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#04-160 Online optical refractive index measurement in research reactor core

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There is a growing interest in fiber optic measurements for applications in radiation environments. They can be used to monitor environmental parameters such as temperature, size, pressure, chemical composition, irradiation doses and dose rates…. Often, the developed systems imply no propagation of the light beam outside the fiber, but for some applications, fiber optic is combined with an optical system that collects or focuses the light beam. The question then arises not only about the impact of the RIA (Radiation Induced Attenuation), which has already been largely studied, but also of the radiation induced change of the refractive index of the used glasses, which is a determining value for the optical function. Studies of refractive index variations under irradiation are already being carried to evaluate their impact on imager performances [1]. Also, for the development of optical sensors for applications in research reactors core, CEA is preparing an irradiation in the BR2 reactor of SCK.CEN in Belgium. We implemented an on-line refractive index measuring device in order to test various glasses that can be good candidate to take place in a hardened optical system. The assembly uses an interferometric measurement system, which is a challenge because of its very small size (diameter of 9 mm), the impossibility of making optical adjustments once installed, and the goal of monitoring these changes at an elevated high temperature. The refractive index variation of silica for example under high fluence – 1019 n/cm^2 (E>1MeV) and several GGy in gamma- is in the range of some 10-3 [2]. The precision required for the measurement is then very ambitious for such difficult conditions. In addition, the variation in density observed at high neutron fluence on silica causes an elongation of the optical components [3], the targeted online measurement therefore becomes an optical path measurement (product of the length by the refractive index) and no longer just the one of the refractive index. Apart from this online monitoring, we expect to perform post-mortem measurements of irradiated sample dimensions which could help to dissociate the refractive index and length variations. In this work, we will present the planned irradiation and the first results of the index change measurement under the effect of temperature. The index variation between 20℃ and 350 ° C is of the same order of magnitude as the variation of the refractive index of silica expected under reactor core neutron fluence. This work is now going on in the framework of a PHD at the French Alternative Energies and Atomic Energy Commission (CEA) in collaboration with the Laboratoire Hubert Curien (LabHC) of the University of Saint-Etienne and also the STIL company [4].

[1] C. Muller, « Conception optique pour les environnements radiatifs et application à une caméra résistante à des doses élevées (MGy) », PhD thesis, University of Saint-Etienne, France, 2020.
[2] W. Primak, "Fast neutron induced changes in quartz and vitreous silica," Phys. Rev. B, vol. 110, no. 6, pp. 1240–1254, 1958.
[3] L. Remy, G. Cheymol, A. Gusarov, A. Morana, E. Marin, and S. Girard, "Compaction in optical fibres and fibre Bragg gratings under nuclear reactor high neutron and gamma fluence," IEEE Trans. Nucl. Sci., vol. 63, no. 4, pp. 2317–2322, Aug. 2016.
[4] http://www.stil-sensors.com/?lang=EN

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