Characterization of Photon Cascade Phosphors under Electron Beam and Vacuum Ultraviolet Excitation

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A variety of rare-earth activated aluminates, phosphates, and oxides have been studied as potential photon cascade phosphors. The photoluminescence of these materials under vacuum ultraviolet (VUV) excitation has been well studied. In this work, cathodoluminescence (CL) spectra were collected to complement the PL spectra and obtain a better understanding of the excitation mechanisms in these materials. CL and high energy PL are similar in that both modes of excitation are indirect excitation mechanisms. In both mechanisms, the host absorbs the excitation energy, resulting in the generation of electron-hole pairs. Th e-h pairs radiatively recombine at activator ions.

For cathodoluminescence measurements, the phosphors were characterized in a high vacuum chamber (1×10^{-7} Torr) with a hot filament electron gun. The samples were packed into 5 mm diameter stainless steel cups and placed inside the vacuum chamber. To collect secondary electrons during characterization, the samples were held at a potential of +50 V relative to ground. An aluminum shield with a 5 mm diameter aperture was placed above the samples to prevent bombardment by secondary electrons originating from the walls of the chamber. In our system, the electron beam was magnetically deflected through a 90-degree angle through the aperture using external Helmholtz coils. The magnetic deflection of the beam minimizes filament light contamination, avoids filament evaporation products and separates electrons from possible negative ions. Photometric data were collected using a spectroradiometer. The samples were characterized at 6, 8 and 10 kV electron accelerating voltages and a current density of 6.4 $\mu A/cm^2$.

For VUV characterization, samples were excited from 115 to 205 nm at a chamber pressure of 5×10^{-5} Torr, using a deuterium lamp and vacuum monochromator. Integrated emission intensities were measured relative to a sodium salicylate standard. All emission spectra were corrected for the wavelength-dependent response of the emission spectrometer. To obtain excitation spectra we integrated the emission bands in each spectrum and plotted the integrated intensities versus excitation wavelength. The excitation spectrum of sodium salicylate reproduces the intensity spectrum of the deuterium lamp.

The CL and PL spectra were closely matched for certain samples. However, the emission spectra of Pr^{3+} and Eu^{3+} - activated samples were affected by the mode of excitation.