# Structure, Morphology and Luminescent Properties of $YVO_4$: $Dy^{3+}$, $Bi^{3+}$ Phosphors


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## ABSTRACT


$Dy^{3+}$- $Bi^{3+}$ co-doped $YVO_4$ ($YVO_4$: 3at%$Dy^{3+}$, $x$$Bi^{3+}$) phosphors have been synthesized and subsequently characterized by XRD, SEM, photoluminescence and Raman spectroscopy to study the simultaneous effect of the activator and sensitizer on the luminescent properties of said phosphor.

The observations in this case were subsequently explained on the basis of change in the local symmetry of the dopant ion, due to change in the host morphology.


## INTRODUCTION

### History of Light


Oil lamp

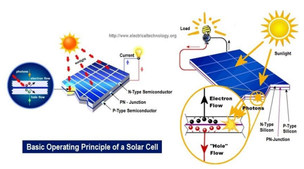

Incandescent bulb

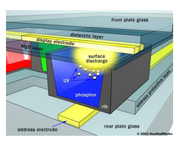

Fluorescent bulb


LEDs

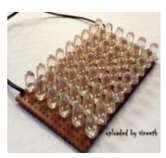
- Luminescence is a cold light.
- Materials exhibiting this phenomenon are called Phosphors.
- The research on rare earth (RE) doped luminescence materials is always the most active field owing to the large need in the field of illuminations.

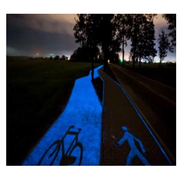

Solar Cells



Plasma Displays


LED Solar cells



- Their wide application include solar Cells, plasma displays, LEDs, CRTs, fluorescent lamps, etc.
- $YVO_4$ is a promising host material for various optical applications, especially doped with trivalent rare earth cations.
- Dy doped $YVO_4$ is considered as potential phosphors due to its high absorption and luminescence efficiencies in UV region.

## EXPERIMENTAL

$YVO_4$:$Dy^{3+}$,$x$$Bi^{3+}$ powder samples were prepared by solid state route.

$Y_2O_3$ , $V_2O_5$ , $Dy_2O_3$ , $Bi_2O_3$

↓ ground for 6hrs

↓ calcined at 900°C , 6hrs

↓ sintered at 1100°C , 6hrs

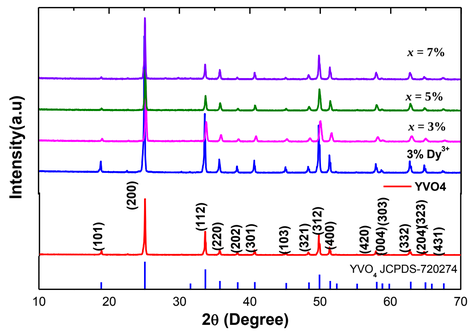
$YVO_4$: 3%$Dy^{3+}$, $x$$Bi^{3+}$ ($x$ = 0,3,5,7 )

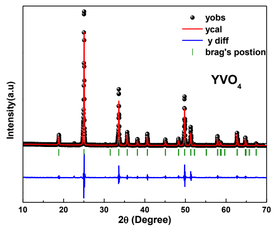
- *XRD: Rigaku, Japan (with Cu-Kα )*
- SEM: JEOL, USA
- RAMAN: Witech Micro Raman Spectrometer
- PL: Perkin Elmer LS55

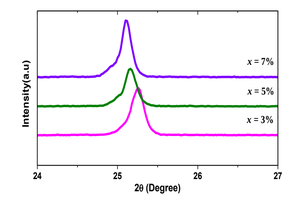
## RESULTS AND DISCUSSION

### XRD

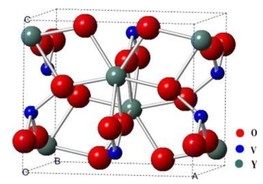
($YVO_4$: 3%$Dy^{3+}$, $x$$Bi^{3+}$)



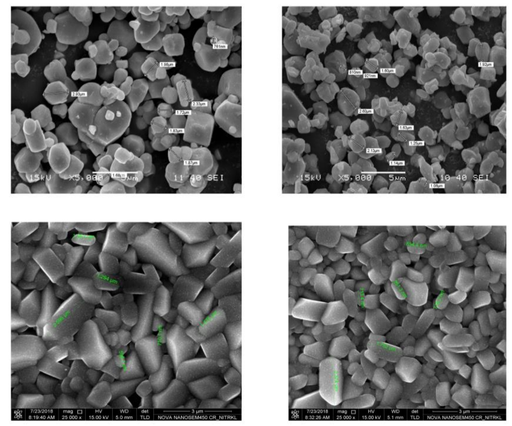




- Figure shows the few representative XRD patterns of the $YVO_4$: $Dy^{3+}$, $Bi^{3+}$ phosphors annealed at 1100°C.
- The exact structure of the samples, Rietveld analysis of the XRD data of the parent samples is carried out by using Fullprof program.




