Quantum Information Processing with Ions

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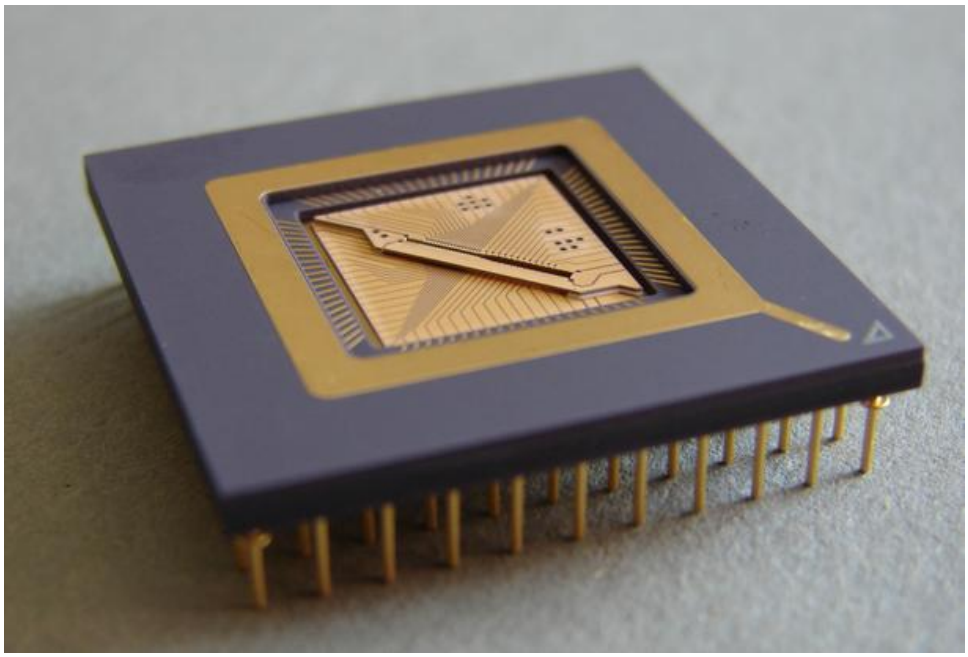
Superpositions of quantum logic states |0> und |1> are stored and manipulated in the electronic excitation of ions for a future quantum computer [1]. So far, we know how to deal with a single, two [2,3], and up to eight qubits. For a realization of a scalable quantum device we employ linear segmented micro-structured Paul-traps [4], see figure below. Noise and decoherence measurements of the qubits will be presented. Especially in µm-scale trap devices we use the ion as a sensitive local probe of electric and magnetic fields. We report on recent progress towards quantum gate operations and experimental studies of non-equilibrium thermodynamics [5].

As alternative to Paul traps, ions for quantum devices may be confined in the matrix of a solid state crystal. While quantum gate operations have been demonstrated for two of such qubits [6], no scalable solid state devices have been fabricated. We have proposed a method which uses a linear Paul trap a deterministic source of sympathetically cooled doping ions [7]. Recently, we have proven experimentally deterministic extraction and focussing of cold ions [8], and we outline the next steps towards a single ion nano-implanter.

[1] J. I. Cirac und P. Zoller, Phys. Rev. Lett. 74, 4091(1995).
[2] F. Schmidt-Kaler et al., Nature 422, 408 (2003).
[3] D. Leibfried et al., Nature 422, 412 (2003).
[4] S. Schulz, et al., New Journal of Physics 10, 045007(2008) and U. Poschinger et al, J. Phys. B: At. Mol. Opt. Phys. 42 154013.
[5] G. Huber, F. Schmidt-Kaler, S. Deffner, E. Lutz, Phys. Rev. Lett 101, 070403 (2008).
[6] P. Neumann et al., Science 320, 1326 (2008).
[7] J. Meijer, et. al. , Appl. Phys. A 83, 321 (2006).
[8] W. Schnitzler et al, arXiv:0912.1258 and W. Schnitzler et al, PRL 102, 070501 (2009).



Ulm micro ion trap