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Picosecond-Switching Optical Bistability in a TM-Wave Injected BH Laser

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Semiconductor laser optical bistability, in which input light signal is used as the triggers for both switch-up and -down, has been widely studied, however, its switching speed was not so high [1,2]. In this paper, we demonstrate optical bistability between the transverse electric (TE) mode and the transverse magnetic (TM) mode in a buried heterostructure (BH) laser. The turn-on and -off times of less than a few hundred picoseconds are successfully achieved when the TM wave signal is injected into the laser.

Figure 1 shows the schematic diagram of the used equipment. LD is our InGaAsP BH laser (λg=1.3μm, I_{th}=13.7mA at 24°C) operating in a pure TE mode, and its light-output vs. current characteristic is kink-free (see Fig.4)[3]. The light source consists of the same laser as LD. Our YIG optical isolator has an isolation value of more than 30dB. The TM wave selected by means of a polarizer is perpendicularly injected into the facet of the LD active layer.

We have observed the hysteresis loop in light-output vs. light-input characteristic of LD, while the current is constantly injected at 14.4mA (1.05xI_{th}), as shown in Fig.2. The vertical axis shows the TM component of the light output. We have modulated the light input power at the sweep rate of 80nsec/one-way (corresponding to 6.3MHz) to obtain 1.5mW_{p-p} optical pulses superposed on DC level of 1.0mW. The input and output signals are monitored by a Ge-APD and displayed on a digital oscilloscope. There is a difference of 530μW in the light input between the switch-up point and the switch-down point, and 420μW in the light output between the higher state and the lower state. Figures 3 (a) and (b) show the response characteristics for the positive input pulse with the rise time of 1.4nsec and the negative one with the fall time of 1.0nsec, respectively. The turn-on and -off times obtained are less than 200psec and 430psec, respectively, while these values are limited by the time constants of the measurement system.

In addition, when the TM wave with 0.7mW is constantly injected, we have also observed the hysteresis loop in the light-output vs. current characteristic of LD, as shown in Fig.4. We have confirmed that LD has operated in the TM mode at the higher state of the hysteresis loop and operated in the TE mode at the lower state of it, in each case of Figs.2 and 4. From these results, it has been found that the mode with the higher gain can suppress the other mode gain and then the suppression causes the optical polarization bistability which means the optical bistability between the TE mode and the TM mode.

In summary, we have first observed the optical polarization bistability of the TM-wave injected BH laser. The turn-on and -off times by injection of light pulses are less than 200psec and 430psec, respectively. It is probably caused by the interaction of the gain between the TE mode and the TM mode.

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References

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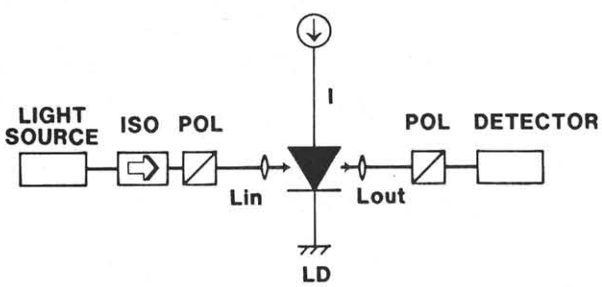

Fig.1. The experimental set-up. LD: BH laser; POL: polarizer; ISO: optical isolator.

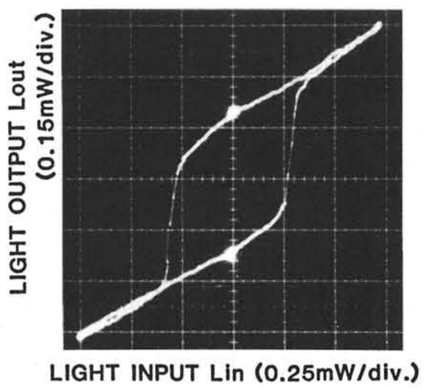

Fig.2. Optical bistability in light-output vs. light-input. Sweep rate is 80nsec/one-way.

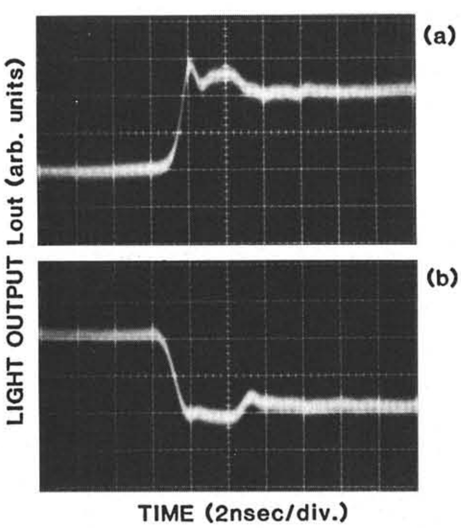

Fig.3. Response characteristics of light-output of the optical bistability. (a) switch-up, (b) switch-down.

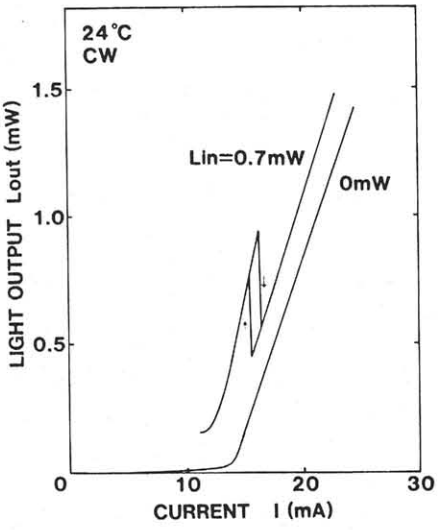

Fig.4. Light output vs. current characteristics.