



Standard Test Method for Use of 2N2222A Silicon Bipolar Transistors as Neutron Spectrum Sensors and Displacement Damage Monitors¹

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1. Scope

1.1 This test method covers the use of 2N2222A silicon bipolar transistors as dosimetry sensors in the determination of neutron energy spectra and as 1 Mev(Si) equivalent displacement damage fluence monitors.

1.2 The neutron displacement in silicon can serve as a neutron spectrum sensor in the range 0.1 to 2.0 MeV when fission foils are not available. It has been applied in the fluence range between 2×10^{12} n/cm² to 1×10^{14} n/cm² and should be useful up to 1×10^{15} n/cm². This test method details the acquisition and use of 1 Mev(Si) equivalent fluence information for the partial determination of the neutron spectra by using 2N2222A transistors.

1.3 This sensor yields a direct measurement of the silicon 1 Mev equivalent fluence by the transfer technique.

1.4 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.5 *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 requirements prior to use.*

2. Referenced Documents

2.1 The ASTM standards E170, E261, and E265 provide a background for understanding how sensors are used in radiation measurements and general dosimetry. The rest of the standards referenced in the list discuss the choice of sensors, spectrum determinations with sensor data, and the prediction of neutron displacement damage in some semiconductor devices, particularly silicon.

¹ This test method is under the jurisdiction of ASTM Committee E10 on Nuclear Technology and Applications and is the direct responsibility of Subcommittee E10.07 on Radiation Dosimetry for Radiation Effects on Materials and Devices.

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2.2 ASTM Standards:²

E170 Terminology Relating to Radiation Measurements and Dosimetry

E261 Practice for Determining Neutron Fluence, Fluence Rate, and Spectra by Radioactivation Techniques

E265 Test Method for Measuring Reaction Rates and Fast-Neutron Fluences by Radioactivation of Sulfur-32

E720 Guide for Selection and Use of Neutron Sensors for Determining Neutron Spectra Employed in Radiation-Hardness Testing of Electronics

E721 Guide for Determining Neutron Energy Spectra from Neutron Sensors for Radiation-Hardness Testing of Electronics

E722 Practice for Characterizing Neutron Fluence Spectra in Terms of an Equivalent Monoenergetic Neutron Fluence for Radiation-Hardness Testing of Electronics

E844 Guide for Sensor Set Design and Irradiation for Reactor Surveillance, E 706 (IIC)

E944 Guide for Application of Neutron Spectrum Adjustment Methods in Reactor Surveillance, E 706 (IIA)

E1854 Practice for Ensuring Test Consistency in Neutron-Induced Displacement Damage of Electronic Parts

E2005 Guide for Benchmark Testing of Reactor Dosimetry in Standard and Reference Neutron Fields

E2450 Practice for Application of CaF₂(Mn) Thermoluminescence Dosimeters in Mixed Neutron-Photon Environments

3. Terminology

3.1 Symbols:

Φ_1 = the silicon 1 Mev equivalent fluence (see Practice E722).
 $h_{FE} = i_c/i_b$ where i_c is the collector current and i_b is the base current, in a common emitter circuit.

4. Summary of Test Method

4.1 Gain degradation of 2N2222A silicon bipolar transistors measured in a test (simulation) environment is compared with a measured reference neutron environment. The Φ_{1r} in the

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.