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Radiation hardness of Rare Earth doped sol-gel silica fibers for High Energy Physics Detectors

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In recent years, the sol-gel technique was proven to allow a good control, at a relatively low densification temperature, of rare earth (RE) ions incorporation and of their dispersion inside the glass matrix [1]. The glass synthesis can be performed by using high purity precursors, reducing the level of unwanted impurities, which is an essential feature for the radiation hardness of such materials. Several studies demonstrated that RE-doped silica glasses prepared by sol-gel route are suitable materials for the realization of scintillating optical fibers [2], and have application perspectives as wavelength shifters for the collection and transport of scintillation light in High Energy Physics (HEP) experiments. Moreover, the use of RE-doped fibers as scintillators in HEP detectors, possibly in parallel with undoped fibers exploiting Cherenkov light [3], has been recently proposed. An extremely good radiation resistance and fast response are crucial properties for such application.
In this work we present a detailed study of the scintillation properties of SiO_2: 0.05 mol% Ce glasses and the results of irradiation tests using gamma-rays from a ^{60}Co source and X-rays up to an integrated dose of 1 kGy.

Radio-luminescence investigations have been combined with optical absorption and attenuation length measurements before and after irradiation with X-rays and with ^{60}Co gamma-rays. Comparisons between bulk preforms and fibers have been carried out, in order to disclose the role of the fiber drawing process in the radiation hardness properties. Fibers with a lower (0.0125 mol%) Ce concentration have also been considered, pointing to a reduction of the radiation damage related to the decrease of the dopant concentration. Fibers with fluorinated glass or polymeric cladding have been compared, looking towards a future engineering of the fiber structure to improve the light propagation and the radiation resistance.
The evolution of the optical absorption spectra and of the attenuation length as a function of time after irradiation has been investigated in order to understand the room temperature stability of radiation-induced point defects acting as color centers. Moreover, the samples have been subjected to thermal annealing cycles, to check the temperature activated carrier release from radiation-induced defects and the possibility of a complete recovery of the damage.
Further analyses on the properties of sol-gel silica fibers have been carried out: the homogeneity of the Ce distribution along the fiber length has been tested by means of the X-ray fluorescence technique.

Eventually, we will report the results of the forthcoming test of Ce-doped fibers, assembled in a calorimeter prototype, with GeV electron beams at the CERN test beam facilities, to better investigate the application perspectives of such kind of material as scintillator in High Energy Physics detectors.

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