
Infrastructure for Optical Characterization Facility in Support of Advanced Nuclear Energy Technologies

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ABSTRACT:

Instrumentation and control systems adapted to advanced fission fuel cycles (reactors and fuel reprocessing) and fusion reactors should ideally operate in situ, in real time, and be resilient to high-temperature and high-radiation-field conditions. The advanced optical sensors employing modern photonics and plasma technologies have a strong potential to meet these needs. The primary objective of this project is to establish the Optical Characterization Facility (OCF) at the University of Michigan (UM) to support the invention, development, advancement, testing, and qualification of novel optical sensors suitable for advanced nuclear reactors and fuel cycles. This initiative aims to enhance research capabilities, fill significant gaps in current infrastructure, and provide comprehensive training for students in advanced optical sensing technologies.

The OCF will focus on addressing the pressing need for advanced sensors and instrumentation capable of performing rapid, accurate, and reliable measurements of physical parameters in nuclear systems. These measurements are crucial for ensuring the safe and economical operation of nuclear systems, safeguarding special nuclear materials, and diagnosing and controlling fusion plasmas. The project involves procuring and integrating state-of-the-art equipment into the OCF, including an optical spectrum analyzer, a tunable picosecond laser, and a fast camera. The equipment will be used for high-resolution testing of fiber optic sensors, enhancing measurement capabilities for both narrowband and broadband optical sources, improving sensitivity to fundamental physical processes in irradiated optical materials, and increasing light detection efficiency while reducing the data acquisition time, respectively. The integration of these instruments will bridge several gaps in the existing infrastructure, enabling advanced research in nuclear engineering and enhancing the educational experience.

The establishment of the OCF at UM will have significant impacts on both research and education. In research, the advanced sensors and instrumentation will address long-standing challenges in nuclear safety, material control, and safeguards, contributing to the development of more economical nuclear systems. In education, the OCF will provide world-class training for students at various levels (B.S., M.S., and Ph.D.), preparing them for careers in nuclear engineering and related fields. Additionally, the project will foster collaborations with other universities, national laboratories, and industry partners, expanding the community of users and enhancing the overall research capabilities at UM.