Rewriting quantum chips with new laser technique

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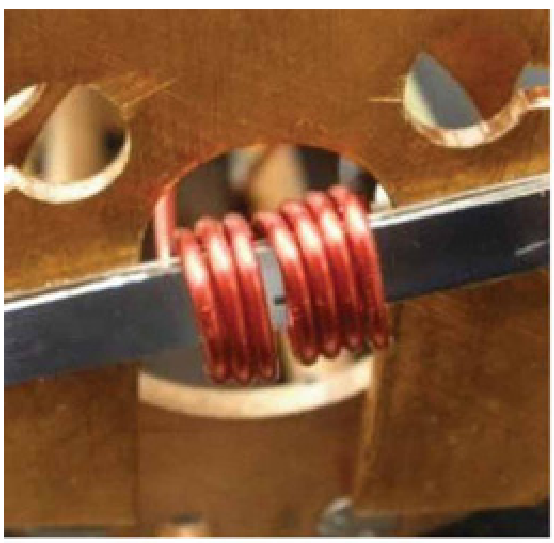
The probe head used to send radio-frequency pulses onto the coil used for pulsed spin manipulation of a gallium arsenide (semiconductor) sample. (Credit: Yunpu Li)

(Phys.org) -- The promise of ultrafast quantum computing has moved a step closer to reality with a technique to create rewritable computer chips using a beam of light. Researchers from The City College of New York (CCNY) and the University of California Berkeley (UCB) used light to control the spin of an atom's nucleus in order to encode information.

The technique could pave the way for quantum computing, a long-sought leap forward toward computers with processing speeds many times faster than today's. The group will publish their results on June 26 in *Nature Communications*.

Current electronic devices are approaching the upper limits in processing speed, and they rely on etching a pattern into a semiconductor to create a chip or integrated circuit. These patterns of interconnections serve as highways to shuttle information around the circuit, but there is a drawback.

"Once the chip is printed, it can only be used one way," explained Dr. Jeffrey Reimer, UCB professor of chemical and biomolecular engineering and the study co-author.



Close up of the mount used to hold a gallium arsenide (semiconductor) sample, showing the radio-frequency coil used for pulsed spin manipulation. (Credit: Yunpu Li)

The team – including CCNY Professor of Physics Carlos Meriles and PhD graduate students Jonathan King of UCB and Yunpu Li of CCNY– saw a remedy for these problems in the emerging sciences of spintronics and quantum computing.

They have developed a technique to use laser light to pattern the alignment of "spin" within atoms so that the pattern can be rewritten on the fly. Such a technique may one day lead to rewritable spintronic circuits.

Digital electronics and conventional computing rely on translating electrical charges into the zeros and ones of binary code. A "spintronics" computer, on the other hand, would use the quantum property of electron spin, which enables the electron to store any number between zero and one.

Imagine this as if the electron were a "yin-yang" symbol in which the proportions of the dark and light areas—representing values from zero to one—could vary at will. This would mean that multiple computations could be done simultaneously, which would amp up processing power.

Attempts at using electrons for quantum computing have been plagued, however, by the fact that electron spins switch back and forth rapidly. Thus, they make very unstable vehicles to hold information. To suppress the random switching back and forth of electrons, the UCB and CCNY researchers used laser light to produce long-lasting nuclear spin "magnets" that can pull, push, or stabilize the spins of the electrons.

They did this by illuminating a sample of gallium arsenide – the same semiconductor used in cell phone chips – with a pattern of light, much as lithography etches a physical pattern onto a traditional integrated circuit. The illuminated pattern aligned the spins of all the atomic nuclei, and, thus, their electrons, at once, creating a spintronic circuit.

"What you could have is a chip you can erase and rewrite on the fly with just the use of a light beam," said Professor Meriles. Changing the pattern of light altered the layout of the circuit instantly.

"If you can actually rewrite with a beam of light and alter this pattern, you can make the circuit morph to adapt to different requirements," he added. "Imagine what you can make a system like that do for you!"

More information: Jonathan P. King, Yunpu Li, Carlos A. Meriles, and Jeffrey A. Reimer. Optically Re-Writable Patterns of Nuclear Magnetization in Gallium Arsenide. 26 June, *Nat. Commun.* dx.doi.org/10.1038/ncomms1918

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