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Temperature Dependent Decay Measurements of Ce^{3+} Doped Garnets and Eu^{2+} Doped Sulfides and Sulfoselenides

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Introduction

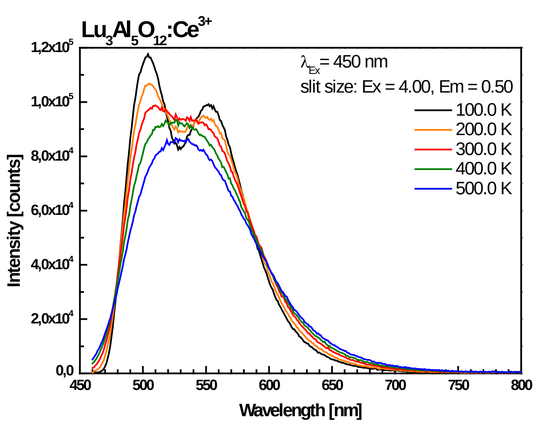
Eu^{2+} and Ce^{3+} activated phosphors are widely applied in phosphor converted light emitting diodes (pcLEDs). These are the most favoured activator ions because of their tuneable emission colour, fast decay, and their broad excitation range. Another advantage is their high quantum efficiency also at elevated temperatures; however, this strongly depends on the host lattice.

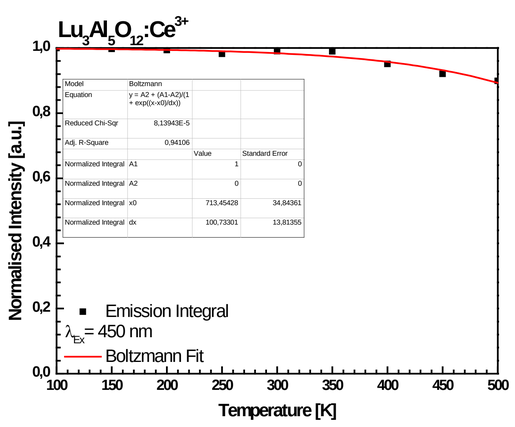
In this study, Ce^{3+} activated garnets and Eu^{2+} activated sulfides and sulfoselenides were investigated with respect to their thermal quenching and to their fluorescence lifetime between 100 and 500 K.

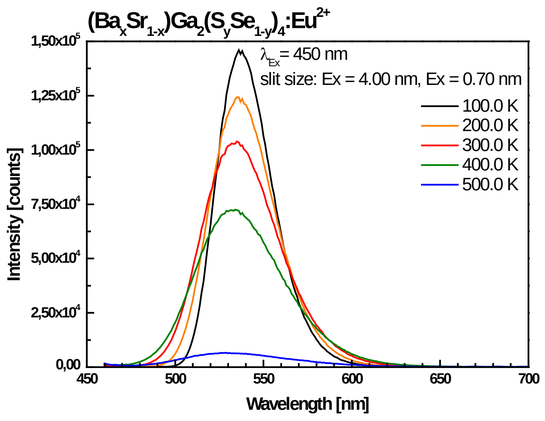
Due to the fact that high power LED dies have a working temperature of 373 K or even higher, temperature dependent characterisation of LED phosphors are necessary.

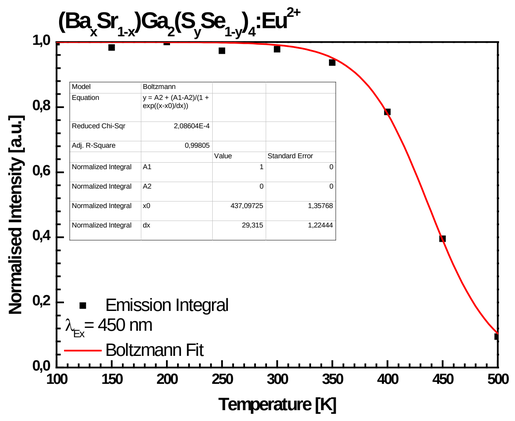
The measurements were performed on an Edinburgh Instrument FLS920 fluorescence spectrometer equipped with a 450 W xenon discharge lamp for steady state and an EPL 440 LASER diode for lifetime measurements, a Microstate N from Oxford Instruments for working with liquid N_2 and a R2658 photomultiplier tube from Hamamatsu cooled to -20 °C for detection was used.

