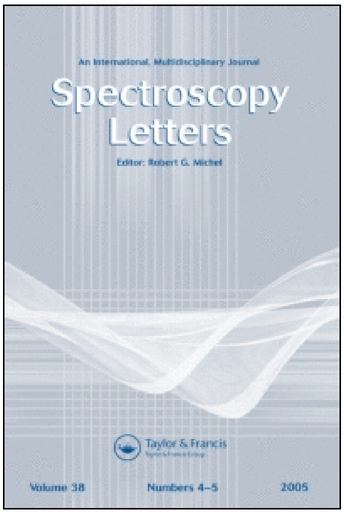

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FLASHLAMP PUMPED EMULSION DYE LASER

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ABSTRACT

Results of experimental study of flashlamp pumped α-NPO emulsion dye laser are reported. Superior quality α-NPO emulsion over α-NPO solution in n-hexane is found.

INTRODUCTION

It is known that the radiation from a flashlamp absorbed in the active medium of dye lasers heats up the dye solution producing in this way refractive index gradients which deteriorate the divergence of laser beam and its spectral purity, decrease the power output, and extinguish laser emission prematurely (see e.g. ref.1). These refractive index gradients are formed in less than 1 μs after the illumination of the dye solution by the flashlamp. The magnitude of these gradients depends upon thermo-optical qualities of the pumped liquid solution, specific heat C_p and upon the refractive index change with temperature $d\mu/dT$. Water has by far the best thermo--optical properties of any common solvent. Unfortunately most of laser dyes are not soluble in water, so one has to use solvents with poor thermo-optical qualities.

Matheson and Thorne[2] solved this problem by, disolving laser dye in an organic solvent and later by emulsifing the solution in water. In this way they obtained enough of lasing dye in the emulsion so the lasing action is achieved while small droplets of the dye solution in the mixture rapidly give excessive heat to the water and in this way preserve good optical quality of the active medium.

Large laser radiation losses with this type of laser may be introduced by scattering of laser radiation on small droplets in the emulsion. However, the loss can be decreased by adjusting the index of refraction of both phases in the emulsion. This can be easily understood from the equation which describes the transmission of radiation due to the scattering of small spherical droplets of radius r[2,3]

$$\frac{I}{I_o} = \exp\left[-6\pi^2 r \ell V \left(\frac{\mu_1}{\mu_2} - 1\right)^2/\lambda^2\right] \quad (1)$$

where ℓ is the length or optical path through scattering medium, V-the volume of organic phase in the emulsion, and μ_1 and μ_2 are refractive indexes of the two phases. To minimize V, good solvent for the dye should be used so the required concentration for the laser operation can be easily achieved. Further, one should use as good as possible technique for emulsification so that droplets of smallest radius r can be obtained. However from eq. (1) it is clear that the difference between indexes of refraction μ_1 and μ_2 plays the most important role if one intends to decrease scattering in the emulsion. Therefore, Matheson and Thorne[2] emulsified the solution of BBOQ (4,4-di (2-butoctoxy-1)-p-quaterphenyl) in n-hexane in the mixture of glycerol and water. Glycerol was mixed with water in the ratio 35:65 wt% to match the refractive index of n-hexane.

The operation of emulsion laser[2] is achieved in a 10 mm quartz cuvette. The emulsion was pumped by a 50 kW nitrogen laser beam, and lasing was observed perpendicular to the incident pump light.

Although in ref. 2. the advantage of dye emulsion for flashlamp pumped dye lasers has been predicted, it remained to be tested. In this paper we report the results and details of the experimental study of an emulsion flashlamp pumped dye laser where the effects of dye solution heating are more severe than in nitrogen pumped dye lasers.

EXPERIMENT AND RESULTS

The emulsion for this experiment is prepared in the following way: equal volumes of saturated solution of α-NPO (2-(1-naphthyl)-5-phenyloxazole) in n-hexane and mixture of water and glycerol are emulsified in a blender. Glycerol was mixed with water in the ratio 35:65 wt% to match the refractive index of n-hexane. Fine adjustment of refractive index is achieved with the help of a refractometer. Since complete emulsification has not been achieved, only the layer of the glycerol -water mixture with emulsified dye solution in n-hexane has been used for testing. For comparison the same concentration solution of α-NPO in n-hexane has been made. Concentration of the dye in emulsion and in solution has been determined with a fluorimeter.

