Physicists create first superconductor hybrid nanoscale heat transistor

July 25 2007, By Miranda Marquit

Low temperature research has been at the forefront of cooling applications for quite some time. One project, a nanoscale heat transistor, has been built in Finland in cooperation with an Italian researcher at the Helsinki University of Technology.

This is the first heat transistor of its kind, making use of a hybrid of normal metal and a superconductor. The results of the project are explained in *Physical Review Letters* in a piece titled, “Heat Transistor: Demonstration of Gate-Controlled Electronic Refrigeration.”

One of the scientists working on the project, Matthias Meschke, tells *PhysOrg.com* that the heat transistor represents a step toward creating more convenient cooling devices. “Right now this is very fundamental, and more for research. But the principles could be used in the future, especially for space applications.” Some of these applications include cooling for radiation detectors sent into space, as well as the possibility of using such heat transistor technology for imaging sensors.

The biggest advantage of this tiny heat transistor is its nanoscale size. “Conventional cooling techniques are nice, but you normally need big and heavy equipment,” Meschke points out. “We have these things, but they take a great deal of effort and expense. These kinds of heat transistor devices might help to reach low temperatures without that same effort.”

Another discovery made by the Low Temperature Laboratory in Finland also centers around the use of gates in the transistor device. Normally, in more traditional transistor schemes, gate voltage is used to control the electrical current. Meschke and his colleagues discovered that gate control can also affect the temperature.

“In principle, “ explains Meschke, “this is very easy. We have superconductors connected via tunnel junctions to a piece of normal metal and you apply voltage between two junctions from the battery. An applied voltage to the gate then allows us to control the flow of individual electrons. We can tune the contact further so that only the hot electrons can escape. This results in cooling.”

But the heat transistor doesn’t just work in one direction. The process can be switched so that rather than a cooling effect, it is possible to get a heating effect. “This is good because it really proves that our concept is sound and works in both directions,” says Meschke.

Meschke and his Helsinki University of Technology peers were excited because they built the transistor as a single electron device. Meschke explains: “If you want to increase the sensitivity, you make it as small as you can. However, when you make a device as small as we did, a single electron can change the energy so a second cannot follow. Shrinking the device can stop it from working. This is where the gate helps. It makes it possible to control the electrons, and allow this tiny device to work.”

The Helsinki team managed to build the device so that it operates at a temperature right around 1/10 of a degree above absolute zero. Meschke stresses that right now the science is fairly basic, and this discovery is more of a step in understanding the potential for nanoscale, single electron refrigeration technology. “We hope to take this further,” he says, “and try to reach even lower temperatures and provide research on how these electrons work so that they can be used in future applications.”

Citation: Physicists create first superconductor hybrid nanoscale heat transistor (2007, July 25) retrieved 27 April 2024 from
https://phys.org/news/2007-07-physicists-superconductor-hybrid-nanoscale-transistor.html