



METRIC
Designation: F 1192M – 95

Standard Guide for the Measurement of Single Event Phenomena (SEP) Induced by Heavy Ion Irradiation of Semiconductor Devices [Metric]¹

This standard is issued under the fixed designation F 1192M; 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 defines the requirements and procedures for testing integrated circuits and other devices for the effects of single event phenomena (SEP) induced by irradiation with heavy ions having an atomic number $Z \geq 2$. This description specifically excludes the effects of neutrons, protons, and other lighter particles that may induce SEP via another mechanism. SEP includes any manifestation of upset induced by a single ion strike, including soft errors (one or more simultaneous reversible bit flips), hard errors (irreversible bit flips), latchup (permanent high conducting state), transients induced in combinatorial devices which may introduce a soft error in nearby circuits, power field effect transistor (FET) burn-out and gate rupture. This test may be considered to be destructive because it often involves the removal of device lids prior to irradiation. Bit flips are usually associated with digital devices and latchup is usually confined to bulk complementary metal oxide semiconductor, (CMOS) devices, but heavy ion induced SEP is also observed in combinatorial logic programmable read only memory, (PROMs), and certain linear devices that may respond to a heavy ion induced charge transient. Power transistors require a special test approach that has not yet been formalized.

1.2 The procedures described here can be used to simulate and predict SEP arising from the natural space environment, including galactic cosmic rays, planetary trapped ions and solar flares. The techniques do not, however, simulate heavy ion beam effects proposed for military programs. The end product of the test is a plot of the SEP cross section (the number of upsets per unit fluence) as a function of ion LET (linear energy transfer, or ionization deposited along the ion's path through the semiconductor). This data can be combined with the system's heavy ion environment to estimate a system upset rate.

1.3 Although protons can cause SEP, they are not included in this guide. A separate guide addressing proton induced SEP is being considered.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Terminology

2.1 Definitions of Terms Specific to This Standard:

2.1.1 *californium-252 source*—californium-252 is a fissionable isotope used for heavy ion tests, emitting fission particles with a bimodal mass distribution and bimodal energy spectrum having a mean LET of ~ 45 MeV/(mg/cm²). Alpha-particles accompanying the fissions can be used for source strength determinations.

2.1.2 *DUT*—device under test.

2.1.3 *fluence*—the flux integrated over time, expressed as ions/cm².

2.1.4 *flux*—the number of ions/s passing through a one cm² area perpendicular to the beam (ions/cm²-s).

2.1.5 *LET*—the linear transfer, also known as the stopping power dE/dx, is the amount of energy deposited per unit length along the path of the incident ion, typically expressed as MeV-cm²/mg.

2.1.5.1 *Discussion*—LET values are obtained by dividing the energy per unit track length by the density of the irradiated medium. Since the energy lost along the track generates electron-hole pairs, one can also express LET as charge deposited per unit path length (for example, picocoulombs/micron) if it is known how much energy is required to generate an electron-hole pair in the irradiated material. (For silicon, 3.62 eV is required per electron-hole pair.)

A correction, important for lower energy ions in particular, is made to allow for the loss of ion energy after it has penetrated overlayers above the device sensitive volume. Thus the ion's energy E at the sensitive volume is related to its initial energy E_0 as:

¹ This guide is under the jurisdiction of ASTM Committee F-1 on Electronics and is the direct responsibility of Subcommittee F01.11 on Quality and Hardness Assurance. Current edition approved Sept. 15, 1995. Published November 1995. Originally published as F 1192 – 88. Last previous edition F 1192 – 90.