Temperature Effects on Phosphor Fluorescence Lifetime

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Introduction

Europium-doped phosphor compounds can exhibit temperature-dependent flourescence lifetimes for certain emission lines. In europium-doped lanthanum oxysulfide (La_2O_2S:Eu), the variable overlap of a charge-transfer (CT) state with the ^5D_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 a sample of La_2O_2S:Eu between $-10\,°C$ 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 (**Figure 1, D**). Focused light from a pulsing laser diode (**A**) was reflected (**B**) and focused (**C**) on the surface of the sample, causing fluorescence at the 514 nm, $^5D_2$ emission line (among others). Fluoresced light was then band-passed (**E**) and focused (**F**) into a photomultiplier tube (PMT) (**G**). The PMT-amplified fluorescence response signal was then passed with the original impulse signal to be overlayed on a digital oscilloscope for data collection.

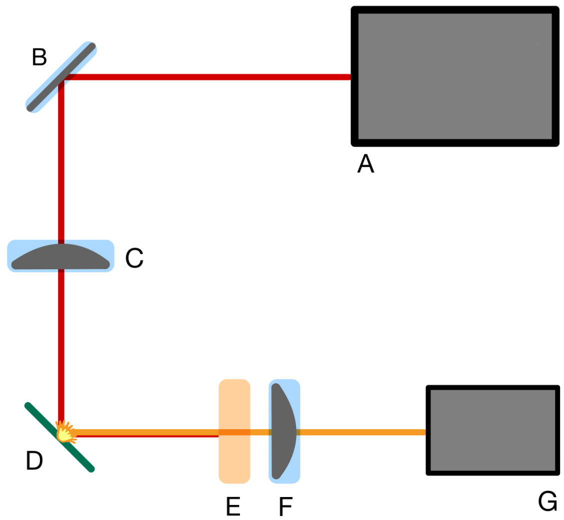

Figure 1. *A diagrammatic representation of the experimental setup.*

After setting the pulse width of the laser diode to approximately 1 µs, 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 offset subtraction during analysis).

Results

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