Semiconductor Membrane Lasers toward On-chip Optical Interconnects

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1. Introduction

The optical interconnect is advantageous when the clock speed in the LSI becomes faster and faster since it is immune from the RC time delay and the power consumption in electrical wiring. Recently optical interconnections have been introduced in modern supercomputers because of their high-speed signal transmission capability with low-power-consumption. In order to introduce optical interconnects into the LSI chip level, optical links with extremely low-power-consumption operation are required.

As a candidate to realize such optical interconnects, we proposed an optical link based on membrane photonic devices as shown in Fig. 1 [1]. Since this membrane structure can strongly confine the optical field into the active region, which leads to an enhancement of a modal gain as well as an index-coupling coefficient in a distributed feedback (DFB) laser, an extremely low threshold current operation can be expected by shortening the cavity length. A theoretical investigation of such optical link revealed that an energy cost of less than 50 fJ/bit could be possible for 10 Gbps transmission [2].

2. General Instructions

Recently, we demonstrated extremely low threshold current operations of a membrane buried hetero-structure (BH) DFB laser [3] as well as a membrane BH distributed-reflector (DR) laser [4], consisting of a DFB section and a distributed-Bragg-reflector (DBR) section in order to enhance optical output to one side of the cavity [5] as shown in Fig. 2. A threshold current of 230 μA and a side-mode-suppression-ratio (SMSR) of 28dB were obtained for the membrane BH-DFB laser (cavity length of 50 μm). Similar values of 250 μA and 22dB were obtained for the membrane BH-DR laser (DFB section length of 30 μm), but the differential quantum efficiency was much improved owing to the DBR section and the output power ratio between the front and rear of 6.7 was obtained (Fig. 3). Now, dynamic properties such as a 3-dB bandwidth and SMSR under a high-speed direct modulation are under investigation.

3. Conclusions

Very low-threshold-current operations of membrane DFB and DR lasers were demonstrated. Further investigations of a low-loss waveguide and a high-speed detector as an optical-electronic converter will be very important to build up the on-chip optical interconnects.

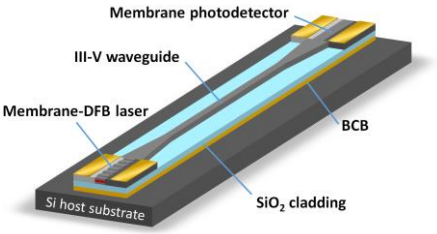

Fig. 1 Schematic of an optical link based on membrane photonic devices on a Si host substrate.

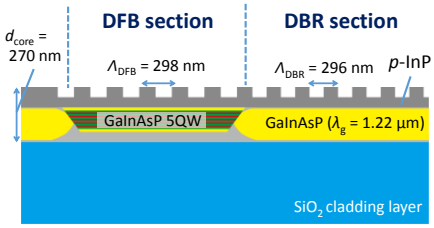

Fig. 2. Cross-sectional view of the LCI-membrane DR laser.

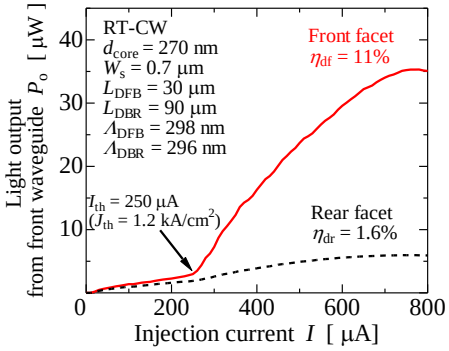

Fig. 3. Light output-injection current characteristics of LCI-membrane DR laser.

Acknowledgments

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