BLUE - GREEN LASER RADIATION FROM DYES IN MATRIX

T.N. Kopylova, A.V. Reznichenko*, G.V. Mayer, L.G. Samsonova,V.A. Svetlichny, R.T. Kuznetsova, V.B. Sukhanov, E.N. Telminov.

Siberian Physical-Technical Institute, Revolution sq.,1, 634050 Tomsk, Russia*Alpha-Aconis, LTD, Likhachevskii projezd, 5, Dolgoprudny, Moscow Region, Russia

ABSTRACT

Lasing properties of two dyes in polymeric matrix radiating in blue-green region of the spectrum pumped by a XeCl laser are studied. The lasing efficiency and photostability of the solid state active media are compared with corresponding characteristics of the same liquid active midia.

Keywords : solid dye lasers, blue-green radiation, XeCl laser pumping, lasing efficiency and photostability.

1. INTRODUCTION

Tunable lasers lasing on dye solutions found their applications for laser isotope separation, remote gas and liquid sounding and initiation of photochemical reaction [1]. However, solutions as active media have disadvantages in operation. Using of solid state dye active media will result in more compact, laser devices with fire safe, untoxic working substance and eliminate inhomogeneties connected with liquid flow fluctuations and solvent vaporization.

The first attempt to active solid state dye laser operation was made in 1967-1968 when lasing from Rhodamine in PMMA was demonstrated [2,3]. However, both efficiency and photostability of these media was low. Successes in creation of new matrices which possess high ray stability were achieved in 80-Th. giving rise new pulse in solid state dye lasers [4-7]. In last years, new efficient dyes were obtained as well as new ways of dye input into the matrix were developed. Thus, design of solid state dye lasers for specific applications was successfully stored [8-11].

Polymethylmethacrylate has the greatest potentials for dye matrix since its structure is close to structure of dyes, it has high optical homogeneity and allows easy treatment. Modifications leading to improve appreciably its ray stability as well as photostability of dye in it were found.

However, only red region of spectrum has been successfully covered by existing solid state active media. Under excitation by second harmonics of Nd-YAG output (λ=532 nm) the solid state active media based on pyrromethenes provide laser radiation with efficiency higher then 50% and photostability as high as 10^6 pulses [12,13]. These parameters are already close to those obtained with dye solutions and demonstrate real prospects for solid state tunable dye laser design [14-16].

Development of blue-green active media is less successful [17-19]. This is related to specific features of UV excitation requiring high transparency and ray stability of matrix as well as high photostability of the dye. The number of molecules providing blue-green lasing is limited (coumarines, benzimidazoles. As a rule, they are pumped by low power XeCl and N_2 lasers [18,19].

2. EXPERIMENTAL

In this paper, spectral-luminescent and lasing properties of two dyes providing radiation in UV and blue-green region of spectrum were studied. Both solutions and filled matrices of modified PMMA (MPMMA) were pumped by XeCl - laser (E_p =10-100 mJ, $\tau_{1/2}$ =40 ns, λ=308 nm) or by dye laser (E_p =20-30 mJ, $\tau_{1/2}$ =35 ns, λ=375 nm).

Solid state samples were rectangles with dimensions of 8×4×30 mm. Laser degree of surface purification was not achieved. The absorption of MPMMA at λ=308 nm was measured to be k = 0.3 cm^{-1} and ray stability that was defined as laser energy density initiating point scattering defect in the volume was found to be depended on pumping power density and wavelength. It was determined to be 0.5 J/cm^2 (N=10 pulses) at P=10-20 MW/cm^2 and λ=308 nm and 0.6-0.8 J/cm^2

(N>40 pulses) at λ=375 and 470 nm. In these experiments, the pumping power value was selected to provide the highest efficiency.

Structure of organic compounds under investigation is presented in Fig.1. Absorption and fluorescence spectra of active media were monitored using standard devices and methods (Specord M40, Hitachi 850). Both liquid and solid state laser parameters were studied with transverse excitation. The spectrum of laser radiation was monitored with photoelectric system, its energy and temporal characteristics were measured with IMO-2 and 'technical vision" system conjugated with PC. Photostability of active media was estimated basing on energy deposited in the unit volume before laser efficiency drops to a half of its initial value. Besides, it was connected with quantum yield of photodecay whose value was obtained taking into account reduction of absorption of dye solution in long wavelength band using the following equation: $\gamma=N/N^*$, where N is number of degraded molecules in unit volume and N^* is number of excited molecules in unit volume.

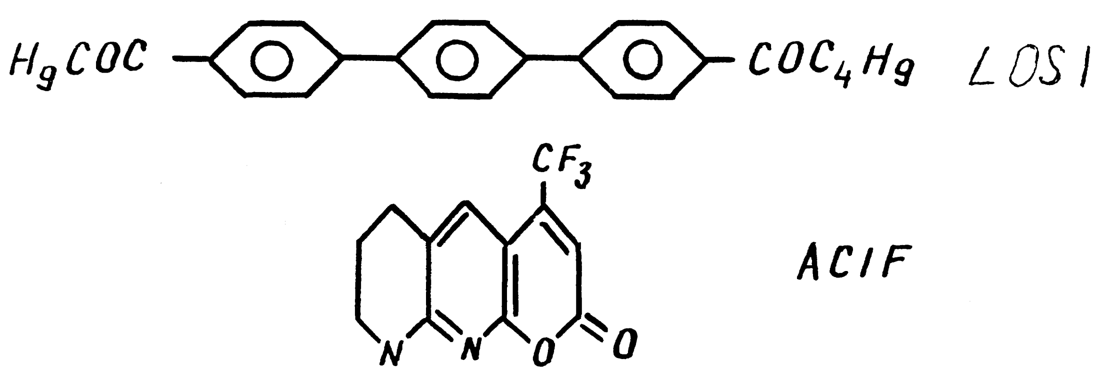

Fig.1 Molecular structures of tested dyes.

