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A1-2 DFB Laser in CdS under Electron Beam Excitation

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Recently, M. Nakamura et al.[1)] reported a successful observation of a DFB laser in GaAs semiconductors. DFB lasers in materials such as CdS of which lasing wavelength is in the region of blue or green are important because they are expected as optical excitation or modulation sources in an integrated optics.

In this note single mode DFB laser oscillations in CdS under electron beam excitation are reported. The typical line width of the lasing spectrum was less than 0.8 Å.

Figure 1 shows a cross section of our CdS DFB lasers. The thickness of the crystal is about 10μm. End windows of CdS crystals were tilted with respect to one another so that effects of superious feedback were avoided. The photoresist (n=1.62 at R.T.) on CdS crystals(n=2.84 at 77°K) was corrugated by a holographic technique with a period between 1730 Å and 1770 Å, which corresponds to the 2nd order Bragg reflection. CdS crystals were excited by electron beam at the temperature of 80°K through the corrugated photoresist to obtain a spacial modulation of a gain constant. A spacial modulation of an effective refractive index in CdS was also obtained by the corrugated photoresist over the surface[2)].

Figure 2 shows spectra of a typical DFB laser(b) and a spontaneous emission(a). The line width of the DFB laser is less than 0.8 Å which is the limit of our spectroscopic resolution. The line width of the emission spectrum without corrugation(c) under the same pumping condition is about 20 Å which shows superradiance features. The spectrum of the DFB laser is much narrower than the spectrum of the laser with a conventional optical cavity[3)] in which minimum line width is about 2 Å.

In a double pulse technique[3)] we observed that without corrugation an intense emission is observed at the wavelength of about 4960 Å under the first pulse excitation but an intense emission for the second pulse is shifted toward longer wavelength and is observed at 4970 Å. The same behavior was observed in the laser with conventional cavity[3)]. On the other hand in the DFB structure the intense and sharp emission are observed at around 4960 Å at both excitation pulses and the lasing wavelength does not shift largely. The lasing spectrum does not observed at the wavelength of 4970 Å. Since the shift of the lasing wavelength without corrugation is interpreted by the increase of the temperature of the sample by electron beam excitation[3)], these results suggest that the DFB lasers are more insensitive to the temperature than conventional CdS lasers. It was also found that in this configulation the DFB laser is observed only at begining part of the excitation pulse in contrast to the conventional CdS laser in which the laser oscillation is shifted toward longer wavelength with increasing the delay time after begining of the excitation pulse[3], and the pulse shape of the DFB laser is much sharper than that of the conventional laser. These features in the DFB laser could be explained by the diffusion effect of carriers in high gain regions.

Figure 3 shows the amount of the shift of the wavelength of the DFB laser with increasing the temperature. The holizontal axis shows the peak wavelength of spontaneous emission at various temperatures. The vertical axis shows the relative shift of the DFB laser to the spontaneous emission. This figure shows the DFB laser is less sensitive to the temperature than the conventional laser of which shift coincides with that of spontaneous emission. The small temperature dependence of the DFB laser is attributed to the refractive index change by the temperature.

In conclusion we can emphasize that 1) DFB laser oscillations in CdS are observed under electron beam excitation and the line width of the spectrum is less than 0.8 Å , 2) the spectrum of the DFB laser oscillation is insensitive to the temperature in comparison with the conventional lasers, and 3) the DFB lasing action occurs only at the begining of the excitation pulse in contrast to the conventional laser.

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References

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2) P. K. Tien et al: J. Opt. Soc. Am., 60 (1970) 1325
3) S. Iwai and S. Namba: Japan. J. Appl. Phys., 12 (1973) 1382

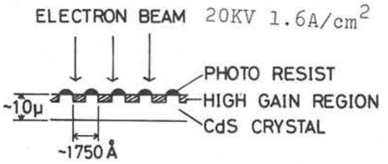

Fig.1 The cross section of the CdS DFB laser.

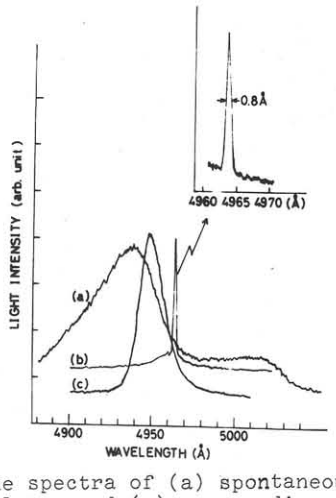

Fig.2 The spectra of (a) spontaneous emisson (b) DFB laser and (c) superradiance.

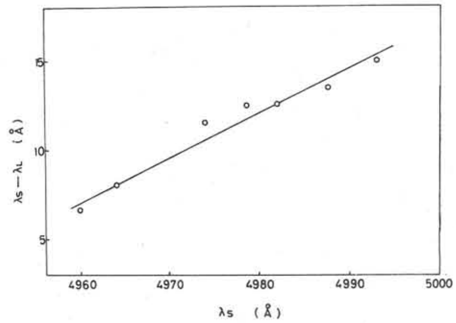

Fig.3 The relative lasing wavelength shift of the DFB laser.