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Gallium Oxide Schottky Diode Detectors for Measurement of Actinide Concentrations from Measured Alpha Activities in Molten Salts

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ABSTRACT:

This proposal describes a collaboration between researchers from the Nuclear Engineering (NE) Program at the proposing university (The Ohio State University (OSU)) and a national lab (Oak Ridge National Laboratory (ORNL)) to develop and test, to high temperatures, a Schottky diode alpha particle detector that is based upon the rapidly emerging ultrawide band gap semiconductor material **gallium oxide** (Ga_2O_3). Due to their ultrawide band gap, Ga_2O_3 Schottky diode detectors offer the potential of detecting alpha particles at high temperatures, with better resolution than SiC Schottky diode detectors, which we have previously developed for similar purposes. Among the potential applications of Ga_2O_3 Schottky diode alpha particle detectors is real time, or near-real time, monitoring of alpha emitter concentrations (and hence inventories) in Molten Salt Reactor (identified henceforth as simply MSR) fuel and in pyro-chemical fuel processing streams (that may be a part of the MSR system, or which may be independent of the MSR and used to reprocess the fuels of other reactor types). This technology would be cross-cutting and could be used to actively monitor alpha emissions by actinides in sodium, lead, lead-bismuth eutectic, or molten salt cooled reactors (such as the Fluoride High Temperature Reactor (FHR)).

The project includes fabrication of gallium oxide Schottky diode alpha particle detectors and separate effects testing of the detectors; first with an alpha particle source at high temperature in a bell-jar at OSU to determine the alpha particle detector energy resolution and its degradation with time and temperature for high temperatures (up to 700 °C); and then with a Li-6 fluoride convertor foil using the Li-6(n,alpha)H-3 reaction in a thermal neutron field at the OSU Research Reactor (OSURR) to determine the degradation of the alpha particle detector energy resolution with alpha particle fluence.

Our primary goal is to develop an alpha particle detector with a resolution at 700 °C that is sufficiently good that the detector can be used to distinguish among the alpha emissions of the various actinides in a MSR's fuel salt. The successful completion of this project will allow for the development of innovative materials control and accounting methodologies for MSRs, by providing a technology for measuring the alpha particle energy spectrum in the MSR's fuel salt, with sufficient resolution to identify the actinide concentrations in the salt. The Ga_2O_3 alpha particle detector will extend the technology that we have developed using SiC, as a semiconductor material, from temperatures that are appropriate for pyro-processing (500 °C) to temperatures that are characteristic of operating MSRs (700 °C). In addition, due to its better resolution at 500 °C, the Ga_2O_3 Schottky diode detectors should be able to provide improved accuracy and reliability of estimates of actinide concentrations in pyro-processing systems, thus enabling more accurate material quantification and/or tracking capability in these systems. Therefore, if we are not successful in building a Ga_2O_3 Schottky diode detectors, with sufficient resolution for their application at 700 °C in MSRs, a fall-back goal is the development of Ga_2O_3 Schottky diode alpha particle detectors, with a resolution at 550 °C that is sufficient for the detector to be used to distinguish among the alpha emissions of the various actinides in a molten salt pyro-processing system, with better resolution than the SiC Schottky diode alpha particle detectors that we have previously developed for this purpose.