Development of the LDS698 Solid Dye Laser for High Durability

Ji-Hun Kim, Chan-Ju Lim, Sang-Beom Joa and Heon-Ju Lee
Faculty of Mechanical & Energy System Engineering, Cheju National Univ., 1 Ara-1 Dong, Jeju-Do, Korea
hjlee@cheju.ac.kr

1. Introduction

It is essential to use a tunable laser in atomic spectroscopy and environmental analysis. LDS 698 dye laser can be used for hydrogen plasma spectroscopy. Solid dye laser has the advantages that are cheap, compact and simple to operate. Recently, compact solid dye lasers have been developed by many researchers with various solid-host materials by the sol-gel and polymerization methods. However, the durability is the main problem in the solid dye laser because of the dye bleaching. To fabricate the reliable diagnostic system of plasma, it is necessary to increase the durability of the solid dye laser. In this study, the LDS 698 solid dye laser for the plasma diagnostics was fabricated and its characteristics were investigated.

2. Experiment and results

To increase the durability of a solid dye laser, an additive-PETA (pentaerythritol triacrylate) was included in the dye cell and the characteristics of a LDS 698 solid dye laser were checked.

2.1 LDS 698 Solid Dye Laser

2.1.1 LDS 698 solid dye cell property

LDS 698 was selected as a dye for the laser because its spectrum range is 640 – 690nms and the H_α line of hydrogen is 656.3 nm. Solid dye cell was fabricated by a PMMA method. Dye cell dimensions are 20×40×8mm, and concentration of dye is 2×10^{-2} mol/liter. The concentrations of doped PETA were 0, 10 and 20 weight-% compared to LDS 698 dye.

Table1. LDS 698 Dye Cells with PETA Doping

Dye Cell Number	Dye	Dye Concentration (mol/liter)	PETA Concentration (%)
P0	LDS 698	2×10^{-2}	0
P1	LDS 698	2×10^{-2}	10
P2	LDS 698	2×10^{-2}	20

2.1.2 Resonator Design of a LDS 698 Solid Dye Laser

The schematic configuration of the dye laser is shown on Fig. 1. To construct a resonator, a holographic grating, which has grooves of 2400 lines/mm, is set in grazing incidence configuration with an incident angle of 11.4°. The reflectivity of the rear mirror is 99% and its dimension are 50 × 50mm. The reflectivity of the partial reflector is 10% at 650nm. The solid dye cell is located between the total reflector and the diffraction grating. The partial reflector is in the direction of 1st order diffracted light from the grating. The length of the resonator is 80 nm. The solid dye cell is pumped by the 2nd harmonics of the Nd-YAG laser (532nm). When a narrower spectrum or a scanning of the spectrum is needed, it can be achieved by adding a turning mirror at the position of the 0th order diffraction beam.

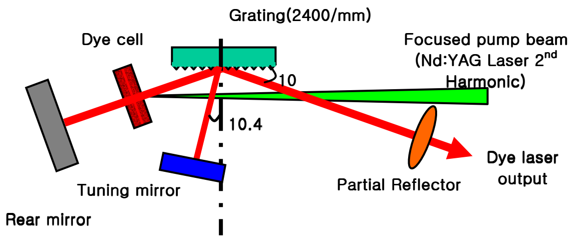

Figure1. Resonator of a LDS 698 Solid Dye Laser

2.2 Characteristics of a LDS 698 Solid Dye Laser

2.2.1 Measurement of Spontaneous Emission from a LDS 698 Solid Dye Cell

The spectrum of spontaneous emission from the dye cell was measured. To measure the spectrum of the dye laser, a KMAC spectra-view 2000 spectrometer, which has a maximum resolution of 0.3nm and an effective wavelength range of 185-1100nm, was used. The result is shown on Table 2.

Table2. Spontaneous emission spectrum of the LDS 698 solid dye cells

Dye Cell Number	Emission Range(nm)	Δλ(nm)	Peak Wavelength(nm)
P0	591-674	83	635
P1	609-662	53	634
P2	599-676	78	633

By the result, the wavelength for emission peak is shifted to shorter side with the increase of PETA concentration.

2.2.2 Energy Measurements of a LDS 698 Solid Dye Laser

To measure the energy of the dye laser, a OPHIR NOVA laser energy monitor, which has a maximum energy of 25mJ and an effective wavelength range of 185-1100nm, is used. The laser can be tuned from 650 nm to 665 nm and has FWHM of 2-3 nm. The obtained maximum power at initial stage is 500 μJ for P0 cell. Its laser efficiency is about 2%. The energy from the solid dye laser decreased with the operation time. Especially, the energy from a dye cell P0, that is not doped, is rapidly reduced to below 100 μJ during the first 3 min when the repetition rate is 5 Hz.

