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Study of Addition of Tetraethyl Orthosilicate (TEOS) on Microstructure and Luminescence Properties of Nanoparticles of Y_2O_3: Tb^{3+} Phosphor Materials

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1. Introduction

In the recent years the phosphor materials with their interesting and versatile characteristics have been concentrated in many industries. Among these applications, electronic parts, solid-state lasers, LEDs, solar cells, optical sensors and monitors can be considered. The luminescence properties of phosphors can be obtained through their doping by rare earths. Generally Y_2O_3 has been known as a host oxide, proper for rare earth elements. According to the results of previous researches, the addition of silica to the luminescent materials results in the reduction of costs and enhancement of luminescence excitation and emission.

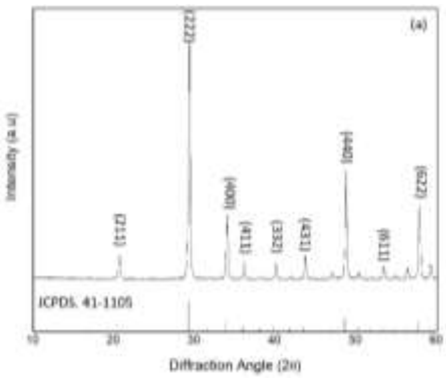
2. Experimental

The initial materials include $Tb(CH_3COO)_3.H_2O$, TEOS ($SiC_8H_{20}O_4$) and $Y(CH_3COO)_3.H_2O$, used without any further modifications. Then, via the addition of TEOS to the considered raw materials, the doped YSO compounds in the presence of different quantities of SiO_2 were produced. Then the production was heated in an electric oven at 50 ˚C for 3 days to be dried well. Finally, to remove the remained organic materials and also to reach the proper crystal structure, the obtained productions were calcined at 1200 ˚C for 1 hour.

3. Results and Discussion

In Figure 1 the XRD spectra show that the peaks at the 2θ of 21.98, 28.44, 31.46, 36.08, 47.06, and 48.61 have been originated from silica.

Finally it was proved that the produced phases include SiO_2, Y_2SiO_5 and Y_2O_3 phases. In this investigation it was interestingly seen that the addition of silica results in the remarkable grain growth while this size increases from 80 nm to about 300-400 nm (Figure 2).



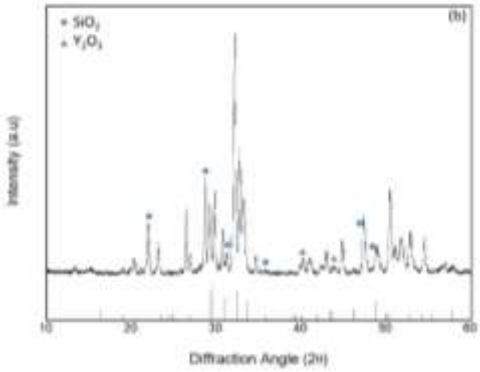


Figure 1. The XRD spectra of (a) Y_2O_3:Tb^{3+} and (b) Y_2SiO_5:Tb^{3+} after heating at 1200 ˚C

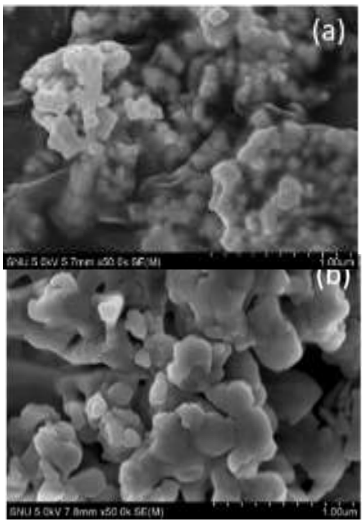


Figure 2. FESEM images of (a) Y_2O_3:Tb^{3+} and (b) Y2SiO:Tb^{3+} phosphors

In addition, it was observed that via the addition of TEOS the surface of synthesized particles is smoother with lower microscopic roughness which results in the enhancement of optical characteristics of phosphor materials. To study the luminescence emission properties, the phosphors were excited under 270 nm. According to Figure 3, it was seen that under the mentioned excitation, the emission peaks have occurred in the wavelength range of 450-600 nm which are related to $^5D_4$–^7F_J (J=6,5,4). The graphs of intensity vs. wavelength reveal that the most intense peak was occurred at the wavelength of 541.5 nm, corresponding to $^5D_4$–$^7F_5$ electronic transaction. It was found that whenever the amount of SiO_2 is enough for the formation of Y_2SiO_5, the highest intensity of emission is achieved while higher amounts of silica gives rise to the reduction of luminescence characteristics, which this issue can be interpreted with the presence of impurities beside Y_2SiO_5 phase.

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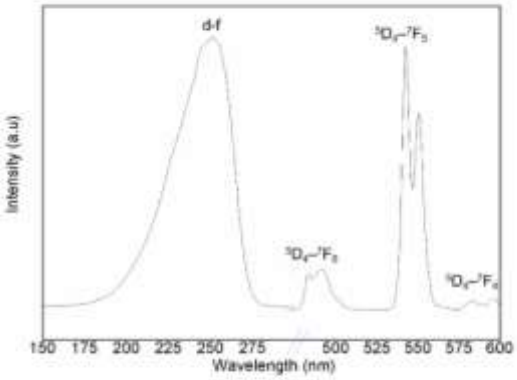

Figure 3. Excitation and emission spectra of Y_2SiO_5:Tb $^{+3}$

4. Conclusion

In this investigation it was shown that the highest emission characteristics of YSO materials occurs in the compounds which the amounts of consumed SiO_2 is equal to the stoichiometric materials for the formation of Y_2SiO_5.