Distribution of Eu ion in nano-size Y_2O_3:Eu Nanopowder prepared by solution combustion method

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Y_2O_3:Eu compound is known as the best red phosphor source for three color fluorescent lamps and color displays [1]. The chemical and thermal stability of this compound is better than sulfide based phosphors such as $Y_2O_2SO_4$:Eu [2]. It also exhibits higher quantum efficiency and stability against high current densities [3]. Although, the optical properties of micron-size Y_2O_3:Eu powder have been optimized [3], they are not optimized for nanosize Y_2O_3:Eu . In our previous work [4, 5] , we demonstrated that quenching concentration of nanosize Y_2O_3:Eu is about 5 percent of Eu concentration which had conflict with the result of Ye et al[6]. They believed that upon decreasing the size of Y_2O_3:Eu compound the quenching concentration could be enhanced. In this work, we present solid reasons and mechanism in order to explain this phenomenon.

Y_2O_3:Eu nanopowder was prepared by urea solution combustion method. The samples were then analyzed by X-ray diffraction (XRD), high resolution transmission electron microscopy (HRTEM) and energy dispersive X-ray analysis (EDX). Photoluminescence of the samples was measured employing 230 nm excitation. To analyze Y_2O_3:Eu (3%) sample with Warren-Averbach (WA) method, the XRD pattern was taken with the step time of 5 sec. for 222 and 444 peak.

Fig. 1 shows HRTEM picture of Y_2O_3:Eu (3%) sample. In inset of this figure, reduced FFT image of the selected area in HRTEM image is shown. It can be seen that good crystallinity was obtained by solution combustion synthesis method.

Result of WA analysis of Y_2O_3:Eu (3%) sample is shown in Fig. 2 and 3. The trend of the micro-strain distribution (Fig. 3 b) is nearly proportional to 1/ L, indicating that defects (line and point) are preferentially localized along grain boundaries [7]. These result also showed that Eu is accumulated near the grain boundary of each crystallite and therefore quenching concentration decreased. This hypothesis was confirmed by EDX Analysis (Table 1). Moreover the distribution of crystallite size was computed by Bertuat method [8]. The distribution of crystallite size was also computed from the HRTEM micrograph. Figure 4 shows the distribution of crystallites computed from HRTEM micrograph and Warren-Averbach method. It can be seen that there is good correlation between them. Mean value of crystallite size is about 5-7 nm which is much smaller than the one determined by Scherrer's formula (about 25 nm).

Scherrer's formula determines the crystallite size with the assumption that crystallites have uniform distribution. The difference between the result of WA and Scherrer's formula comes from this limitation of Scherrer's formula.

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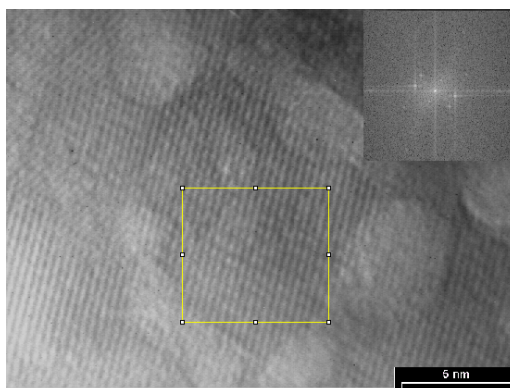
Figures:

