論文 / 著書情報
Article / Book Information

題目(和文)	
Title(English)	Slow-light bragg reflector waveguide-based functional devices for use in next-generation optical networks
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出典(和文)	学位:博士(工学), 学位授与機関:東京工業大学, 報告番号:甲第9654号, 授与年月日:2014年9月25日, 学位の種別:課程博士, 審査員:小山　二三夫,淺田　雅洋,梶川　浩太郎,植之原　裕行,宮本　智之,鈴木　賢哉
Citation(English)	Degree:Doctor (Engineering), Conferring organization: Tokyo Institute of Technology, Report number:甲第9654号, Conferred date:2014/9/25, Degree Type:Course doctor, Examiner:,,,,,
学位種別(和文)	博士論文
Category(English)	Doctoral Thesis
種別(和文)	論文要旨
Type(English)	Summary

（博士課程）
Doctoral Program

論 文 要 旨

THESIS SUMMARY

専攻： Department of	物理電子システム創造　専攻	申請学位（専攻分野）： Academic Degree Requested	博士 Doctor of　（　工学　）
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要旨（英文 800 語程度）
Thesis Summary（approx.800 English Words ）

This study focuses on design, fabrication, and characterization of novel photonic functional devices using a slow-light Bragg reflector waveguide. The slow-light mode, which travels in a low group velocity in the waveguide, enables large interaction between light and matter and exhibits a large dispersion. Utilizing these special properties, it is possible to make breakthroughs over the bottlenecks of current photonic technologies. Especially, the author paid attentions on designing devices which are capable for use in next-generation optical communication networks and interconnection systems. The device sizes, operating performances, and power consumptions are key evaluating criterions. Main achievements of this study are summarized as follows:

The first outcome is a small-size electro-absorption type optical modulator. Due to the slowed-down light propagation, stronger modulation is possible at a very short distance. The modulator can be made small hence the device parasitic capacitance is largely reduced. The author carried out numerical simulations and succeeded in fabricating such a device. A 20 μm-long modulator showed a modulation bandwidth over 20GHz, which can be further increased by continuously downsizing or other techniques such as impedance matching. The device provides large extinction ratio over 10dB even with a low driving voltage below 1 V. As a result, extremely low power consumption is achievable, which is estimated to be even lower than 10fJ/bit for dynamic dissipation. The outstanding properties reveal the proposed device's capabilities for use as an ultra-fast and green external modulator in optical interconnection systems.

Secondly, the author proposed and demonstrated a revolutionary non-mechanical beam deflector based on the slow-light waveguide structure. This design is of high novelty and breaks the bottlenecks in other approaches that long limit the application developments. To summarize the highlighting characteristics of this technology, it provides large steering range over 60° and a beam divergence in the order of 0.01°. Experimentally, a number of resolution-points, which is the key of merits for those beam-steering technologies, exceeds 1,000 on a millimeter-order device. It is the highest number for any non-mechanical steering technologies ever reported. It is noted that the technology is flexible for any wavelengths-band thus various applications are expected. Preliminary experiments were also carried and revealed the possibilities in polarization-independent steering, in thermal steering, and on-chip electrical steering.

Inspired by the excellent property of the Bragg reflector waveguide beam deflector, the author designed a novel wavelength selective switch (WSS) for use in reconfigurable optical add/drop multiplexing (ROADM) systems. The WSS setup is simple in the optical configuration and very compact comparing with other approaches. It can provide large numbers of switching ports and wavelength channels at the same time. A prototype device, which gives out 182 output-ports and supports 60 wavelength-channels, was succeeded in fabrication and functioning. After improvements and optimizations, this WSS can be soon adapted to current optical networks and keep playing an important role in the future.

Last but not least, the author suggested the future prospects of the slow-light Bragg reflector waveguide-based technologies. There are strong desires for making faster optical modulators, for realizing higher quality beam-steering, for making more intelligent optical switches in ROADM node, etc. Some theoretical analysis and designs were given, which all show the great potentials and significances in the future of this study. The author wishes and believes that the outcomes of this study will become key building blocks in the next-generation optical communication networks and interconnection systems.