Photoluminescence, X -ray Luminescence and FT-IR investigation of $Y(Ta,Nb)O_4:Eu^{3+}$ Phosphors

Ivan Arellano, Mihail Nazarov, Clare C. Byeon*, Elisabeth-Jeanne Popovici**, Do Young Noh,
Gwangju Institute of Science and Technology, Department of Marterials Science and Engineering,
*Gwangju Institute of Science and Technology, Advanced Photonics Research Institute,
**"Raluca Ripan" Institute for Research in Chemistry, Babes Bolyai University, Romania.
ivan@gist.ac.kr

There is a great interest in red emitting europium activated yttrium tantalate, yttrium niobium-tantalate and yttrium niobate to both scientific and application point of view. In these phosphors, europium (Eu^{3+}) ions can be widely used as luminescent centers which exhibit the characteristic red emission corresponding to its $^5D \rightarrow {}^7F_j$ transitions. These materials are a new class of phosphors which are supposed to replace the classic calcium tungstate X-ray phosphors. $YTa_{1-x}Nb_xO_4:Eu^{3+}$ (where x = 0, 0.15, 1) phosphors were prepared by solid state reaction from the flux of homogeneous mixture consisting of Y_2O_3, Eu_2O_3, Nb_2O_5, Ta_2O_5 and Na_2SO_4. UV and X-ray excitation luminescence as well as X-ray diffraction (XRD) and Fourier transform-infrared (FT-IR) spectroscopy were used to investigate the luminescent and structural properties of $YTa_{1-x}Nb_xO_4:Eu^{3+}$ phosphors.

Comparing UV (254 nm) and X-ray excitation (50 KeV, 100 mA), we found in different investigated host lattices that the relative intensity of $^5D_0 \rightarrow {}^7F_j$ emission peaks, so called the branch ratio, varies with not only the europium activation but also with the excitation wavelength. We can see this variation in Figure 1 and in Table 1. Moreover, the $^5D_0 \rightarrow {}^7F_4$ emission peak at around 700 nm becomes conspicuous for all the samples when X-ray excitation is applied. Under UV excitation, the $^5D_0 \rightarrow {}^7F_4$ emission is mostly trapped by the empty upper levels. In contrast, it is more likely that such empty levels can be readily filled under X-ray excitation. This model explains the appearance of $^5D_0 \rightarrow {}^7F_4$ transition and the increment of the luminescence intensity under X-ray excitation.

The FT-IR spectra and XRD (Figure 2 and 3, respectively) clearly show the difference between the crystalline structures M′-$YTaO_4$ and M-$YNbO_4$ also known as fergusonite.

From our results, we can conclude that the substitution of Y atoms by Eu^{3+} ions in M-$YNbO_4$ shows the best luminescence in comparison with the other host lattices. This phosphor is a good candidate for application in X-ray intensifying screens and other optoelectronic devices.

