

JEDEC STANDARD

Test Method for Total Ionizing Dose (TID) from X-ray Exposure in Terrestrial Applications

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TEST PROCEDURE FOR TOTAL IONIZING DOSE (TID) FROM X-RAY EXPOSURE IN TERRESTRIAL APPLICATIONS

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Foreword

Within the JC-14 ‘Quality and Reliability of Solid State Products’, the Task Group on ‘X-ray Terrestrial Ionization Radiation Test Procedure’ TG141.1 committee was initiated and validated during the JC-14.1 ‘Reliability Test Methods / Packaged Devices’ meeting number 129 in January 2022. A liaison with JC- 13.4 sub-committee has been established to take advantage of its Rad-Hard’s expertise.

The test method of this standard defines the testing requirements to measure the parasitic radiation dose deposited and determine any consequential damage or effects to semiconductor devices exposed to X-ray imaging during normal manufacturing, inspections, and Surface Mount Technology (SMT) processes. The objective is to determine the Total Ionizing Dose (TID) limit (as a failure limit or a supplier limit) due to X-ray exposure in terrestrial applications.

TEST PROCEDURE FOR TOTAL IONIZING DOSE (TID) FROM X-RAY EXPOSURE IN TERRESTRIAL APPLICATIONS

From JEDEC Board Ballot JCB-23-51, formulated under the cognizance of the JC-14 Committee on Quality and Reliability of Solid State Products.

1 Scope

This test procedure covers X-ray imaging for terrestrial applications on packaged devices but does not exclude the option to characterize on bare die or wafers as long as potential dose absorption or amplification effects are considered in the final assessment.

Terrestrial X-ray-imaging techniques are suitable for finding hidden defects in buried structures within Integrated Circuit (IC) packages. These techniques are complementary to the optical-inspection techniques used to find surface defects.

The X-ray system targeted for semiconductor product inspection can be used to replicate total cumulative dose for any X-ray exposure system (e.g., scanner imaging during shipping with IC devices inside, solder-joint inspection, and returned-material analysis) for characterization of dose effects.

2 References

Informative:

The following documents contain provisions that, through references in the text, are informative in this standard. At the time of publication, the editions indicated were valid. All standards are subject to revisions.

[1] T.R. Oldham, “Basic Mechanism of TID and DDD Response in MOS and Bipolar” NEPP.NASA.GOV Files, 2011

[2] D.M. Fleetwood, “Evolution of Total Ionizing Dose Effects in MOS Devices with Moore’s Law Scaling”, IEEE Trans. Nucl. Sc., vol. 65, n°. 8, August 2018

[3] N. Wrachien, “Investigation of Proton and X-ray Irradiation Effects on Nanocrystal and Floating Gate Memory Cell Arrays”, IEEE Trans. Nucl. Sc., vol. 55, n°. 6, December 2008

[4] Md Mahbub Alam, “Impact of X-ray Tomography on the Reliability of Integrated Circuits”, IEEE Trans. on device and materials reliability, vol. 17, n°. 1, March 2017

[5] A. Ditali, MICRON Tech., “Kinetic Analysis of X-ray Irradiation Induced Static Refresh Failure Mechanism in DRAM”, IEEE 45th Annual Int. Reliability Physics Symposium, 2007

[6] R.K Lawrence, “TID Considerations in Space Bound Electronics Subjected to Real Time X ray Radioscopic Examinations”, IEEE Radiation Effects Data NSREC Conference, 2011

2 References (cont'd)

- [7] G. Borghello, "Dose-Rate Sensitivity of 65-nm MOSFETs Exposed to Ultrahigh Doses", IEEE Trans. Nucl. Sc., vol. 65, n° 8, August 2018
- [8] X. Wang, "Accelerated Test of ELDRS of Ultralow Dose Rates for Bipolar Devices", 18th European Conference on radiation and its effects on components and systems RADECS, 2018
- [9] W. Beezhold, "A Review of the 40-year History of the NSREC'S Dosimetry and Facilities Session 1963-2003", IEEE Trans. Nucl. Sc., vol. 50, n°. 3, June 2003

Normative:

The following normative documents contain provisions that, through reference in this text, constitute provisions of this standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies.

- [10] NIST standard, J. H. Hubbell and S. M. Seltzer, Nat. Inst. Standards Technol., Gaithersburg, MD, USA, Tech. Rep., "Tables of X-ray mass attenuation coefficients and mass energy-absorption coefficients", 2004
- [11] ISO/ASTM 51956 standard, "Practices for Use of a Thermoluminescence-Dosimetry System (TLD system) for Radiation Processing"
- [12] JESD47 standard, JEDEC Standard Solid State Technology Association, "Stress-Test-Driven Qualification of Integrated Circuits"

3 Terminology

For the purpose of this standard, the following terms, definitions, acronyms, abbreviations, units and conversions apply.

3.1 Terms and Definitions

Total Ionizing Dose (TID): The absorbed cumulative dose i.e., the energy imparted by ionizing radiation per unit mass of irradiated material. The SI units for the dose is Joule per kilogram or Gray (Gy).

Kilovoltage: The energy acquired by a particle with one electron charge in passing through a potential of 1000 volts in vacuum (note: current convention is to use kV for photons and keV for electrons).

Kinetic Energy Released in Matter (KERMA): The sum of all energies released per unit mass and transferred of all the charged particles from the ionization chamber divided by the mass of the material of interest (air for example). The SI unit of air KERMA is Joule per kilogram or Gray (Gy).