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Thin Film Dye Laser Based on BBQ Doped Poly (Methyl Meth-Acrylate)

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Abstract

This paper reports on the laser emission properties of the BBQ dye in poly (methyl meth-acrylate)(PMMA). This host material combines the advantages of an organic environment for dye with the thermoptical mechanical properties of an organic dye. A BBQ dye solid solution in PMMA polymer. A nitrogen laser in untuned laser cavity has pumped thin films. We developed the concentration and the thickness to get high efficiency. The laser efficiency had been increased from 7% at thickness 1.5 μm to 16.5% at thickness 3.5μm, and from 1% to 10% when concentration increased from $1x10^{-5}$M to $1x10^{-3}$ M

ليزرات الأغشية الرقيقة البوليمرية من نوع بولي مثيل ميثا أكربليت المطعمة بصبغة BBQ

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الخلاصة

يتناول هذا البحث دراسة مواصفات الانبعاث الليزري من صبغة BBQ المطعمة في مادة بولي مثيل ميثا اكرليت PMMA. هذا النوع من الأوساط الليزرية يتصف بالاستقرار الضوئي الحراري ومقاومة التأثيرات الميكانيكية. شرائح صبغة BBQ المطعمة في مادة بولي مثيل ميثا اكرليت PMMA ضخت بليزر النايتروجين بدون تنغيم.

تناولت هذه الدراسة تأثير زيادة سمك العينة على الكفاءة وقد تبين إن الكفاءة ازدادت من 7% عند السمك 1.5μ لتصبح عند السمك 3.5μ ، أيضا ازدادت الكفاءة من 1% الى 10% عند تغيير التركيز من $1x10^{-5}$ مولاري الى $1x10^{-3}$مولاري.

Introduction

Dye lasers are the fulfillment that an experimental pipe dream that was as old as the laser itself to have a laser that is easily tunable over a wide rang of frequency or wavelength [1]. Dye lasers are unique in that they are class of lasers whose medium is a liquid, depending on the particular dye used. Liquid dye lasers have been widely used as a tunable coherent light source for spectroscopy analysis in the visible wavelength region from approximately 400 to 900 nm [2]. The last few years have witnesse advancement in synthesis of laser molecules and the formation of solid state polymer hosts.

Solid state dye laser has been developed as an attractive to convential liquid dye laser due to its low cost, fabrication techniques compactures, lack of toxicity or flammability, suppers of flow fluctuation and evaporation of solvent. Several solid host materials such as poly (methyl meth-acrylates) (PMMA) , polystyren , polyethyl – acrylat – etc have been embedded with dyes to obtain laser emission.

However low laser efficiency has suppressed the usage of this class of laser. Therefore, the laser damage resistance dye host materials have been developed.

In this paper we present the study that have been carried out on the losing properties of

BBQ doped in poly (methyl meth–acrylate) (PMMA) with various concentrations. This polymer doped dye films, which show promise as gain materials for solid state organic dye laser. This films show very little concentration quenching and very low self absorption due to the large stocks shifts [3]. The detail of studies will be discussed.

Experimental

Figure (1) shows a schematic of the experimental arrangement. A pumping nitrogen laser source (Molectron λ_{las} = 337.1nm, τ_p= 10 nsec, E_{out} = 10 mJ, was employed. A cylindrical quartz lens was used to focus the nitrogen laser beam on BBQ doped PMMA films. The pulse energy was measured using joule meter (Molectron J3-05 DW). The laser emission was measured using an optical multichannel analyzer III (EG & G Princeton Applied Research model 1461). An aperture before the cylindrical lens was used to control the size the optical beam, and density filter was used in front of detector to attenuate laser emission.

The polymer PMMA doped with BBQ (lambeda physiks) was prepared by radical polymerization method. The concentration dye of the changed from $1x10^{-5}$ M to $1x10^{-2}$ M, where dimethylsuloxide (DMSO) wes used as solvent. The additive for these series of samples is methyl alcohol, which is usually used to increase the dye solubility. The PMMA solution was added to dye solution and stirring. The mixture was left for one hour after stirring in order to eliminate the bubbles.

The dye doped polymethyl methacrylate (PMMA) was fabricated on the substrate by solution deposition.

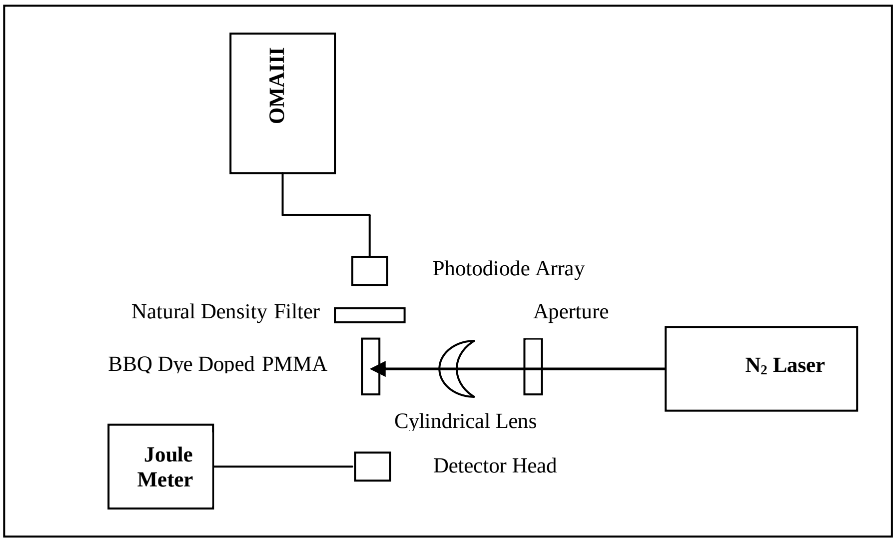
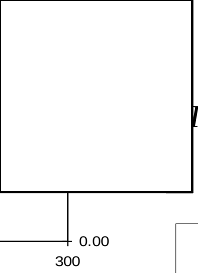


