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Standard Guide for Ionizing Radiation (Total Dose) Effects Testing of Semiconductor Devices[1]

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INTRODUCTION

This guide is designed to assist investigators in performing ionizing radiation effects testing of semiconductor devices, commonly termed total dose testing. When actual use conditions, which include dose, dose rate, temperature, and bias conditions and the time sequence of application of these conditions, are the same as those used in the test procedure, the results obtained using this guide applies without qualification. For some part types, results obtained when following this guide are much more broadly applicable. There are many part types, however, where care must be used in extrapolating test results to situations that do not duplicate all aspects of the test conditions in which the response data were obtained. For example, some linear bipolar devices and devices containing metal oxide semiconductor (MOS) structures require special treatment. This guide provides direction for appropriate testing of such devices.

1. Scope

1.1 This guide presents background and guidelines for establishing an appropriate sequence of tests and data analysis procedures for determining the ionizing radiation (total dose) hardness of microelectronic devices for dose rates below 300 rd(SiO_2)/s. These tests and analysis will be appropriate to assist in the determination of the ability of the devices under test to meet specific hardness requirements or to evaluate the parts for use in a range of radiation environments.

1.2 The methods and guidelines presented will be applicable to characterization, qualification, and lot acceptance of silicon-based MOS and bipolar discrete devices and integrated circuits. They will be appropriate for treatment of the effects of electron and photon irradiation.

1.3 This guide provides a framework for choosing a test sequence based on general characteristics of the parts to be tested and the radiation hardness requirements or goals for these parts.

1.4 This guide provides for tradeoffs between minimizing the conservative nature of the testing method and minimizing the required testing effort.

1.5 Determination of an effective and economical hardness test typically will require several kinds of decisions. A partial enumeration of the decisions that typically must be made is as follows:

1.5.1 *Determination of the Need to Perform Device Characterization*—For some cases it may be more appropriate to adopt some kind of worst case testing scheme that does not require device characterization. For other cases it may be most effective to determine the effect of dose-rate on the radiation sensitivity of a device. As necessary, the appropriate level of detail of such a characterization also must be determined.

1.5.2 *Determination of an Effective Strategy for Minimizing the Effects of Irradiation Dose Rate on the Test Result*—The results of radiation testing on some types of devices are relatively insensitive to the dose rate of the radiation applied in the test. In contrast, many MOS devices and some bipolar devices have a significant sensitivity to dose rate. Several different strategies for managing the dose rate sensitivity of test results will be discussed.

1.5.3 *Choice of an Effective Test Methodology*—The selection of effective test methodologies will be discussed.

1.6 *Low Dose Requirements*—Hardness testing of MOS and bipolar microelectronic devices for the purpose of qualification or lot acceptance is not necessary when the required hardness is 100 rd(SiO_2) or lower.

1.7 *Sources*—This guide will cover effects due to device testing using irradiation from photon sources, such as ^{60}Co γ irradiators, ^{137}Cs γ irradiators, and low energy (approximately 10 keV) X-ray sources. Other sources of test radiation such as

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