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#4-218 Distributed Fiber Optic Dosimetry using a multi-wavelength Optical Time Domain Reflectometer

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Fiber Optic Dosimeters (FOD), in particular silica-based ones, are catching on in harsh environments, characterized by ionizing radiations, such as nuclear reactors, space, high energy physics, medical field⋯Such dosimeters employ mainly two phenomena induced by radiations in the optical fiber (OF) material: the radiation-induced attenuation (RIA) and the radiation-induced emission (RIE), which is constituted by the Cherenkov emission and/or the radioluminescence. The RIA consists in an increase of the OF attenuation due to the absorption bands associated with the radiation-generated centers. Consequently, the RIA-based dosimeters deduce the deposited dose into the optical fiber, by measuring the radiation-induced losses. Therefore, these sensors exploit radiation-sensitive fibers, among which phosphosilicate fibers have, to date, the best dosimetry properties, above all in the NIR range. These P-doped fibers, indeed, present a very stable center, known as P1, that is induced by radiations and whose absorption band, peaked around 1550 nm, is responsible for the RIA in the NIR range. Consequently, the 1550 nm RIA linearly increases with the dose up to ~500 Gy, with almost no dose rate and temperature dependence. The RIA-based dosimeters can be both point or distributed sensors, depending on its architecture. In the case of a point sensor, the losses induced on the whole fiber length are measured; generally, this is a double-ended sensor able to detect very low radiation levels, as LUMINA, a FOD installed in August 2021 inside the International Space Station (ISS). Distributed fiber dosimeters, instead, can be obtained by coupling the sensitive fiber with single-ended reflectometry techniques, as Optical Time Domain Reflectometer (OTDR) or Optical Frequency Domain Reflectometer (OFDR), which allow to measure locally the RIA with different spatial resolution. Several distributed FODs based on OTDRs working at 1550 nm are today installed at CERN.

The RIA-based dosimeter exploiting the P-doped fiber at 1550 nm is characterized by a radiation sensitivity of 4 dB km-1 Gy-1. This high sensitivity is generally considered an advantage of such dosimeter but sometimes it reduces its sensing length, because of the limited optical budget of the instrumentation, that is about 10 dB. To overcome this difficulty, we propose to replace a classical single wavelength OTDR with a multi wavelength one. We had the opportunity to test an OTDR whose laser source can be tuned between 1270 and 1610 nm with a step of 20 nm, for a total of 18 investigated wavelengths. It is worth noticing that the investigated range is still affected by the presence of the same defects, the P1, in the P-doped fiber. As an example, the radiation sensitivity of the P-doped fiber reduced by about 40 % when working at 1270 nm, compared to the value obtained at 1550 nm. This increases by a factor almost two the sensing length of the distributed dosimeter, because, when the losses induced at 1550 nm will be too high to investigate all the fiber length (at the farthest positions along the fiber from the input end the signal reached the noise level) the dose measurement will be still accessible by working at shorter wavelengths. This multi-wavelength approach extends the sensing length of the dosimeter.

At the ANIMMA conference, we will present the dose-rate and temperature dependences of the radiation-sensitivity of the P-doped fiber in this wide spectral range. Moreover, in the search for other sensitive fibers, suitable for dosimetry applications, other samples with different composition, as the Al-doped core ones, were tested and will be reported.

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