4-1 INVITED: Interaction of Light Beams in Semiconductor Laser Diode *

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The idea of the monolithic integrated optics was published by G.J.Lasher (1) and C.J.Koester (2), which based on the saturation of excited carriers or on the common mode. Another group of integrated optics is rather electro-optical, because the coupled laser diodes are controlled electrically, therefore the speed of operation is always limited by the time constant of the electro-optical conversion.

If the d-c biased laser diode was illuminated by a light beam from another laser diode, the output light from the first diode is controlled. In such case, the real optical logical control can be expected. Some of such experiments were published; the light amplification by J.W.Crowe and R.M.Craig (3), and the light quenching by A.B.Fowler (4). But some others are mixed with ignition and quenching of the common mode which can be expected in the case of very tight coupling, this can be avoided by the increase of the distance between two laser diodes. And these pure optical interactions can be explained based on the scramble of injected carriers by each optical mode.

As the author expected (5), the population and the distribution of the injected carriers are changed by the start of lasing, the lifetime of carriers is seriously reduced because of the induced radiative recombination (6), which suggested the impedance of the laser diode seriously changes at the lasing. But till now anyone has not yet observed, which would be thought because of the rather larger series resistance of the diode.

The probability of induced radiative recombination is proportional to the density of electromagnetic energy and to the excess carrier density. And if the cross sectional area is assumed to be constant, density of energy is proportional to the flowing current, which is also proportional to the total recombination density per unit time. Therefore, the output light intensity does show nearly linear relation to the flowing current, not any special higher order relation. Interesting L-I characteristics are expected caused only from sudden changing participation function, from spontaneous or indirect to stimulated emission, and L-V characteristics can be rather expectable for such application.

Only the interesting characteristic are observed in the case of controlling output light by the injection of another light beam, which induces the radiative recombination belonging new injected mode and plunder the carriers injected from the original mode.

Therefore, if controlling light beam is injected, the carriers begin to recombine quickly, then the carriers are gathered from the neighborhood. When the gathering can not follow up the induced radiative recombination, the original mode starts to be weakened and sometimes quenched. But if the applied voltage can be constant, the population of the injected carriers can not be changed in other places,

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* Though the chairman D'asaro didn't record, the idea of the first half of this paper was read in Semiconductor Laser Conference 1972.

then the original mode even spontaneous emission doesn't change. And when the increase of the supplied current is dissipated in the conversion to one mode, other modes even spontaneous keep nearly constant independent to the current as was shown by T.L.Paoli (7).

In the case of time dependent measurement, rather low Q mode can build up quicker (8) compared to the higher Q mode which starts to plunder injected carriers from the neighborhood with time and quench the low Q mode. Report by E.M.Philipp-Rutz (9) can be understood by the idea above mentioned and also the time delay to distribute in each places, where the each mode will built up, apart from junction plane. In the case of the pulse measurement (10), both phenomena are included. To obtain efficient control, the mobile carriers in active region are proposed, as an example DH diode, which has strong limitation about allowed mode in the same time.

To realize such logic element or integrated circuit, most important thing is a stable materials. In the case of GaAs, interstitial As (Possibly Ga vacancy) and As vacancy, those both form complex acceptor level with donor impurity, balance at about 100 mm Hg As pressure and lower temperature (11). Therefore the control of vapour pressure is playing a large role as well as GaP (12). In the sametime, the lattice misfit between GaAs and GaAl As, as an example, usually form lattice defect, which develop into large damage absorbing high of lasing field. Then, nice fitting between GaSbP and InGaP has been developed (13) and they are giving low contact resistance and low recombination in GaSbP. Moreover, this type of structure has not any carrier confinement (14). By the way, the lowest threshold current in GaAs-GaAlAs DH diode is 350A/cm^2 in pulse operation at room temperature (15) already. These are another approach to realize optical IC.

References

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