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Standard Guide for Design of Flat, Straight-Line Test Structures for Detecting Metallization Open-Circuit or Resistance-Increase Failure Due to Electromigration (Metric)[1]

This standard is issued under the fixed designation F1259M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This guide covers recommended design features for test structures used in accelerated stress tests, as described in Test Method F1260M, to characterize the failure distribution of interconnect metallizations that fail due to electromigration.

1.2 This guide is restricted to structures with a straight test line on a flat surface that are used to detect failures due to an open-circuit or a percent-increase in resistance of the test line.

1.3 This guide is not intended for testing metal lines whose widths are approximately equal to or less than the estimated mean size of the metal grains in the metallization line.

1.4 This guide is not intended for test structures used to detect random defects in a metallization line.

1.5 Metallizations tested and characterized are those that are used in microelectronic circuits and devices.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

F1260M Test Method for Estimating Electromigration Median Time-To-Failure and Sigma of Integrated Circuit Metallizations (Metric)

F1261M Test Method for Determining the Average Electrical Width of a Straight, Thin-Film Metal Line (Metric)[3]

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *test chip*—an area on a semiconductor wafer containing one or more test structures having a specified or implied purpose.

3.1.2 *test structure*—a passive metallization structure, with terminals to permit electrical access that is fabricated on a semiconductor wafer by the normal procedures used to manufacture microelectronic integrated devices.

3.1.3 *metallization*—the thin-film metallic conductor that serves as the primary conductor path in electrical interconnects of microelectronic integrated circuits.

4. Significance and Use

4.1 This guide is intended for the design of test structures used in measuring the median-time-to-failure and sigma (see Test Method F1260M) of metallizations fabricated in ways that are of interest to the parties to the test.

4.2 This guide is intended to provide design features that facilitate accurate test-line resistance measurements used in estimating metallization temperature. The design features are also intended to promote temperature uniformity along the test line and a minimum temperature gradient at the ends of the test line when significant joule heating is produced during the accelerated stress test.

5. Design Features

5.1 The test structure shall have at least four terminals: two to conduct current and two to measure the voltage. The basic features are illustrated in Fig. 1.

5.1.1 The metallization to be characterized by the test structure shall be in the form of a straight test line of width w, where w shall be larger than the estimated mean size of the metal grains in the metallization of the test line.

NOTE 1—The median-time-to-failure, t_{50}, (see Test Method F1260M) will be a monotonically increasing function of line width w, when w is larger than the mean size of the metal grains in the test line.

NOTE 2—If the mean size of the metal grains in the test line is larger than the line width, there is an increasing probability, for decreasing line width, that failure will occur in the wider end segment of the structure, rather in the test line, for decreasing line width. This is because both t_{50} and sigma increase with decreasing line width in this regime.

5.1.2 The length of the test line shall be 800 µm. Adjacent-running lines may be included in the design to simulate actual-circuit layout, or to serve as monitor lines to detect electromigration-induced metal extrusions from the test line.

[1] This guide is under the jurisdiction of ASTM Committee F01 on Electronics and is the direct responsibility of Subcommittee F01.11 on Nuclear and Space Radiation Effects.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Withdrawn. The last approved version of this historical standard is referenced on www.astm.org.

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