Radiophotoluminescent Ag+ doped phosphate glasses used for high level dosimetry: online radiation induced attenuation and photoluminescence studies at high doses.

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High level dosimetry is necessary to characterize intense and complex radiation environments, such as the ones produced by particle accelerators, irradiation facilities, fission and fusion reactors, medical physics facilities, radioactive waste plants and long run space missions. Doses up to MGy levels are delivered in operation, limiting the lifetime and compromising the functionality of the structural facility elements. Despite the increasing doses, the dosimetry techniques adapted to this range are very limited.

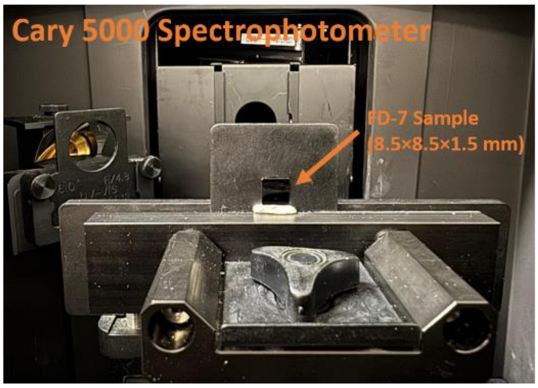

Figure 1 – Irradiated Flat FD-7 RPL sample under Cary 5000 spectrophotometer.

At CERN, a readout system extending the sensitivity of commercial FD-7 glass Radiophotoluminescent (RPL) dosimeters up to MGy is available. CERN's system make use of both RPL light following UV illumination, traditionally used for dosimetry, and transmittance at 445 nm to attribute the dose. In fact, FD-7 dosimeters are made of a metaphosphate glass doped with Ag^+, and at doses exceeding the kGy, both RPL and color centers, typically Ag^0, Ag^{2+}, Ag_2^+ and further high-order Ag^{n+}_m (where m = n + 1) clusters and POHC defect, making the glass progressively darker, are competitively produced [1]. The nature and kinetics of those defects are well-known at lower doses, but are still being investigated at doses exceeding the kGy, where several aspects such as defects rearrangement, buildup, response of light absorption in visible-NIR range are unidentified and debated in the community.

Motivated by this context, spectral online transmission studies have been performed with the commercial X-ray irradiators of the PETRA platform at *Laboratoire Hubert Curien*, operated at 100, 160, and 225 kV, and 2.5 MeV electron irradiation of the SIRIUS platform at *Laboratoire des Solides Irradiés*, to characterize the growth of the Radiation Induced Attenuation (RIA) during the exposure and its recovery after irradiation up to the MGy level, at dose rates ranging from 0.04 Gy/s to 300 Gy/s, and at temperatures up to 120 °C. Dedicated setups have been developed to be compatible with two different glass geometries: cylindrical (8.5 mm long, 1.5 mm diameter) and flat (8.5×8.5×1.5 mm). Adding to their relevance for the high-level dosimetry technique, spectral RIA analyses in both visible and near infrared domains and its dependence on dose rate and temperature reveal optical bands providing information on the nature of radiation-induced defects, especially at irradiation dose and dose rates well exceeding the usual applications. Ongoing time-resolved photoluminescence analyses, spectral RPL light analyses performed under irradiation, Raman spectroscopy, spectrophotometry (see Figure 1) and EPR analyses provide complementary information on the main defects.

The results collected in several irradiation campaigns allow assessing the validity and the limitations of the current readout system, paving the way for future refinements of this dosimetry technique and opening new approaches, especially targeting the high and ultra-high doses.