

Upscreening of Class B Microcircuits For Space Applications

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Introduction

Monolithic microcircuits, also referred to as integrated circuits, are designed for use in a wide range of applications and environments. Some applications are very benign while other applications require careful selection of the proper type of device to ensure system reliability. Semiconductor devices are designed and manufactured for various environments ranging from desktop computers to manned space vehicles. Each environment has very different requirements that must be addressed in specifying the microcircuits used in that environment.

Class B and Class S Processing Differences

Historically military applications have utilized ceramic packaged microcircuits assembled and screened to either Class Level B or Class Level S (Space Level) as defined by MIL-STD-883 Method 5004 with Quality Conformance Inspection performed in accordance with MIL-STD-883 Method 5005. If requirements for radiation hardened performance are ignored, the differences between Class B and Class S microcircuits are screening and lot acceptance related. Table 1 summarizes the screening differences between these types of devices.

Table 1 - Class Level S and Class Level B Screening Requirements

Screen	Class S	Class B
Wafer Lot Acceptance	100%	Not Required
Nondestructive Bond Pull	100%	Not Required
Internal Visual	100% - Condition A 100X	100% - Condition B 40X only allowed
Temperature Cycling	100% - Condition C 50 Cycles	100% - Condition C 10 Cycles Allowed
Constant Acceleration	100% - Y1 only	100% - Y1 only
Visual Inspection	Optional	Optional
Particle Impact Noise Detection (PIND)	100%	Not Required
Serialization	100%	Not Required
Pre Burn-In Electrical Parameters	100% - read & record	100% - Go/No-Go
Burn-In Test	240 hours at 125 °C	160 hours at 125 °C
Interim (Post Burn-In) Parameters	100%	Not Required
Reverse Bias Burn-In	72 hours at 150 °C	Not Required
Interim (Post Burn-In) Electrical Parameters	100% with deltas	100% - Go/No-Go
Percent Defective Allowable Calculation	All lots	All lots
Final Electrical Test	100%	100%
Seal Hermetic Test	100%	100%
Radiographic Inspection (X-ray)	100%	Not required
QCI Sample Selection	See 5005	See 5005
External Visual	100%	100%
Radiation Latch-Up Acceptance	As required by procurement document	Typically not supplied

Both Class B and Class S microcircuits originate from the same wafer fabrication facilities. Both are fabricated under the control of a quality system in accordance with MIL-PRF-38535. For Class S devices, a wafer lot acceptance is performed in accordance with MIL-STD-883 Method 5007. For Class B devices, the manufacturer's defined Quality Management Plan for the wafer fabrication process is used.

In addition to the 100% screening, Quality Conformance Inspection (QCI) is performed. QCI includes Group A electrical lot acceptance which is performed for both Class B and Class S devices. Group B assembly process monitors are performed by lot for Class S. For Class B, Group B is typically performed once during each week of seal for each package family. Table 2 summarizes the Group B QCI requirements.

Table 2 - Class Level S and Class Level B QCI Requirements (Group B)

QCI Test	Class S By Lot	Class B By Package Family
Physical Dimensions	2(0)	Not Required
Internal Water Vapor	3(0) or 5(1)	Not Required
Resistance To Solvents	3(0)	3(0)
Internal Visual And Mechanical	2(0)	Not Required
Bond Strength	22(0) wires	15(0) Wires
Die Attach Strength	3(0)	Not Required
Solderability	22(0) leads	22(0) leads
Lead Integrity	45(0) leads	Not Required
Lid Torque	As applicable	Not Required
Steady State Life	45(0)	Not Required
Temperature Cycling Constant Acceleration	15(0)	Not Required

Group C QCI consists of die related life tests and is performed annually for Class B products on representative devices from each microcircuit group from each wafer fabrication facility. For Class S products life test is included as part of Group B.

Group D QCI consists of package related tests performed every 36 weeks on representative samples of each package family at each assembly facility. Class B and Class S requirements are the same for Group D.

QML Class B Considerations

Under MIL-PRF-38535, a QML certified manufacturer is permitted to modify, substitute, or delete tests that do not improve the quality and/or reliability of the finished device as defined by the applicable device specification. Therefore the end user of a Class B microcircuit should not assume that all screening detailed in MIL-STD-883 Method 5004 and all quality conformance inspections detailed in Method 5005 are performed. Following is an excerpt from MIL-PRF-38535 authorizing the removal or modification of non-value added processes, screens, and inspections:

1.1 Scope. This specification establishes the general performance requirements for integrated circuits or microcircuits and the quality and reliability assurance requirements which must be met for their acquisition. The intent of this specification is to allow the device manufacturer the flexibility to implement best commercial practices to the maximum extent possible while still providing product which meets the military performance needs. ... If sufficient quality and reliability data is available, the manufacturer, through the QM program and the manufacturer's review system, may modify substitute or delete tests.

