Oxidation and luminescence quenching of europium doped $BaMgAl_{10}O_{17}$ probed by HERFD-XANES

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Eu-doped $BaMgAl_{10}O_{17}$ (BAM) is an excellent inorganic phosphor. Its luminescence efficiency is however severely degraded during prolonged vacuum-ultraviolet (VUV) excitation. Furthermore, the degradation process at the atomic level is not yet fully understood. To shed light on this process, we simultaneously employed X-rays as an equivalent but accelerated source of damage, as an excitation source of luminescence and as an element-selective probe of both dopants and host-lattice chemical species.

We investigated commercial samples of Eu doped and Mn, Eu co-doped BAM. We measured High-Energy Resolution Fluorescence Detected (HERFD)-XANES at Eu and Ba L_3-edges and at Mn K-edge. The X-ray induced radio-luminescence (RL) and the HERFD-XANES spectra were simultaneously acquired while progressive damage was induced.

The evolution of the RL spectra confirms that the degradation induced by X-rays and by VUV irradiation are equivalent. The HERFD-XANES reveals that Ba and Mn are stable under the X-ray beam, while Eu^{2+} undergoes a rapid oxidation to Eu^{3+}. We found that the correlation between Eu oxidation and RL intensity decay is non-linear and that a significant fraction of Eu^{2+} resists to irradiation, implying that an additional mechanism is responsible for the quenching of the remaining Eu^{2+}. A kinetic Monte Carlo simulation indicates that the creation of defects acting as killer centers in the vicinity of a photo-oxidized Eu^{3+} can reproduce the dynamics observed on RL and Eu oxidation.

By simultaneously degrading and probing Eu-doped BAM we found [1] that the degradation process is due to oxidation of the luminescence impurities combined with the formation of killer centers that quench the luminescence of the remaining Eu^{2+}.

[1] L. Amidani, K. Korthout, J. J. Joos, M. van der Linden, H. F. Sijbom, A. Meijerink, D. Poelman, P. F. Smet, P. Glatzel, Chem. Mater. 2017, 29, 10122-10129.