Figure (1): Experimental setup for laser emission investigation from BBQ dye doped PMMA.

Results and discussion

When the concentration increased from $1x10^{-5}$ to $1x10^{-2}$ M, the peak wavelength of the laser emission exhibited red shift from 396 nm to 402 nm and the intensity of laser emission increased figure (2). This result agreed with Lim Chic Haw indication [4] where dye emission peaks tended to red shift in polymer.



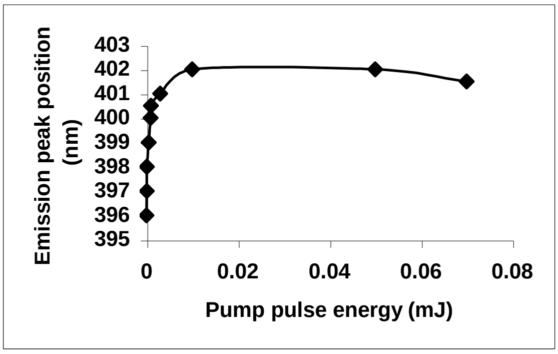


Figure (2): Peak laser wavelength as a function of BBQ dye concentration in PMMA films.

This increase in emission is due to increase in the number of unexcied dye molecules that will absorb the emitted radiation by the other molecule (self absorption).

The efficiency of laser emission also increased from 1% to 10% when the concentration increased from $1x10^{-5}$ to $5x10^{-3}$ M figure (3). After that the efficiency will be decreased dramatically from 10% to 2% at concentration $1x10^{-2}$ M.

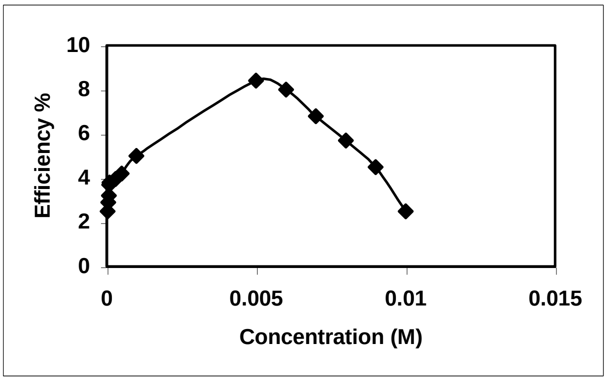


Figure (3): The laser efficiency as a function of concentration.

This behavior is due to complex molecules formation that quench the due molecules emission.

The optimum laser efficiency of BBQ doped PMMA films is 10% at the concentration $5x10^{-3}$ M.

We can increased the laser efficiency of the film of dye doped PMMA by increasing the thickness of films. The thickness increasing by increasing the number of films or the thickness of film. In this study we have increased the thickness of films from 1.25 μm to 7 μm figure (4) .

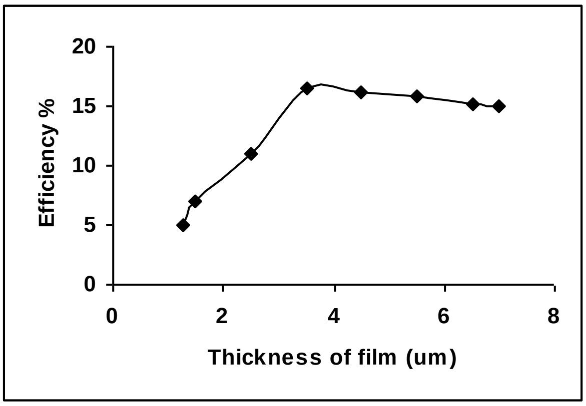


Figure (4): The laser efficiency as a function of thickness of BBQ dye doped PMMA.

The efficiency had increased from 7% at the thickness 1.5 μm to 16.5 % when the thickness increased to 3.5 μm. When we increased the thickness of the films further the efficiency decreased slowly.

Conclusion

The peak wavelength of laser emission from BBQ doped PMMA red shifted when dye concentration increased and the efficiency was decreasing dramatically when the concentration increased above $3x10^{-5}$M. The efficiency of BBQ films increases with increasing the thickness of the films. The optimum laser efficiency at films was 16.5% at thickness 3.5 μm, and then decreased slowly above this concentration.

References

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