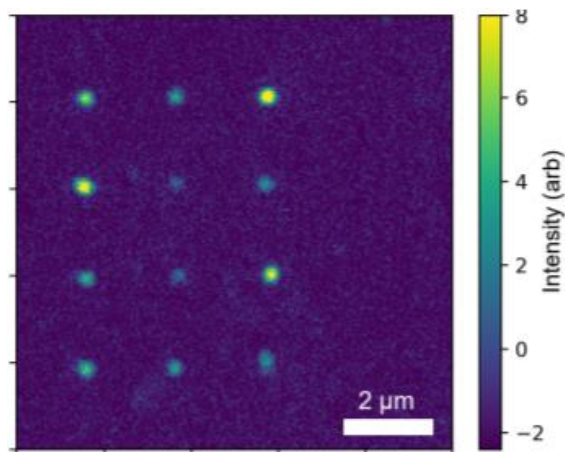


# Modern Quantum Technologies with Trapped Ions

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Quantum technologies allow for fully novel schemes of computing, simulation and sensing. For quantum computing, we employ trapped ions in modern segmented ion traps as scalable and freely reconfigurable qubit register [1,2]. I will give an overview of the recent progress, where gate fidelities of 99.995% (single bit) and 99.6% (two bit) are reached. Alternative platforms for quantum computers in solid state technology would largely benefit from deterministic schemes to fabricate qubit registers with nm-accuracy. I describe our deterministic ion source, which allows for delivering  $\text{Ca}^+$  ions on demand and focus it into a spot of a few nm [3]. The source can be operated with any other doping ion, which is co-trapped and sympathetically cooled together with a single  $\text{Ca}^+$  ion, eventually extracted and implanted. We have started structuring solid state samples such as diamond with  $\text{N}_2^+$  molecular ions to generate NV centers, rare-earth Praseodymium ions [4,5] in YAG samples and will start implanting  $\text{P}^+$  ions into ultrapure Silicon [6], with the vision to fabricate devices for quantum information processing.

- [1] Kaufmann et al, Phys. Rev. Lett. 119, 150503 (2017),
- [2] A. Bermudez, et al, Phys. Rev. X 7, 041061 (2017)
- [3] Jacob et al, Phys. Rev. Lett. 117, 043001 (2016)
- [4] Kornher et al, Appl. Phys. Lett. 108, 053108 (2016),
- [5] K. Groot-Berning, et al, arXiv:1902.05308
- [6] van Donkelaar et al, J. Phys.: Condens. Matter 27, 154204 (2015)



Implantation pattern of  $\text{Pr}^+$  with distance  $2\mu\text{m}$  and spot size of about  $30\text{nm}$ . The confocal optical microscope has a  $200\text{nm}$  resolution. Background spots are from impurity ions which have been before in the host crystal, from [5]

Segmented micro ion trap for quantum processing with  $^{40}\text{Ca}^+$  ions, used in [1]

