B－2－3 Integration of a laser diode and a twin FET

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Integration of laser diodes and other elements, for instance a current modulator, is a major breakthrough to high efficient and compact devices for optical communication and data processing.[1,2] The integration not only makes it possible to reduce parasitic impedances, and leads to low power, high speed, and high frequency opperation, but also is suitable for mass production, which can supply the devices at low cost to meet ever increasing needs in near future.

Therefore integration of a double heterostructure semiconductor laser diode and field effect transistors (FETs), involving only planer type processes of fabrication has been studied.[3] This paper discusses the detailed functions of the integrated circuits and also explains about a new structure that consists of a laser diode and a twin FET.

The device consists of GaAs/GaAlAs double heterostructure layers for laser on a n-GaAs substrate, a GaAlAs semi-insulating layer, a GaAs FET active layer, Ohmic electrodes of AuGeNi alloy, Schottky electrodes of CrAu, and a separation layer of SiO_2. All the GaAs/GaAlAs layers were grown by means of liquid phase epitaxy (LPE) method. The patterning of the circuit was done by photo-lithography combined with lift-off technique. The overall structure is schematically shown in Figure 1, for the case of the new type.

The current flows from the drain electrode (D) to the source electrode (S), and down the Zn diffused path to reach the laser active layer, and out the device from the n-side electrode. Current voltage curves at different gate biases are shown in Figure 2. High speed modulation of semiconductor lasers requires optimization of both bias current and modulation current, in order to obtain high extinction ratio and also get rid of pattern effect. With this twin structure, it is possible to choose the bias current level, for instance slightly above the laser threshold, by a DC voltage on one gate, and also to modulate the laser current by signals on the other gate.

Moreover, an auto-bias due to the built-in potential in the laser diode makes it possible to operate it by positively pulsed gate signals, as demonstrated in Figure 3. The rise time of the laser output pulse is about

0.4 ns, and comparable to that of the input pulse, ans also the output pulse hight is more than 80 % of the total maximum outpul. This should suggest the possibility of low noise modulation in GHz frequency bands.

It is demonstrated that the planer integration of a laser diode and FETs is feasible for practical application, and that the twin structure is useful to match the specifications of FETs to laser diodes by way of monolithic fabrication.

References

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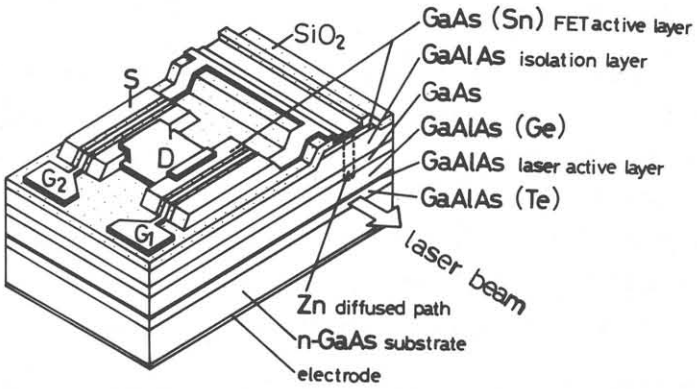

Figure 1. An overall structure of integration of a laser diode and a twin FET. Elements in parentheses are dopants.

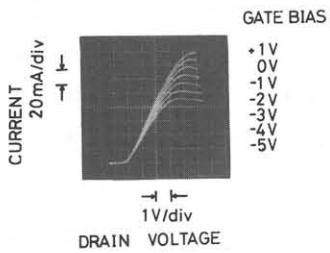

Figure 2. Current voltage curves at different gate biases.

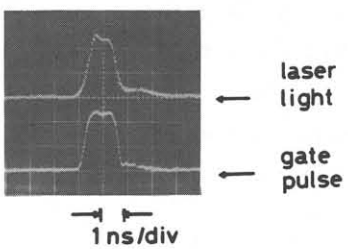

Figure 3. A positive pulse response of laser output.