MONOLITHIC INTEGRATION OF A METALENS WITH A SURFACE TRAP FOR EFFICIENT FLUORESCENCE COLLECTION OF TRAPPED IONS OVER A WIDE AREA

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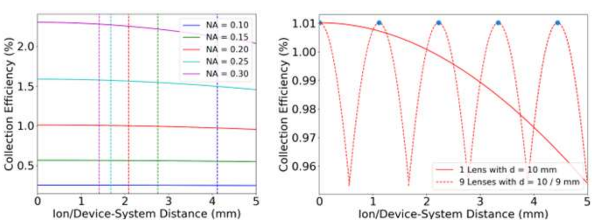
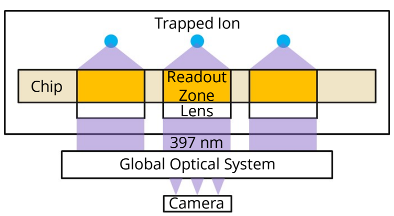
Introduction

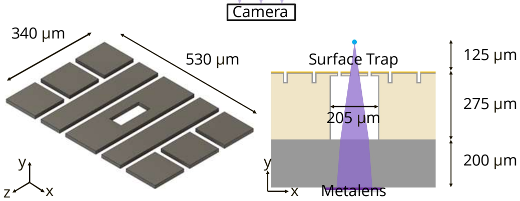
- To implement practical trapped-ion quantum computers, we need an imaging system with a high maximum collection efficiency and a larger full width near the maximum (FWNM) of collection efficiency.
- With a two-lens optical system, even a small increase in the numerical aperture (NA) of the collimating lens causes a large decrease in the FWNM.
- Replacing the single collimating lens with multiple smaller ones not only makes the FWNM robust to a change in the FWNM but also increases it.



System & Device

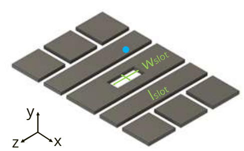
- A surface trap with a slot for fluorescence collection through the device
- Integration of a metalens below the device for fluorescence collimation
- A thick Si substrate to mitigate motional heating of ions due to the BSG
- An undercut to the Si substrate to enhance collection efficiency

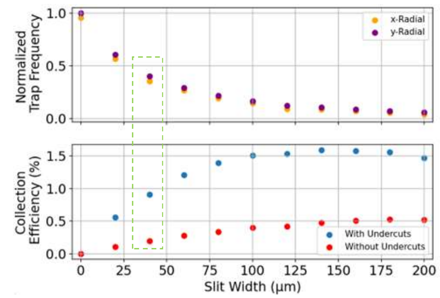




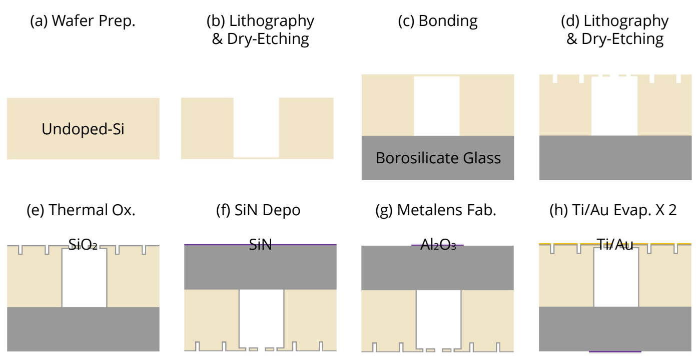
Simulation

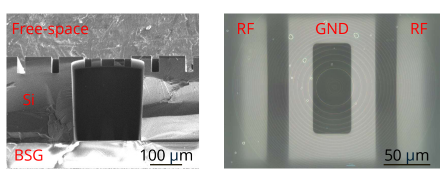
- With w_{slot} = 40 μm and l_{slot} = 100 μm,
- $f_{trap,x}$ = 0.37 and $f_{trap,y}$ = 0.40
- h_{null} = 125 μm and Collection Efficiency with Undercut (without Undercut) = 0.91 % (0.20 %)





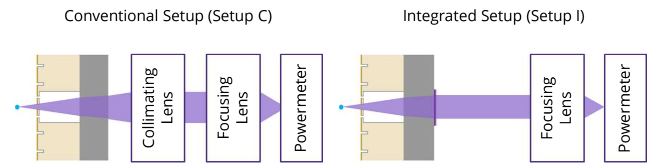
Fabrication

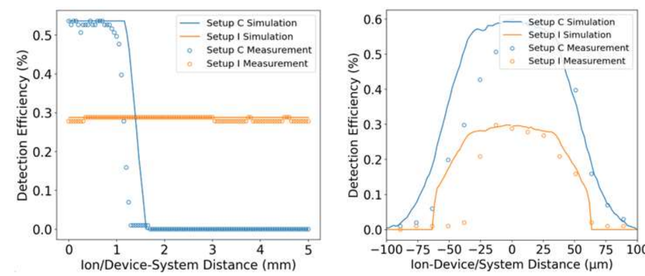




Measurement

- Maximum Detection Efficiency for Setup I (Setup C) = 0.28 % (0.54 %)
- FWNM for Setup I (Setup C) = 5.000 mm (0.926 mm)





Future Work

- Building a fully-functioning ultra-high-vacuum chamber to verify the performance of the setup with real trapped ions
- Monolithic integration of a single metalens for not only fluorescence collection but also control of trapped ions as qubits

Acknowlegements

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