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**Standard method for measuring and
using the temperature coefficient of
resistance to determine the temperature
of a metallization line**

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ELECTROTECHNICAL
COMMISSION



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**Standard Method for Measuring and
Using the Temperature Coefficient of
Resistance to Determine the
Temperature of a Metallization Line**

EIA/JESD33-A

(Revision of JESD33)

OCTOBER 1995

**ELECTRONIC INDUSTRIES ASSOCIATION
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INTERNATIONAL ELECTROTECHNICAL COMMISSION

STANDARD METHOD FOR MEASURING AND USING THE TEMPERATURE COEFFICIENT OF RESISTANCE TO DETERMINE THE TEMPERATURE OF A METALLIZATION LINE

FOREWORD

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**STANDARD METHOD FOR MEASURING AND USING THE
TEMPERATURE COEFFICIENT OF RESISTANCE TO DETERMINE
THE TEMPERATURE OF A METALLIZATION LINE**

CONTENTS

	Page
1 Scope	1
2 Introduction: Significance and use	1
3 Definitions	2
4 Summary of method	
4.1 Assumptions	3
4.2 Relations Used	3
4.3 Procedures	4
4.4 Parameters to be selected	5
5 Precautions and measurement in references	
5.1 Linear dependence	6
5.2 Stability of resistance	7
5.3 Test current	8
5.4 Wafer-level measurements	8
5.5 Package-level measurements	8
5.6 Thermal equilibrium	9
5.7 Mean temperature of test line	9
5.8 Peak temperature of test line	9
5.9 Thermal-EMF voltage	9
5.10 Probe cleanliness	10
5.11 Dew point	10
5.12 Temperature sensors	10
5.13 Concurrent testing	10
6 Test apparatus	
6.1 Current supply	10
6.2 Voltmeter	10

**STANDARD METHOD FOR MEASURING AND USING THE
TEMPERATURE COEFFICIENT OF RESISTANCE TO DETERMINE
THE TEMPERATURE OF A METALLIZATION LINE**

CONTENTS (continued)

	Page
7 Ambient temperature controller	
7.1 Wafer-level measurements	11
7.2 Package-level measurements	11
8 Procedure for $TCR(T_{ref})$ measurement	
8.1 Ambient temperature adjustment	11
8.2 Determine ambient temperature	11
8.3 Measure resistance $R(T_1)$	11
8.4 Determine $R(T)$ at other temperatures	12
8.5 Analysis of $R(T)$ data	12
8.6 Calculate $TCR(T_{ref})$	12
9 Procedure for measuring increase in test-line temperature due to joule heating	
9.1 Determine ambient temperature of test line, T_a	13
9.2 Measure $R(T_a)$	13
9.3 Calculate $R(T_{ref})$	13
9.4 Measure resistance $R(T)$	13
9.5 Calculate mean temperature increase $T - T_a$	14
10 Procedure for measuring ambient temperature with test line	
10.1 Apply measurement current, I_m	14
10.2 Calculate resistance $R_1(T) = V_m/I_m$	14
10.3 Reverse measurement current	14
10.4 Calculate $R(T)$	14
10.5 Calculate temperature of test line	14
11 Measurement bias and precision	
11.1 Within-laboratory precision	15
11.2 Between-laboratory precision and bias	15
12 Required reporting	
12.1 $TCR(T_{ref})$	15
12.2 T_{ref}	15

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EIA/JEDEC STANDARD No. 33-A

**STANDARD METHOD FOR MEASURING AND USING THE
TEMPERATURE COEFFICIENT OF RESISTANCE TO DETERMINE
THE TEMPERATURE OF A METALLIZATION LINE**

CONTENTS *(continued)*

	Page
13 Additional, optional information to report	
13.1 Results of TCR(T) measurements	15
13.2 Results of joule heating measurements	16
13.3 Results of test-line temperature measurements	16
14 References	17

**STANDARD METHOD FOR MEASURING AND USING THE
TEMPERATURE COEFFICIENT OF RESISTANCE TO DETERMINE
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(From JEDEC Council Ballot JCB-95-11, formulated under the cognizance of JC-14.2
Committee on Wafer Level Reliability.)

1 Scope

This method is intended for determining the temperature coefficient of resistance (at a given reference temperature) of aluminum and aluminum-alloy thin-film metallizations that are used in microelectronic circuits and devices.

This method is intended for estimating a mean temperature of a metallization line stressed in an accelerated electromigration stress test before any irreversible change in resistivity occurs due to the current-density and temperature stresses imposed.

This method is intended for using a metallization test line as an ambient-temperature sensor. It uses the predetermined values for the temperature coefficient of resistance of the metallization and the resistance of the test line at the reference temperature.

The method is intended for use only under time, temperature, and current-density conditions where the metallization resistivity is linearly dependent on temperature and where it does not suffer any irreversible changes. These conditions may be different for different metal alloys and different deposition and treatment processes.

While the method is designed for use with aluminum and aluminum-alloy metallizations, it may also be used with other metals and alloys for conditions that satisfy the linear dependence and stability stipulations in the previous paragraph.

The metallization structure used in the method may be measured while on a wafer or a part therefrom, or as part of a test chip bonded to a package and electrically accessible via package terminals.

2 Introduction: Significance and use

The temperature increase of a test line due to joule heating can be an important parameter in accelerated stress tests used to characterize the susceptibility of a metallization test line to electromigration failure at a given temperature and current density [1],[2]. A measure of this susceptibility is the median-time-to-failure of test lines in such tests. Accurate knowledge about the metallization temperature during the test is important because the median-time-to-failure is exponentially dependent on the reciprocal of the metallization stress temperature (in K). For example, an error of 5 °C in stress temperature introduces a 25% error in the sample estimate for t_{50} (at 150 °C and when the activation energy is 0.7 eV).

Electromigration is a metallization failure mechanism that is of great concern, especially for the reliability assessment of very large scale integrated (VLSI) microelectronic devices.

The linear dependence of the resistance of the metallization on temperature permits a test line to be used as a temperature sensor as long as the environmental conditions do not cause irreversible changes in the resistivity of the metallization.

The temperature coefficient of resistance of aluminum metallization is essentially dependent only on the residual resistivity whose magnitude is determined by departures from the structural order of pure, bulk aluminum that contribute to electron scattering [3]. As such, the temperature coefficient of resistance is a fundamental characteristic of the metallization.

3 Definitions

Metallization: a thin-film metallic conductor used to make electrical interconnects in a microelectronic integrated circuit.

Temperature Coefficient of Resistance, TCR(T): the fractional change in resistance per unit change in temperature at a specified temperature T,

$$\text{TCR}(T) = \frac{1}{R(T)} \times \frac{\Delta R}{\Delta T} \quad (^\circ\text{C}^{-1}), \quad (1)$$

where $R(T)$ is the resistance of the test line at temperature T.

Test Line: a metallization line of specified dimensions, the length of which is defined by the locations of two voltage taps used to make Kelvin-type resistance measurements of the test line when two other terminals force a current through the line. (See 4.4.1.)