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Requirements for Microelectronic Screening and Test Optimization

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REQUIREMENTS FOR MICROELECTRONIC SCREENING AND TEST OPTIMIZATION

(From JEDEC Board Ballot, JCB-06-60, formulated under the cognizance of the JC-13.2 Subcommittee on Microelectronic Devices.)

1 Scope

This document defines the methodology for the optimization (elimination, reduction, or alternative approach) of the MIL-PRF-38535 screening and testing requirements for MIL-PRF-38535, Classes Q and V, Microcircuits. Inherent in this methodology is the application of "In-line Process Controls" and "SPC" techniques to the applicable manufacturing processes. This document includes the process for initial approval and subsequent maintenance of the testing and screening optimizations.

The purpose of this document provides the basis for the optimization of 100% screening/stress operations and sample inspection test activities. This document is designed to assist the manufacturer in optimizing the test flow while maintaining and/or improving assurance of providing high quality and reliable product in an efficient manner. This will allow for optimization of testing that is not adding value, hence, reducing cycle time and costs.

2 Referenced documents

2.1 Military specifications

MIL-PRF-38535, Integrated Circuits (Microcircuits) Manufacturing, General Specification For

2.2 Military Standards

MIL-STD-883 (Test Method Standard Microcircuits)

2.3 EIA Documents/publications

ANSI/EIA Standard No. 557, Statistical Process Control Systems

EIA-625 Requirements for Handling Electrostatic- Discharge-Sensitive (ESDS) Devices

JEDEC publication No. 132, Process Characterization Guideline

3 General Requirements

3.1 Test Optimization Foundation

The manufacturer has to establish the foundation for "Test Optimization" before implementing these optimizations into the manufacturing and/or test flow. The manufacturing flow shall have an SPC system in place and an underlying philosophy that assures continuous improvement. Each critical operation relative to optimization of test shall have controls sufficient to ensure product meets the Technology Conformance Inspection (TCI) requirements of MIL-PRF-38535. The applicable Level I, II, and III quality characteristics' controls defined herein shall be in place for the test to be eliminated. A facility granted approval for optimization of tests shall pursue efforts toward continuous improvement. This assumes changes to the approved system and associated critical operations will occur. As changes to Level I, II and III quality characteristics control system are implemented, the manufacturer shall assure that sufficient evaluations have been performed to prevent the generation of defects that would result in degradation in product performance at a test that has been optimized. The manufacturer's control system shall be sensitive to detrimental trends or shifts in the process that may appear in the product. Changes in the Level I, II and III quality characteristics control system shall be communicated to the qualifying activity in accordance with the specified change notification requirements.

This publication primarily focuses on the required controls to eliminate screens and/or tests. The manufacturer may use other "test optimization" approaches to detect potential quality and reliability issues, such as; modify manufacturing flow to minimize handling and reduce risk of potential product damage, use in-process controls or tests for earlier detection, develop alternative sampling plans, or develop alternative test techniques to effectively identify and/or screen defective product. These alternative approaches should consider the Level I, II, and III quality characteristics described herein, and understand the potential causes and detection of process quality or reliability defects as applicable in establishing the alternative test plans.

3.2 Statistical Process Control (SPC) System

An SPC system must be fully implemented before test optimization is initiated. A comprehensive SPC system must first be developed in accordance with EIA Standard 557. JEDEC Publication 132 can be used as a guideline to assist the manufacturer in characterizing processes.

3.3 Quality characteristics

Once the SPC system is fully implemented, the manufacturer can start the optimization of screens and or tests. The first step in this process is the identification of the primary quality characteristics that are to be controlled. The "Quality Characteristics" are those measurable product parameters identified and defined by the manufacturer as critical to the device operation or function.

3.3.1 Level I quality characteristics

Level I quality characteristics are measurable by the customer on the end product. The relationship between Level I characteristics and the potential effect on product performance varies widely for each product parameter.

3.3 Quality characteristics (cont'd)

3.3.2 Level II quality characteristics

Level II quality characteristics are process parameters that occur at the critical process node which relate to the output Level I Quality Characteristics.

3.3.3 Level III quality characteristics

Level III quality characteristics are those parameters controlled prior to the process. This includes material and environment parameters (e.g. gases, chemicals, D.I. water, humidity, etc.) affecting each critical process node. These parameters must be characterized with respect to the input/output relationships and interactions, and how they impact the Level I and II Quality Characteristics. The manufacturer must demonstrate how those parameters are under control.

3.3.3.1 Assuring quality of incoming materials

The manufacturer must have an active control system in place to ensure the quality of incoming materials. This control may be accomplished by either requiring the supplier to have an SPC control system for the key parameter, or the manufacturer's control system ensures the quality of received materials.

3.3.3.2 Foreign Material Control System

A foreign material control system shall be established which provides control, prevention, monitoring, sampling and reporting of foreign materials that may affect device performance. The plan must also involve corrective action when appropriate.

