New, Unusual Semiconductor is a Switch-Hitter

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(PhysOrg.com) -- A research group in Germany has discovered a semiconducting material that can switch its semiconducting properties -- turning from one type of semiconductor to another -- via a simple change in temperature. This intriguing behavior may make the material useful in efforts to create better performing integrated circuits, which form the backbone of almost all electronic devices.

Semiconductors are essential to integrated circuits, and any significant advances in semiconductor materials could mean big changes for the future of electronic technologies. For example, this new finding may further developments in data-storage technology. At a more fundamental level, the material could change how semiconductor chips are designed.

"This new material may be able to help simplify chip production in the future," the study's corresponding researcher, chemist Tom Nilges of the University of Muenster, in Germany, said to *PhysOrg.com*. "Instead of using two materials to build transistors for integrated circuits, there is now a reasonable chance that this job could be performed by a single material."

The material is a compound containing silver, tellurium, and bromine, abbreviated $Ag_{10}Te_4Br_3$. At three distinct temperatures—290 degrees Kelvin (K), 317 K, and 390 K (62, 111, and 242 degrees Fahrenheit, respectively)—the material changes from a p-type semiconductor (excess positively charged "holes," or electron absences) to an n-type (excess negative carriers), and back to a p-type. These changes are reversible.

Silver-based semiconducting compounds tend to have many interesting electrical properties, mainly because they can conduct both electrons and silver ions exceptionally well. This makes them useful in a variety of electronics applications. For example, they are being eyed as good candidates for a certain type of memory device.

Another possible application for these materials is in the relatively cheap production of electricity without the simultaneous emission of planet-warming greenhouse gases. $Ag_{10}Te_4Br_3$ may be particularly suited to this, as it has interesting thermal properties. For example, over the temperature range 355 K - 410 K, the material displays a strong and broad endothermic response, meaning it absorbs a large amount of heat from its surroundings.

In addition, it does not rapidly adjust its temperature in relation to its surroundings -- it has a very low "thermal diffusivity" -- and displays a huge thermopower drop, meaning the voltage across the material changes rapidly in response to changing temperature. Such a large thermopower change has not before been observed.

The ability of $Ag_{10}Te_4Br_3$ to switch from p-type to n-type and back again is the result of several complex structural changes it undergoes in response to the changing temperature. In combination, these changes allow the material's electrical properties to morph so dramatically. Some of the tellurium ions form mobile chains; the silver ions coordinate to those chains. There is also a shift in the concentration of charge carriers—electrons and holes—which is connected with the chain-forming tendency of tellurium.

Future research into $Ag_{10}Te_4Br_3$ may focus on its potential to allow fine-tuning of its physical properties, beyond the changes caused by temperature alone.

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