Dye solution and emulsion have been compared first in the nitrogen laser pumped system. In the next step the emulsion and dye solution are used with a flashlamp pumped laser. This laser and atmoshperic pressure flashlamp in particular are described elsewhere[4], while here only minimum details and schematic diagram od the apparatus, Fig.1, will be given for completeness. Atmospheric

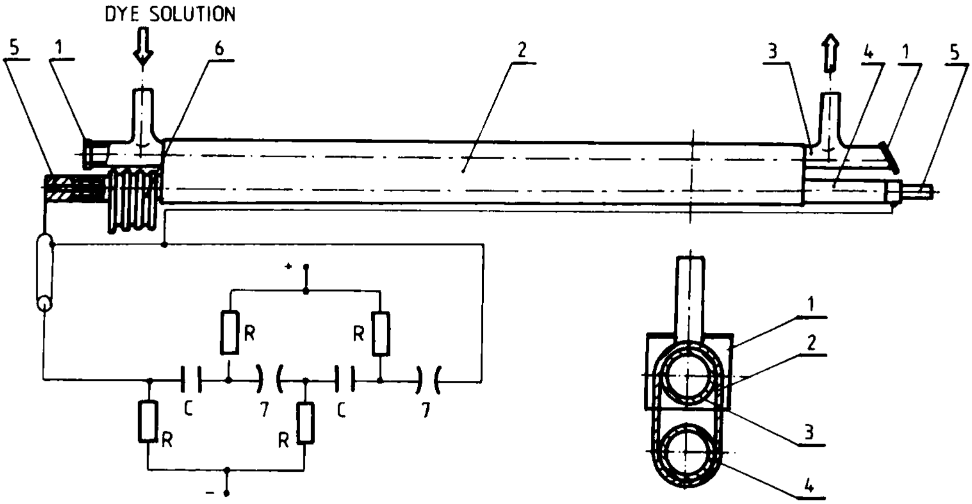

Figure 1. Schematic diagram of the flashlamp pumped dye laser system.

pressure, continuous flow (50-100 cm^3/min) flashlamp is made of a standard quartz tube 4 mm dia, 20 cm long. The holes of 2 mm dia are located at the center of both brass electrodes. These holes make possible the continuous flow of argon through the flashlamp and they allow the expansion of the hot gas produced by electric discharge. Laser cuvette is made of standard Pyrex tube with 4 mm internal dia. One of the dye cuvette windows, (see Fig.1) is tilted to prevent unwanted oscillations in laser active medium. Cuvette windows are uncoated and made of 1 mm thick microscope glass slides.The discharge tube and the dye cuvette are wrapped together with an aluminum foil to reflect a part of radiation back into the dye solution. Lasing is achieved without optical resonator in a superradiant made.

The energy storage capacitor bank consists of two inductance 0,1 μF, 40 kV capacitors connected in a two stage Marx generator. The capacitors are charged in paralle (typically between 15 and 23 kV) via charging resistor. By triggering spark gaps, capacitors are connected in series and doubled charging voltage appears at the flashlamp electrodes. High frequency and high vol-

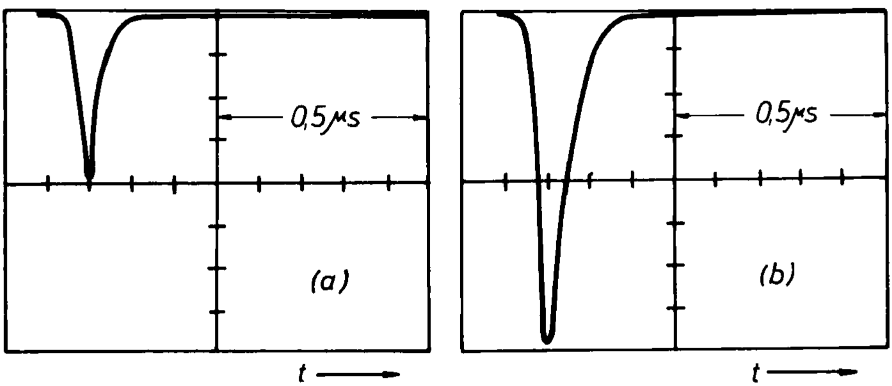

Fig.2. Typical laser pulse waveforms from the solution α-NPO in n-hexane (a) and α-NPO in emulsion (b) under same experimental conditions and dye concentration.

tage field induced between one electrode and a nearby lead, Fig. 1, produce preionization which facilitates the breakdown between electrodes. The light output waveform of the flashlamp taken with planar photodiode without spectrally selective filter exibits a risetime of 120 ns and the duration (FWHM) arround 600 ns.

With the described flashlamp dye laser system, emulsion of α-NPO is found in all experiments to be superior to α-NPO solution in n-hexane. Typically in increase of 2.5 times in energy output is detected with emulsion. Peak output power is doubled while duration of the laser pulse is extended for about 30% (see Fig.2).

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