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Remote laser based nondestructive evaluation for post irradiation examination of ATF cladding

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ABSTRACT:

Safe, reliable, and economic operation of the nation's nuclear power reactors has always been a top priority for the United States' nuclear industry. Continual improvement of technology, including advanced materials and nuclear fuels, remains central to the industry's success. One of the missions of the Department of Energy's Office of Nuclear Energy (NE) is to develop nuclear fuels and claddings with enhanced accident tolerance. NE initiated accident tolerant fuel (ATF) development as a primary component of the Fuel Cycle Research and Development (FCRD) Advanced Fuels Campaign after the 2011 Fukushima accident. For the design and development of new coated claddings, both coating adhesion and coating layer thickness on the cladding are important parameters that need to be evaluated. Additionally, in-pile corrosion can develop as well as delamination between the coating and cladding substrate, which need to be detected in a timely fashion.

Tied strongly to the development of ATF claddings for the need of advanced non-destructive characterization techniques, the objective of this project is to develop an innovative multifunctional remote nondestructive PIE approach that can measure the cladding coating layer thickness and detect/distinguish defects under it such as corrosion, micro-cracking and delamination, without the need for exact knowledge of the cladding properties. The NDE technology developed in this project meets ATF cladding characterization need and fills the gap of the nuclear nondestructive evaluation methods by providing a transformative tool for cladding thickness measurement and indication of significant oxidation, as well as possible degradation mechanism such as micro-cracking and debonding between layers after exposure to high temperature. The systematic methods will also allow for consistent testing to be conducted and repeated for comparing different ATF cladding quality and integrity.

The research outcome of this project will be a game-changing tool that can benefit the ATF program and ensure nuclear component integrity by providing robust nondestructive evaluations. Our research will lead to the new knowledge of laser ultrasonics and add its generation mechanisms to the state of the art of using laser techniques in nuclear field. In the long run, the success of the proposed technology will pave the path toward poolside deployment which will significantly reduce the cost and time related to the current testing conducted in hot cell to the best interest of industries, private sectors and government agencies.