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Dichromatic switching effect in two thin-film DFB dye lasers

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Interaction between two thin-film DFB dye lasers which are excited simultaneously in the same film plane has been investigated. A dichromatic switching effect of one of the lasers caused by the on and off switching of the excitation of another laser has been observed and an adequate model for the effect has been discussed.

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The distributed feedback (DFB) laser has been investigated[1–3] as the light source of an integrated optical circuit. Modulation of the laser beam in the thin-film waveguide has been required for the optical communication system. Most methods published so far for modulating the light beam in the thin film use the variation of the parameters of the material of the thin film by electro-optical, acousto-optical, magneto-optical, or photo-optical means.[4,5] This paper describes the interaction between two DFB lasers which are excited simultaneously in the same film and show the possibility of modulation of the light beam by the direct action of another light beam.

Figure 1 shows the experimental setup for the observation of the interaction between two thin-film dye lasers. Two DFB dye lasers having different wavelengths are constructed in the same organic film by the technique which was previously published by the authors.[6] Each DFB laser is pumped by a N_2 laser beam (Lambda Phisik K300; 100 kW). The dye-laser beams generated in DFB regions are propagated to the right and left in the film. The wavelength and intensity of the propagated laser beams are observed at scratches A and B made on the film using an optical multichannel analyzer (OMA) through an optical fiber whose one end is fixed at the scratch and the other end is put into the OMA system.

When only laser *a* is excited by the N_2 laser, light with wavelength λ_a, which is characteristic of laser *a*, is observed at point A, as shown on the left-hand side of Fig. 2(a). When lasers *a* and *b* are excited simultaneously by the N_2 laser, light with λ_a decreases and strong light with wavelength λ_b, which is characteristic of laser *b*, is observed at point A as shown on the left-hand side of Fig. 2(b). Namely, when laser *b* is switched on, the main peak of the laser spectrum observed at point A is converted from λ_a to λ_b; thus, the dichromatic switching takes place. On the other hand, if the observing point is changed from A to B, the dichromatic switching from λ_b to λ_a occurs by the switching on of the excitation of laser *a* as shown in the right figure of Fig. 2.

The period of grating was varied from 1813 to 2000 Å. The corresponding wavelength of the lasers ranged from 5800 to 6400 Å. A super-radiation whose center of wavelength is located at about 6030 Å is observed by N_2 laser irradiation at the no-grating region on the sample. It should be noted here that a clear dichromatic switching

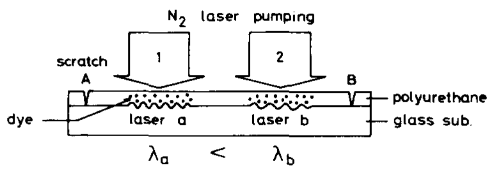

FIG. 1. Experimental setup for observing the interaction of two DFB lasers (lasers *a* and *b*).

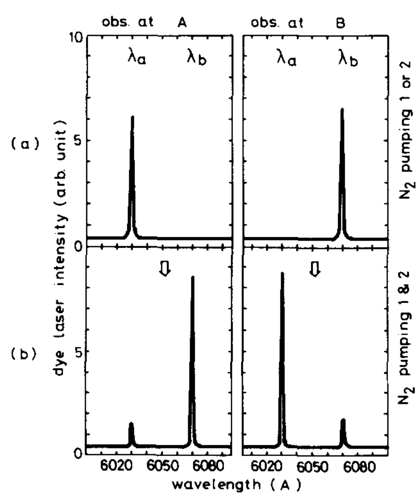

FIG. 2. Observed wavelength and intensity at points A and B when (a) the N_2 laser excitation 1 or 2 is on and (b) when N_2 laser excitations 1 and 2 are on.

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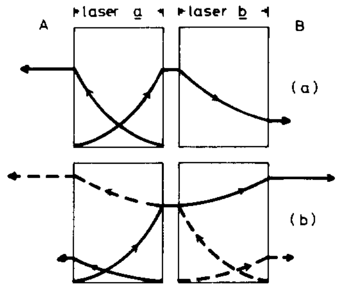

FIG. 3. Expected intensity profile of the two light waves in lasers a and b regions when (a) only laser a is excited and (b) when lasers a and b are excited.

effect is observed in the wavelength range from 5950 to 6120 Å. Namely, when λ_a and λ_b are located near the center of the super-radiation range, the interaction between lasers a and b strongly occurs. The magnitude of the effect is not strongly dependent on the wavelength difference between lasers a and b, and the effect is clearly observed in two lasers whose wavelength difference is from 10 to 200 Å.

Figure 3(a) shows the expected intensity profile of the two light waves which travel to the right and left when only laser a is excited. The intensity of the light waves grow within laser a because of the presence of gain in the DFB structure.[7] The intensity of the light wave traveling to the right is decreased in the laser-b region by the scattering and absorption of the light by dispersed dye. In the case of simultaneous excitation of lasers a and b, as shown in Fig. 3(b), since the intensive light wave with wavelength λ_b generated from laser b induces the wave with the same wavelength, amplification of the wave with wavelength λ_b takes place in the laser-a region in spite of the mismatching of the period of grating with the wavelength. The intensity profile of such a wave is shown by a dashed line in Fig. 3(b). In this case, the light wave with wavelength λ_a, which is generated in laser a and travels to the left, does not grow as much in intensity [see the solid line on the left-hand side of Fig. 3(b)] since most of the light waves traveling to the left are induced by the very intensive light with wavelength λ_b from laser b. Thus, at observing point A, the dichromatic switching from λ_a to λ_b occurs by the switching on of the excitation of laser b. The same consideration can be applicable to the switching from λ_b to λ_a at point B by the switching on of the excitation of laser a.

In conclusion, two lasers whose wavelengths fall within the photoluminescence spectrum region of the laser material can interact with each other. With the on and off action of the excitation of one of the two lasers direct and fast dichromatic switching occurs, and the effect could be applicable to an optical active devices.

It should be noted that the effect is a realization of the directional "Ziehung effect" or forced oscillation[8] in the visible light frequency region.

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