DIRECTION DEPENDENT TRANSMISSION CHARACTERISTICS OF DYE MIXTURE DOPED POLYMER OPTICAL FIBRE PREFORMS

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Abstract: The direction dependant wavelength selective transmission mechanism in poly (methyl methacrylate)(PMMA) rods doped with C 540 dye and C 540:Rh.B dye mixture as a combination has been investigated. When a polished slice of pure C 540 doped polymer rod was used side by side with a C540:Rh B doped rod with acceptor concentration [A] = 7x10-4 m/l , we could notice more than 100% change in the transmitted intensity along opposite directions at the C 540, Rh B emission and the excitation wavelengths . A blue high bright LED emitting at a peak wavelength 465nm was used as the excitation source.

1. INTRODUCTION

The primary motivation for the use of mixture of dyes as lasing medium was either an improvement in the laser performance or the possibility of multi frequency operation [1]. Even though a number of techniques exist for obtaining two or more wavelengths simultaneously from a single dye laser, they use several wavelength selective elements in the dye laser cavity. [2-4]. The use of dye mixture doped transparent polymers in solid-state dye lasers and polymer optical fibre amplifiers can be a very good method to extend these conventional approaches.

One of the important advantages of transparent polymers compared to the traditional optical materials is that it is possible to introduce organic dyes or other compounds that can play the role of active components into the polymers, which appreciably changes the characteristics of the polymer matrix [5,6]. In the case of a dye mixture doped polymer, the amount of energy transferred from donor to acceptor and net fluorescence emission characteristics will depend on the excitation wavelength [7]. In this paper we describe the fabrication and characterization direction dependent transmission characteristics of dye mixture doped polymer rods.

2. EXPERIMENTAL

A series of dye mixture doped polymer rods were fabricated by the standard procedure for making the polymer optical fiber performs without cladding. The donor concentration was kept constant at 10^{-5} m/l whereas the acceptor concentration was varied from $4x10^{-5}$ m/l to $7x10^{-4}$ m/l. The absorption spectra and the fluorescence emission from the samples were recorded. A slice of the dye mixture doped sample (with [A] = $7x10^{-4}$) which completely quenches the donor emission was kept side by side with a sample doped with pure donor to form an optical diode like mechanism. A high bright LED emitting around 465 nm was used as the excitation source for investigating the transmission characteristics. The sample with [A] = $7x10^{-4}$ of thicknesses 2mm, 4mm, 8mm and 16mm and sample doped with pure donor of thicknesses 1mm, 2mm , 3mm and 12mm were used for the present study.

3. RESULTS AND DISCUSSION

Fig.1 A photograph of the fabricated performs

Figure 1 shows the photograph of the fabricated polymer rods. The net absorption spectra of the samples were recorded and the figure 2 shows the spectra along with the emission spectrum of the donor C 540.It is clear that there are significant modifications in the absorption pattern with acceptor concentrations and the extent of overlap between the C540 emission and C540:Rh.B mixture absorption is varying continuously. It is clear that the sample 9 with acceptor concentration [A] = $7x10^{-4}$ m/l shows a broad and strong absorption compared to the samples with less acceptor concentrations and the pure Rhodamine B emission (sample no.10) . As a consequence, the emission spectrum of the donor C 540 around 500nm is completely inside its absorption curve. These characteristics of the fabricated rods can

lead to interesting properties like direction dependent transmission of different wavelengths.

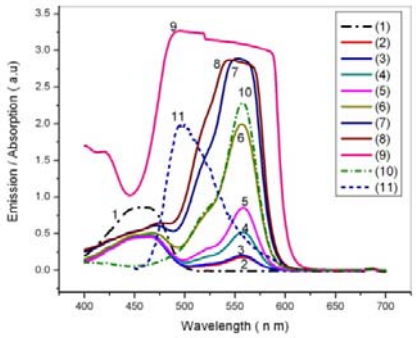

Fig. 2 Net absorption spectra of dye mixture doped PMMA rods along with pure donor emission. 1- [D] only ($5x10^{-5}$ m/l), 2-[A] =$4x10^{-5}$, 3- [A] = $7x10^{-5}$, 4-[A]= 10^{-4}, 5- [A]= $2x\ 10^{-4}$, 6- [A] = $4x\ 10^{-4}$, 7- [A] = $5x10^{-4}$, 8 – [A] = $6x10^{-4}$, 9-[A] = $7x10^{-4}$, 10-[A] (10^{-4} m/l) only, 11- donor emission

Fig.3 shows the fluorescence emission obtained from the samples at an excitation wavelength of 465nm using a fluorescence spectrophotometer. In the present study, we have noticed that both relative intensities and peak emission wavelengths are varying with acceptor concentration. It was seen that sample with acceptor concentration [A] = $7x10^{-4}$ completely quenches the donor emission around 500nm.

