Fabrication and properties of europium and ytterbium Eu^{3+}/Yb^{3+} doped polymethylmethacrylate film

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Films of polymethylmethacrylate are prepared on microscopic glass substrate using spin coating technique at 1000rps for 30s. Measurement were mode of the transmission Spectra in the wavelength ranges from 400-900nm for the Eu^{3+} doped sample and from 950-1020 nm for the Yb^{3+} doped sample. Refractive index of thin film has been determined using ultraviolet –visible –near infrared spectrometer in the spectral rang 400-900nm. Such film may be considered as prospective materials for fabrication of planar optical waveguides.

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1. Introduction

Most research has focused on RE ions which can emit in the visible region about the properties of GaN layers doped with Eu^3 and Tm^3 ions. They obtained photoemission from higher excited RE states in GaN covering the entire visible spectrum light emission in the green (from Er at 525/550 nm), red (from Pr 625/645 nm) and blue (Tm at 455 nm) spectral regions. A second major field of study deals with RE ions which can emit in the infrared region. For these purposes, the RE ions are most often studied for telecommunication system.

Polymers are being used in optical telecommunication applications and are in increasing demand for optical signal amplifying systems [1]. As polymers interfere with optical signals by absorbing part of their energy, transmission distance in polymer optical fibers is limited. To enlarge the transmission distance of optical signals in polymer optical fibers one must compensate for the loss of energy. By coupling the fibers to an optical amplifying device, a weakened optical signal is boosted and thus regenerated in strength. The properties of polymeric materials, intended for applications in electronic and optoelectronic structures, are affected, besides of other phenomena, especially by their physical aging.

Therefore, Eu_2O_3 is an attractive material for use in a variety of device size regimes, from nanoscale to macroscopic. Recent studies have sought to take advantage of the optical properties of europium oxide nanocrystals and other rare-earth-based materials for implementation in nanoscale optical devices, such as biocompatible bioimaging reagents or nanocrystalline light-emitting diodes .Thin films of Eu_2O_3 nanocrystals also could be employed in nanoscale applications, such as fluorescent video displays photoactive coating optical data storage.

In this paper ,we present the fabrication and properties of Eu and Eu/Yb doped polymer layers. As a polymer material we chose polymethylmethacrylate (PMMA)due to its low optical absorption ,simple synthesis and low cot .These characteristics make it a suitable host material for RE ions .Eu^{3+} ions were chosen due to fact that Eu^{3+} ions now play a key role in long - distant optical communication system. Doping was applied because the addition of ytterbium ions increased the intensity of the luminescence [2-9].

2. Experimental details.

Polymethylmethacrylate (PMMA) was synthesized in our laboratory by polymerizing methylmethacrylate using benzoyl peroxide. PMMA were supplied by GSFCL, India. The characteristics of PMMA used are given in Table 1. Figure 1 shows the structure of PMMA. Spin coating technique (at 1000 rpm for 30 s) was employed for the deposition of PMMA films. Microscopic glass (Blue Star, India) slides were used as substrate.

Table 1. Material characteristics of PMMA .

Material	Density (g/cc)	Molecular weight (M_w)	Polydispersity
I-PMMA	1.1	5.26×10^5	2.34
II-PMMA	1.1	9.85×10^5	2.07
III-PMMA	1.1	13.67×10^5	1.53

Europium and ytterbium (Goodfellow) were dissolved in dimethyl sulphoxide (C2H6OS).

The layers was fabricated in such away that the content of europium in the solutions varied from 1.0 at% to 15.0 at %,and were then added to the polymer .The samples containing 1.0% of europium were co-doped with ytterbium in amount varying from 1.0% to 15.% .

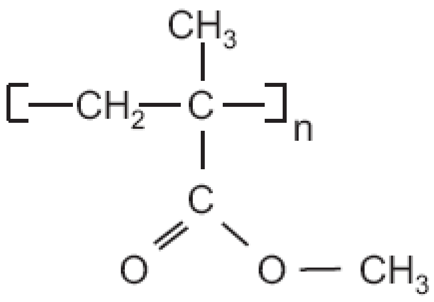

Fig. 1 Molecular structure of PMMA .

