How Robust are MEMS for Space Applications?

I. Marozau, M. Lahti •, D. Vogel ••, F. Souchon *, O. Sereda

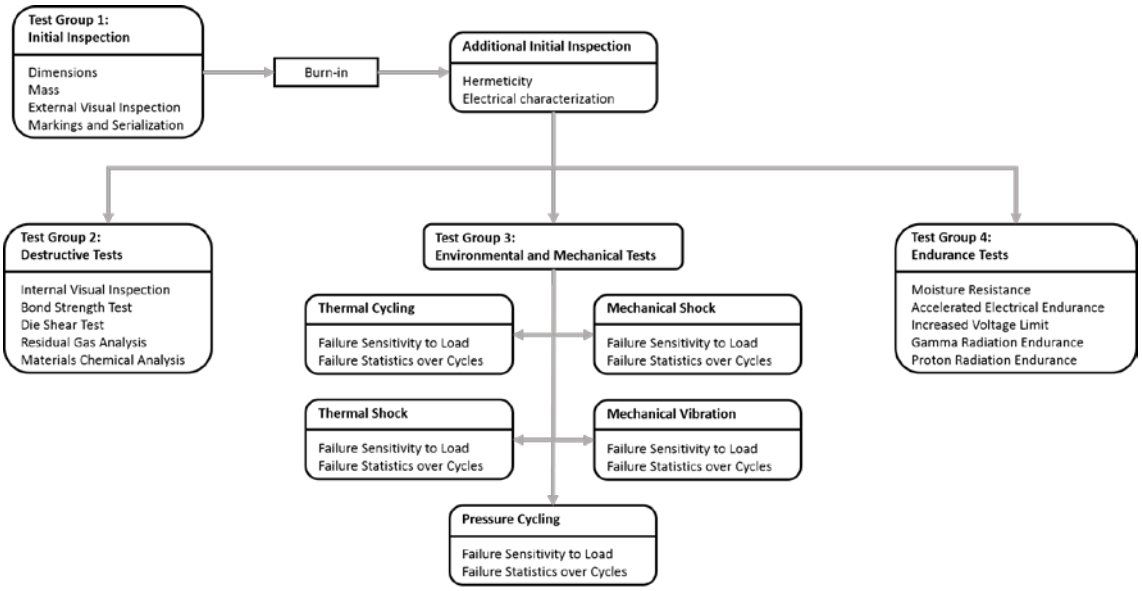
Micro Electro Mechanical Systems (MEMS) have proven themselves in Earth-based applications such as automotive, medical, displays by showing outstanding performance and reliability figures. In space, MEMS have a large potential in applications like communication, navigation, Earth observation and scientific mission. In particular, MEMS can be utilized for fostering new types of scientific missions and instruments; reducing size, mass, cost, and time from mission conception to launch; increasing performances, reliability and redundancy of certain components. An approach for MEMS reliability assessment is being developed by a consortium of European characterization centres led by CSEM with an aim to develop a standardization methodology and Technical Memorandum for the reliability assessment of MEMS products for space applications.

The dramatically lower mass, the lower-power consumption, the smaller volume, and the possibility of tight integration with electronics, the field of MEMS offers new functionality and performance advantages, but also brings new challenges, particularly in the fields of testing and qualification. Today, only a few MEMS components have been or are planned to be used in space applications. Despites the growing interest for this new technology for space and the great reliability figures shown by earth-based sensors for application, specific space MEMS components have a low technology readiness level. One important reason for this low technology readiness level is the lack of possibility to assess the reliability of MEMS component in a standardized fashion and the lack of appropriate standards for qualification of MEMS components on which the industry could base themselves for future development and space usage.

The main aim of the present activity is to establish a Technical Memorandum for the standardization methodology for reliability assessment of MEMS products. The methodology is to be followed in evaluation of the product's capabilities as required for space applications and thereby to anticipate, as far as possible, component behaviour during reliability testing. Therefore, the aim of such testing is to overstress specific characteristics of the component concerned with a view to the detection of possible failure modes. A detailed destructive physical analysis is performed to facilitate failure analysis.

The developed methodology includes four groups of tests to address reliability of MEMS devices regarding packaging, mechanical movement of MEMS parts, and application-specific integration circuit [1]. A scheme of the testing plan is shown in the figure below.

In order to test and prove the established reliability assessment methodology, capacitive MEMS accelerometers from three different suppliers were tested. This also allowed to perform their comparative evaluation and to identify suitable MEMS components for their use in space application. The selected accelerometers were represented by ceramic- and plastic-packaged devices. Packaging type has a strong influence on the pressure cycling behaviour: ceramic-packaged devices have passed the tests with no failures, whereas plastic-packaged ones failed at a certain overpressure limit. All devices showed a high robustness in thermal tests. Chip soldering quality was identified to be the main reliability limiting factor in this case. Mechanical tests revealed that the predominant failure mode was detachment of wire bonds from bonding pads. Filling the device package interior volume with a viscous gel material can significantly improve the mechanical shock resistance. Radiation endurance tests showed that only one type of devices exhibits failures at high gamma or proton radiation doses (≥50 krad). The most probable origin for the failures is ionization and displacement effects in application-specific integration circuit components. The performed reliability testing campaign has proven relevance of the established methodology for MEMS reliability assessment for space applications.



• VTT Technical Research Centre of Finland, Finland

•• Fraunhofer-ENAS, Germany

* CEA-LETI, MINATEC Campus, France

[1] MIL-STD-883 Test method standard microcircuits, DLA Land and Maritime - VA, P.O. Box 3990, Columbus, OH 43218-3990.