Playing music by throwing a piano down the stairs: X-ray spectroscopy on luminescent materials

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When we started to study luminescent materials on ID26 I found an interesting quote of a pioneer in luminescence materials: "ultraviolet excitation compares to striking one key of a piano, X-ray excitation compares to throwing the piano down the stairs" [1]. Our experience on ID26 proposes a variation: X-rays strike fading notes while the piano is falling. Is X-ray damage thus always a bug or can it be made a feature? Is it possible to extract information beyond the damage we get? We will discuss examples for both scenarios.

Inorganic phosphors are based on luminescent centers, typically transition metal or rare earth impurities. The latter can be easily excited and emit visible light during the de-excitation process. Optical techniques are ideal means to characterize such materials. Why then bothering shooting X-rays and throw the piano down the stairs? Because with X-ray spectroscopies we directly probe the oxidation state and the local environment of all impurities, not only the luminescent ones. It is worth therefore to develop measurement strategies to take advantage and/or minimize the side effects of using X-rays, i.e. the damage and the X-ray induced excitation that are unavoidable when measuring these systems.

We will discuss two cases illustrating opposite situations: in the first case the X-rays are employed simultaneously to probe Eu oxidation state, to induce Eu luminescence and as an accelerated source of damage. The aim is to get new insight into the degradation process of the phosphor under study [2]. In the second case we want to measure the change of oxidation state of Eu and Dy impurities during the optical excitation process. Ideally, we want X-rays to be a probe and we want to minimize both damage and X-ray induced excitation [3].

To reach these goals some technical aspects of sample manipulation are fundamental: sample homogeneity, the use of a well-established measurement strategy to deal with X-ray damage, the parallel acquisition of UV-vis and X-ray spectra and the use of lasers to efficiently excite or de-excite the sample.

References

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