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# Lasing Wavelength Dependence on Injection Current of GaInAsP/InP Membrane Distributed Reflector Laser with Thin-BCB Layer

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## 1.Introduction

An introduction of photonic integrated circuits (PICs) is considered as one of promising solutions to replace global electrical wiring on Si-LSIs. For this purpose, we have proposed the concept of a membrane PIC composed of InP-based photonic platform with a semiconductor membrane DR laser bonded on a Si substrate using a benzocyclobutene (BCB) adhesive wafer bonding. However its high thermal resistance was considered to be a problem for high temperature CW operation [1]. In order to solve it, we reduced the thickness of the BCB and shortened the distance between the active region and *p*-electrode, and measured the lasing wavelength dependences on injection current.

## 2. Device structure and experimental results

Fig. 1 shows the schematic of a membrane DR laser with a 1-μm-thick $SiO_2$ bonded with the BCB material on a Si substrate. In the previously reported device [1], the thickness of the BCB was 2 μm and the distance between the active region to the *p*-electrode was 3 μm, and both of them were reduced to 0.5 μm.

Fig. 2 shows the light output and voltage-current characteristics of the DR laser with lengths of the DFB, the DBR, and front GaInAsP waveguide regions of 40, 50, and 150 μm, respectively. The active layer width was 0.8 μm. A differential resistance of 375 Ω, which was about 1/3 of the previously reported device [1], was obtained thanks to the shortening of the *p*-electrode distance. The threshold current and the external differential quantum efficiency of 0.3 mA and 10.9% were obtained.

Fig. 3 shows the temperature dependence of the lasing wavelength under a fixed injection current of 1 mA (CW condition) controlled by thermal electric cooler under the chip. The wavelength varied almost linearly with the temperature with the slope of 0.095 nm/K, which is quite similar to 0.098 nm/K of the previously reported device [1] and conventional GaInAsP/InP lasers.

Fig. 4 shows the lasing wavelength as a function of input electrical power (a product of injected current and the bias voltage) under a fixed temperature of 20°C. The slope was interpolated to be 0.019 nm/mW, which was very small (1/27) compared with the previously reported one (0.52 nm/mW) [1]. This may be attributed to not only reduced distance of *p*-electrode and the reduction of the BCB thickness, but also the 150 μm long front waveguide section which is immune from refractive index variation due to an injection current into the DFB section.

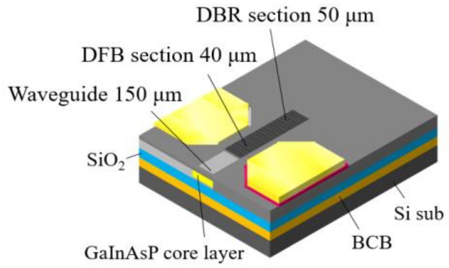

Fig. 1 Schematic of measured membrane DR laser.

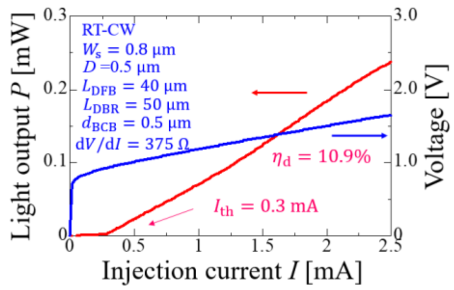

Fig. 2 Light output and voltage characteristics of measured membrane DR laser.

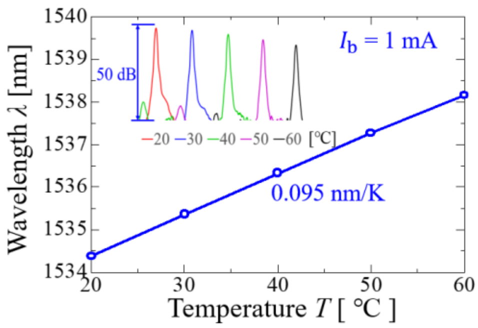

Fig. 3 Temperature dependence of lasing wavelength.

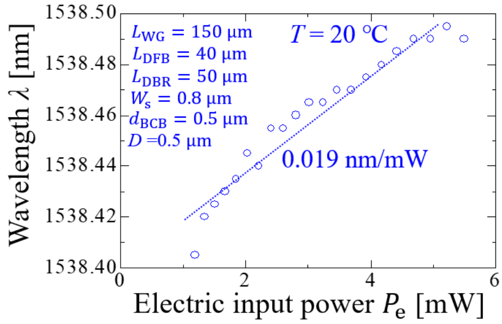

Fig. 4 Lasing wavelength as a function of input electric power.

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**Reference**

[1] T. Hiratani et al., Appl. Phys, vol. 10, no. 3, 032702, Feb. 2017.