Neutron Imaging Sensor Using Silicon Carbide Technology

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Abstract:

In this poster, we present the development of a neutron sensor using silicon carbide (SiC) technology. Detection of neutron radiation has important applications in nuclear power, material characterization, and physics research. The proposed sensor for neutron detection consists of a SiC PiN photodiode connected with SiC CMOS readout circuits. Previous neutron sensors have employed silicon photodiodes and silicon integrated circuits. Silicon carbide, as a wide-bandgap material, can enable superior neutron sensor design because it can allow the sensor to operate under the harsh conditions of high temperature and radioactivity.

During operation, the SiC PiN diode is reverse biased under a high voltage. The bulk of the PiN diode will be depleted to generate a space charge region for charge collection. Incident fast neutrons undergo inelastic scattering by carbon atoms, while incident thermal neutrons undergo absorption with a neutron conversion layer. This will increase the level of current and induce a pulse. This increase can be sensed by the readout circuit, thus providing a measure of the neutron radiation level.

The idea of the overall design is to have an array of PiN diodes supported by CMOS circuitry to make an imaging array that is capable of detecting neutrons in real-time with spatial resolution. Each PiN diode in the array will act as a pixel in a camera which makes it possible to make motion pictures of incoming radiation.

So far, simulations with LTSpice have been made for the larger CMOS circuit, and simulations in Silvaco Atlas, as well as laboratory measurements, have been made for SiC PiN diodes. It is aspired that this project matures to a design that reliably and accurately detects neutron radiation levels as well as radiation profiles.