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COAXIAL GLASS FLASHLAMP AND DYE LASER SYSTEM

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Abstract: This paper describes simple, glass, coaxial flashlamp and dye laser system. Spectral characteristics of the flashlamp and the influence of the light converter to its emission spectrum are also reported.

1. Introduction

Since the discovery of flashlamp-pumped organic dye lasers as a tunable source of intense coherent radiation they are gaining popularity in applications in various fields of physics, chemistry and biology. Therefore a great effort has been involved in development of different types of flash lamps[1-6].

The aim of this paper is to present a simple, compact, glass flashlamp and dye laser system, representing further improvement of the device previously reported[6]. The attention will be paid to the spectral characteristics of this flashlamp and to the the influence of the light converter[7-8] to its emission spectrum.

2. Experimental apparatus and procedure

Coaxial, xenon flashlamps (Fig. 1) were made of Pyrex glass with internal diameter 5.8 mm. Cooling jacket and the outer tube had a wall thickness of 1.2 mm while the inner tube wall was 1.0 mm thick. Cooling and arc channel had a thickness of 0.8 mm. Two types of flashlamps were made with discharge length (distance between tungsten electrodes) of 7.0 and 1.36 cm respectively.

Research grade xenon gas was used at a pressures of 160, 300 and 500 Torr. Gas filling system and the flashlamp were evacuated below 10^{-6} Torr and later filled up to the desired pressure. The whole flashlamp was wrapped in a white paper or in aluminium foil to reflect part of the radiation back into the dye solution located in the central part of the flashlamp. The dye cuvette was closed with perpendicular windows, cutted from the glass of the spectrographic plates, with no antireflection coating. The dye solution and the coolant (water or ethyl alcohol) were circulated in all experiments by means of a peristaltic miniflow pump. Hemispherical laser resonator consisted of one flat and one curved (radius 100 cm), helium-neon laser mirrors which were spaced approximately 25 cm appart.

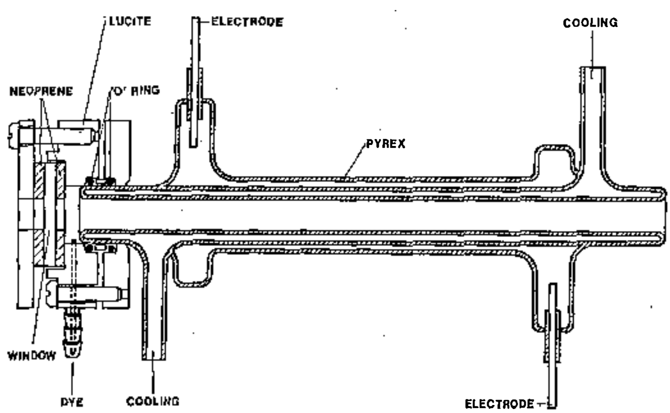

Fig. 1. Schematic diagram of the flashlamp.

Flashlamp was mounted on the low inductance, 2.5 μF capacitor charged from 3.0 to 6.0 kV. The discharge was initiated by high voltage pulse applied to external coiled wire electrode. Rogowski coil was used to measure discharge current while transient voltage was monitored by Tektronix high voltage probe.

For the investigations of spectral characteristics of the flashlamp conical aluminium mirror was placed inside the dye cell to reflect light into the monochromator. Spectroscopic observations, shot-by-shot, were achieved by photomultiplier (RCA 1P28) grating spectrometer (Zeiss SPM-2) system with inverse linear dispersion of 40 Å/mm. Relative spectral intensity measurements were taken at 108 Å intervals with the entrance and exit slit widths of the monochromator of 4 Å. Care was always taken to insure linear response of the photomultiplier and amplifier. Light intensity was displayed on a double beam oscilloscope, Tektronix 555, together with the current waveform. The spectrometer detector system was previously calibrated for spectral response against a standard tungsten ribbon lamp.

