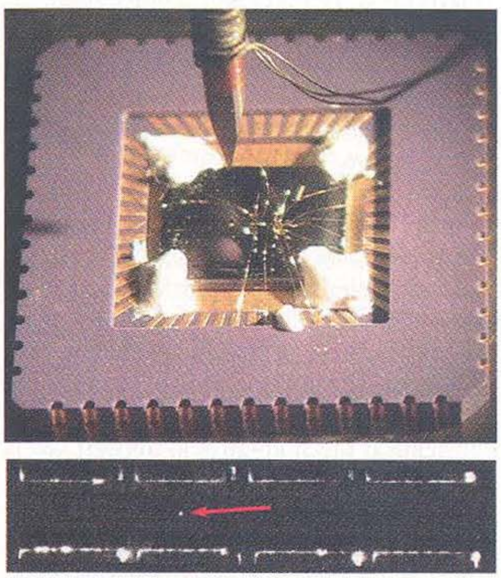
SCIENCE NEWS
This Week

Quantum Chip

Device handles ions as if they were data

Physicists have created a microchip that can hold an electrically charged atom and move it back and forth within a narrow channel. These manipulations lay the groundwork for using trapped ions as data bits in computer chips, the developers of the new device say.

The scientists created the chip as a step toward a new breed of computers, called quantum computers, which represent information using quantum properties of particles (*SN: 7/17/04, p. 46*). Those potentially mighty, yet currently rudimentary, machines are expected to efficiently handle calculations—for instance, breaking encryption codes used for Internet transactions—that would take conventional computers a billion years.



ION INSIDE **The black chip (top) within this purple-and-gold holder fulfills a quantum-information–processing goal by trapping and manipulating an ion. A tip installs electrical connections between the chip and holder. In a micrograph, a trapped, fluorescent cadmium ion (bottom, arrow) hovers between rows of electrodes (white line segments).**

Led by Christopher R. Monroe of the University of Michigan in Ann Arbor, the new chip's makers also propose additional uses of their device. With further development, it might serve as a component of minuscule atomic clocks (*SN: 9/4/04, p. 150*) or of tiny mass spectrometers, which identify substances by ionizing and measuring fragments of their molecules (*SN: 6/12/04, p. 373*).

The team unveils the chip, which operates in a vacuum at room temperature, in the January *Nature Physics*.

"This will be a great stepping-stone," comments atomic physicist Jörg Schmiedmayer of the University of Heidelberg in Germany. "Miniaturization is, in my opinion, the best way to extend ion trapping."

Since the 1950s, physicists have machined and assembled larger containers to hold just a few ions for such purposes as studying fundamental physics and creating atomic clocks. More recently, researchers have trained lasers on eight trapped ions to tune the particles' quantum states in ways needed for computing.

Traps on chips are the way to go to create quantum computers, says Monroe. Traps will need to be smaller than the machined ones to confine ions tightly, so as to maintain their collective quantum states and to speed their interactions. Practical quantum computers will require manipulations of a few dozen to a million or so ions in close proximity, Monroe says.

On chips, the ion-trap designs could be easily repeated to handle more particles, Monroe says.

Miniaturization onto chips has already played a role in the manipulation of neutral atoms (*SN: 6/17/00, p. 399*). However, notes Schmiedmayer, a pioneer of the neutral-atom chip, that technology differs from what's required for handling ions.

To build the new ion device, Monroe and his colleagues used conventional microchip-fabrication methods to first deposit layers of the semiconductor compounds gallium arsenide and aluminum gallium arsenide onto a gallium arsenide wafer. The scientists next etched away portions of the wafer and the overlying layers to create a gap that's wide at the bottom of the structure, permitting laser-beam access, but only 60 micrometers across at the top.

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Although the devices made so far can store and move only one cadmium ion at a time, the route is now open to chips containing more ions, Monroe says. With those, he adds, scientists will probably duplicate and then surpass the feats of quantum manipulation already attained with conventional ion traps. —P. WEISS