

Temperature Effects on Phosphor Fluorescence Lifetime

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Introduction

Europium-doped phosphor compounds can exhibit temperature-dependent fluorescence lifetimes for certain emission lines. In europium-doped lanthanum oxysulfide ($\text{La}_2\text{O}_2\text{S:Eu}$), the variable overlap of a charge-transfer (CT) state with the $^5\text{D}_i$ energy levels leads to an increased availability of non-radiative de-excitation pathways as temperature is increased. For lower temperatures, the CT state becomes less available and radiative emission dominates, leading to longer fluorescence lifetimes. We measured fluorescence lifetimes for $\text{La}_2\text{O}_2\text{S:Eu}$ for a range of temperatures within -10°C and 100°C , and observed a (linear/logarithmic) decrease in decay lifetimes for increasing temperatures.

Methods

To modulate its temperature, the phosphor sample was mounted on a Peltier device attached to a manually-variable current source. Focused light from a pulsing laser diode shone on the surface of the sample, causing fluorescence at the 514 nm, $^5\text{D}_2$ emission line (among others). Fluoresced light was then band-passed and focused into a photomultiplier tube (PMT). The PMT-amplified fluorescence response signal was then passed with the original impulse signal to be overlaid on a digital oscilloscope for data collection.

After setting the pulse width of the laser diode to approximately 1 μ s, we began varying the current supplied to the Peltier device to set the temperature at approximate steps of 10 °C ranging from -10 °C to 100 °C. Three snapshots of oscilloscope data were collected at each increment, where the oscilloscope timing window was variably tuned to meet the following specifications:

1. maximize timing resolution by including as many non-zero response values as possible, and
2. include information about the fluorescence response's offset prior to the laser impulse for later offset subtraction.

Results

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