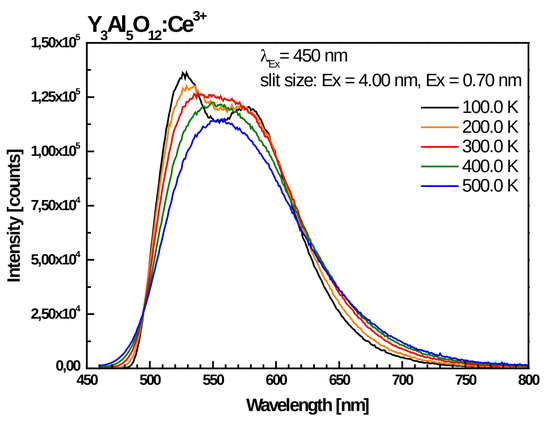
Temperature Dependent Emission Spectra and Quenching Curves

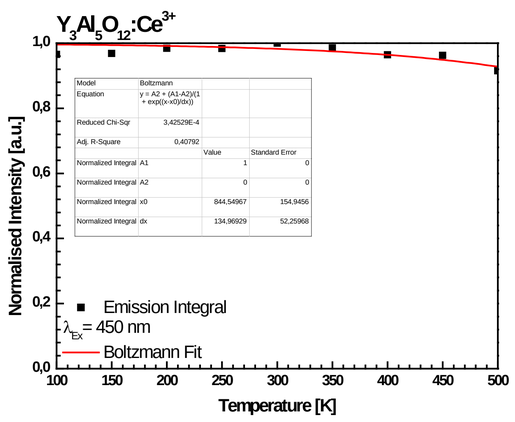


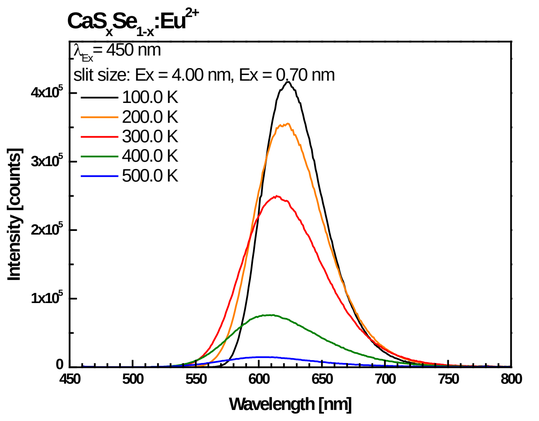


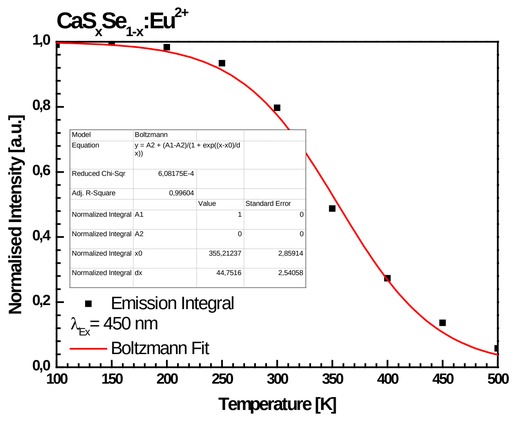




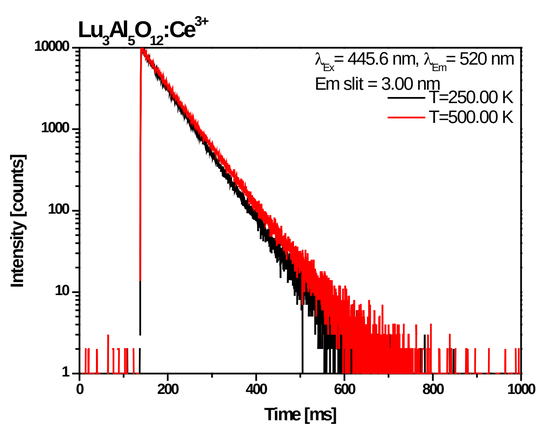


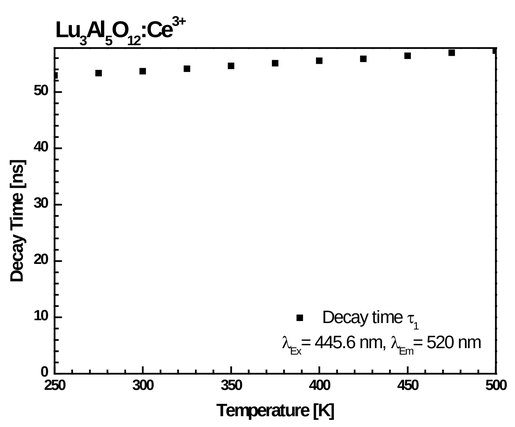


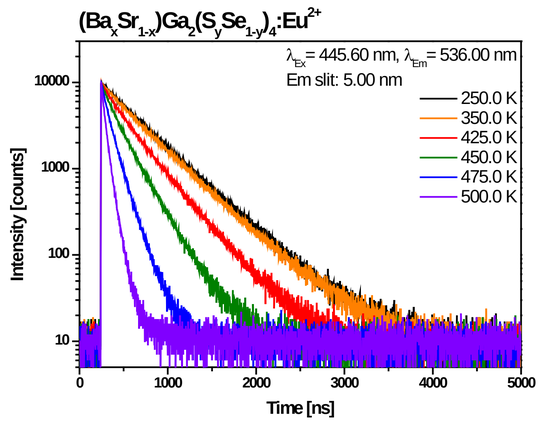


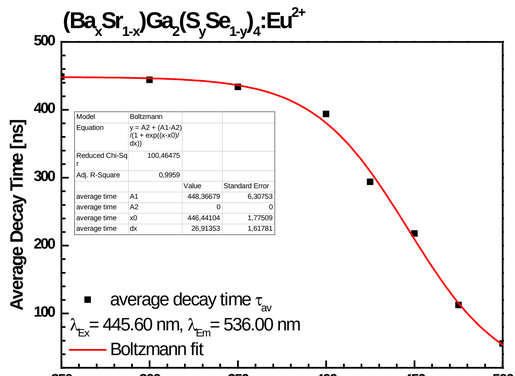


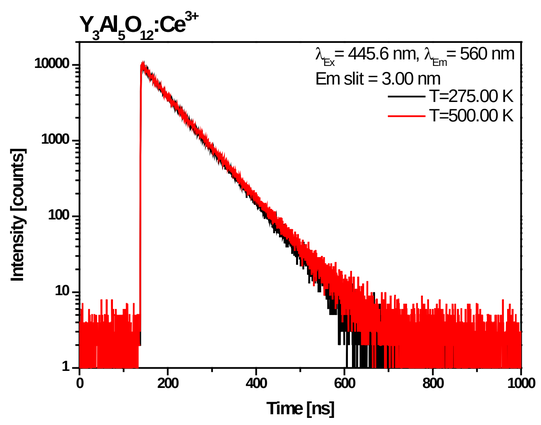
Temperature Dependent Decay Measurements

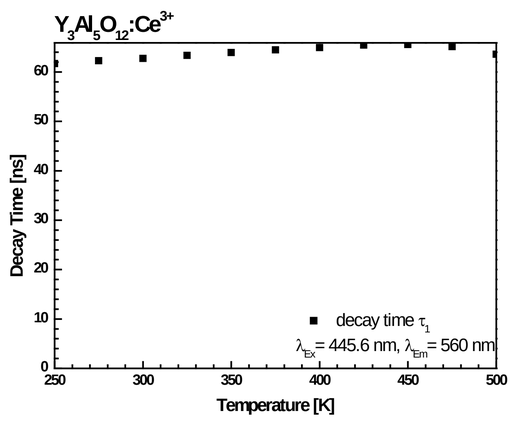


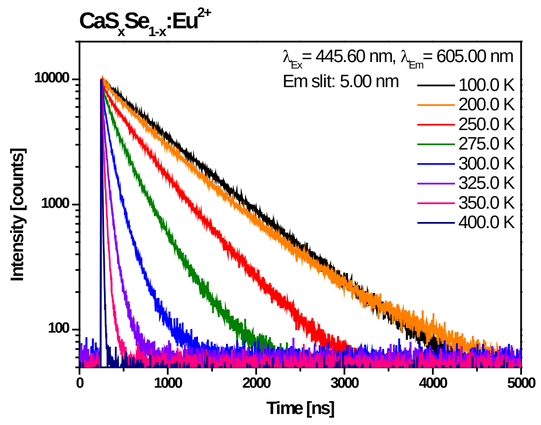


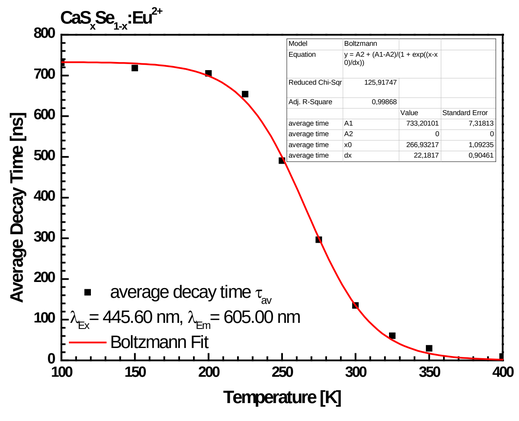












Conclusions

The slight decrease in luminescence intensity of the Ce^{3+} doped garnets $Lu_3Al_5O_{12}$ and $Y_3Al_5O_{12}$ with increasing temperature is due to re-absorption caused by the broadening of the excitation and emission band. The decay measurements proved that quenching of the excited state of the activator is not an issue up to 500 K. The colour point of both garnets are almost stable in the 100 – 500 K range.

The luminescence of the Eu^{2+} doped sulfoselenide and sulfide is nearly completely quenched at 500 K, which is in line with our decay measurements.

The distinct blue shift of the emission band of both Eu^{2+} phosphors is assigned to the decrease in crystal field splitting of the d-levels of the excited $[Xe]4f^65d^1$ configuration caused by thermal expansion of the host lattice.