

【Grant-in-Aid for Scientific Research (S)】

Science and Engineering (Engineering)



Title of Project : Creation of Ultra-low Power-consumption Semiconductor Membrane Photonic Integrated Circuits toward On-chip Optical Interconnections

Shigehisa Arai

(Tokyo Institute of Technology, Graduate School of Science and Engineering, Professor)

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Research Area : Engineering, Electrical and Electronic Engineering

Keyword : Photonic devices, Photonic circuits

【Purpose and Background of the Research】

Recently, optical communication technology has been implemented in board-to-board and rack-to-rack communications in most of high-performance super-computers as can be seen in the TOP500 (www.top500.org). This trend will be extended to chip-to-chip communication in LSIs with many core architecture, and on-chip optical interconnections will be very important in next generation LSIs.

In such optical interconnects, not only compactness of each element but also ultra-low energy-cost for signal transmission such as 10-100 fJ/bit will be required. We proposed “semiconductor membrane laser,” which consists of a thin core layer sandwiched by low refractive-index dielectric materials or air so as to enhance an optical confinement into the active region by a factor of around 3 compared with that of conventional semiconductor lasers, and demonstrated record-low threshold current operation of distributed-feedback (DFB) lasers, wire waveguides, and photodiodes based on GaInAsP/InP membrane structure prepared on a Si substrate.

The purpose of this research is to create a photonic integrated circuit (PIC) based on the semiconductor membrane structure, as shown in Fig. 1, toward on-chip optical interconnects in next generation LSIs.

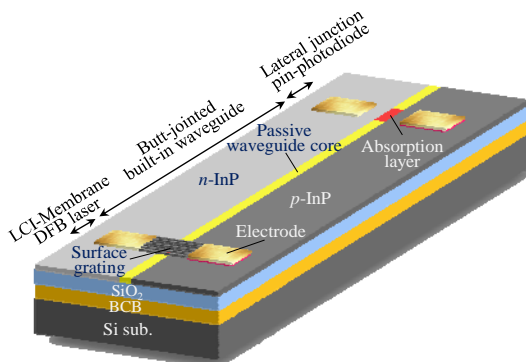


Figure 1 Fundamental structure of semiconductor membrane photonic integrated circuit.

【Research Methods】

We promote the research concerning the following 4 targets.

- (1) **Elemental technology:** Design and fabrication of the light source, the waveguide, and the photodetector.
- (2) **Monolithic/hybrid integration technology:** Monolithic integration of elements above and heterogeneous integration by surface activated bonding (SAB) technology.
- (3) **Integration on Si-substrate:** High efficiency operation for high-speed with low energy-cost.
- (4) **Integration on CMOS platform**

【Expected Research Achievements and Scientific Significance】

This research will contribute for realization of ultra-low energy consumption photonic devices toward next generation LSIs as well as their heterogeneous integration on various combinations of substrates by wafer bonding technologies.

【Publications Relevant to the Project】

- D. Inoue et al., Appl. Phys. Express, vol. 7, no. 7, pp. 072701-1-4, July 2014.
- S. Matsuo, et al., IEEE J. Sel. Top. Quantum Electron., vol. 19, no. 4, p 4900311, July/Aug. 2013.
- K. Takeda et al., Nature Photonics, vol. 7, no. 7, pp. 569 – 575, May 2013.
- S. Arai et al., IEEE J. Sel. Top. Quantum Electron., vol. 17, no. 5, pp. 1381-1389, Sep. 2011.

【Term of Project】 FY2015-2018

【Budget Allocation】 153,200 Thousand Yen

【Homepage Address and Other Contact Information】

<http://www.pe.titech.ac.jp/AraiLab/index.html>
arai@pe.titech.ac.jp