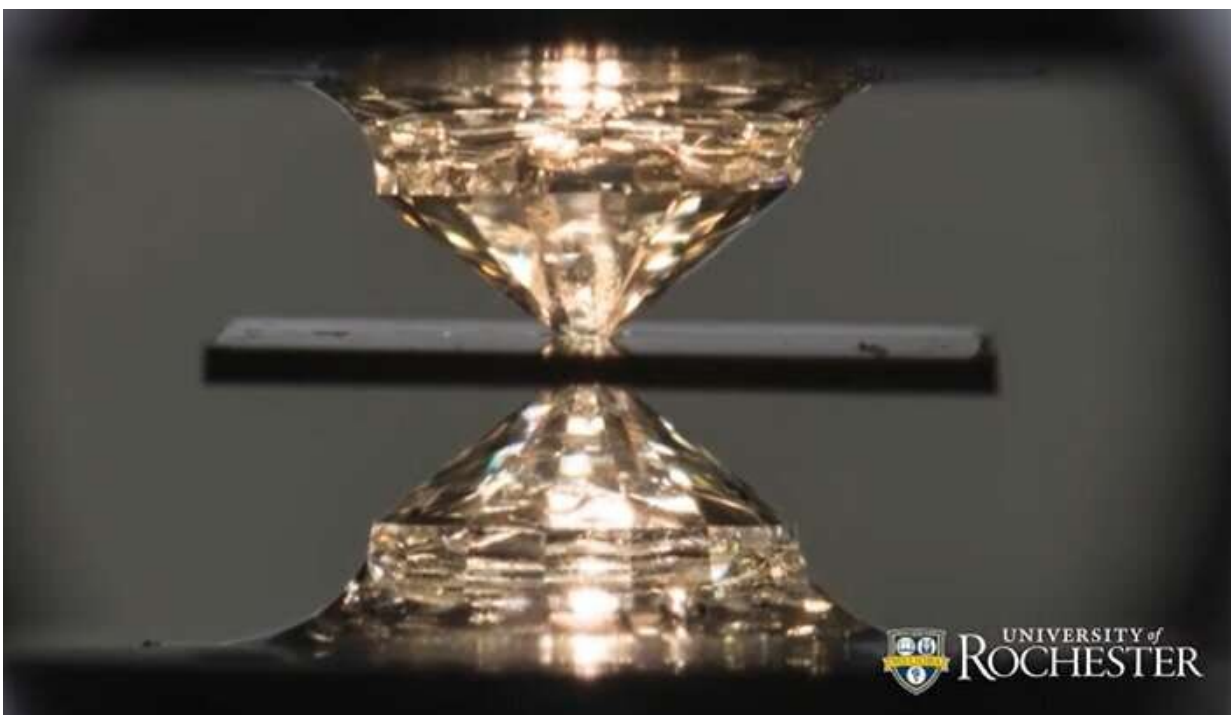


Room-temperature superconductors could revolutionize electronics—an electrical engineer explains (Retracted paper)

March 28 2023, by Massoud Pedram



Credit: University of Rochester / AJ Pow

Superconductors make highly efficient electronics, but the ultralow temperatures and ultrahigh pressures required to make them work are costly and difficult to implement. Room-temperature superconductors promise to change that.

RETRACTION NOTE:

Nature Publishing group has retracted this controversial research paper claiming the discovery of a superconductor.

Nature has provided the following note:

This article has been retracted at the request of the authors Nathan Dasenbrock-Gammon, Elliot Snider, Raymond McBride, Hiranya Pasan, Dylan Durkee, Sachith E. Dissanayake, Keith V. Lawler and Ashkan Salamat. They have expressed the view as researchers who contributed to the work that the published paper does not accurately reflect the provenance of the investigated materials, the experimental measurements undertaken and the data-processing protocols applied. The above-named authors have concluded that these issues undermine the integrity of the published paper.

In addition, and separately, concerns have been independently raised with the journal regarding the reliability of the electrical resistance data presented in the paper. An investigation by the journal and post-publication review have concluded that these concerns are credible, substantial and remain unresolved.

Nugzari Khalvashi-Sutter, Sasanka Munasinghe and Ranga P. Dias have not stated whether they agree or disagree with this retraction.

The recent announcement by researchers at the University of Rochester of a new material that is [a superconductor at room temperature](#), albeit at [high pressure](#), is an exciting development—if proved. If the material or one like it works reliably and can be economically mass-produced, it could revolutionize electronics.

Room-temperature [superconducting materials](#) would lead to many new

possibilities for practical applications, including ultraefficient electricity grids, ultrafast and energy-efficient computer chips, and ultrapowerful magnets that can be used to levitate trains and control fusion reactors.

