Visible photoluminescence of color centers in LiF crystals exposed to 6 MV x-ray clinical beams
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Point defects (impurity ions, colour centres (CCs) etc.) in insulating materials are successfully used for radiation detection and dosimetry [1]. Pure and doped lithium fluoride (LiF) materials have been successfully used as a Thermoluminescence (TL) dosimeter for more than 50 years. In the last 20 years optically stimulated luminescence (OSL) dosimetry has been commercially adopted, taking advantage of availability of materials (although still limited in comparison with TL), mainly Al₂O₃:Ca [2]. Among the advantages of OSL dosimetry there is simplicity, accuracy, wide dynamic range of measured dose, ease of automation, read capability and ability to perform imaging for dose mapping. However oxides (with the exception of BeO) have tissue equivalence significantly higher than water, making them more difficult to use in clinical dosimetry. The effective atomic number, Z_eff of a material is often used to describe the extent to which a material approximates or deviates from soft tissue (tissue equivalence) in its interaction with a radiation field, which is an important parameter, particularly in medical applications. LiF has a good tissue equivalence (LiF Z_eff = 8.3 vs. Al₂O₃:Ca Z_eff = 11.3 to be compared with H₂O Z_eff = 7.3). Lately, photoluminescence (PL) of radiation-induced light-emitting color centers (CCs) has also been explored in pure and doped LiF [3]. Among them, F₂ and F₁⁺ electronic defects, stable and laser-active at room temperature (RT), are produced in LiF crystals and films by different kinds of radiation. Under blue optical pumping in their broad overlapping absorption bands, the efficient optical emission spans over the green-red visible spectral range. In the last decade they were proposed for novel solid state luminescent imaging detectors with submicrometric spatial resolution for soft x rays up to 80 keV [4]. Recently, their use was extended to advanced proton beam characterization and imaging [5]. In this work, the results of the optical investigation of radiation-induced CCs in 6 MV x-ray irradiated pure LiF crystals in the clinically relevant dose range of 1-100 Gy are presented. Even at these low doses, optical absorption and laser-excited PL spectra were measured at RT using a conventional optical fluorescence microscope for reading of the integrated visible PL signal [6].

Polished commercially available LiF crystals 5x5x0.5 mm³ were irradiated using 6 MV x-rays produced by a clinical linear accelerator at the Tom Baker Cancer Centre, Calgary, Canada. The doses (absorbed dose to water) covered the 1-100 Gy range. Under modulated continuous wave Argon laser excitation at 458 nm at low power and by using a lock-in technique, the corrected PL spectra of the irradiated LiF crystals clearly exhibited the characteristic F₂ and F₁⁺ visible broad emission bands (Fig.1). A background correction was applied: the net PL spectra were obtained by subtracting a blank spectrum (the spectrum of an unirradiated LiF crystal) from the results of the optical investigation of radiation-induced CCs in 6 MV x-ray irradiated pure LiF crystals in the clinically relevant dose range of 1-100 Gy. Even at these low doses, optical absorption and laser-excited PL spectra were measured at RT using a conventional optical fluorescence microscope for reading of the integrated visible PL signal [6]. Polished commercially available LiF crystals 5x5x0.5 mm³ were irradiated using 6 MV x-rays produced by a clinical linear accelerator at the Tom Baker Cancer Centre, Calgary, Canada. The doses (absorbed dose to water) covered the 1-100 Gy range. Under modulated continuous wave Argon laser excitation at 458 nm at low power and by using a lock-in technique, the corrected PL spectra of the irradiated LiF crystals clearly exhibited the characteristic F₂ and F₁⁺ visible broad emission bands (Fig.1). A background correction was applied: the net PL spectra were obtained by subtracting a blank spectrum (the spectrum of an unirradiated LiF crystal) from the results of the optical investigation of radiation-induced CCs in 6 MV x-ray irradiated pure LiF crystals in the clinically relevant dose range of 1-100 Gy. Even at these low doses, optical absorption and laser-excited PL spectra were measured at RT using a conventional optical fluorescence microscope for reading of the integrated visible PL signal [6].

![Figure 1](image1.png)  
**Figure 1.** RT laser induced (458 nm) PL spectra of 6MV x-ray irradiated LiF crystals at 10, 50 and 100 Gy.

![Figure 2](image2.png)  
**Figure 2.** Net PL spectrum of the 6 MV x-ray irradiated LiF crystal at 10 Gy, best-fitted as the sum of two Gaussians bands, ascribed to the F₂ and F₁⁺ CCs emission bands.

![Figure 3](image3.png)  
**Figure 3.** Integrated PL intensity as a function of the absorbed dose for all the 6 MV x rays LiF irradiated crystals and linear best fit (solid line).

![Figure 4](image4.png)  
**Figure 4.** RT optical absorption spectra of 6 MV x rays irradiated LiF crystals at several doses. The spectrum of a blank crystal is reported for comparison (thickness 0.5 mm).