

FET-Based Radiation Sensor

RADFET dosimeter provides reliable ionizing radiation measurements

Overview

An ionizing radiation dosimeter developed at Sandia National Laboratories provides increased reliability and versatility. Existing integrated dosimeters (i.e., thermoluminescent) have several drawbacks: radiation measurements can fade as much as 20% in a few weeks; total dose information is lost after the measurement is read; the dose information is difficult to interface directly with an electronic signal; and they cannot be used in situations that require remote readings.

In comparison, Sandia's radiation sensing, field effect transistor (RADFET) sensor not only provides a total dose measurement in real time but also retains a permanent record of the ionizing radiation exposure. Dose readings remain in the RADFET after it has been electronically interrogated to determine the total ionizing radiation exposure.

The RADFET can be designed and configured to monitor ionizing radiation for a broad range of applications, such as performing radiation dose measurements without applied electrical power or remote sensing in locations with limited access.

The RADFET provides a direct electrical voltage output and has a simple control circuit that can be integrated on the same small chip with the sensor. Exposure to ionizing radiation -- such as gamma-rays, x-rays, electrons, and high-energy protons -- causes the RADFET's voltage output to change in a predictable manner. The silicon-based sensor can be inexpensively manufactured in a standard metal oxide semiconductor (MOS) integrated circuit fabrication facility.

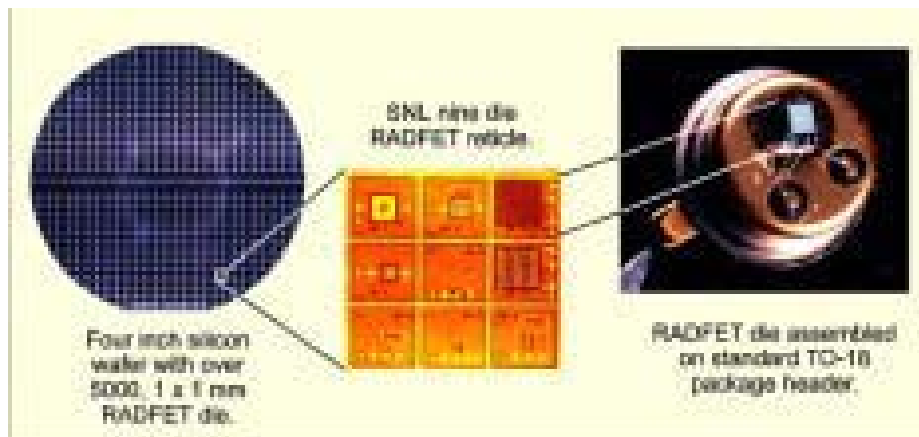


Figure 1. A 4-inch diameter silicon wafer.

Applications

A number of applications for the RADFET already have been identified in the areas of health care, safety, and environmental monitoring, including:

- Installation in a medical catheter for in vivo measurement of radiation doses inside the human body during cancer therapy irradiation.
- Use on a robotic arm system to determine the radioactivity level in buried waste tanks.
- Monitoring the exposure of personnel to ionizing radiation.
- Detecting radiation during nuclear waste transportation, disposal and storage.
- Measuring radiation during the disarming and storage of nuclear weapons.
- Real-time, total dose measurements of radiation during laboratory experiments.

Technical Approach

Low levels of ionizing radiation interact with the RADFET to generate electrical charge that is trapped in the dosimeter's gate dielectric. The trapped charge produces a permanent change in the sensor's threshold voltage. This change is the basis for the RADFET's unique dosimeter feature that enables the sensor to retain a measurement of past exposures to ionizing radiation.

RADFETs with radiation sensitivities from 50 $\mu\text{V}/\text{rad}$ to 25 mV/rad have been designed, fabricated, characterized and test stages various applications. The RADFET can be configured with a constant gate-biasing voltage or with zero volts for applications that have extremely low electrical power consumption requirements. A tracking-gate configuration offers a continuous voltage output for use in applications that require higher accuracy and simplicity. A hand-held, battery operated RadFET array spectrometer prototype has been constructed and field tested using four RadFETs, each with a different filter for distinguishing different radiation sources and isotopes.

Though the RADFET cannot detect a single x-ray photon, Figure 2 shows the data from four RadFETs in the array spectrometer monitoring excess Pu. The base dose rate is 70 millirads/hour and the linearity during exposure and the flat response before and after the two week exposure can be seen. Total doses as high as 500krad have been measured with a RADFET sensitivity of 90 $\mu\text{V}/\text{rad}$. RADFETs can be designed with lower radiation sensitivities to detect total doses greater than 500krad.

Sandia is actively seeking industry partners to license and/or further develop this technology.

For additional information or questions, please email us at BioNano@sandia.gov.

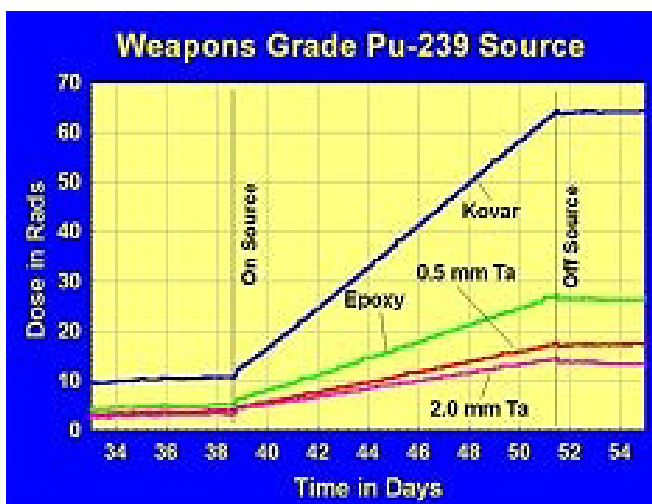


Figure 2. Data from the RadFET array, hand-held, battery operated unit.