



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

This standard is issued under the fixed designation E 1855; 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 test method covers how 2N2222A silicon bipolar transistors can be used either as dosimetry sensors in the determination of neutron energy spectra, or as silicon 1-MeV equivalent displacement damage fluence monitors.

1.2 The neutron displacement damage is especially valuable as a 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 and 1×10^{14} n/cm² and, in theory, should be useful up to 10^{15} n/cm². This test method details the steps for the acquisition and use of silicon 1-MeV equivalent fluence information (in a manner similar to the use of activation foil data) for the determination of neutron spectra.

1.3 In addition, this sensor can provide important confirmation of neutron spectra determined with other sensors, and yields a direct measurement of the silicon 1-MeV fluence by the transfer technique.

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. Referenced Documents

2.1 The ASTM standards listed in 2.2 from Terminology E 170 through Test Method E 265 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.

2.2 ASTM Standards:

E 170 Terminology Relating to Radiation Measurements and Dosimetry²

E 261 Practice for Determining Neutron Fluence Rate, Fluence, and Spectra Radioactivation Techniques²

E 263 Test Method for Measuring Fast-Neutron Reaction Rates by Radioactivation of Iron²

E 265 Test Method for Measuring Reaction Rates and Fast-Neutron Fluences by Radioactivation of Sulfur-32²

E 720 Guide for Selection and Use of Neutron-Activation Foils for Determining Neutron Spectra Employed in Radiation-Hardness Testing of Electronics²

E 721 Guide for Determining Neutron Energy Spectra from Neutron Sensors for Radiation-Hardness Testing of Electronics²

E 722 Practice for Characterizing Neutron Energy Fluence Spectra in Terms of an Equivalent Monoenergetic Neutron Fluence for Radiation-Hardness Testing of Electronics²

E 844 Guide for Sensor Set Design and Irradiation for Reactor Surveillance, E706 (IIC)²

E 854 Test Method for Application and Analysis of Solid State Track Recorder (SSTR) Monitors for Reactor Surveillance, E706 (IIIB)²

E 944 Practice for Application of Neutron Spectrum Adjustment Methods in Reactor Surveillance, (IIA)²

3. Terminology

3.1 Symbols:

Φ_1 = the silicon 1-MeV equivalent fluence (see Practice E 722).

$h_{FE} = i_c/i_b$ where i_c is the collector current and i_b is base current, in a common emitter circuit.

4. Summary of Test Method

4.1 Gain degradation of 2N2222A silicon bipolar transistors measured in the test (simulation) environment is compared with that measured in a reference neutron environment. The Φ_{1r} in the reference environment is derived from the known reference spectrum and is used to determine a measured Φ_{1t} in the test environment **(1,2)**³ by the transfer technique. The r and t refer to the reference and test environments respectively.

4.2 The measured Φ_{1t} may be used as a sensor response in a spectrum adjustment code in a manner similar to the use of reaction foil activities to determine the spectrum **(3,4)**.

4.3 Spectra compatible with the responses of many sensors may be used to calculate a more reliable measure of the displacement damage.

¹ This test method is under the jurisdiction of ASTM Committee E-10 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 Annual Book of ASTM Standards, Vol 12.02.

³ The boldface numbers in parentheses refer to a list of references at the end of this test method.

