論 文 の 内 容 の 要 旨

A study of silicon microphotonics
for telecommunication applications
(シリコンマイクロフォトニクスの通信応用に関する研究)

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This thesis focuses on two big issues to develop Si microphotonic devices in communication systems.

In Chapter 1, trends of information and communication industries have been summarized. Information explosion raises serious technical and social issues including huge needs for access telecommunication facilities and heavy consumption of electricity. Si microphotonics is one of the most promising candidates to provide low-cost and energy-saving photonic devices. However Si microphotonics for telecommunication applications have two big issues; polarization manipulation for passive devices and photonic characteristics compensation.

In Chapter 2, basic technologies for polarization manipulation based on mode coupling have been proposed. The polarization splitter made of simple directional coupler can work as a polarization splitter, and measured polarization extinction ratio was 23 dB, which is good enough for practical networks. A double-core type polarization rotator was also proposed and confirmed their performance both theoretically and experimentally. The rotator has rotated the polarization plane about 72 degree.

In Chapter 3, advanced technologies for polarization manipulation have been proposed and demonstrated. A dual-core type rotator has exhibited wide wavelength range of over 150 nm with low insertion loss of less than 1 dB and high polarization extinction ratio of more than 10 dB, and advantage for fabrication process. In addition, basic performance of polarization diversity circuit including the splitters and the rotators were successfully confirmed in both continuous wave operation and high speed data transmission with random polarization.

In Chapter 4, basic technologies for photonic characteristics compensation based on the stress generated by bending of a cantilever beam have been discussed. Stress-induced bandgap change can control the operation wavelength and compensate the fluctuation of photonic properties of optical modulators without excess power consumption. It was revealed that neck structure enables stress concentration, and small holes on the beam support formation of large beam with minimum undercut, which degrades the stress around the neck(s). Bandgap controls by mechanical bending of the beam were demonstrated for the proof-of-concept. There were good agreements between experiments and calculations.

In Chapter 5, advanced technologies for stress-bandgap control have been discussed. From a view point of industrial application, mechanical actuators are difficult to implement in Si microphotonic devices. To solve this problem, electrostatic bending method has been investigated. The most serious concern was electrical isolation between the beam and a substrate. Partial etching technique has successfully resolved this issue. Although measured wavelength change was too small to compensate photonic characteristics such as operating wavelength range of modulators, it was a great milestone for electrostatic control for photonic devices other than thermal tuning techniques. This technique can be employed not only for modulators but also for other photonic devices such as laser diodes and wavelength filters, Compact, energy-saving, and tunable λ-locking devices will break the limitations of conventional DWDM architecture.

These accomplishments will be essential technologies to implement Si microphotonics for future telecommunication systems.