研 究 速 報

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Efficiency of Xanthene Dyes Pumped by a CuBr Laser
CuBr レーザー励起キサンテン色素レーザーの発振効率

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An operation of a dye laser pumped by a copper-halide laser is reported in this note. The laser action has been observed in three xanthene dyes: Rhodamine 6G,[1,2,3] Rhodamine 610 (Exciton), and Rhodamine 640 (Exciton).

A dye laser oscillation is usually accomplished in an optical pumping arrangement, and a laser is the most popular pumping source. The over-all efficiency of a dye laser is determined by the efficiency of the pumping source, and the optical conversion efficiency from the pumping light to the dye laser output.

A dye laser has high optical conversion efficency in general, but the over-all efficiency is severely limited to a low value by the low efficiency of the pumping laser. A copper laser is known to have the potential capability of high efficient operation.[4,5] It is reported that a theoretical limit of its efficiency is 5 – 10%.[6] The copper-laser-pumped dye laser is expected to be capable of operating at high over-all efficiency. A copper-halide laser is employed for the pumping souce in this experiment. We used a CuBr laser which operates at wavelength of 510.6nm and 578.2nm and at the total output energy of 450μJ in 20ns. The ratio of the 510.6nm to the 578.2nm output energy is about 3 to 1. The beam of the CuBr laser is forcused at one side of a silica cell by a cylindrical and a spherical lenses. The optical cavity of the dye laser consists of a fused quartz flat plate and a 1800lines/mm grating in first order Littrow mount. Three kinds of dyes are all dissolved in ethanol and used in 2.5×10^{-3} M/ℓ concentration.

The output energy as a function of wavelength is shown in Fig. 1. The dotted lines in Fig. 1 represent the output energy when a dielectric mirror is used instead of the grating. The spectral bandwidth of the emission is found to be 1nm with the grating and 15nm with the dielectric mirror. The maximum optical conversion from the output of CuBr laser to that of dye laser is 17% with the grating and 30% with the dielectric mirror, respectively. These results are summerized in Table 1. No attempt was made to vary the concentration and optimize the output energy.

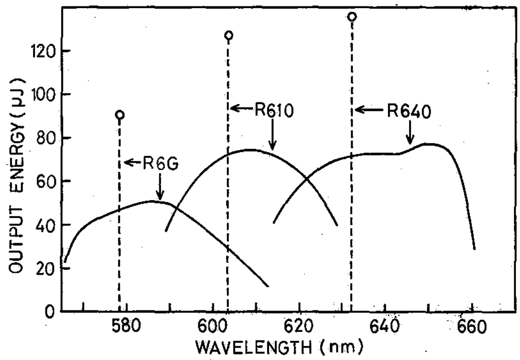

Fig. 1. The wavelength dependence of output energy of the three dyes; Rhodamine 6G (R6G), Rhodamine 610 (R610) and Rhodamine 640 (R640). The dotted lines represent the output energy and the central wavelength of oscillation when the dielectric mirror is used.

Table 1. Output characteristics and optical conversion efficiency of the dye lasers

	Concentration (M/l)	Wavelength (nm)	Maximum output (μJ)	Optical convertion efficiency (%)
Rhodamine 6G	2.5×10^{-3} EtOH	566-612	49.8	11(15)
Rhodamine 610	2.5×10^{-3} EtOH	590-630	72.5	16
Rhodamine 640	3.5×10^{-3} EtOH	615-660	77.0	17

The optical conversion efficiency of Rhodamine 6G is lower than those of the other two dyes. This is because Rhodamine 6G dye solution absorbs only the green line of the copper laser and is transparent for the yellow line. In the case of Rhodamine 6G, if its optical conversion efficiency is taken

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from only 510.6 nm line to the output energy, it is almost the same as the others, and the value is given in parenthese in Table 1.

Rhodamine 6G solution pumped by the green line of the copper laser has gain at the wavelength of 578.2nm, which is the yellow line of the copper laser[1]. In the axial-pumping arrangement, the 578.2 nm beam from the copper laser is amplified by Rhodamine 6G solution. The pumped Rhodamine 6G solution operates as a converter from the green line to the yellow one. The filter which transmits only the green line of the copper laser must be introduced in order to obtain the dye oscillation. However, in the side-pumping arrangement employed in our experiment the yellow line has no influence on the operation of the dye laser, and it passes through the dye solution without any remarkable amplification.

The maximum optical conversion efficiency of 10% is obtained when nitrogen laser is used as a pumping source in the same arrangement with the dye 5×10^{-3} M/ℓ concentration in ethanol. On the other hand, 17% is obtained when the copper laser is used. This difference of the efficiency is explained by the difference of the photon energy between the nitrogen and the copper lasers.

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