3. Result and discussion

Using the experimental data of optical transmittance of PMMA films the refractive index has been calculated. The film has thickness (*d*) and complex refractive index $n^* = n - ik$, where *n* is the refractive index and *k* is the extinction coefficient. The thickness of the substrate is several times larger than the thickness of the film. If the thickness of the film is constant, interference effect will give rise to oscillating curves as shown in Fig. 2.

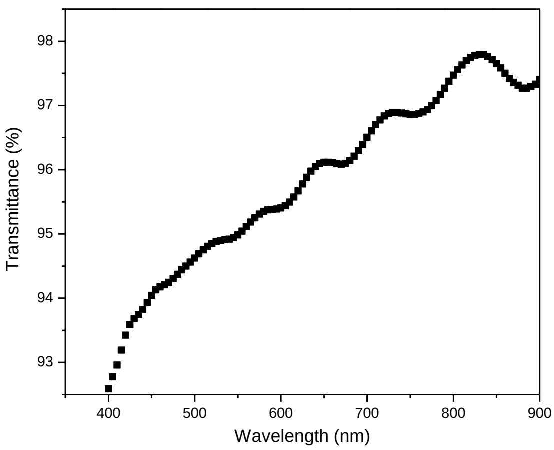

Fig. 2 Transmission spectra of PMMA .

The transmission spectra of Eu^{3+} doped polymer in the spectral range from 500nm to 850 nm are show in Fig. 3. In sample containing 5.0 at. % and 15 at. %, we are observing optical parameters are deduced from the fringes pattern in the transmittance spectrum [10, 11]. According to Swanepoel [10] the value of the transmission spectra of the Eu^{3+} doped polymers co-doped with Yb^{3+} ions using europium and ytterbium (from 1.0 % to 15.0 %) in the spectral range from 950 nm – 1020 nm are show in Fig. 4.

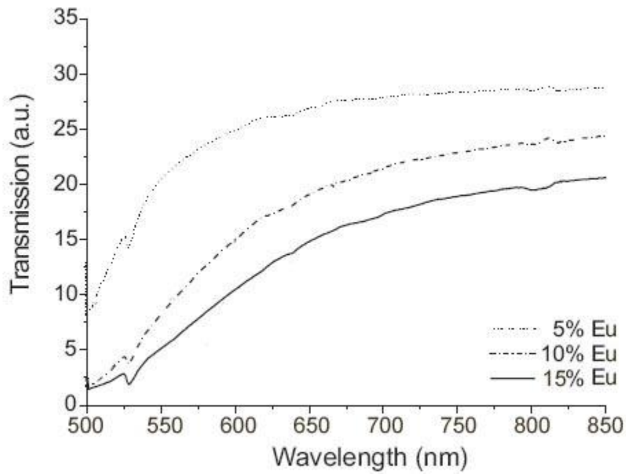

Fig. 3 Transmission spectra of the Eu^{+3} doped PMMA using Europium .

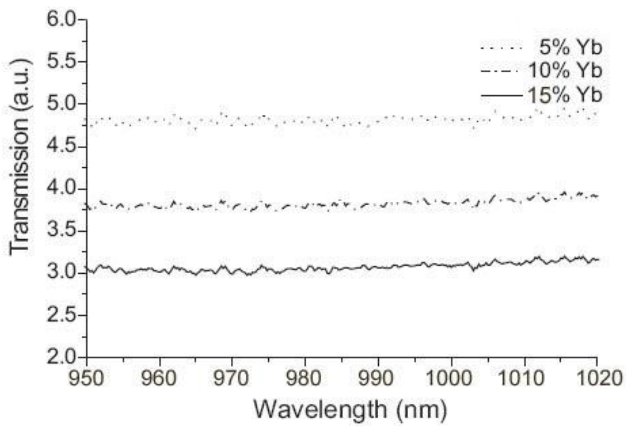

Fig. 4 Transmission spectra of the Eu^{+3} doped PMMA co-doped with Yb^{+3} using europium and Ytterbium .

