Contribution ID: **103** Type: **Oral Presentation**

#4-103 In-core Gamma and Neutron Irradiation of Glass Samples used in the Design of Optical Sensors for Pressurized Water Research Reactors

Wednesday, June 11, 2025 11:20 AM (20 minutes)

In the context of climate change, the goal of achieving carbon neutrality by 2050 represents a major challenge. In France, although renewable energies provide a much greater proportion of electricity than they did a few years ago, their intermittent contribution demands more variability to the nuclear industry. As a result, increasing stresses in the structure and components of nuclear reactor cores requires greater attention and study of fuel rod behavior. As part of this approach, a current project involves developing instrumentation for in-core testing devices at the Jules Horowitz research reactor; in particular an optical sensor to measure fuel rod's swelling in an in-core test device. This optical sensor called « confocal chromatic sensor » aims to perform non-contact and precise measurements. A fundamental step in the design of such a sensor is to qualify the behavior of the candidate optical glasses for its design under the severe conditions expected for the test devices of the future research reactor. Candidate glasses for the confocal chromatic sensor have to be radiation-resistant and chromatic glasses. It is well known that when exposed to radiations, optical glasses are affected by different phenomena such as radiation induced attenuation, radiation induced emission, radiation induced refractive index change and compaction. To test the candidate optical glasses, an irradiation campaign at the Belgian Reactor 2 occurred in December 2023. Online measurements were performed to measure optical path variations of a few selected bulk glasses. The optical path corresponds to the product of the glass refractive index by its physical length. Glass samples for online measurements were housed in measurement modules of 9-milimeters in diameter, which collected a signal formed by the interference of reflections from both sides of a parallel-sided glass sample. The measurement modules were located in a temperature-controlled portion (400 mm) of a 5-meter-long needle that has been immersed into the reactor core. During the entire irradiation process, the temperature measured close to the samples was recorded every minute, along with the gamma dose. The neutron fluence reached at the end of the run was of about 1.5× 〖10〗 ^19 n_fast (>1MeV)/cm^2. Interference spectra were collected for samples of Suprasil 1 (silica) and Sapphire at the wavelength of 1220 nm, allowing us to measure the optical path variations of these two glasses at the operating wavelength of the chromatic sensor under such extreme conditions. Performing such an interferometric measurement in a reactor core remains difficult, and because of these difficulties, we were unable to fully test other chromatic glasses due to a loss of signal either during the needle installation or during the irradiation. For sapphire and silica samples, we were able to measure an increase in the optical path values as the power of the reactor increased. This increase quickly stabilized, followed by a decrease, until about the initial value for sapphire and twice as low for silica sample (indicating probable compaction). Optical path variations differ between the two glasses in terms of absolute values but also in terms of fluence dependences. The relative optical path variations obtained have been corrected for thermal effects, assuming independence of the contribution of variations due to temperature and those due to nuclear radiation. Online measurements ensure that the variations measured are not underestimated due to the annealing phenomenon. To our knowledge, this is the first time that such online measurements have been carried out on glass samples in the reactor core. Post-mortem measurements will also be carried out on samples that were in the container in one of the needles during the irradiation campaign. In particular, this will enable us to collect information on samples that were not tested during the irradiation, as the chromatic glass SF6G05 from SCHOTT manufacturer for instance. These additional tests will also give information about the compaction of these various glass samples and help in decorrelating variations of refractive index and of length. By combining the results obtained during this irra-

diation campaign with simulations with optical design tools, we will propose an initial design for a chromatic sensor able to operate in highly radiative environment.

Keywords: optical glasses, interferometry, high neutrons and gamma irradiation, research reactor, online measurements, radiation induced refractive index change, compaction

Primary author: AGOYAN, Marion (Laboratoire Hubert Curien)

Co-authors: LADACI, Ayoub (CEA Saclay); BOUKENTER, Aziz (Université Jean Monnet); Mr DESTOUCHES, Christophe (CEA/DES/IRESNE/DER/SPESI); MARTIN, Florence (CEA/DES/IRESNE/DER/SPESI/LDCI); CHEYMOL, Guy (CEA); GIRARD, Sylvain (Université Jean Monnet, Saint-Etienne, France)

Presenter: AGOYAN, Marion (Laboratoire Hubert Curien)

Session Classification: #04 - Research Reactors and Particle Accelerators

Track Classification: 04 Research Reactors and Particle Accelerators