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Macroscopic Theory of Injection Lasers

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Introduction Operating characteristics of the injection laser are affected by motion of the injected electrons. Some theoretical conclusions are obtained by authors, and summarized in this paper.

Linear Gain (1) The intra-band electronic relaxation, which is caused by the electron-electron or electron-photon scattering, is counted in the laser gain. The "band tail" of the gain in lightly doped material is explained by the relaxation as shown in Fig.1.

Gain Suppression (1)(2) The laser gain is suppressed by the oscillating field at lasing condition. Reduction of the amplified spontaneous emission is explained by this suppression as shown in Fig.2. Such suppression reveals inhomogeneous and homogeneous gain broadenings in lightly and heavily doped lasers, respectively.

Stability of Axial Modes (1)(3) Behaviors of the axial modes are decided by three factors, namely, transverse mode control, intra-band relaxation time of the electron and thermal stability of the device. Such conditions are theoretically analyzed and experimentally confirmed as Fig.3.

Frequency Responce of Direct Modulation (4) Reduction of the resonant peak at direct modulation is analyzed with the rate equation, considering the effect of spatial diffusion of electrons as shown in Fig.4. Reduction is effective when the stripe width is close to the diffusion length.

Linearity of Direct Modulation (5) Distortion of the linearity at direct modulation is analyzed by the rate equation as shown in Fig.5. Linearity is hampered in phase relation rather than in amplitude relation.

References (1) M.Yamada and Y.Suematsu, Technical Report from IECE of Japan, OQE77-21, OQE77-22 (1977) , (2) M.Yamada, K.Hayano, H.Ishiguro and Y.Suematsu, ibd., OQE78-13 (1978) , (3) M.Yamada, H.Iida, S.Kido and R.Ishibashi, ibd., OQE78-14 (1978), (4) K.Furuya, Y.Suematsu and T.Hong, Optical Society of America, to be published , (5) T.Hong and Y.Suematsu , to be published

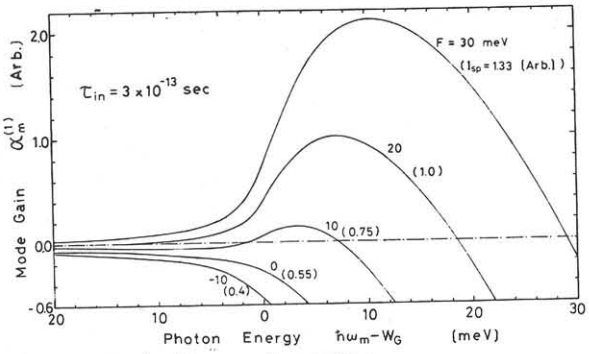

Fig.1 Linear gain profile

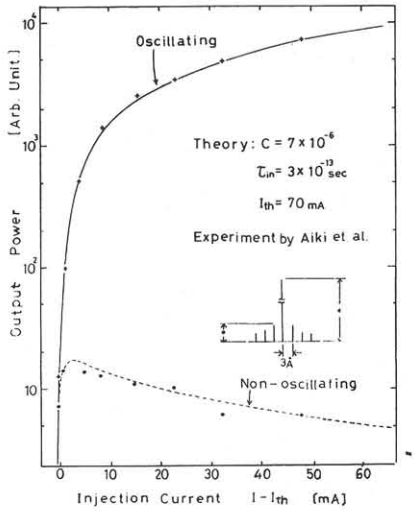

Fig.2 Output power v.s. injection level characteristic in lightly doped AlGaAs laser

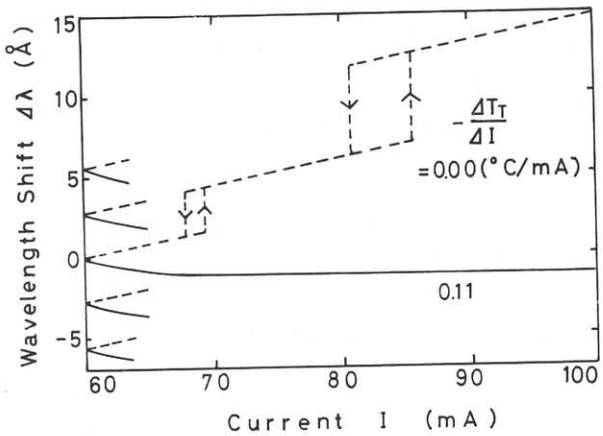

Fig.3 Stabilization of the axial mode

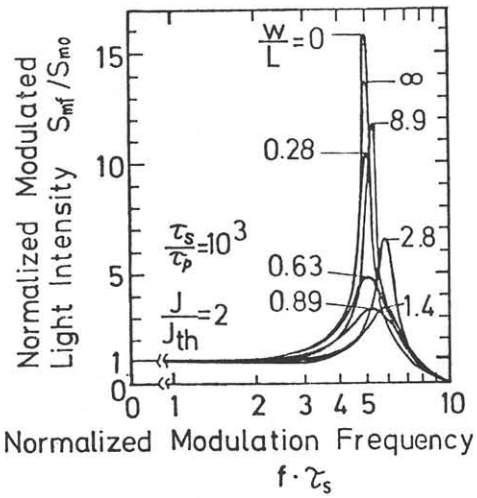

Fig.4 Modulated light intensity v.s. driving frequency

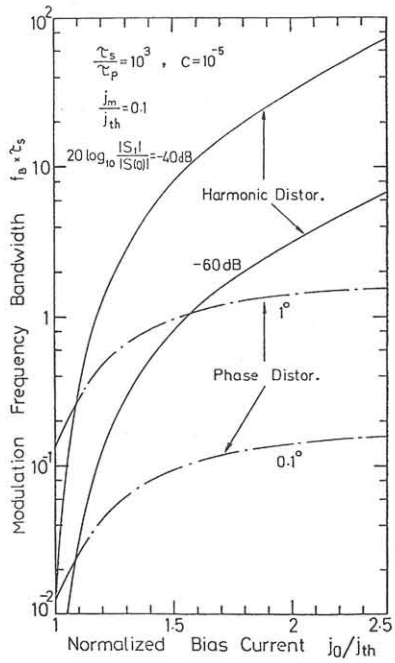

Fig.5 Modulation band width v.s. bias current