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XRD analysis of Fibre Optic Sensors at ESRF post-Irradiation at the SAFARI-1 reactor in South Africa

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Fibre optic sensing (FOS) is being developed for in-core, online, real-time sensing of state parameters for a nuclear reactor at full power. This study focusses on assessing the damage incurred by optical fibres when exposed to a mixed radiation field in a nuclear reactor. Both the high neutron flux and the ionizing radiation in a nuclear reactor can cause physical damage to optical fibres by introducing optical defects through ionization or atomic displacement mechanisms. Such radiation-induced defects can significantly alter the material properties and performance of optical devices. To investigate these effects, different samples of optical fibres were irradiated in the SAFARI-1 Material Test Reactor at the Nuclear Energy Corporation of South Africa (NECSA), with a differential dose up to the cumulative radiation dose (fluence) reaching up to 1 GGy. The SAFARI-1 reactor has a characteristic neutron flux of about 1x1014 n/cm2-s of fast energy neutrons. Silicon dioxide (SiO2) is an organic material extensively used in semiconductor circuits to electrically isolate different conducting regions. Due to its unique properties, SiO2 plays a critical role in wide range of applications, including optical fibres for real-time, online, in-core monitoring of various nuclear reactor parameters, such as temperature, radiation dose, pressure, etc.

Irradiation tests have also been carried out at the IRRAD facility at CERN, up to 1.85 MGy, in in-operando conditions for dose, temperature and humidity sensors, in both radiation hard and radiation soft fibres. This research aims to contribute to the understanding of radiation-induced defects in optical fibres and to support the development of more radiation-resistant materials for FOS nuclear applications. This talk reviews previous x-ray-based studies of radiation damage in fibres, summarizes what is known about the radiation damage effects, and discusses what could be gained from synchrotron-based studies.

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