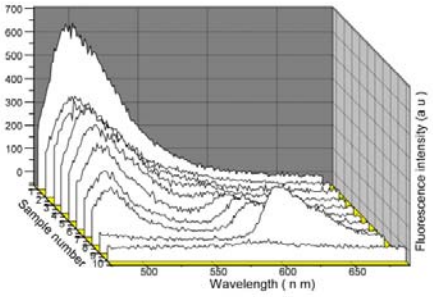

Fig. 3 The recorded fluorescence from dye mixture doped PMMA with 465 nm excitation.

Fig. 4. The photograph of a combination of the two rods.

Polished slices of varying thicknesses were prepared from pure donor doped sample and a sample with [A] = $7x10^{-4}$ as shown in the figure 4.The transmitted intensity of light in both the directions were measured for many donor: mixture rod combinations of varying thicknesses. It was seen that many of the combinations suppress the excitation wavelength in varying magnitudes. It was also observed that the some of the combinations exhibit direction dependent wavelength selective transmission of the emissions around 500 and 600nm. For a combination of donor rod length 12 mm and mixture rod length 16mm, we could observe more than 100% variation in transmitted intensity at wavelengths around 600nm and complete elimination of light around 500nm among light transmitted in opposite directions. The transmission around 500nm was completely blocked by the diode like mechanism when it was illuminated from the donor side. The reason for this direction dependent transmission can be explained using the emission spectra given in fig.4.

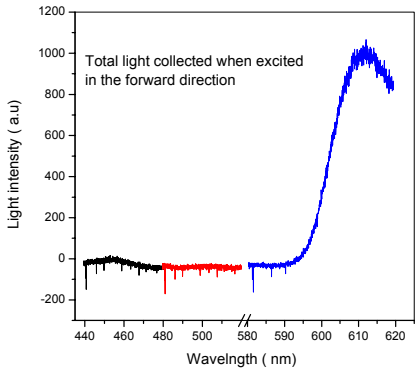

Fig.5 Transmission in the forward direction.

For this purpose, we define forward direction as transmission from C-540 doped rod to C 540: Rh B mixture doped rod. Along this direction, all the light emitted by the source is absorbed by the C 540 doped rod and its emission around 500nm is continuously red shifted during its propagation along the thickness of the rod. From plot 9 of fig.3, we see that the mixture rod has high absorption values around these wavelengths. So As shown in the figure 5 what we get as an output is the light emitted by the mixture doped rod alone that is around 600nm. If the direction of excitation is reversed, there is only partial the absorption of the LED emission by the mixture rod and the rest is transmitted towards the donor rod which is also allowed to emit around 500nm. So the net output spectrum has two peaks as

shown in the figure 6. Another important observation is the direction dependent transmission of the peak excitation wavelength 465 nm. There is considerable transmission in the reverse direction compared to nearly zero transmission in the forward direction. This result can be attributed to the fact that, sample with [A] = $7x10^{-4}$ has low absorption for 465nm compared to the donor emission wavelength 500nm resulting in dissimilar transmission of the excitation wavelength in opposite directions. In the forward direction, most of the excitation wavelength is converted to higher wavelengths by the donor rod which can be completely suppressed by the rod with [A] = $7x10^{-4}$.

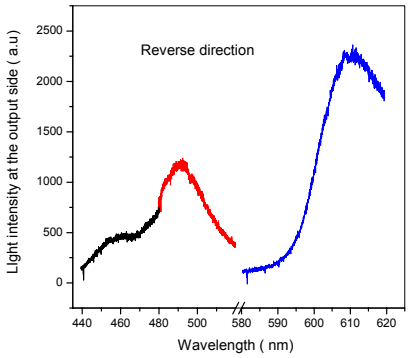

Fig.6 Transmission in the reverse direction.

CONCLUSIONS

A series of dye mixture doped polymer rods were fabricated and polished slices of different lengths were prepared from pure donor doped rod and a dye mixture doped rod with acceptor concentration [A] = $7x10^{-4}$ m/l. The transmitted intensity of light in both the directions were measured for many pure donor: mixture combinations of varying thicknesses. It was seen that many of the combinations suppress the excitation wavelength, emissions at 500 and 600nm in varying magnitudes. It was also observed that the some of the combinations exhibit direction dependent wavelength selective transmission of the emissions around 600nm. We could observe more than 100% variation in transmitted intensity at wavelengths around 600nm among light transmitted along opposite directions. It was also found that the transmission of 500nm light is highly direction dependent.

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