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In-Pile Instrumentation Multi-Parameter System Utilizing Photonic Fibers

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Program: Fuel Cycle R&D

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ABSTRACT

An advanced in-pile multi-parameter reactor monitoring system is being proposed. The proposed effort brings cutting edge, high fidelity optical measurement systems into the reactor environment in an unprecedented fashion including in core, in cladding and in fuel pellet fashions. Unlike instrumented leads, the proposed system provides a unique solution to a multiparameter monitoring need in core while being minimally intrusive in the reactor core. Detector designs proposed herein can monitor fuel compression and expansion in both the radial and axial dimensions as well as monitor linear power profiles and fission rates during the operation of the reactor. In addition to pressure, stress, strain, compression, neutron flux, neutron spectra, temperature can be observed inside the fuel bundle and fuel rod using the proposed system. The proposed research aims at developing radiation hard, harsh environment multi-parameter systems for insertion into the reactor environment. The proposed research holds the potential to drastically increase the fidelity and precision of in-core instrumentation with little or no impact in the neutron economy in the reactor environment while providing a measurement system capable of operation for entire operating cycles. Unlike traditional reactor monitoring systems, it is proposed to develop an advanced in-pile, in-fuel pin real time monitoring system for monitoring thermal gradients, neutron spectra, linear and positional power levels, compression and tension within a fuel bundle as well as radial expansion, torsion and bowing, and pressure differentials in fuel/coolant. This multi-parameter measurement system can be created by using minimally intrusive fiber optic devices through building on cutting edge nanotechnology research. This in core monitoring system aims to bring game changing performance monitoring to the forefront. Many of the limitations of previous fiber optic monitoring systems have been addressed and novel solutions devised. The devices resulting from this proposed research can withstand high doses and still respond accurately and precisely. These measurement fibers are being designed for in-core, during irradiation at full power, for the an entire run cycle. These fibers being proposed here can measure temperatures and the other parameters described above in a single fuel element, single pellet, as a function of radial location, even inside the fuel pellet. Through novel innovations proposed here, many different signals can be collected from the same fiber simultaneously. This is unlike any other system currently available. These fibers can withstand extreme radiation fields and do not suffer from the standard problems associated with *all* other previous fiber optic measurement methods.