3.3.3.3 Electrostatic Discharge/Electrical Overstress

The manufacturer must have an ESD protection program in place in accordance with EIA625 to prevent potential damage to product.

3.4 Reinstitution of screens

A plan must be in place to reinstitute the tests/screens if process controls or monitor tests indicate that control is lost. A system must be in place for validating the integrity of the product when special cause signals occur.

3.5 Reliable product characteristics

Manufacturers shall document a plan to demonstrate periodically that their manufacturing and quality systems ensure reliable performance in accordance with MIL-PRF-38535 technology conformance inspections. The manufacturer shall define in their Quality Management (QM) Plan the frequency and sample plans for the performance of periodic re-validations of the TCI requirements.

The frequency and sample size depend on whether; the screen and/or test had been eliminated, accomplished by an alternative method, or moved to a different point in the flow.

3.6 Military specifications/standards changes

Any changes to military specifications/standards that may impact any elimination or optimization of test conditions installed at any manufacturer shall be cause for the following:

The responsibility lies with the manufacturer to perform an assessment to determine the impact of any specification changes on the test screen optimization program and the ability of the manufacturer to maintain test optimization.

This assessment for specification changes and any changes to the manufacturer's test screen optimization program shall be provided to the qualifying activity.

3.7 Deviations from established procedures

If product is exposed to additional or non-standard processing (examples include additional handling resulting in ESD or foreign material exposure, or special tests) outside of established practices for the optimized Level I quality characteristic, then the manufacturer will apply appropriate actions to ensure product quality and/or reliability had not been compromised.

3.8 Test and field failures.

When a test failure occurs during in-coming inspection, in-process monitor, end of line/TCI testing, or a confirmed field failure, and an associated screen or test has been optimized, then the following must be addressed.

- 1) The failure shall be analyzed to establish root cause.
- 2) If the failure analysis determines the cause of the failure is not related to the optimized test conditions, then corrective actions shall be taken in accordance with MIL-PRF-38535 requirements.
- 3) If the failure analysis determines the presence of the failure is associated with an optimized test, then the following actions must be taken.
 - a) Product(s) for the optimized manufacturing flow shall not be processed using the affected optimization, but can use un-optimized processing until the following actions are successfully completed.
 - b) Determine if the product quality and/or reliability is acceptable to the levels established for the implementation of test optimization. The defect rate can be determined by either using probability analysis to calculate the defect rate, or perform the standard TCI test to confirm product acceptance.
 - c) If the levels are determined unacceptable then action must be taken to identify affected product(s) for rescreen or retest, and notify affected customers to return product for retest.
 - d) The affected screen or test must be modified to address the failure to achieve acceptable quality and/or reliability levels, and be submitted to the qualifying activity for test optimization approval. If acceptable levels can not be achieved, then the standard screening or TCI test must be reinstated.
 - e) The qualifying activity shall be notified and provided the information on the actions taken.
 - f) The identified actions shall be documented and retained in accordance with record retention procedure requirements.

4 Streamlining matrix

Table 1 compares the relationship/risk associated with a given process and the associated tests. In developing this data, the question was asked; "What is the relationship/risk between a process (e.g., silver-glass die attach) and the 100% screen being considered (e.g., centrifuge)?" It is based on this risk/relationship that all other tables were developed.

For example, if there is a strong relationship between the process and the test, then all levels of process control (Level I, II, and III) are required to satisfy the risk matrix. If there is a moderate relationship between the process and the test, then two levels of process control (Level I and II) are required to satisfy the risk matrix. If there is a slight relationship between the process and the test, then one level of process control (Level I) was required to satisfy the risk matrix. If there was no relationship between the two, then no level of process control was required.

In some cases, the result of a process may be an incoming quality characteristic of another process. In those cases, the control of the incoming quality characteristic is picked up as a Level III control and called "DI" (Direct Impact). For example, backside preparation is not considered as a Level I, II, or III quality characteristic for the elimination of centrifuge, but it is an incoming quality characteristic which must be considered for Level III of die attach.

4.1 Level I risk considerations (Annex A)

This set of tables compares the Level I Quality Characteristics directly to the screen to be eliminated. If a check is present, this quality characteristic must be considered for the elimination of the screen. The process capability data must meet the characteristic defect rates and confidence levels specified below. The process capability study shall include evaluating lot to lot process variation. The number of lots and sample size depend on whether variables or attributes data are used. For example, the number of lots needed to establish the confidence level may need to be 20 lots minimum, or may require collection of data from all lots processed over a two to three year period, in order to have sufficient lot to lot data to demonstrate the confidence level. The capability requirements are expressed as maximum allowable (device level, fully processed) product defect rates.

The following definitions provide a means of differentiating characteristics that dramatically influence product performance from those that bear minimal influence. Test optimization requirements vary accordingly.

The level of demonstrated control is based on the P, S or T associated with each row. The Level I risk charts has abbreviated "Primary", "Secondary", and "Tertiary" as P, S, and T, respectively.