3. *Experimental results*

Electrical characteristics. The discharge current was critically dumped with the pulse widths, at 1/3 of current maximum, of 3.4—4.3 μs and rise times of 1.0—1.4 μs depending upon flashlamp length and slightly upon xenon pressure. Peak current varied from 2.5 to 6.8 kA, power input from 4.2 to 16.2 MW, what corresponded to the current density of 7.8 to 21.0 kA/cm^2 if it was assumed that the whole arc channel was filled with the discharge. However it should be mentioned that the channel was only partially filled and the local current density exceeded values previously given.

Flashlamp spectral characteristics. Spectrally resolved flashlamp light intensities were measured at the time of appearance of the laser pulse and at the peak of discharge current. The characteristic results are given in Fig. 2 for two capacitor bank energies and at various time instants and in (Fig. 2a) relative spectral flashlamp intensities in the presence of ethanolic solution of Rhodamine 6G, concentration $6 \cdot 10^{-4}$ mol/l, in the cooling region of the flashlamp (Fig. 1). Here rhodamine 6G acts as a light converter increasing the light intensity of the flashlamp n the region of its fluorescence emission.

From Fig. 2 following features of emitted flashlamp light can be noted:

-appearance of well defined line spectrum; similar to those has been already obtained in the spherical flashlamps[9] with the discharge without defined discharge channel,

-with an increase of electrical power input there is an increase of intensity of continuum radiation and the xenon lines are becomming broader; this could be explained by increase of electron density and temperature in the discharge,

-characteristic increase of the intensity of radiation for the wavelengths larger than 5600 Å; this is most probably due to the influence of the line wings of largly broadened infra-red xenon lines, and

-spectral intensity distribution could easily be changed by use of the light converter in the cooling channel of the flashlamp.

From the comparison of the flashlamps with a different xenon filling pressures: 160, 300 and 500 Torr it was found an increase of the light intensity with the presure of about 30%. However the rise time of the flash increases as well and the net effect to the laser is the drop of the power output for 30% when working with the flashlamp filled with 500 instead of 160 Torr of xenon. The advantage of high pressure xenon is that it does not necessitate spark gap switch for the voltages as high as 6 kV in the flashlamp 7 cm long.

The laser characteristics. The laser experiments were carried out with air equilibrated ethanolic solutions containing $5 \cdot 10^{-5}$ M/l of Rhodamine 6G (BDH adsorption indicator) or Rhodamine B (Fluka AG, adsorption indicator) and methanolic solution of cresyl violet $1 \cdot 10^{-4}$ M/l (BDH microscopic stains). Flashlamp power inputs of 9.1, 18.0 and 40.0 J for Rhodamine 6G, Rhodamine B and cresyl violet were measured respectively at the treshold for laser operation

