**Digest of Tech. Papers The 7th Conf. on Solid State Devices, Tokyo, Sep. 1975**

B-7-2

# A NEW TWO-DIMENSIONAL DFB LASER WITH DISTRIBUTED BRAGG AND ACOUSTO-OPTIC REFLECTORS

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It is expected that DFB lasers[1)2)] will play an important role in integrated optics. However, a DFB laser with real time- and wide-tuning characteristics has not yet been realized. In this paper, we proposed a new two-dimensional DFB laser with wavelength tunable characteristics.

We consider a DFB laser where there is one pair of distributed Bragg reflectors (DBR) at the both ends and an acoustic surface wave (ASW) propagates on the planar region between the DBR's, as shown in Fig. 1. Characteristic features of the proposed laser originate from this separation of ASW from DBR's, compared with the previously proposed two-dimensional DFB laser.[3)] On the incidence of a light beam into the acoustic beam, the light beam is diffracted effectively by the ASW if Bragg condition is satisfied: $2\lambda_a \sin\theta_a = \lambda$. The diffracted beam will be reflected by the grating, due to the periodic corrugation, under Bragg condition: $2a\sin\theta_g = \lambda$ i.e. $2a\cos\theta_a = \lambda$. Subsequently, the light beam is reflected sequentialy by the DBR's and ASW, and a feedback-loop, similar to that of a ring laser, will be formed, as shown in Fig. 2. Thus, the oscillation wavelength $\lambda_0$ of the DFB laser will be changed with the acoustic wavelength $\lambda_a$. Analyzing the amplitude and phase conditions of the oscillation, we obtained the following characteristic equation for the small value of acousto-optic Bragg angle $\theta_a$:

$$(g-i\delta)L/\cos\theta_a \pm (\kappa_g L/\cos\theta_a)\sin(\kappa_a \ell/\cos\theta_a)\exp[(g-i\delta)\ell/\cos\theta_a - ik_g\ell/2\cos^2\theta_a]$$
$$=(\gamma_1 L/\cos\theta_a)\coth\gamma_1(L-\ell)/2\cos\theta_a \qquad (1)$$

where, $\delta = k-k_g/2\cos\theta_a$, $k=k_a/2\sin\theta_a$,

and $\gamma^2=(g-i\delta)^2+\kappa_g^2$. (2)

Also, g is the gain coefficient of the light signal, and $\kappa_g$ and $\kappa_a$ are the index coupling constants of the corrugation and ASW, respectively. It should be noted that only the light beam, which go into the acoustic beam with Bragg angle $\theta_a$, can form a closed feedback-loop under the condition of small Bragg angle. From eq. (1) we can see that an oscillation mode with lowest threshold gain occurs just at the complete Bragg condition ($\delta=0$) if $k_g\ell/2\cos^2\theta_a = M\pi$ (M:integer) i.e. if the optical pass-length during one round trip is the integer-multiple of the wavelength, in contrast to the mode spectra of conventional DFB lasers.[3)4)5)] This fact indicates the essential good mode selectivity of the proposed DFB laser.

Figure 3 shows the calculated threshold gain and mode spectra of two-dimensional ring mode under the above complete Bragg condition with those of conventional DFB mode.[5)] We can expect the tuning range of wavelength of 30 Å for the change of the acoustic frequency of ±10 % from the center frequency of 2.75 GHz. ($\lambda_a$=1 μ for ASW on GaAs with the crystal orientation, shown in Fig. 1) If the gain spectrum of GaAs is selected in the form, shown in Fig. 3, the oscillation of the ring mode will occur without that of any conventional DFB mode. Also, a roughly estimated total acoustic power, needed for the diffraction efficiency of 100 %, is only a few mW. Propagation loss of 3-GHz acoustic waves in GaAs is the order of 100 dB/cm but the loss does not serious problen because of small acoustic pass length ( a few hundred micron in typical dimensional lasers).

