JEDEC STANDARD

Failure-Mechanism-Driven Reliability Monitoring

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JEDEC SOLID STATE TECHNOLOGY ASSOCIATION

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CONTENTS

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Introduction

This standard presents a methodology for monitoring component and subassembly reliability. It can be of use to suppliers and users interested in known reliability as an attribute of the component through the production life.

Under this standard, the suite of metrics is tailored to monitor the failure mechanisms which limit the reliability. This is distinguished from a stress-driven monitor approach in which a fixed suite of acceptance stresses or other testing are prescribed and applied without customization according the failure mechanisms for the component or subassembly.

FAILURE-MECHANISM-DRIVEN RELIABILITY MONITORING

(From JEDEC Board ballot JCB-07-19, formulated under the cognizance of JC-14.3 Committee on Silicon Devices Reliability Qualification and Monitoring.)

1 Scope

This standard describes essential requirements for a reliability monitor for components and subassemblies based on the measurement of failure mechanisms which limit reliability. It applies through the post-qualification production period. Both intrinsic (wearout and systematic) and extrinsic (defect-based) sources of failure are addressed.

2 Terms and definitions

For the purposes of this standard, the following definitions apply. Definitions marked by a asterisk (*) are taken from JESD557, *Statistical Process Control Systems*. They are replicated here for completeness.

characteristic*: A distinguishing feature of a process or its output on which variables or attributes data can be collected.

common cause*: A source of natural variation that affects all the individual values of the process output being studied. In control chart analysis it appears as part of the random process variation.

control limits*: The maximum allowable variation of a process characteristic due to common causes alone. Variation beyond a control limit may be evidence that special causes affecting the process. Control limits are calculated from process data and are usually represented as a line (or lines) on a control chart. They are not to be confused with engineering specification limits.

critical failure mechanism: In semiconductor devices, any potential physical failure mechanism that exhibits one or more of the following: intermittency (e.g., bond lifts), increasing failure rate (e.g., electromigration), and inconsistent or unpredictable failure kinetics (e.g., stress-induced metal voiding)

extrinsic failure mechanism: (1) A failure mechanism caused by an error occurring during the design, layout, fabrication, or assembly process or by a defect in the fabrication or assembly materials. (2) A failure mechanism that is directly attributable to a defect created during manufacturing.

failure: (1) The loss of the ability of a component to meet the electrical or physical performance specifications that (by design or testing) it was intended to meet. (2) A component that has failed.

failure mechanism from fabrication processes: A physical failure mechanism in which all products with the same wafer fabrication process, design rules, and processing line are treated as a homogeneous population for the purpose of statistical reliability monitoring independent of package technology, material, construction, and type.

2 Terms and definitions (cont'd)

failure mechanism from assembly: A physical failure mechanism in which all products with the same assembly technology, including assembly material, assembly construction, and package type and built on the same assembly line are treated as a homogeneous population for the purpose of statistical reliability monitoring independent of the fabrication process and line.

intrinsic failure mechanism: (1) A failure mechanism caused by a natural deterioration in the materials or the manner in which the materials are combined during fabrication or assembly processes that are within specification limits. (2) A failure mechanism attributable to natural deterioration of materials processed per specification.

node*: A definable point in the process at which form, fit, or function of the product or service is altered.

nonconformity*: A specific occurrence of a condition that does not conform to specification. Such an occurrence is sometimes called a discrepancy.

parameter: A measurable characteristic.

physical failure mechanism: A physical or chemical process that ultimately results in failure.

process*: (1) A combination of people, procedures, methods, machines, materials, measurement equipment, and/or environment for specific work activities to produce a given product or service. (2) A repeatable sequence of activities with measurable inputs and outputs.

sample:* A set of individuals taken from a population.

special cause; assignable cause:* A source of variation that is intermittent, unpredictable, or unstable, and affects only some of the individual values of the process output being studied.

statistical reliability monitoring (SRM): A statistically based methodology for monitoring and improving reliability involving identification and classification of failure mechanisms, development and use of monitors, and investigation of failure kinetics, allowing prediction of failure rates at use conditions.

statistical reliability monitor family (SRMF): A product or group of products whose process similarities make them a homogeneous population for the purpose of statistical reliability monitoring. A homogeneous population of product from one SRMF shall have similar propensity towards the physical failure mechanisms being monitored when that product is stressed by accelerated tests or operated in its intended system application. Each product in an SRMF will have the same failure rate for each mechanism only when the factors affecting a failure mechanism are identical for each product type.

variables data*: A measure of a characteristic where every value within a given interval is possible.

3 Process controls

The supplier shall define a Statistical Process Control (SPC) system for all critical process nodes in accordance with JESD557, *Statistical Process Control Systems*. This shall include establishing critical equipment capabilities, preventive maintenance, and calibration procedures.

SPC metrics can intersect with those used for monitoring reliability, but are not required to do so. An SPC system alone might not address all requirements for a failure-mechanism driven reliability monitor program.

4 Identifying failure mechanisms

The supplier shall assess the failure mechanisms which significantly contribute to the field failure rate and institute respective monitors for those mechanisms. The identification of failure mechanisms may be based on
mechanisms observed during development characterizing product sensitivities or process capabilities, mechanisms observed during qualification, mechanisms identified as part of Failure Mode and Effects Analysis (FMEA), or mechanisms observed in previous test or field experience with products using like processes, materials set, or tooling and production facilities.

JEP131 provides guidance on FMEA.

Stress-driven qualifications (e.g., JESD47) and evaluations in which sampling is structured to show compliance to an acceptance criterion without generating failures will not provide an adequate basis for identifying the set of reliability-limiting failure mechanisms for a component. See section 6 regarding continuing acceptability to the original qualification criteria.

The supplier shall be able to identify the rationale for the adequacy of the set of failure mechanisms identified for monitoring.

The failure mechanisms requiring monitoring shall be reassessed for completeness and appropriateness when the process is changed or the product undergoes modifications which may alter its sensitivity to the existing process.