Texas Instruments Class B Processing

Texas Instruments is certified and listed by the Defense Supply Center Columbus (DSCC) as a manufacturer of QML Class B microcircuits (integrated circuits) in accordance with MIL-PRF-38535 (General Specification For Manufacturing Integrated Circuits). The Quality System utilized by Texas Instruments in the manufacture of these microcircuits is fully compliant to the requirements of MIL-PRF-38535 and ISO9001.

Texas Instruments produces QML (Device Type Q) microcircuits as Class B only. The practice of “up screening” microcircuits from Class B to Class S is not supported by Texas Instruments. Texas Instruments will not be responsible for any component or system failure due to the misapplication of its products and may not warrant components subjected to “up screening.” The use of Texas Instruments Class Type B devices in Class Type S or Space applications is understood to be fully at the risk of the buyer.

All processing, screening, and Quality Conformance Inspection (QCI) is performed to Level B in compliance with the test methods of MIL-STD-883, Microcircuits Test Method Standard, with exceptions as allowed by Paragraph 1.1 of MIL-PRF-38535. While Texas Instruments no longer manufactures Class S devices, Texas Instruments devices are manufactured to the strictest quality and reliability standards. Wafer fabrication process controls and process indices are constantly monitored to ensure uniform consistency.

Current Density and Metallization Step Coverage

As noted above, wafer lot acceptance is not required for Class B product. With respect to metallization step coverage, Texas Instruments device design is performed in accordance with Texas Instruments Design Rules per MIL-PRF-38535 Appendix A Paragraph A.3.5.5 – “Individual device calculations are not required when appropriate documented design rules or requirements have been used, which limit or control the current density in the resulting design.” Please note that these design rules are intellectual property and will not be disclosed outside of Texas Instruments. The actual maximum current density in a contact or metallization run is not available for specific devices as this verification is performed using Computer Aided Design tools.

Metal integrity is assured through a combination of these design rules and techniques, process development, manufacturing controls, and end-of-line screening and reliability testing as outlined in MIL-STD-883 Test Method 2018.3 Scanning Electron Microscope (SEM) Inspections, “Appendix A Metal Integrity Alternate To SEM Inspection.” The design controls defined by Texas Instruments include reliability rules, layout rules, computer aided rules checking, and on-going process development programs. Manufacturing controls include statistical process controls and equipment defect and foreign material control. Ongoing reliability monitors utilizing accelerated testing augment these controls.

Semiconductor processing technology has advanced several generations since MIL-STD-883 Method 2018.3 was last updated in 1989. When Method 2018.3 was written, the industry standard feature size was in the 3-micron range. Current leading edge technology is fabricated with feature sizes of less than 0.25 microns. Texas Instruments devices with feature sizes of less than 1 micron do not meet the Class S step coverage requirements defined by MIL-STD-883 Method 2018 and therefore will not meet the Class S Wafer Lot Acceptance criteria. The physical characteristics of aluminum preclude deposition in such small geometries. For devices with these geometries, both the aluminum and the barrier metal(s) are considered current carrying conductors.

In the case of mature products, the maximum current density criterion is met without requiring the metallization step coverage of MIL-STD-883 Method 2018. Overall reduction of metallization step coverage to well below 50% still results in acceptable reliability performance. In some cases step coverage of less than 15% is acceptable when the perimeter of the contact is considered since the total cross-sectional area of the contact typically exceeds the cross-sectional area of the metal line. Multiple via contacts are used in structures such as input/output circuits where higher current densities are expected. In addition, the metal system itself is capable of current densities in excess of the maximum allowable current density specified in the Texas Instruments design rules. For a discussion of this topic, please see the technical article entitled Electromigration Characteristics Of Vias in Ti:W/Al-Cu(2wt%) Multilayered Metallization published by Texas Instruments in the proceedings of the 1991 IEEE International Reliability Physics Symposium.

For additional information on this topic or any other inquiries, please contact the Texas Instruments Product Information Center at (972) 644-5580 or via the Internet at <http://www.ti.com>.