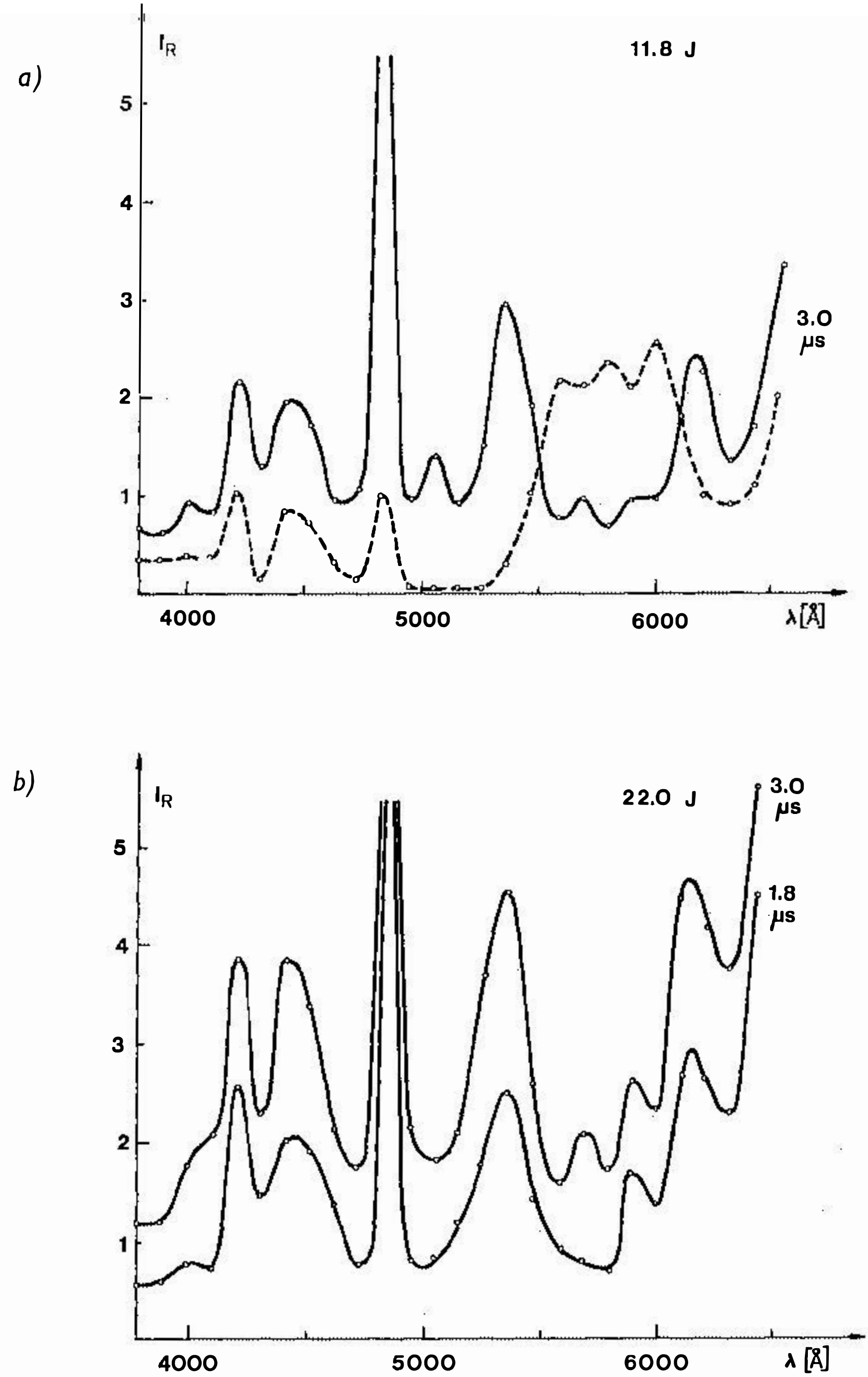

Fig. 2. Spectrally resolved flashlamp intensities (xenon pressure 500 mmHg) at various time instances after the beginning of the discharge current for two capacitor bank energies a) 11.8J and b) 22.0J. Broken line shows spectral distribution in the presence of ethanolic solution of Rhodamine 6G, 6 . 10^{-4} M/1 acting as a light converter.

with the Xenon flashlamp filled at a pressure of 500 Torr. The typical laser pulse halfwidth with Rhodamine 6G was 0.8 μs with a rise time of 600 ns and it appeared 2.0 μs after the beginning of the flashlamp light pulse.

4. Conclusion

A compact flashlamp-dye laser system capable of operating in the visible part of spectrum has been discribed. Newly designed dye laser has a cooling channel in between the flash lamp and cuvette facilitating cooling of the dye so much important for high repetition rate operation.

On the basis of spectroscopic investigations one may conclude that this flash lamp should be very efficient for the optical pumping of organic dyes with the peak absorption band at the wavelengths of strong xenon emission lines. Further, if the light converter is used as a cooling medium the spectrum of the pumping light could be changed to satisfy the optimal conditions of the specific dyes.

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KOAKSIJALNA, IMPULSNA LAMPA I SISTEM ZA TEČNE LASERE SA ORGANSKIM BOJAMA

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Sadržaj

U radu je opisana kompaktna koakcijalna impulsna lampa i sistem za lasere sa organskim bojama. Ispitivane su električne i spektralne karakteristike ovih impulsnih lampi kao i uticaj svetlosnih pretvarača na njihov emisioni spektar.

Na osnovu spektroskopskih i laserskih istraživanja pokazano je da su ove lampe efikasne za optičko pumpanje organskih boja sa apsorpcionim maksimumom u oblasti talasnih dužina spektralnih linija ksenona. Efikasnost se dalje može povećati korišćenjem tečnih svetlosnih pretvarača.