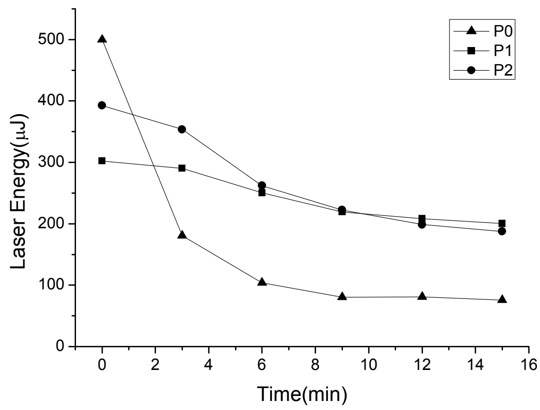

Figure2. Output energy of solid dye laser with different PETA concentration (P0:0% doped, P1:10% doped, P2:20% doped)

2.2.3 Durability Analysis of a LDS 698 Solid Dye Laser

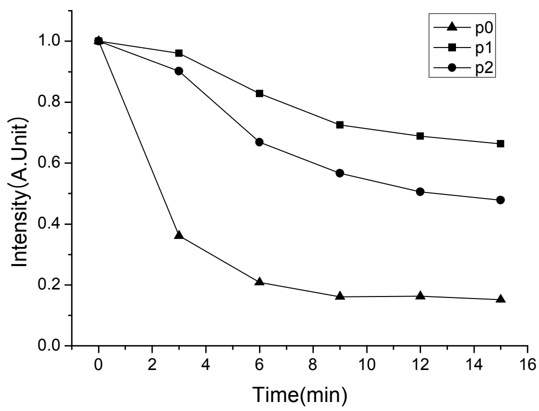

Figure3. Reducing rate of output energy from a solid dye laser (P0:0% doped, P1:10% doped, P2:20% doped)

To compare the durability of the dye lasers with different PETA concentration, the output power is normalized to their initial values. The reducing rate of P0 is the highest in spite of its initial energy is the highest. The durability increases with the concentration of doped PETA.

3. Conclusion

LDS 698 Solid dye cell is fabricated by PMMA method. To increase the durability, PETA is doped in dye cell.

The wavelength for spontaneous emission peak is shifted to shorter side with the increase of PETA concentration. The durability of a solid dye laser is affected by the concentration of PETA and is very high when PETA concentration is 10%.

Acknowledgement

This work was supported by the 2002 Plasma and Fusion User's Program of the Korea Basic Science Institute, grant R01-1999-000-00092-0 from the Korea Science and Engineering Foundation and grant R-2004-096-0-00 from the Ministry of Commerce, Industry and Energy, Korea.

REFERENCES

[1] Gwon Lim, Do-Kyeong, Hyun Su Kim, Byung Heon Cha and Jongmin Lee, Single Longitudinal Mode Operation of a Solid-State Dye Laser Oscillator, Journal of Korea Physical Society 37, 783 ,2000

[2] K.M. Abedina, M. Alvarezb, A. Costelab, I. Garcia Moreno, O. Garcıa, R. Sastre, D.W. Coutts, C.E. Webb, 10 kHz repetition rate solid-state dye laser pumped by diode-pumped solid-state laser, Optics Communications, Vol. 218, pp. 359–363, 2003

[3] Eli Yariv, Silke Schultheiss, Tsiala Saraidarov, Renata Reisfeld, Efficiency and photostability of dye-doped solid-state lasers in different hosts, Optical Materials, Vol. 16, pp.29-38, 2001

[4] Angel Costela, Inmaulada Garcia-Moreno, Clara Gomez, Olga Garcia, Roberto Sastre, Enhancement of laser properties of pyrromethene 567 dye incorporated into new organic-inorganic hybrid materials, Chemical Physics Letters, Vol. 369, pp. 656-661 ,2003

[5] Angel Costela, Inmaulada Garcia-Moreno, Clara Gomez, Olga Garcia, Leoncio Garrido, Roberto Sastre, Highly efficient and stable doped hybrid organic-inorganic materials for solid-state dye lasers, Chemical Physics Letters, Vol. 387, pp. 496-501, 2004

[6] A. Bergmann, W. Holzer, R. Stark, H. Gratz, A. Penzkofer, F. Amat-Guerri, A. Costela, I, Garcia-Moreno, R. Sastre, Photophysical characterization of pyrromethene dyes in solid matrices of acylic copolymers, Chemical Physics, Vol. 271, pp. 201-213, 2001