- Samples exhibited single phase tetragonal structures in space group *I141/amd* which is also consistent with the JCPDS Card No. 72-0274 of pure crystalline tetragonal $YVO_4$.
- With increase in the $Bi^{3+}$ concentration in $YVO_4$ samples, the (200) diffraction peak shifts to lower angle side, might be due to the reason that the ionic radius of $Bi^{3+}$ ion is slightly higher than that of $Y^{3+}$ ion.
- The crystal structure shown here is obtained from the data obtained from the refinement of XRD data, where the subsequent samples are co-doped with Dy and Bi.

### SEM



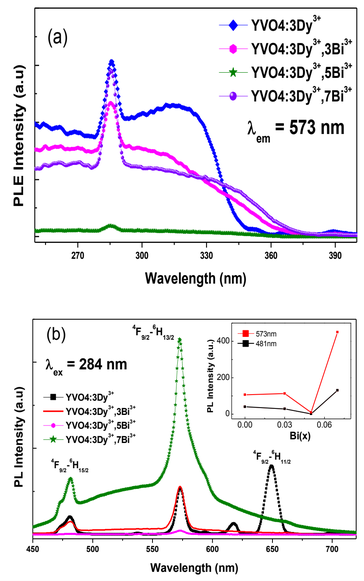
- SEM investigations were carried out to understand surface morphological features and the particle size of the phosphor.
- The SEM micrograph clearly exhibits homogeneous and smooth surfaced grains having almost hexagonal structure.
- The average particle size after heat treatment is found to be ~ 1 µm and this microcrystalline form of crystalline phosphors may result in high luminescent intensities.

## PHOTOLUMINESCENCE

Figure shows the PLE and PL spectra of the Dy singled doped $YVO_4$ and co-doping of $Dy^{3+}$ and $Bi^{3+}$ (inset shows the $I_{max}$ of emission peaks with $Bi^{3+}$ conc.).

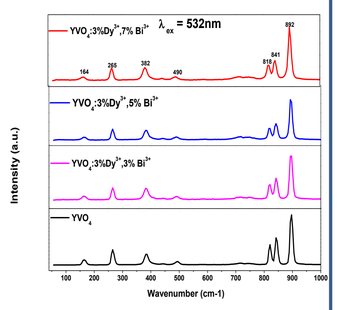
573 nm peak, initially increases with Bi and reaches a maximum for 7at%.

May be due to conc. quenching of RE ions at lower %, which is further compensated by higher Bi.




## RAMAN SPECTROSCOPY

Figure shows the Raman spectra for $Bi^{3+}$ (0, 3, 5, 7 at%) co-doped $YVO_4$ under 532 nm laser excitation.




Strong Raman peaks imply stronger interaction between the atoms, mainly arising from stretching and bending of the shorter metal–oxygen bond within anionic groups.

## CONCLUSION

One significant outcome of the photoluminescence study involved a drastic variation of relative intensity due to 7at% of $Bi^{3+}$ and the variation in the relative intensity of the $^4F_{9/2}$ - $^6H_{13/2}$ transition with respect to the $^4F_{9/2}$ - $^6H_{15/2}$ transition of $Dy^{3+}$ in $YVO_4$: $Dy^{3+}$.


## ACKNOWLEDGEMENT

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## REFERENCES


1. B. C. Chakoumakos, M. M. Abrah and L. A.Boatner, J. Solid state Chem, **109**, 197 (1994).
2. X L Meng, L Zhu, H J Zhang J.. Cryst. Growth, **200**, 199 (1999).
3. J B Gruber, B H Zandi, U V Valiev J. Appl. Phys. **94**, 1030 (2003).
4. H. Xu, C. Wu, H. Li, J. Chu, G. Sun, Y. Xu, and Y. Yan, Appl. Surf. Sci. **256**, 597 (2009).
5. D. Chen, Y. Yu, P. Huang, H. Lin, Z. Shan, L. Zeng, and Y. Wang, Phys. Chem. Chem. Phys., **12**, 7775(2010).
6. Z. P. Ci, Y. H. Wang, and J. C. Zhang, Chin. Phys. B **19**, 057803 (2010).