

Blue-green emission modulation by concentration in $\text{Ba}_2\text{SiO}_4:\text{Tb}^{3+}$ phosphor obtained via sol-gel for white LED application.

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Abstract

$\text{Ba}_2\text{SiO}_4:\text{Tb}^{3+}$ phosphors were successfully obtained via an adapted sol-gel route. The emission color could be modulated from blue to green as the content of Tb^{3+} increases. This material is suitable for white LED designing.

the distance between Tb^{3+} ions in the matrix is short, once again quenching the emission from $^5\text{D}_3$ state level². The CIE diagram³ related to the prepared phosphors show a blue color emission for $\text{Ba}_2\text{SiO}_4:\text{Tb}^{3+}(0.1\%)$ that shifts to green region with increasing concentration of Tb^{3+} .

Introduction

Phosphors based on silicate matrixes have been extensively investigated because of their chemical stability and transparency to visible light¹, which is desirable for optical devices application. The objective of this work was to synthesize by using an adapted sol-gel route a blue-green phosphor Ba_2SiO_4 doped with 0.1-5 charge % of Tb^{3+} aiming potential use in white LEDs.

Results and Discussion

Ba_2SiO_4 isoelectronically doped with Tb^{3+} (0.1-5 ch%) was synthesized from barium acetate, terbium chloride, acetic acid and TEOS, yielding a gel phase that was preheated at 100 °C forming a xerogel, which was calcinated at 1100 °C upon CO reducing atmosphere. Ba_2SiO_4 (orthorhombic crystal structure, spatial group P_{mcn}) with single phase and high crystallinity was confirmed by XRD for all doped samples, Fig.1(a). In Raman spectra, Fig.1(b), bands related to vibrational modes of orthorhombic silicate structure are in accordance with XRD data. In addition, a decrease in band gap values estimated from diffuse reflectance data for doped samples (4.1-5.1 eV) in comparison to undoped one (5.60 eV) was verified. Excitation spectra, Fig.1(c), exhibit a band in 270 nm assigned to the $^7\text{F}_6 \rightarrow 4f^5\text{d}$ Tb^{3+} transition along with other Tb^{3+} internal transitions. Samples excited under 270 nm, Fig.1.(d), emit in the green (542 nm) and blue (376, 415 and 436 nm) regions. By increasing the concentration of Tb^{3+} , the transitions starting from $^5\text{D}_4$ excited level predominate in relation to the ones from $^5\text{D}_3$ level. The ratio between the relative areas of the transitions from both $^5\text{D}_3$ and $^5\text{D}_4$ levels follows an exponential trend. The $^5\text{D}_3$ excited level undergoes an emission quenching as the concentration of Tb^{3+} increases due to the cross relaxation effect involving a near neighbor Tb^{3+} . This process is favored when the distance between Tb^{3+} ions is small (i.e. high Tb^{3+} concentrations), $\text{Tb}^{3+}(^5\text{D}_3) + \text{Tb}^{3+}(^7\text{F}_6) \rightarrow \text{Tb}^{3+}(^5\text{D}_4) + \text{Tb}^{3+}(^7\text{F}_0)$. This effect takes place also when

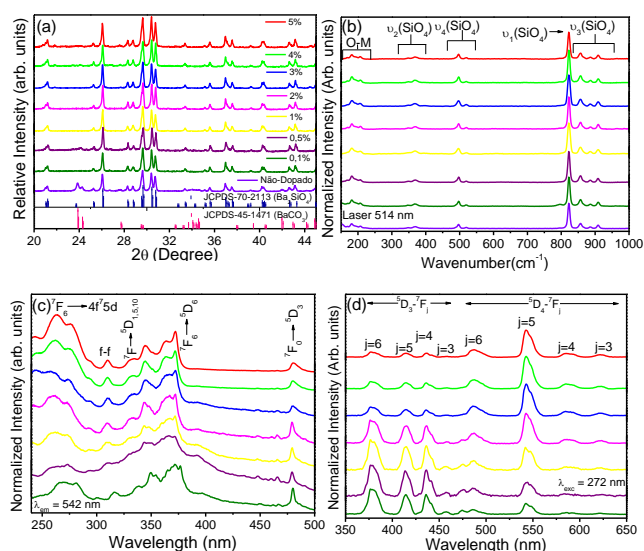


Figure 1.(a) X-ray diffractograms, (b) Raman spectra, (c) excitation and (d) emission spectra of $\text{Ba}_2\text{SiO}_4:\text{Tb}^{3+}$ samples.

Conclusions

The sol-gel route was successfully applied to prepare $\text{Ba}_2\text{SiO}_4:\text{Tb}^{3+}$ phosphors, which emission color shifts from blue to green as the concentration of Tb^{3+} increases. Therefore the produced phosphors show potential application to be used in white LED designing.

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