A superconductor is a material that conducts [direct current](#) without encountering any [electrical resistance](#). Resistance is the property of the material that [hinders the flow of electricity](#). Traditional superconductors must be cooled to extremely low temperatures, close to absolute zero.

In recent decades, researchers have developed so-called [high-temperature superconductors](#), which only have to be chilled to minus-10 degrees Fahrenheit (minus-23 Celsius). Though easier to work with than traditional superconductors, [high-temperature superconductors](#) still require special thermal equipment. In addition to cold temperatures, these materials require very high pressure, 1.67 million times more than the atmospheric pressure of 14.6 pounds per square inch (1 bar).

As the name suggests, [room-temperature](#) superconductors don't need special equipment to cool them. They do need to be pressurized, but [only to a level that's about 10,000 times more than atmospheric pressure](#). This pressure can be achieved by using strong metallic casings.

Where superconductors are used

Superconductor electronics refers to electronic devices and circuits that use superconducting materials to achieve extremely high levels of performance and [energy efficiency](#) that are orders of magnitude better than can be achieved with state-of-the-art semiconductor devices and circuits.

The lack of electrical resistance in superconducting material means that they can support high electrical currents [without any energy loss due to resistance](#). This efficiency makes superconductors very attractive for

[power transmission](#).

Utility provider Commonwealth Edison [installed high-temperature superconducting transmission lines](#) and showcased technologies to bring power to Chicago's north side for a one-year trial period. Compared to conventional copper wire, the upgraded superconducting wire can carry 200 times the electrical current. But the cost of maintaining the low temperatures and high pressures required for today's superconductors makes even this efficiency gain impractical in most cases.

Because the resistance of a superconductor is zero, if a current is applied to a superconducting loop, the current [will persist forever unless the loop is broken](#). This phenomenon can be used in various applications to make large permanent magnets.

Today's magnetic resonance imaging machines [use superconductor magnets](#) to achieve the [magnetic field strength](#) of a few teslas, which is needed for accurate imaging. For comparison, the Earth's magnetic field has a strength, or flux density, of about 50 microteslas. The magnetic field produced by the superconducting magnet in a 1.5 tesla MRI machine is 30,000 times stronger than that produced by the Earth.

The scanner uses the superconducting magnet [to generate a magnetic field](#) that aligns hydrogen nuclei in a patient's body. This process combined with radio waves [produces images of tissue for an MRI exam](#). The strength of the magnet directly affects the strength of the MRI signal. A 1.5 tesla MRI machine requires longer scan times to create clear images than a 3.0 tesla machine.

Superconducting materials expel magnetic fields from inside themselves, which makes them [powerful electromagnets](#). These super-magnets have the potential to [levitate trains](#). Superconducting electromagnets generate 8.3 tesla magnetic fields—more than 100,000 times the Earth's magnetic

field. The electromagnets use a current of 11,080 amperes to produce the field, and a superconducting coil allows the high currents to flow without losing any energy. The [Yamanashi superconducting Maglev train](#) in Japan levitates 4 inches (10 centimeters) above its guideway and travels at speeds up to 311 mph (500 kph).

Superconducting circuits are also a promising technology for quantum computing because they can be [used as qubits](#). Qubits are the basic units of quantum processors, analogous to but much more powerful than transistors in classical computers. Companies such as D-Wave Systems, Google and IBM have built quantum computers that use superconducting qubits. Though superconducting circuits make good qubits, they pose some technological challenges to making quantum computers with large numbers of qubits. A key issue is the need to keep the qubits at very low temperatures, which requires the use of large cryogenic devices known as [dilution refrigerators](#).

Promise of room-temperature superconductors

Room-temperature superconductors would remove many of the challenges associated with the high cost of operating superconductor-based circuits and systems and make it easier to use them in the field.

Room-temperature superconductors would enable ultra high-speed digital interconnects for next-generation computers and low-latency broadband wireless communications. They would also enable high-resolution imaging techniques and emerging sensors for biomedical and security applications, materials and structure analyses, and deep-space radio astrophysics.

Room-temperature [superconductors](#) would mean MRIs could become much less expensive to operate because they would not require liquid helium coolant, which is expensive and in short supply. Electrical power

grids would be at least 20% more power efficient than today's grids, resulting in billions of dollars saved per year, according to my estimates. Maglev trains could operate over longer distances at lower costs. Computers would run faster with orders of magnitude lower power consumption. And quantum computers could be built with many more qubits, enabling them to solve problems that are far beyond the reach of today's most powerful supercomputers.

Whether and how soon this promising future of electronics can be realized depends in part on whether the new room-temperature superconductor material can be verified—and whether it can be economically mass-produced.

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