Scalable device for quantum information processing

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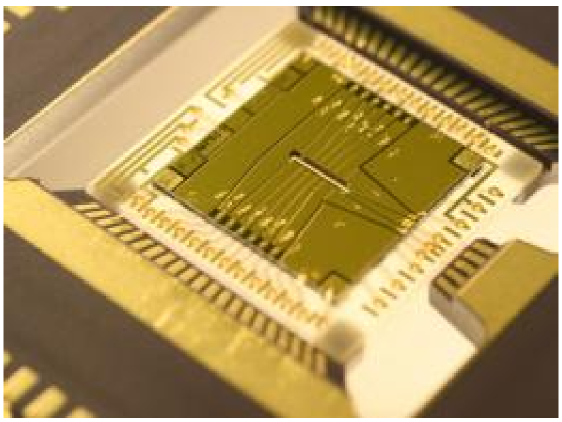

Microtrap chip

(Phys.org) -- Researchers in NPL's Quantum Detection Group have demonstrated for the first time a monolithic 3D ion microtrap array which could be scaled up to handle several tens of ion-based quantum bits (qubits). The research, published in *Nature Nanotechnology*, shows how it is possible to realise this device embedded in a semiconductor chip, and demonstrates the device's ability to confine individual ions at the nanoscale.

As the UK's National Measurement Institute, NPL is interested in how exotic quantum states of matter can be used to make high precision measurements of, for example, time and frequency, ever more accurate. This research, however, has implications wider than measurement. The device could be used in quantum computation, where entangled qubits are used to execute powerful quantum algorithms. As an example, factorisation of large numbers by a quantum algorithm is dramatically faster than with a classical algorithm.

Scalable ion traps consisting of a 2D array of electrodes have been developed, however 3D trap geometries can provide a superior potential for confining the ions. Creating a successful scalable 3D ion trapping device is based on maintaining two qualities - the ability to scale the device to accommodate increasing numbers of atomic particles, whilst preserving the trapping potential which enables precise control of ions at the atomic level. Previous research resulted in compromising at least one of these factors, largely due to limitations in the manufacturing processes.

The team at NPL has now produced the first monolithic ion microtrap array which uniquely combines a near ideal 3D geometry with a scalable fabrication process - a breakthrough in this field. In terms of elementary operating characteristics, the microtrap chip outperforms all other scalable devices for ions.

Using a novel process based on conventional semiconductor fabrication technology, scientists developed the microtrap device from a silica-on-silicon wafer. The team were able to confine individual and strings of up to 14 ions in a single segment of the array. The fabrication process should enable device scaling to handle greatly increased numbers of ions, whilst retaining the ability to individually control each of them.

Due to the enormous progress in nanotechnology, the power of classical processor chips has been scaled up according to Moore's Law. Quantum processors are in their infancy, and the NPL device is a promising approach for advancing the scale of such chips for ion-based qubits.

Alastair Sinclair, Principal Scientist, NPL said: "We managed to produce an essential device or tool, which is critical for state-of-the-art research and development in quantum technologies. This could be the basis of a future atomic clock device, with relevance for location, timing, navigation services or even the basis of a future quantum processor chip based on trapped ions, leading to a quantum computer and a quantum information network."

More information: Read the full paper, A monolithic array of three-dimensional ion traps fabricated with conventional semiconductor technology, in Nature Nanotechnology.

Provided by National Physical Laboratory

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