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Scintillation properties and radiation tolerance of Alkali Free Fluorophosphate Glasses with different dopant concentrations

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One of the main challenges in the development of detectors for future collider experiments is finding materials that can operate in high radiation environments while maintaining their physical, chemical, and optical properties.
In this framework, scintillating materials and Cherenkov radiators, such as crystals and glasses, represent a powerful tool for the design of large area radiation detectors. In particular glasses are produced by using a relatively cheap melting process (with respect to crystal growth) which makes them attractive candidates for the instrumentation of large volumes as in the case of many High Energy Physics (HEP) experiments.
A set of heavy glasses of 1 cm^3 with density of ˜4.1 g/cm^3 and different chemical compositions was produced by AFO Research Inc. and characterized at CERN. These glasses (FP2035) are multicomponent alkali free fluorophosphate glasses, based on Ba(PO3)2 -Al(PO3)3 - BaF2- MgF2 and doped and co-doped respectively with Pb and Ce oxides and fluorides [1]. Undoped glass samples have also been studied for comparison with doped ones.
The scintillation properties and timing performance of the samples have been investigated through laboratory measurements and irradiation studies have also been conducted to assess the effect of ionizing radiation on the optical properties of the samples.
The Ce-doped samples show an emission of light peaking around 370 nm, a decay time of about 40 ns and a light yield ranging from 100 to 600 ph/MeV, depending on the Ce-concentration. Measurements of coincidence time resolution were also performed using high energy pions and value of $\sigma t<35$ ps were obtained with both doped and undoped samples read-out with SiPMs.
The irradiation campaign showed that Ce doped FP2035 glasses have a better radiation resistance, with respect to undoped and Pb-doped glasses, and maintain a better transparency after exposure to 1000 Gy of gamma-rays from a Co-60 source.
A loss of transparency was noticed in the UV part of the spectrum in FP2035 Ce doped glasses between 360-450 nm, overlapping with the scintillation emission peak, and thus responsible for a decrease of light output after irradiation.
Hence, further optimization of the chemical composition of these glasses is required to allow their use as radiation resistant scintillators in radiation environments with
Topic: Defects and Radiation Damage
ionizing doses above 1000 Gy. At the present time, these glasses may have a wide range of applications as radiation hard lenses, windows or optical fibers for light in the visible spectrum (above 450 nm) where the transparency is not degraded by radiation.

References
[1] A.A. Margaryan. Ligands and Modifiers in Vitreous Materials, Spectroscopy of Condensed Systems (World Scientific Press, Singapore, New Jersey, London, Hong Kong, 1999).

Has accepted

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