Sandia National Laboratories

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Radiation Hardening Assurance & Assessments

Radiation Hardening or Rad-Hard is an essential service that Sandia National Laboratories performs. Rad-Hard electronic components are a vital link for systems that operate in space, high altitude, defense systems or in close proximity to nuclear reactors. Due to the ionization effect that radiation produces, hardening provides an additional level of protection that is necessary in extreme environments.

Radiation Physics Total Ionizing Dose Testing

Gamma Ray Radiation Sources

The Radiation Physics, Technology, and Assurance Department maintains 4 gamma ray radiation sources, including two ^{60}Co sources and two ^{137}Cs sources. These sources are routinely used for radiation qualification of Sandia and commercially fabricated ICs, as well as basic studies of the physical mechanisms responsible for radiation effects in semiconductor devices. Radiation testing in these cells requires that the parts to be tested are packaged and mounted on circuit boards. For low-dose-rate irradiations, the department uses three J. L. Shepherd radiation sources shown in Figure 1. The large irradiator in the foreground is a ^{60}Co radiation cell capable of dose rates ranging from < 0.1-30 rad(SiO_2)/s. This cell is primarily used for qualification testing and basic studies of radiation damage mechanisms in electronic components at low to intermediate dose rates. In the background in Figure 1 are two identical ^{137}Cs radiation cells used for studies and qualification testing of electronic components at low dose rates (< 0.001-5 rad(SiO_2)/s).

Figure 1. Sandia Radiation Physics Department Shepherd ^{60}Co and ^{137}Cs gamma radiation sources.

Figure 2. MDS Nordion Gammacell 220 radiation cell.

Figure 2 shows the MDS Nordion Gammacell 220 radiation cell used for qualification testing of electronic components per MIL-STD 883, TM 1019, which requires testing to be performed in the dose rate range of 50-300 rad(SiO_2)/s. The current maximum dose rate achievable in this radiation cell is ~60 rad(SiO_2)/s.

X-ray Radiation Sources

The Radiation Physics, Technology, and Assurance department at Sandia also maintains three Aracor 4100 X-ray irradiators. These irradiators use X-ray tubes to irradiate the device under test, and are especially well suited to wafer-level radiation studies. Figure 3 shows one of these irradiators, which consists of a cabinet in which the x-ray tube is located, as well as a probe station which is used for wafer-level irradiation. Although these irradiators are primarily used for wafer-level radiation testing of products and test structures for technology development and process monitoring of wafers fabricated in Sandia's own fabrication facility, they can also be used to irradiate parts that have already been packaged.

Figure 3. Aracor wafer-level x- ray irradiator.

MICROSYSTEMS SCIENCE, TECHNOLOGY & COMPONENTS

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Radiation Physics Single-Event Effects Testing

Broadbeam Heavy Ion and Proton Accelerators

Single-event effect testing is typically performed off-site at large heavy ion or proton accelerator facilities such as the Brookhaven National Laboratory's Tandem van de Graaff heavy ion accelerator (Figure 4), the Texas A&M heavy ion cyclotron, and the Indiana University or TRIUMF proton cyclotrons. These are all user facilities and are routinely available for parts characterization and evaluation. In such facilities the device under test is typically placed at the end of the beam line and is subjected to energetic particle irradiation while any anomalous behavior is recorded. The resulting measured single-event upset cross section curve is used in conjunction with the expected radiation environment to calculate the predicted upset rate for a given application. The Radiation Physics, Technology, and Assurance department conducts several remote-site radiation tests per year and is intimately familiar with procedures for performing testing at all of these radiation facilities.

Figure 4. Brookhaven National Laboratory Tandem van de Graaff heavy ion accelerator.

Focused Heavy Ion Microbeam

Broadbeam experiments are typically used for heavy ion qualification testing, but an unfortunate drawback of such testing is that no direct positional information on the device response is obtained - only the aggregate response of the entire chip. For diagnostic purposes it is often desirable to acquire positional information. Such information can be gained through the use of a focused ion beam. Sandia operates a focused ion microbeam facility, pictured in Figure 5, which consists of a magnetic lens that focuses the beam exiting a van de Graaff accelerator, and an electrostatic beam scanning capability that allows the resulting submicron ion beam spot to be scanned across the surface of the device under test. By noting the position of the beam corresponding to an observed anomaly in the device being tested, and correlating this position to the circuit design via the layout mask, the precise location and cause of the anomaly can be determined.

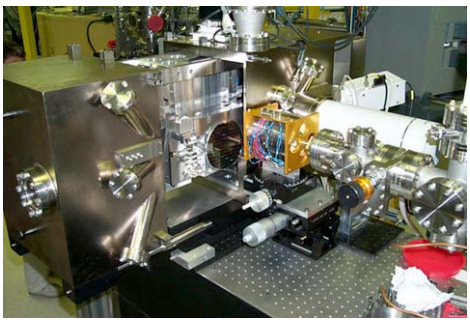

Figure 5. Sandia focused heavy ion microbeam end station.

Radiation Physics Device and IC Test Capabilities

IC Testers

Certimax 105 Portable IC testers, 125 MHz with 128-pin capacity, two units can be connected for 256 pins.

HP 82000 Digital ASIC testers, two portable D50 chassis with 48-pin capacity and 128-pin capacity, and one fixed D100 chassis with 256-pin capacity.

Analog Devices LTS2020 Analog tester for performing parametric and functional tests on bipolar linear ICs.

Parametric Testers

HP 4062UX Parametric Test Systems interfaced to Aracor 4100 X-ray test system.

HP 4145/4156 Semiconductor Parameter Analyzers with high voltage and charge pumping capabilities.

National Instruments PXI Portable Parametric Test System.

Other Test Equipment

Automated wafer probe, multiple ovens for annealing studies, thermally stimulated current test setup, and comprehensive electrical test equipment such as power supplies, oscilloscopes, switch matrices, etc.

For more information email snlasic@sandia.gov

www.sandia.gov/mstc