Flat 'ion trap' holds quantum computing promise

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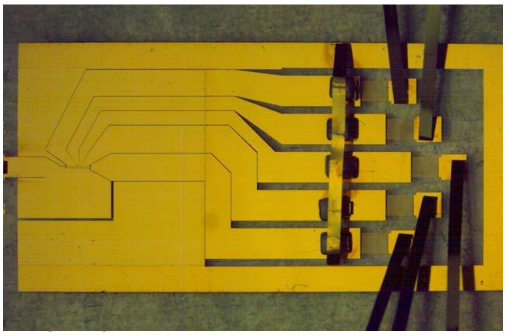
Quantum computers could be more easily mass produced thanks to the development of a two-dimensional ion trap - one of their key components.

A quantum computer could be much faster than a conventional computer. While electronic bits can exist in one of two states – "0" or "1" – a quantum bit, or qubit, can be in both states simultaneously. Connecting lots of qubits together would allow many more calculations to be carried out simultaneously.

Ion traps have so far proved the best way to make qubits, allowing up to eight to be connected together. They work by trapping super-cooled ions in an electric field. Lasers can then be used to manipulate the ions to alter their quantum states.

Researchers at the US National Institute of Standards and Technology (NIST) in Maryland, US, have developed a new way to make ion traps that can be easily scaled up, using technologies common to today's electronics industry.

"Almost all of the groups working in quantum information are trying to find simpler ways to make those structures, and a way to scale this technology up," says David Wineland, the physicist who leads the team that developed the trap.



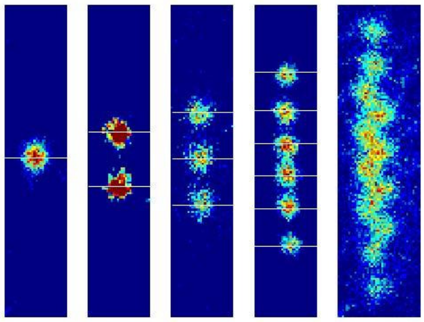
The flat ion trap, roughly 1cm by 2cm, can be made easily using processing techniques used on a large scale in electronics. Ions are trapped 40 microns above the surface of the chip. (Image: Signe Seidelin and John Chiaverini/NIST)

Quantum chip

Ion traps usually have four rod-shaped electrodes arranged in a 3D cage. They emit oscillating electric fields to trap ions. Wineland and colleagues instead made the electrodes into flat strips lying next to each other on a surface. The gold electrodes were deposited onto a quartz chip and the surrounding connections and circuitry were etched onto the surface using photolithography.

"The advantage of this is one much appreciated by the electronics industry," Wineland told **New Scientist**. "You can just as easily make a thousand as make one." Many traps could be lined up together to make a quantum chip.

But the team will not be making them in such numbers. Although they have demonstrated as a proof of principle that the trap can hold twelve magnesium ions, these ions are not ideal candidates for manipulating as qubits using lasers. Wineland is confident that 2D qubits can be made, "but first we have to make sure the 2D traps work with the ions more suitable for the quantum information applications".



False-colour images of magnesium ions loaded into the planar ion trap. Ions are detected using fluorescence, with red indicating the greatest intensity, or the centres of the ions. (Signe Seidelin and John Chiaverini/NIST)

Mixed and match

In January 2006, a team including Winfried Hensinger of Sussex University, UK, produced the first integrated set of 3D ion traps. "By making all the electrodes in one plane these guys have made quite a significant step," says Hensinger. "One advantage is that you can more easily make electrical interconnects between traps on a flat surface."

But Hensinger thinks the performance of 2D traps may differ from conventional ones. "Getting the lasers into the trap to manipulate the ions might be difficult," he explains.

"I think arrays of both flat and 3D traps will form the basis of future quantum computers," he adds. "Conventional traps would be used for parts that need a lot of access to the qubits; flat traps can be used where it is needed less frequently."

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