# Hydration induced coupling of excitonic state and phonon in $Y_2O_3$: negative effect on the luminescence efficiency of nanosize $Y_2O_3$: $Eu^{+3}$ plasma display phosphor

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## Abstract

Europium ion activated cubic $Y_2O_3$ is one of the most important commercial red phosphors used in plasma display panel (PDP), and field emission display (FED). In the recent years, there has been great interest in preparing nanocrystalline phosphors to achieve higher luminescence efficiency and better resolution to the images of a phosphor based display panel; and in that endeavor, $Y_2O_3$: $Eu^{+3}$ red phosphor is of no exception. However, earlier reports on the luminescence efficiency of nanocrystalline $Y_2O_3$: $Eu^{+3}$ are contradictory. Some group reported enhancement of luminescence efficiency with the reduction of particle size while the others observed a significant loss of the same**.** In the present study we have investigated luminescence properties of a series of samples of $Y_2O_3$: $Eu^{+3}$ red phosphor of particle sizes ranging from 50 - 300 nm as a function of time to decipher the long standing mystery of the effect of reduction of particle size on the luminescence efficiency of the material. The samples were found to lose luminescence efficiency (shown in Fig.1) and suffer a change in the excitation profile with time which is most dominant in case of 52 nm sample (shown in Fig. 2). The 212 nm (47100 $cm^{-1}$) host's excitonic band (which is an electronic transition from the oxygen 2p valence band to the yttrium 5d6s conduction band) gradually disappears and a number of phonon side bands at around 210.5 nm (47500 $cm^{-1}$) and 214 nm (46700 $cm^{-1}$) appear in the spectrum with ageing. The energy of separation between these vibronic bands of the aged samples was found to be ~ 400 $cm^{-1}$ or some of its multiple. The IR studies showed that although the samples at their freshly prepared stage were almost free from contaminated water, on ageing in air at room temperature, they absorb the latter. Thus a phenomenon of hydration induced coupling of the excitonic state of $Y_2O_3$ with one of its $F_u$ modes (400 $cm^{-1}$), has been detected in the case of aged sample, which is instrumental in introducing newer nonradiative channels in the system. Because of larger surface to volume ratio, the effect is most pronounced in the case of nanocrystalline samples.

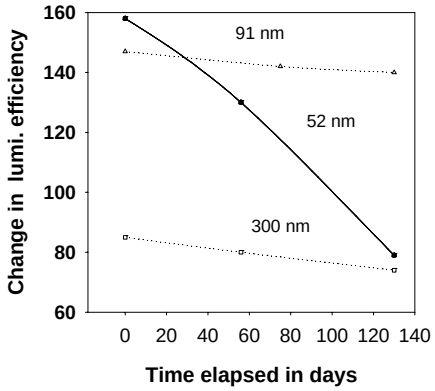


**Figure 1.**.Fall in luminescence efficiency of different nanosize $Y_2O_3$:$Eu^{+3}$ with time.

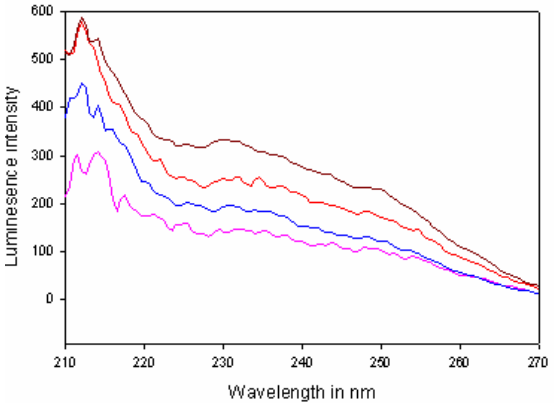


**Figure 2.** Excitation spectra of the red luminescence of the 52nm nanophosphor at different stages of its ageing: (____) as prepared, (___) after 56 days, (____) after 130 days, (____) after heat treatment.