R&D Theme

Research and development for photonic interconnects of ion traps

Progress until FY2022

1. Outline of the project

To realize a large-scale quantum computer using ion traps, this theme pursues quantum photonic interconnects of ion traps. The core of this project is the development of a device that integrates a micro-optical cavity and a linear ion trap. The micro-optical cavity is required for coupling ions and photons, while the linear ion trap is for trapping multiple ions in an array (Fig. 1). Quantum photonic interconnects will be possible only when these are realized simultaneously in a single device.

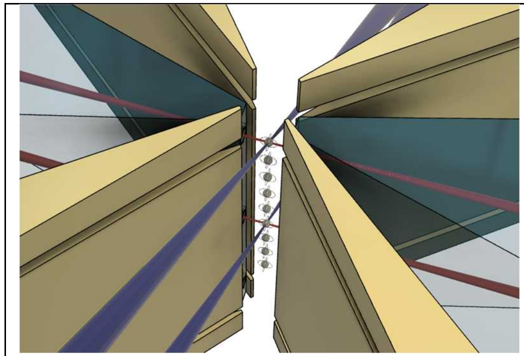

Fig.1 Schematic for an optical cavity-integrated ion trap

We also work on other themes such as enhanced ion-photon coupling using Ba^+ ions and development of an optical cavity using semiconductor mirrors.

2. Outcome so far

A three-dimensional linear ion trap was fabricated using a technique called selective laser etching (SLE). The SLE is a laser-based 3D printing technique that can be used to cut arbitrary three-dimensional structures out of glass. An electrode was created by depositing metal on the surface of the glass structure created in this way, and the ion trap was completed (Fig. 2).

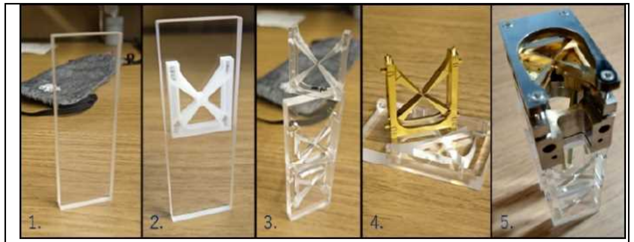

Fig.2 Fabrication of an ion trap using SLE

With an ion trap fabricated in this way, we successfully trapped and laser-cooled a string of ions (Fig. 3).

For the experiment using Ba^+ ions, we evaluated the performance of high-reflectivity mirrors at a wavelength of 493 nm which is the transition wavelength of Ba^+. It was reported that mirrors in the UV and visible ranges would degrade over time in vacuum. By constructing an optical cavity at 493 nm in vacuum and measuring its finesse for a long period of time, we confirmed that such degradation does not happen.

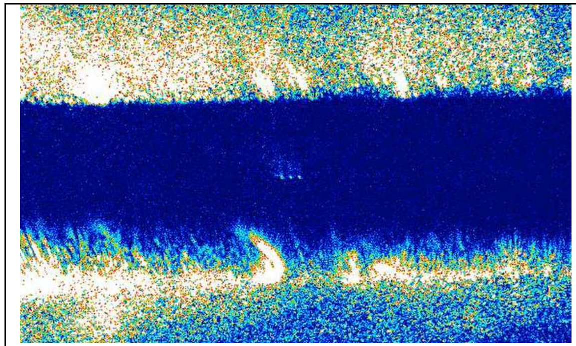

Fig.3 Image of trapped ions in the SLE-made ion trap

The use of semiconductors is expected to avoid the deposition of stray charges on the mirror surface. We have established a technique to form patterned metal electrodes on a semiconductor mirror (Fig. 4)

Fig.4 Patterned electrodes on semiconductor DBR

3. Future plans

We integrate optical cavities in ion traps and aim to couple single ions to the optical cavities.