Here begins our new MIRAI
MOONSHOT RESEARCH & DEVELOPMENT PROGRAM

R&D Theme

Research and development on integrated optical circuits for ion trapping

Progress until FY2022

1. Outline of the project

Many kinds of lasers are utilized in trapped-ion quantum technology. Conventional implementations of light sources are free-space optical circuits with many optical elements mounted on a rigid optical table. However, our R&D project aims at replacing previous system with a photonic circuit fabricated on a tiny chip, which leads to the realization of a "photonically integrated ion trap." Such a technological development can drastically promote the compact and stable implementation of a trapped-ion quantum node, and facile reproduction of it is indeed necessary for a photonically interconnected ion-trap quantum computer.

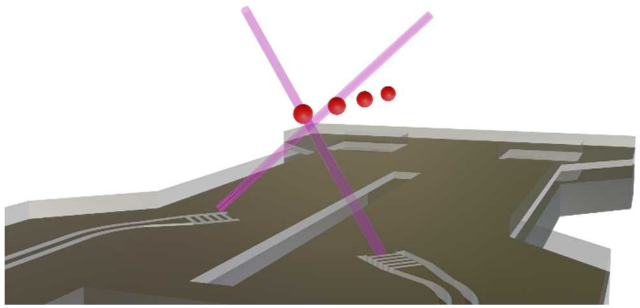
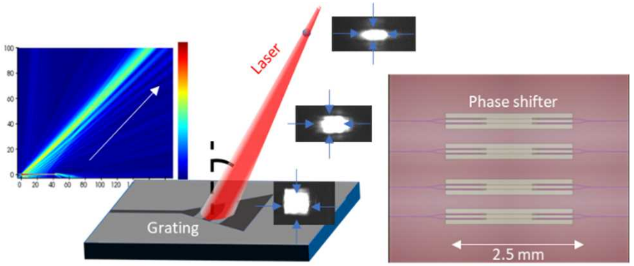


Fig. 1 Schematics of photonically integrated ion trap

2. Outcome so far

We are developing an integrated optical circuit to advance quantum computing technology in the ion trap device. Our focus is on introducing a variety of pump lasers into an ion trap, a critical component for this purpose. The integrated optical circuit we have developed has a wide range of wavelengths, from the visible to the near-infrared. This circuit incorporates silicon-based waveguides that not only have a wide bandwidth, but also have exceptional light integration capabilities. To further improve our on-chip integrated system, we are actively working on the fabrication of small footprint and efficient phase shifter devices. Ultimately, our goal is to implement the advances in the ion trap device being developed at the University of Tokyo.



Fig, 2 Development of photonic circuit elements

We are also developing a method to integrate a photonic chip or photonic elements described above, and in parallel, we are constructing ion-trapping apparatus for a proof-of-concept integration of them in a real trapped-ion quantum node. System constructions are almost completed and ion-trapping is now close at hand.

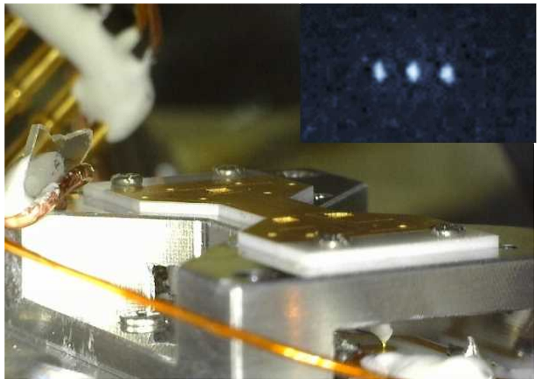


Fig. 3 Constructed ion-trapping apparatus

3. Future plans

By completing first designs of photonic elements and testing them in an ion-trapping experiment, we are demonstrating that we have a test bed for photonically integrated ion trap with photonic elements with additional functionalities, such as nanophotonic modulators. We are pushing up the frontline of a novel field between the ion trap and photonics for better reproducible quantum nodes, and also expecting that we are actually diving into a new field in photonics which aims at "slow but precise" photonics.

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