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研究成果報告書

研究課題名

光信号の符号化・暗号化／復号化技術と高セキュリティ・低消費電力な光通信の実現

Encoding/scrambling and decoding of optical signals, and realization of high-security and low-power-consumption optical communication

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Abstract

It is important to devise new and practical technology including optical logical processing, with which high-speed optical communication signals can be encoded and decoded directly in the optical domain, and investigate low-power-consumption optical devices that can carry out the optical logical processing. In this research, by verifying application possibility of the optical logical processing to optical communication systems, we intended to contribute to the future realization of highly secure and low-power-consumption optical communication systems, and safe and secure society. Specific research contents are described below.

In the preliminary research stage, we comprehensively compared characteristics between two kinds of optical exclusive OR (XOR) circuits, which we devised for encoding and decoding technology, by carrying out simulation and preliminary experiments. In consequence, we adopted the circuit, which was composed of a balanced photo-detector (PD) and a Mach-Zehnder interferometer-type optical intensity modulator, due to its stable operation and simple configuration. We carried out subsequent investigation using this circuit configuration. In addition, we sped up the optical XOR circuit so that it could process 40 Gbit/s on-off keying (OOK) signals. In the full-fledged research stage, we first evaluated the fundamental characteristics of the optical XOR circuit in detail, which we realized in the preliminary research stage, and simulated and measured the operation of the optical XOR circuit to various kinds of pseudo-random sequences . Then, we investigate codes to improve the security of the optical logical processing, and considered application fields of the optical logical processing. We finally tried to integrate the components of the optical XOR circuit.

We summarize the contents of the full-fledged research below.

We constructed a bit error rate measurement set-up for 40 Gbit/s OOK signals, and quantitatively evaluated operation of the optical XOR circuit.

We investigated the properties of several pseudo-random sequences used for encoding and decoding of signals.

We actually inputted the above-mentioned pseudo-random sequences into the optical XOR circuit, and measured the operational characteristics of the circuit. We carried out sub-system experiments.

We proposed a time-varying code with a view to improving security of the optical logical processing, and evaluated the properties of the code.

We examined application of the optical logical processing to new fields including error correction of optical signals, which can also contribute to security and have low-power-consumption characteristics.

We considered further operation stabilization and miniaturization of the optical logical circuit by trying to integrate the circuit. In particular, we tried to fabricate an integrated-photonic XOR circuit by utilizing the available technology. However, the fabricated circuit did not work.

In addition to the above-described contents, during the full-fledged research period, we discussed the research with experts in optical communication system fields when needed, and could get useful advice.

To sum up, although we could realize a practical high-speed optical XOR circuit based on the combined technology of photonics and electronics, and could evaluate the circuit characteristics in detail, we could not have enough time to investigate application fields of the optical logical processing technology. Also, we could not

achieve the realization of an integrated-photonic XOR circuit, which was an important goal in the last year. Please note, however, that we could get challenging tasks and useful knowledge to develop application fields and to realize an integrated-photonic XOR circuit in the future.