Temperature dependence of threshold current of GaInAsP/InP membrane lasers with Bragg wavelength detuning

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On-chip optical interconnection is attractive for future wiring in LSIs. A membrane distributed-feedback (DFB) or distributed-reflector (DR) laser is a candidate as the light source of such applications, because strong optical confinement in the membrane structure enables extremely low-threshold current operation. In previous work, 85°C continuous wave (CW) operation in a optically pumped condition was achieved [1]. However, current-injection type devices operated under CW condition up to 50°C, and the threshold current was rapidly increased with increment of heat sink temperature [2]. Since much higher temperature operating will be needed for the on-chip light source, we introduced the Bragg wavelength detuning to the membrane DFB and DR [3] lasers in order to improve temperature dependence of their lasing properties.

Figure 1 shows a schematic structure of fabricated membrane DR laser, which consists of 30-µm-long DFB section and 50-µm-long DBR section integrated with GaInAsP passive waveguide. Figure 2 shows a cross section at the DFB section, where 270-nm-thick semiconductor core layer with SiO_2 cladding was bonded onto a Si substrate by BCB layer. DFB lasers (50-µm-long DFB region) were also fabricated from the same initial wafer.

Figure 3 shows emission spectra of DR and DFB lasers measured at the heat sink temperature of 20°C. The bias currents were chosen so that the active region temperature becomes 28°C which was estimated using thermal resistance and input power to the device. These devices had Bragg wavelength detuning values (with respect to the gain peak wavelength) of 45nm and 53 nm, respectively. The depth of the surface grating was approximately 60 nm, and an index-coupling coefficient, κ, of the grating was estimated to be 1800 cm^{-1} from the stopband width measurement.

Figures 4 and 5 show light output characteristics at temperatures from 20 to 60°C of the DR and DFB lasers, respectively. Figure 6 shows measured temperature dependence of threshold currents of these lasers. While the threshold current of the DR laser monotonically increased from 20 to 90 °C, it was below 1 mA even at 90°C CW condition. In case of the DFB laser, there was a bowing and relatively stable temperature dependence was obtained due to larger Bragg wavelength detuning of 53 nm at 20°C. Further increase of the detuning will be effective for higher temperature operation under a CW condition.

References

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Figures

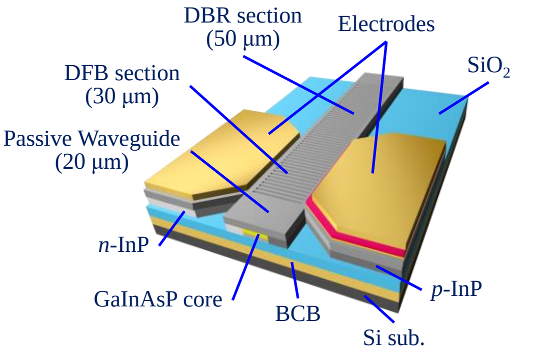

Fig. 1. Schematic structure of a membrane DR laser.

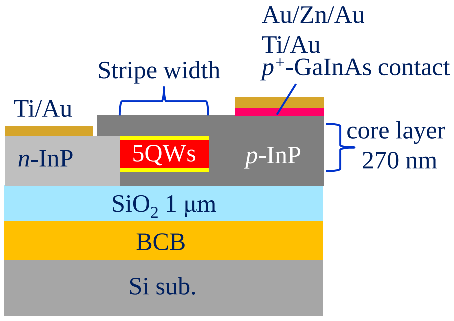

Fig. 2. Cross section at DFB section of fabricated devices.

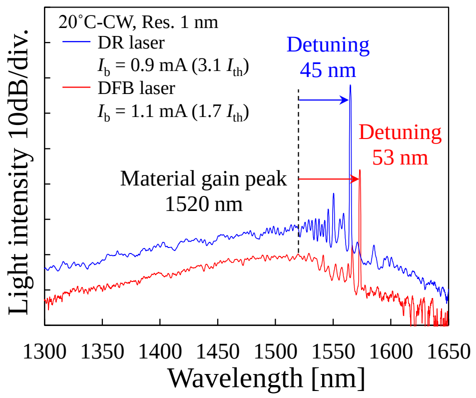

Fig. 3. Emission spectra of membrane DR and DFB lasers.

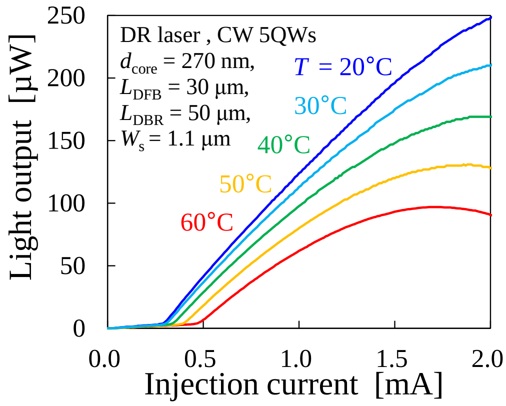

Fig. 4. Light output characteristics of membrane DR laser for various temperatures.

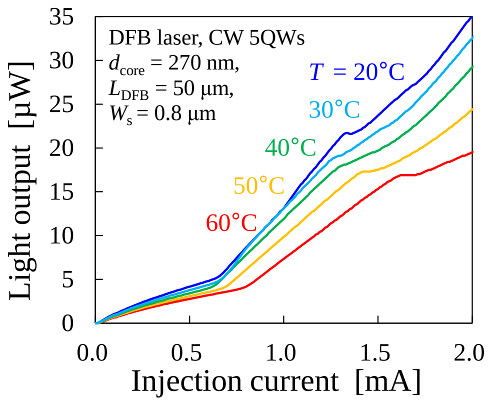

Fig. 5. Light output characteristics of membrane DFB laser for various temperatures.

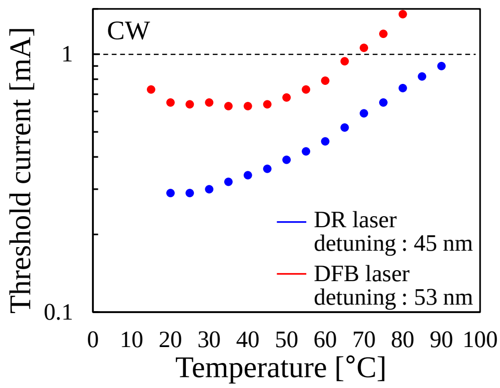

Fig. 6. Threshold current of membrane DR and DFB lasers as a function of temperature.