And ytterbium co-doped with Yb ions using europium

$$n = [N + (N^2 - s^2)^{1/2}]^{1/2} \quad (1)$$

where

$$N = \frac{2s}{T_m} - \frac{(s^2+1)}{2} \quad (2)$$

and T_m is the envelope function of minimum transmittance and *s* is the refractive index of substrate. In the weak region where $\alpha \neq 0$ the transmittance decreases due to the influence of α, equation (2) is given by

$$N = 2s\frac{T_M - T_m}{T_M T_m} + \frac{(s^2+1)}{2} \quad (3)$$

where T_M is the envelope function of maximum transmittance. Refractive index can be estimated by extrapolating envelops corresponding to T_M and T_m. If n_1 and n_2 are the refractive indices of two adjacent maxima or minima at wavelengths λ_1 and λ_2, then the thickness of the film is given by

$$d = \lambda_1 \lambda_2 / 2(\lambda_1 n_2 - \lambda_2 n_1) \quad (4)$$

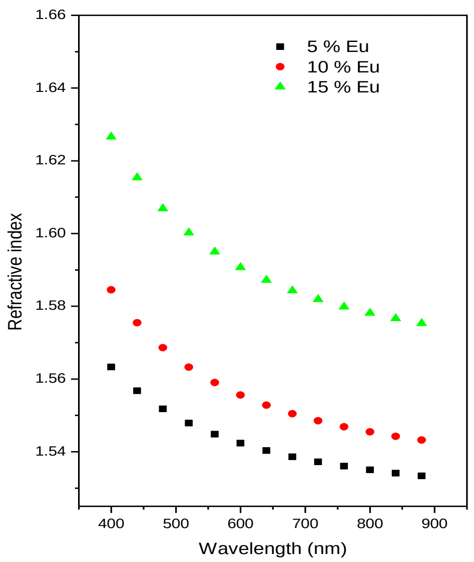

Fig. 5 Wavelength dependence of the refractive index of the Eu^{+3}.

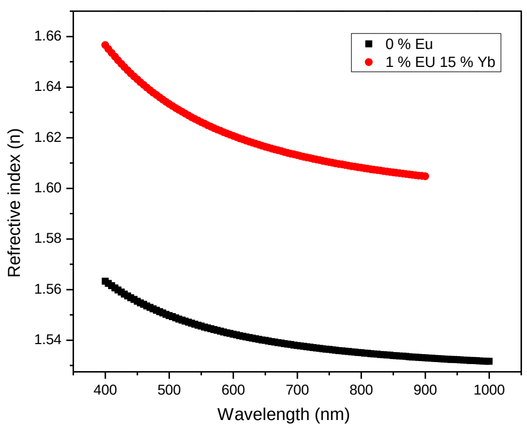

Fig. 6 Wavelength dependence of the refractive index Eu^{+3}+Yb^{+3} doped PMMA layers using the europium and ytterbium .

The refractive index of substrate used is 1.51. The measurement were carried out in the spectral range from 400 to 1000 nm . Fig. 5 show the dependence of the refractive index of Eu doped PMMA(europium), and figure 6 show the dependence of the refractive indices of the 1 at % Eu^{3+} (europium) doped PMMA with Yb^{3+} co-doped (Ytterbium).

4. Conclusion

It was observed that the refractive index of Eu^{3+} decreases with increasing wavelength no matter what the concentration of Eu^{3+} is. But when the content of Eu^{3+} was increased, higher values for refractive index were observed as shown in Fig. 5.

Further as shown in Fig. 6, same pattern was observed where the refractive index of Eu^{3+}+Yb^{3+} also decreased with increasing wavelength no matter what the concentration of Eu^{3+}+Yb^{3+} is. But when the content of Eu^{3+}+Yb^{3+} was increased, higher values for refractive index were observed for this PMMA as well.

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