Fig. 1 HRTEM picture of Y_2O_3:Eu (3%) sample, inset) reduced FFT of selected area in HRTEM image.
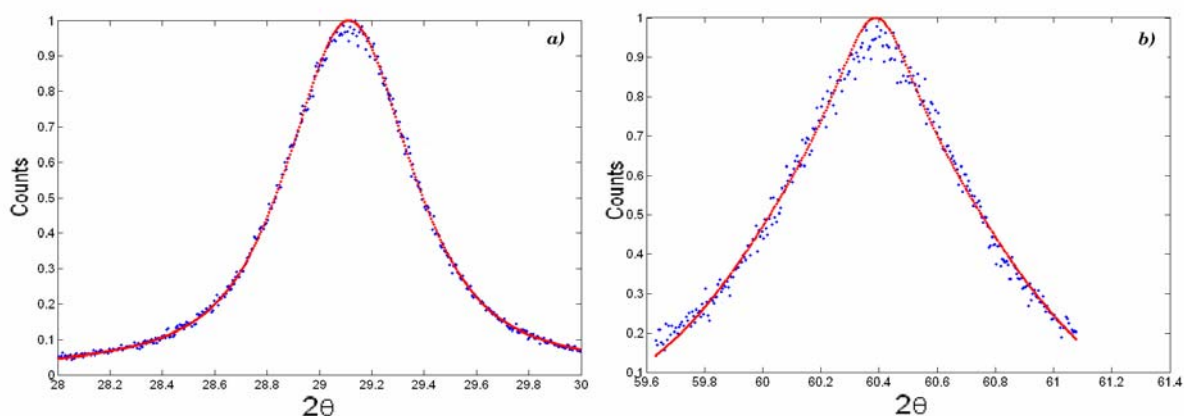

Fig. 2 Fitting by pseudo-Voigt functions of the a) (111), b) (222) peaks for the Y_2O_3:Eu (3%) sample (step time 5 sec.)
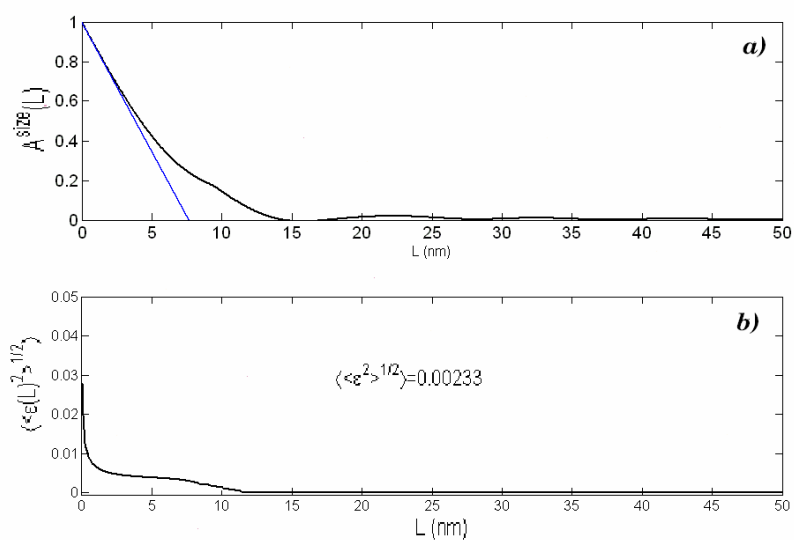
Fig. 3 Fourier transform coefficient of Y_2O_3:Eu (3%) sample after correction for instrument broadening by stokes method and removing of strain broadening. b) distribution of micro-strain vs. correlation length.
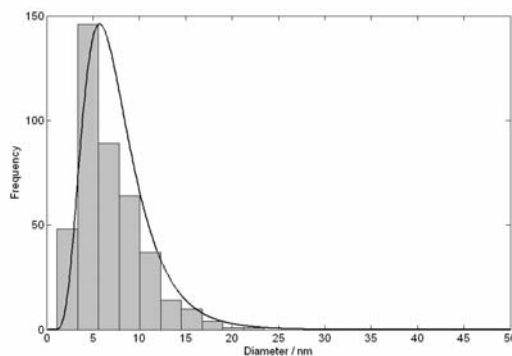

Fig. 4 Crystallite size distribution of Y_2O_3:Eu (3%) sample determined by warren-averbach method and HTEM picture.

Table 1 EDX analysis of the Y_2O_3:Eu (3%) in three different points

Point	1	2	3	AVE	STD DEV
Eu(% mol)	3.73	3.66	4.37	3.92	0.39
Y (% mol)	96.27	96.34	95.63	96.08	0.39