High-performance nanostructured thermoelectric materials and generators for in-pile power harvesting

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ABSTRACT:
The goal of this project is to investigate the in-pile performance of high-efficiency nanostructured thermoelectric materials, and develop high-performance and irradiation-resistant thermoelectric devices for in-pile power harvesting and sensing. We will fabricate several top-performing *nanostructured bulk half-Heusler and lead chalcogenides* thermoelectric materials and devices, and study their in-pile performance and the irradiation effect on material properties and device performance. To achieve our proposed research goal, we will complete the following three major tasks: (1) Fabricate and optimize nanostructured bulk thermoelectric materials; (2) Design, fabricate and test high-temperature nanostructured bulk thermoelectric devices; (3) Study in-pile performances and irradiation effect on nanostructured thermoelectric materials and devices. The project will deliver the high-performance thermoelectric devices suitable for in-pile power harvesting, and a comprehensive understanding of the irradiation effect on these nanostructured materials and devices.

The large temperature gradient available in the nuclear reactor makes *thermoelectric generators* an ideal power harvesting technology to enable self-powered sensors. The majority of sensors and instrumentation for in-pile measurement require an external power supply, which poses a significant challenge due to the difficulties in installing power cables connecting sensors to external power supplies. The proposed research has the potential to result in a robust and efficient in-pile power harvesting technology of crosscutting significance to address a critical technology gap for in-pile sensors and instrumentation. In-pile thermoelectric power harvesters can enable self-powered sensors that offer significant expansion on in-pile sensors and instrumentation. In addition, efficient and reliable power harvesting can not only expand remote monitoring of nuclear facilities and offer major cost savings, but also enhance safe and long-term monitoring of all reactor designs and fuel cycle concepts over current approaches requiring cable installation and external power sources. This research will advance our knowledge and understanding on atomic/nanoscale origin of potential irradiation-induced structure and property changes in nanostructured thermoelectric materials, and expedite innovations in nanostructured materials with enhanced irradiation tolerance for nuclear science and engineering applications.