

Synchrotron Radiation and Plasma Excited Emission Spectra of Lanthanide Borates

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Several phosphor compositions based on rare earth orthoborates, LnBO_3 , with $\text{Ln} = [\text{Y}_{0.95-y}\text{Gd}_y\text{Eu}_{0.05}]$ or $[\text{Y}_{0.95-y}\text{Gd}_y\text{Tb}_{0.05}]$, have been synthesized by spray-pyrolysis and additional thermal treatments. Samples with the unique hexagonal YBO_3 type phase have been obtained. The cubic oxide $(\text{Y}_{0.96}\text{Eu}_{0.04})_2\text{O}_3$ has also been obtained by same synthesis method and analysed for comparison. The response of these phosphors to VUV excitation has been investigated by two complementary experiments: i) the luminescence excitation spectra have been recorded in the 130 – 300 nm wavelength range, and ii) the relative intensities in the emission spectra of these phosphors excited by rare gas discharges have been measured in a specially developed experimental set-up, Fig. 1(a). This specific set-up consists of a stainless steel chamber filled with a mixture of Ne-Xe at variable composition and pressure (50-200 torr). The objective is to mimic the working conditions of the phosphors in plasma display panels or in Hg-free lighting.

The excitation spectra of Eu^{3+} in the VUV-UV range are interpreted considering the absorption into the ligand to metal charge transfer state, and the host absorption, besides the intra- $4f^7$ absorption of Gd^{3+} for the mixed yttrium-gadolinium borates. Compared to the excitation spectra of Eu^{3+} in the oxide (Y_2O_3), borates are not more efficiently excited at wavelengths shorter than 175 nm (down to 140 nm). This effect is well reproduced by comparing the luminescence efficiencies of europium-doped borates and oxides in the plasma chamber, Fig. 1(c). In pure Xe at low pressure, the VUV photons are emitted by the resonance states of xenon (147 nm), and the borates are as efficient as the oxide. With increasing pressure of the Ne-Xe mixture, the first continuum (150 nm) and second continuum (173 nm)

become more prominent, and it is observed that emission from Eu^{3+} in the oxide is more intense than in borates. Also it is observed that the borates with higher Gd/Y ratio are more efficient, specifically at high pressure.

Terbium excitation spectra in the VUV-UV range are interpreted considering the $4f^85d^0$ to $4f^75d^1$ transitions of Tb^{3+} and the host absorption, besides weak intra- $4f^n$ absorptions of Tb^{3+} , or of Gd^{3+} . Under plasma excitation, it is observed that the phosphor with higher Gd/Y ratio is more efficient, specifically at high pressure.

Fig. 1. (a) The plasma set-up. (b) Emission of $\text{YBO}_3:\text{Eu}^{3+}$ under plasma excitation. (c) Comparison of integrated emission intensities of $\text{Y}_2\text{O}_3:\text{Eu}^{3+}$, $\text{Y}_{0.6}\text{Gd}_{0.4}\text{BO}_3:\text{Eu}^{3+}$, and $\text{YBO}_3:\text{Eu}^{3+}$ with different gas pressures in the plasma set-up.

