Environmental Management Science Program

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Gamma Ray Imaging for Environmental Remediation

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Research Objective

The objective of this research is the development of high resolution germanium detector systems for direct imaging of spent nuclear fuels and fissile materials and Compton scatter imaging of large objects of arbitrary size. A small configuration of detectors shall be assembled to demonstrate the performance of such a system.

Research Progress and Implications

The efforts in this first year of a three year program have been focused on the design and procurement of a four detector array of germanium strip detectors. The basic detector is a 5 cm x 5 cm x 1 cm thick planar germanium detector with segmented anode and cathode. These segmentations are in the form of strips with a pitch of 2 millimeters. The strips on the anode side run orthogonal to the strips on the cathode side so that, in a gamma-ray interaction, the collection of electrons and holes on opposite electrodes produces signals which identify the interaction position in two dimensions. Each detector in the array has 25 anode contacts and 25 cathode contacts.

The detector array has been designed as a planar array providing 100 square centimeters of active area mounted in a single cryostat. To reduce electronics channel count, parallel strips from adjacent detectors are electrically joined together effectively making strips that are 10 cm long. In this configuration, 100 channels of electronics are required to readout the array.

In a related project, we are investigating processes to produce improved contacts for germanium strip detectors which would offer both more reliable extended use and the potential for finer strip pitch or position resolution. Investigating amorphous contacts, we have, to date, prepared two Ge test detectors. One was produced using n-type Ge and the other p-type Ge. The p-type detector has a Li diffused contact on one side while the n-type detector has a B ion-implanted contact. Amorphous contacts have been formed on the opposite side of each detector by RF sputtering. We are currently conducting a series of leakage current versus operating temperature measurements in order to determine the barrier heights of the amorphous contacts. The use of n and p type detectors will allow us to measure the electron and hole blocking behavior of the contacts respectively. This will provide important information on the nature of these contacts and will determine if double-sided strip detectors can be produced using only amorphous contacts.

Planned Activities

The germanium detector array will shall be delivered in December of 1998. Electronic preamps, provided by NRL, will have been installed. Operational testing will consist of connecting to a CAMAC/NIM data acquisition system consisting of shaping amplifiers, discriminators, and pulse height analyzers controlled by a computer. The detectors will be characterized for energy resolution and position resolution using laboratory radioactive sources, ^{241}Am and ^{137}Cs. In the Spring of 1999, coded aperture masks will be incorporated into the configuration to demonstrate direct imaging of phantoms and plutonium buttons.

The detector contact development will continue with test detectors fabricated with amorphous contacts deposited under different sputter conditions such as hydrogen concentration in the sputter gas. Also, both amorphous Ge and amorphous Si will be investigated as the contact material.