Prague, Czech Republic June 21-25, 2021

Contribution ID: **71** Type: **Oral presentation**

#11-71 Silicon Carbide Neutron Detectors for Harsh Nuclear Environments: A Review of the State of the Art

Wednesday, June 23, 2021 8:40 AM (20 minutes)

Silicon carbide (SiC) semiconductor is an ideal material for solid-state nuclear radiation detectors to be used in high-temperature, high-radiation environments. Such harsh environments are typically encountered in nuclear reactor measurement locations as well as high-level radioactive waste and/or "hot"dismantling-decommissioning operations. In the present fleet of commercial nuclear reactors, temperatures in excess of 300 ℃ are often encountered, and temperatures up to 800 ℃ are anticipated in advanced reactor designs. The wide bandgap for SiC (3.27 eV) compared to more widely used semiconductors such as silicon (1.12 eV at room temperature) has allowed low-noise measurements to be carried out at temperatures up to 600 ℃. The concentration of thermally induced charge carriers in SiC at 600 ℃ is about four orders of magnitude less than that of silicon at room temperature.

Furthermore, SiC radiation detectors have been demonstrated to be much more resistant to the effects of radiation-induced damage than more conventional semiconductors such as silicon, germanium or cadmium zinc telluride (CZT), and have been demonstrated to be operational after extremely high gamma-ray, neutron and charged-particle doses.

Other factors that are advantageous for SiC include:

• high thermal conductivity (10-22 W/cm-K)

• a maximum breakdown field that is eight times that of silicon allowing higher biases to be applied resulting in higher drift velocities and more efficient charge collection

• a high saturated drift velocity (nearly twice that of silicon) leading to low charge trapping

The purpose of the present review is to provide an updated state of the art for SiC neutron detectors and to explore their applications in harsh high-temperature, high-radiation nuclear reactor applications. Specifically, the following will be reviewed:

• Designs of SiC thermal- and fast-neutron detectors

• SiC detector neutron-response measurements

• Radiation damage effects in SiC neutron detectors

• Applications of SiC neutron detectors in harsh nuclear measurement environments

Conclusions related to the current state-of-the-art of SiC neutron detectors will be presented, and specific ideal applications will be discussed.

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Session Classification: 11 Current Trends in Development of Radiation Detectors

Track Classification: 11 Current Trends in Development of Radiation Detectors