

論文 / 著書情報  
Article / Book Information

題目(和文)	自己保持型磁気光学スイッチの低エネルギー化に関する研究
Title(English)	Study on low energy driving of self-holding magneto-optic switch
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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

系・コース： Department of, Graduate major in	電気電子 電気電子	系 コース	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)

Recently, due to the increased popularity in video streaming, remote work and cloud services, the IP traffic is increasing. This large amount of traffic is supported by fiber optic communication system which provides high bandwidth communication with a low power loss. However, in the current times, most of the traffic is intra-datacenter or inter-datacenter due to serverless architectures, artificial intelligence data transfer and data replication. This large amount of traffic is supported by a technology called silicon photonics which integrates the bulk optical components into integrated silicon circuits, which is used to create high performance optical transceivers. However, since silicon cannot realize functions such as laser, high speed modulation, self-holding switches and isolators, recent research aims on hybrid integration of non-silicon materials onto silicon. This research uses hybrid integrated magneto-optic materials to realize a self-holding switch, which can hold the state of a switch without power consumption after the state is changed with a pulsed current.

This research improved the characteristics of the self-holding magneto-optic switch by solving the problems of the previous research. The first problem was not being able to drive at high frequencies due to impedance mismatch. The second problem was low magnetization ratio at the self-holding state due to inefficient magnet position.

The first problem of not being able to drive at high frequencies due to impedance mismatch was solved by designing an impedance matched electrode. The electrode was simulated, then loaded onto the optical switch and the wavelength and temporal characteristics were analyzed. The peak wavelength was 1 GHz, thus the designed electrode was shown to be capable of handling the high frequencies of 300 MHz used in the self-holding switch. Furthermore, orthogonal direction magnetic field increased the operation speed to 2 GHz, which can be further increased by using a stronger magnetic field.

The second problem of low magnetization ratio at the self-holding state was solved by improving the placement of the thin-film magnet by simulation. The optimized structure was fabricated and measured. Operation up to 2 ns was demonstrated and  $\pi$  shift was achieved at 5 ns. The switching energy for  $\pi$  shift was calculated to be 5.3 nJ. Then, the rewrite cycle duration was measured and 1.37 trillion rewrite cycles was demonstrated. Furthermore, the maximum achievable magnetization ratio was increased to 2 times by depositing a material to fill the side of the electrode to improve the magnetization characteristics. The performance compared to the previous device has write cycle durability improved by 750 times, switching energy was decreased to 1/301, and the switching speed was shortened to 1/500.

Finally, the use cases of the non-self-holding MO modulator and the self-holding MO switch were discussed and the performance were estimated. The use cases are optical communication in cryogenic environments, smart glasses, machine learning and optimization problem solvers. Furthermore, futher architecture of the self-holding MO switch is discussed. Various methods utilizing direct deposition and surface activated bonding are discussed. Lastly, further improvements of the device are discussed. The approach is to coil the waveguide and reduce the electrode length, which can decrease the switching energy to 1/5 and the footprint to 1/21.

As a conclusion, this thesis realized a high performance self-holding optical switch. Compared to other methods, the write cycle durability is more than 10 orders higher, the write energy lower than the fast switching methods, and the switching speed is 1 order faster than the other methods.

備考：論文要旨は、和文 2000 字と英文 300 語を 1 部ずつ提出するか、もしくは英文 800 語を 1 部提出してください。

Note：Thesis Summary should be submitted in either a copy of 2000 Japanese Characters and 300 Words (English) or 1copy of 800 Words (English).

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