P or Primary defect level is a defect, which in and of itself will cause a device failure. The manufacturer must demonstrate that the defect rate is less than or equal to 500 ppm with a 99% confidence (Beta error = 5% at 600 ppm defect rate.).

S or secondary defect level is a defect which, when combined with another defect, will cause a device failure. The manufacturer must demonstrate that the defect rate is less than or equal to 3% with a 95% confidence level (Beta error = 10% @ 4 % defect rate).

4.1 Level I risk considerations (Annex A) (cont'd)

T or Tertiary defect level is a defect that must interact with 2 or more defects to cause a device failure.

The manufacturer must demonstrate that the defect rate is less than or equal to 4% with a 90% confidence level (Beta error = 15% @ 5% defect rate).

Table 1 — Streamlining matrix (See Notes 4 and 5)

Relationship between Process \ Test	Low Power Visual (LP) M2010	High Power Visual (HP) M2010	Post saw Visual M2010	Centrifuge (CENT) M2001	Thermal Cycle (TC/TS) M1010 / M1011	Fine leak (FL) M1014	Gross Leak (GL) M1014	NDWP M2023	PIND M2020	X-ray M2012	Burn-In (BI) M1015	Elect Test (ET) 2/	External Visual (EV) M2009
Wafer fab		I, II, III		DI	DI			DI	DI		1, II, III	1, II, III	
Backside prep				DI	DI				DI	DI			
Wafer probe		I, II									I, II	I, II	
Saw	I, II	I, II, III						DI	I		I		
Eutectic die attach	I, II, III	I		I, II, III	I, II, III	I, II	I, II	DI	I, II, III	I, II, III	I, II	I, II	
Silver glass die attach	I, II, III	I		I, II, III	I, II, III	I, II	I, II	DI	I, II, III	I, II, III	I, II	I, II	
Aluminum / gold wirebond	I, II, III	I		I, II, III	I, II			I, II, III	I, II	I, II, III 1/	I, II/I, II, III	I, II	
Lead finish						I, II	I				I	I, II	I, II, III
Mark													I, II, III
Solder seal				I	I, II, III	I, II, III	I, II, III		I, II, III	I, II, III	I, II	I	I, II, III
Glass frit seal				I	I, II, III	I, II, III	I, II, III			I, II, III	I, II		I, II, III
Weld seal				I	I, II, III	I, II, III	I, II, III		I, II, III	I, II, III		I	I, II, III
Lead trim						I, II	I		DI 3/				I, II

NOTE 1 For aluminum wire bond, there are no critical quality characteristics. However, for gold wire bond, all three levels apply.

NOTE 2 Two out of three electrical tests may be eliminated (e.g. cold and room temperature). However, the most critical temperature test cannot be eliminated. The evaluation must be made in relation to the applicable Standard Military Drawings (SMDs).

NOTE 3 Trimmed leads of flatpack packages may cause false failures.

NOTE 4 The test methods referenced in the header (e.g. MXXX) are the applicable test methods as defined in MIL-STD-883.

NOTE 5 DI = Direct Impact (See section 4)

4.2 Level I, II, and III requirements by process (Annex B)

These tables describe the Level I, II, and III quality characteristics for a given process.

Level I Quality Characteristics are those which can be measured on a delivered product. The required capability (column 2) is based on the defect type (P/S/T per the tables in annex A). The variable relationship column provides a means of assessing or assuring performance of Level I Quality Characteristics.

Level II Quality Characteristics are those which can be measured during the process (e.g., pre-seal bond pull monitor). The required capability and control mechanisms of these quality characteristics will be determined by the manufacturer after identifying the Level I Quality Characteristics. It is recommended that the manufacturer give consideration to the process conditions listed when performing designed experiments.

Level III considerations are pre-process or incoming quality characteristics which should be considered. The control of these incoming process parameters will be dependant upon the significance of the parameter to the outgoing Level I Quality Characteristics.

5 Conditions for deletion of control levels

5.1 Deletion of Level I quality characteristic monitors

Control of Level I quality characteristics shall be verified via statistically sound process monitors in order to support optimization of screens related to that quality characteristic. Upon documented agreement with the qualifying activity, a process monitor may be determined unnecessary to ensure control of a Level I quality characteristic based upon any of the following factors:

- Adequate Level II and III controls to maintain Level I capability.
- The Level I variable is inapplicable to the technology or the screen being eliminated (e.g. X-ray for Al Wedge Bond).
- Sound Engineering rationale confirms that variation in the Level I characteristic has been reduced to a low level and the unlikely incidence of an occurrence of a failure has been reduced to meet the specified defect rate and confidence level for the given characteristic as a result of robust product/process design.

5.2 Deletion of Levels II and III quality characteristic monitors

The considerations described in 5.1 apply to Levels II and III as well.

5.3 Sequence of optimization

5.3.1 Non-value added processes

Optimization of some screening operations warrant concurrent (or prior) optimization of upstream stressing operations (e.g. tightening electrical test at one temperature eliminates the value of testing at other temperatures).