Designing oxynitride nanostructured thin films to enhance europium white light emission for efficient solid state emitters.

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Nowadays, the state of art in integrated light emitting devices involves the correct choice of a suitable emitter and a proper functional matrix with good stability and electro-optical properties. In order to build a CMOS compatible device SiO_2, Si_3N_4, and Al_2O_3 are suitable hosts as they show high chemical stability; and active emitting elements ranging from nano-particles, e.g. Si-np, down to single ions (usually rare-earth ions) can be easily embedded. [1] In the search of efficient light emission oxides have been studied extensively, and more recently the use of mixed compounds such as oxynitrides, has shown clear promise due to the possibility of varying their composition in order to tune their optical response. There are recent reports of oxynitrides as light emitters both under electrical excitation [2] and under optical excitation for the UV-visible broad band conversion of UV LEDS. [3]

In the present work we study the visible light emission of europium (Eu) ions embedded in two different matrices (amorphous aluminum oxide (a-Al_2O_3) and ceramic SiAlON) as a function of the Eu distribution and concentration. Eu-doped thin films were produced using the pulsed laser deposition technique by the alternating ablation of the matrix target and the Eu target; as a result nanostructured Eu-doped multilayers were formed. The Eu in-depth distribution was modified by varying the host inter-layer thickness, which ranged from 1 to 15 nm, and the Eu content per layer was modified by varying the number of pulses on the Eu target.

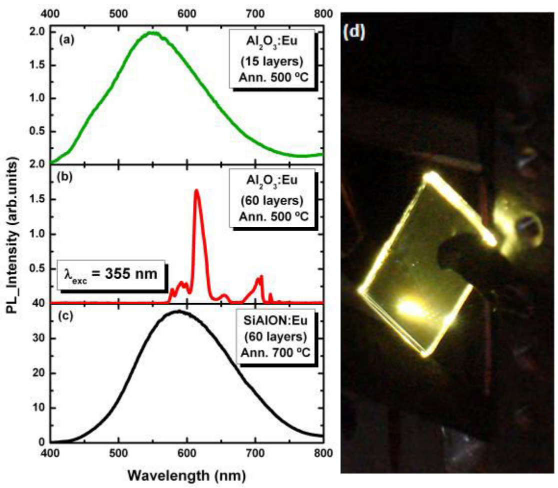

Fig. 1 Photoluminescence emission of Eu-doped films under 355 nm excitation in (a) Al_2O_3:Eu 15 layers annealed at 500 ºC, (b) Al_2O_3:Eu 60 layers annealed at 500 ºC, (c) SiAlON:Eu 60 layers annealed at 700 ºC, (d) Photograph of the emission of sample (a) deposited on fused silica.

Under UV excitation (355 nm), the as-deposited films of both matrices showed a broadband emission (FWHM ~200 nm), that has been related to the superposition of the 5d levels to the 4f levels of the Eu^{2+}, which is rarely found in pure oxides. This broad emission was further enhanced keeping the same spectral distribution upon annealing treatments up to 500 ºC for the a-Al_2O_3 (Fig. 1a) and 700 ºC for the SiAlON (Fig. 1c). However for samples with higher Eu content and at the higher annealing temperatures the spectral shape emission changed and the emission spectra showed narrow and well-defined emission peaks. These have been identified as resulting from the 4f → 4f transitions of Eu^{3+} (Fig. 1b). Therefore, it has been found that two distinct and efficient Eu-related emissions can be obtained by a suitable design of the Eu distribution and concentration. This is due to a change of oxidation state of Eu in the films, which will be discussed. These Eu-doped films have a high potential for the development of either solid state lighting LEDs with broadband emission, or integrated lasers with narrow emission lines.

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References

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