3. RESULTS AND DISCUSSION

The experimental date obtained are summarized in Table. Analysis of these date demonstrates that absorption, fluorescence and lasing spectra of solid state dye medium is shifted to short wavelength as compared to corresponding spectra of dyes in solution at the same concentration of working substance. This is not favorable for high laser efficiency with transverse excitation, since reabsorption in the dye at its high concentration leads to excitation energy losses. Nevertheless, sufficiently efficient lasing was obtained with both dyes in MPMMA under XeCl laser pumping. Maximum laser efficiency with LOS-1 was 17.6 % at λ_{out}=365 nm, with AC1F it was 12.4% at λ_{out}=467 nm. Though laser efficiency obtained with these dyes in solutions is higher these results are of interest since efficiency of solid state dye laser can be improved due to non-conventional excitation schemes and higher degree of surface purification.

Fig 2 present efficiency of active media studied versus pumping power density (MW/cm^2). It should be noted, that this dependence is stronger in dye solutions. This is apparently connected with in sufficient surface treatment of solid state samples and possibility of simultaneous detection both lasing and amplified spontaneous emission from these samples. Pulse duration of solid state dye laser does not change very much as compared with pumping pulse duration (τ_{out}/τ_{pump} ~0.6 - 0.8), see Fig.2.

Photostability of active media is also an important parameter. The date presented in Table demonstrate that lifetime of dyes in MPMMA matrix and in solution under excitation of by sufficiently high power XeCl laser is comparable. Thus, practical using of these samples is reel.

Table 1.

Active media c, mol/l	λ_{fl}, nm	λ_{las}, nm	efficiency, η,%		lifetime, J/cm^3		$\gamma \times 10^3$
			λ_{pump}=308	λ_{pump}=375	λ_{pump}=308	λ_{pump}=375	
LOS-1, PMMA	365	365	17.6		84		
LOS-1, 5x10^{-4} ethanol	373	375	36		40[1]		0.5
AC 1 F PMMA 10^{-3}	467	467	3.4	19	20	375	
10^{-2}	485	480	12.4	6	87	570	
AC 1 F, ethanol 10^{-3}	480	490	14	10	45	35[2]	1.3
2x10^{-3}			25	30	230		

1- η/η_0=0.8, 2- η/η_0 =0.6.

Excitation of AC1F in MPMMA by laser output from LOS-1 ethanol solution (λ_{pump}=375 nm) allowed us to obtain laser efficiency of 19 % and dye lifetime of 375 J/cm^3 under conditions of our experiments (c=10^{-3} mol/ l). This result is of interest for comparison of solid state dye laser parameters pumped by different wavelengths.

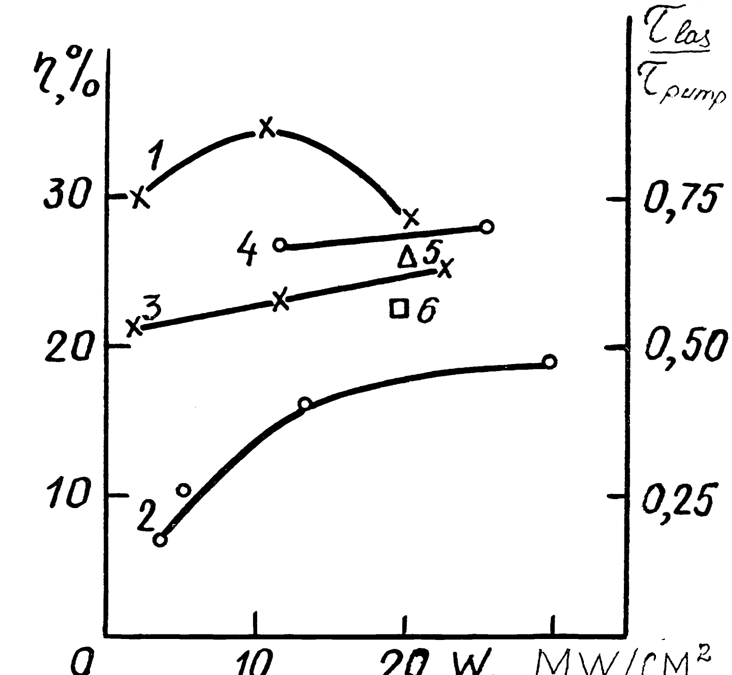

Fig.2. Dependence lasing efficiency - 1,2 and relation of τ_{las}/τ_{pump} -3-6 versus radiation intensity of XeCl laser. 1,5 - LOS-1 in ethanol; LOS-1 in MPMMA; 3-AC!F 5×10^{-3} mol/l in ethanol; 4- AC1F 10^{-2} mol/l in MPMMA

It should be stressed that at AC1F concentration of 10^{-3} mol/ l the laser efficiency is higher in matrix (19 %) then in solution (10 %). This is attributed to lower absorption of pumping radiation at λ=375 nm in solution then in matrix. Low absorption results in unstable lasing and short lifetime of AC1F in ethanol at this concentration. The pumping conditions are more optimal in matrix due to shift of absorption to shorter wavelength.

Thus, we have developed and studied solid state active medium LOS-1 in MPMMA. It provides UV lasing at λ=365 nm with efficiency 17.6 % and sufficiently high photostability (80 J/cm^3) under XeCl laser pumping with E=100 mJ and τ=40 ns. Blue-green laser radiation was obtained with AC1F in MPMMA, laser efficiency being 12.4 % under XeCl laser pumping and 19 % under dye laser pumping at λ=375 nm.

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