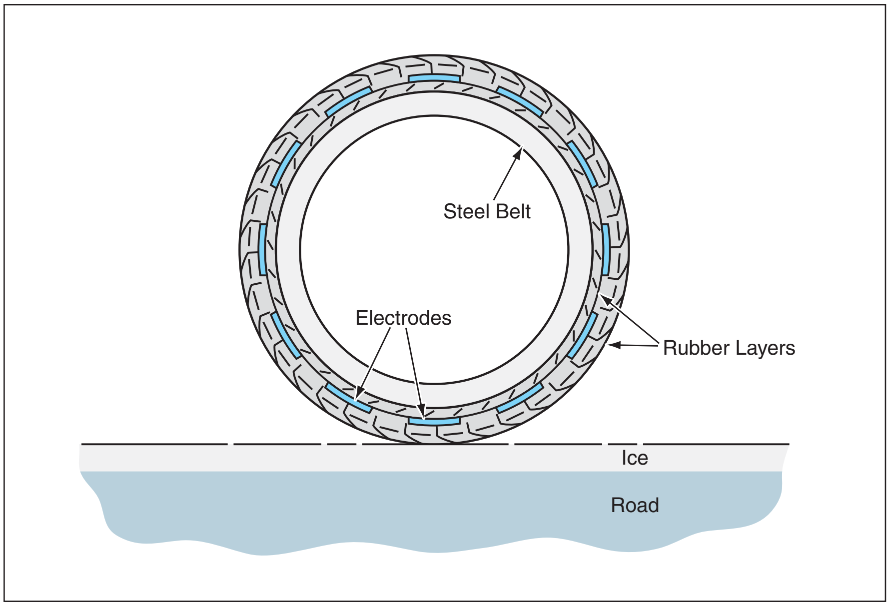
Wheel-Based Ice Sensors for Road Vehicles

Ice would be sensed via its electric permittivity.

Lyndon B. Johnson Space Center, Houston, Texas

Wheel-based sensors for detection of ice on roads and approximate measurement of the thickness of the ice are under development. These sensors could be used to alert drivers to hazardous local icing conditions in real time. In addition, local ice-thickness measurements by these sensors could serve as guidance for the minimum amount of sand and salt required to be dispensed locally onto road surfaces to ensure safety, thereby helping road crews to utilize their total supplies of sand and salt more efficiently.

Like some aircraft wing-surface ice sensors described in a number of previous *NASA Tech Briefs* articles, the wheel-based ice sensors are based, variously, on measurements of changes in capacitance and/or in radio-frequency impedance as affected by ice on surfaces. In the case of ice on road surfaces, the measurable changes in capacitance and/or impedance are attributable to differences among the electric permittivities of air, ice, water, concrete, and soil. In addition, a related phenomenon that can be useful for distinguishing between ice and water is a specific transition in the permittivity of ice at a temperature-dependent frequency. This feature also provides a continuous calibration of the sensor to allow for changing road conditions.



Multiple Electrodes Embedded in a Tire near its outer surface would be excited with alternating voltages. The capacitance between the electrodes at the bottom would be measured as an indication of the thickness of ice (if any) on the road.

Several configurations of wheel-based ice sensors are under consideration. For example, in a simple two-electrode capacitor configuration, one of the electrodes would be a circumferential electrode within a tire, and the ground would be used as the second electrode. Optionally, the steel belts that are already standard parts of many tires could be used as the circumferential electrodes. In another example (see figure), multiple electrodes would be embedded in rubber between the steel belt and the outer tire surface. These electrodes would be excited in alternating polarities at one or more suitable audio or radio frequencies to provide nearly continuous monitoring of the road surface under the tire. In still another example, one or more microwave stripline(s) or coplanar waveguide(s) would be embedded in a tire near its outer surface; in comparison with lower-frequency capacitive devices, a device of this type could be more sensitive.

This work was done by G. Dickey Arndt, Patrick W. Fink, and Phong H. Ngo of Johnson Space Center and James R. Carl (independent consultant). Further information is contained in a TSP (see page 1). MSC-23565-1