CHARACTERIZATION OF A NOVEL SELF-POWERED SOLID-STATE NEUTRON DETECTOR

By

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ABSTRACT

There is a strong interest in being able to reliably detect special nuclear materials (SNM) from illegal passage across international borders. Detectors usually use isotopes of Pu or U for detection of these materials by detecting thermal neutrons. Currently, gas-filled tube detectors are the dominant technology but they have many drawbacks. They are bulky, and require a high voltage bias for operation. There is currently much work being done investigating solid-state detectors as an effective replacement. The most basic solid-state neutron detector is a planar device where the semiconductor is covered in a conversion material. Since the semiconductor itself cannot detect the thermal neutrons, the conversion material converts them into detectable α-particles. Current conversion materials being studied include ^{10}B and ^{6}Li. These planar detectors are low-cost, simple to fabricate and easy to transport, but suffer from extremely low detection efficiencies. In order to mitigate the issues of planar detectors, deep-trenched perforated detectors were proposed and tested. These detectors boasted improved detection efficiency at the cost of more complicated fabrication and large reverse biases required for operation.

This thesis explores a further evolution of the perforated detector, a continuous p^+-n junction detector. A honeycomb-like geometry of deep trenches were filled with boron as the conversion material. This device was able to achieve neutron detection efficiencies of up to 22.5%, with theoretical efficiencies as high as 49%. There is much demand to be able to easily scale the area of these detectors. The larger the area of the device, the more easily it can detect neutrons. Scaling the device down to smaller sizes also has uses when it needs to be highly portable. This thesis examines the characteristics of the detector as the device area is scaled in sizes ranging from 1x1mm^2 up to 5x5mm^2. Both reverse leakage current density and capacitance per unit area are critical parameters involved in scaling the device, and these are looked at in depth. Relatively constant scaling for both parameters was found in addition to the leakage current density being almost 4 orders of magnitude smaller than the best result from a perforated detector.