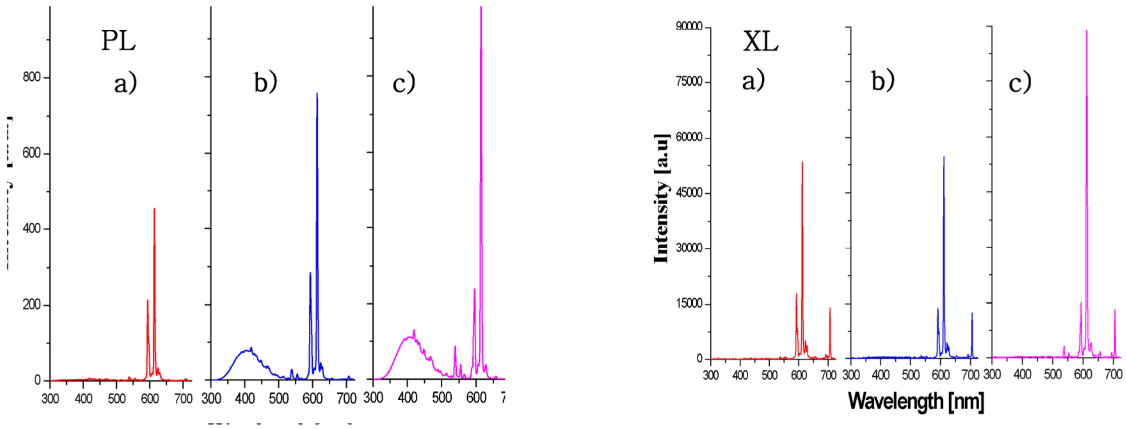

Figure 1. Photoluminescence and X-ray excitation of a) $YTaO_4$ Eu^{3+}, b) Y(Ta, Nb)O_4:Eu^{3+} and c) $YNbO_4$:Eu^{3+}.

Table 1. Branching ratio of $^5D_0 \rightarrow {}^7F_j$ Transitions (Eu concentration = 0.05mol)

Transitions	Phosphor materials		
	$YTaO_4$:Eu^{3+}	Y(TaNb)O_4:Eu^{3+}	$YNbO_4$:Eu^{3+}
PL excitation			
$^5D_0 \rightarrow {}^7F_1$	48	39	25
$^5D_0 \rightarrow {}^7F_2$	100	100	100
$^5D_0 \rightarrow {}^7F_4$	1.3	1.4	1.1
X-ray excitation			
$^5D_0 \rightarrow {}^7F_1$	33	25	17
$^5D_0 \rightarrow {}^7F_2$	100	100	100
$^5D_0 \rightarrow {}^7F_4$	26	23	15

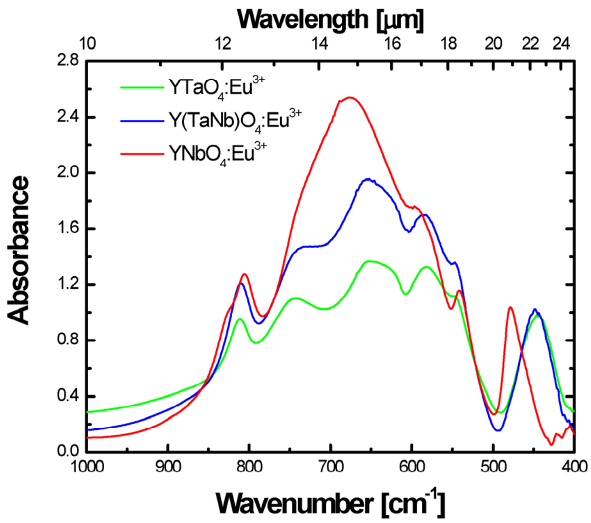

Figure 2. FT-IR Spectra of $YTa_{1-x}Nb_xO_4$:Eu^{3+} phosphors

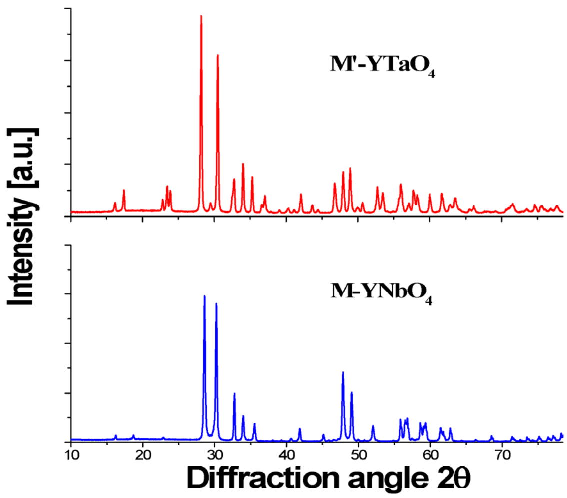

Figure 3. XRD Patterns of $YTaO_4$ and $YNbO_4$