In the uses of this DFB laser as regenerative amplifier, neither of two output beam turns back to input-side because of the ring shaped feedback-loop. (see Fig. 4) This is a desirable feature in practical application of the laser as an amplifier. An example of the calculated gain of the regenerative (Bragg) amplifier is shown in Fig. 4 which indicates narrow gain spectra, characteristic of Bragg amplifier.[6]

The proposed DFB laser will be used as a tunable laser, multi-fiber coupling laser, a chirped light pulse generator, and a Bragg amplifier. More detail oscillation and amplification characteristics will be described at the presentation. Also, the possibilities of the guiding action for the acoustic wave, due to the change of the acoustic velocity with Al contents of $Ga_{1-x}Al_xAs$ in DH injection laser, of the resonant enhancement[7] of photoelastic constant for the photon with the wavelength near the band edge, and of the transducer of GHz-acoustic wave (for example, the generation of the acoustic wave by Gunn oscillator[8]) will be discussed from the point of view of practical laser structure.

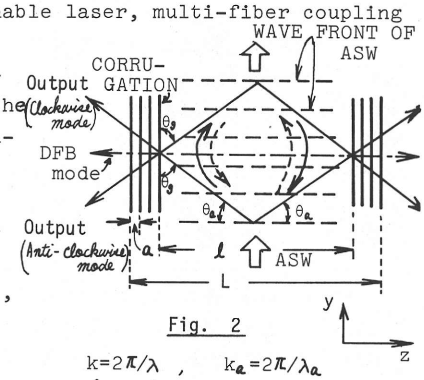


Fig. 2

$k=2\pi/\lambda$ , $k_a=2\pi/\lambda_a$
$k_g=2\pi/a$


References

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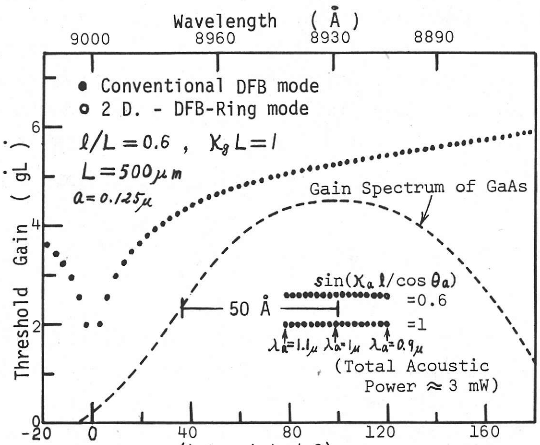


Fig. 3

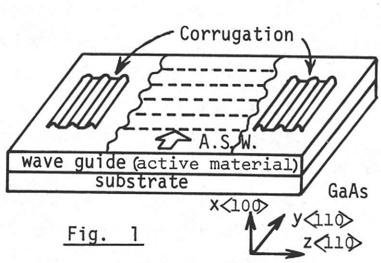


Fig. 1

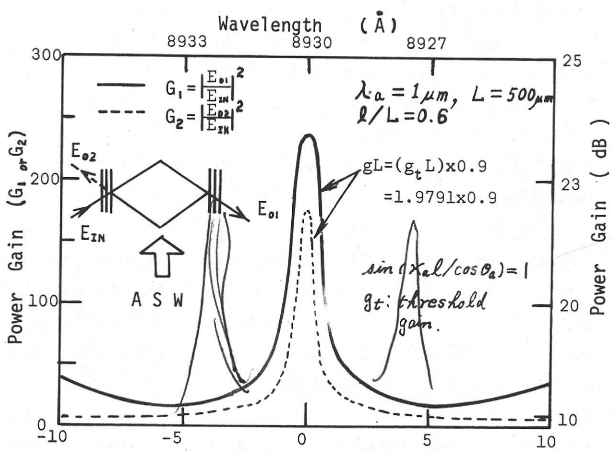


Fig. 4 δ L = k L - kg L /2cos θa