Electronic congestion in the microchips of the future

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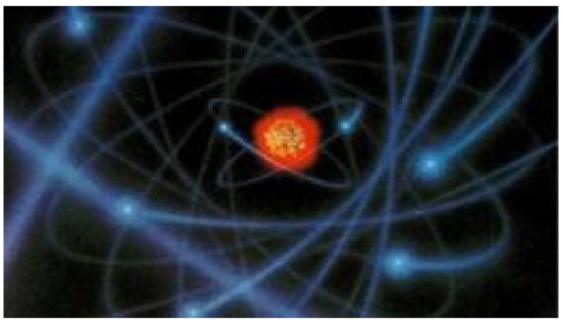

Credit: 2012 EPFL

(Phys.org) -- Electrons within some materials can stick together like cars on a traffic jam. Swiss researchers studying promising materials for the future of electronics have been able to highlight this phenomenon

Countless researches have been carried out on new promising materials for the world of electronics, such as graphene or molybdenite. Their bi-dimensional structure, that is: consisting of a single layer of atoms, has paved the way to an increasingly advanced miniaturization of chips, to flexible screens, as well as to a greater efficiency in computer systems. But what about the electrical conductivity of these new materials? Are they as reliable as traditional silicon?

Researchers at the Ultrafast Microscopy & Electron Scattering laboratory (Lumes) at EPFL have highlighted some situations where the flow of electrons can be disrupted. The results of their study were recently published in the scientific journal *PNAS*.

The scientists focused on a material with a distinctive structure that causes electrons to move in a single line of atoms. They found that these electrons could sometimes stick together, as it happens in a slowdown caused by a traffic overload on the highway. A "traffic jam" that occurs in the space of a few femtoseconds (10^{-15} s). This causes the material to pass from being a conductor to becoming an insulator.

This phenomenon can also occur in bi-dimensional materials, for example due to the vibration between two atoms. Additionally, it sometimes happens as a result of defects in the material or due to the presence of impurities like atoms of iron, gold or other metals. Even though they are present in very small quantities, these elements can change, in their surrounding area, the properties of the host material.

Advantage or disadvantage?

"There are so many researches and hopes pinned on low dimensional materials that it is crucial to properly understand their behavior and to be able to identify the microscopic phenomena taking place within them", says Fabrizio Carbone, one of the authors of the research. His work aims to understanding the way these ‘jams’ are formed in order to find means to avoiding or, on the contrary, triggering them. "This kind of disruption can be perceived as a malfunction or as an asset, depending on the application desired for this material," the scientist explains.

If the objective is to take advantage of the material’s property of transitioning from conductor to insulator, provoking or controlling the vibration that triggers such a transition will be required. This can be done by a laser whose wavelength will be determined, or by the intervention of an electric field. On the other hand, if a material with a good conductivity is desired, it will be manufactured so as to eliminate the sources of this vibration. This can be achieved by removing the material's impurities or by transforming the structure of the unit cell where the atoms are organized.

More information: Evidence for a Peierls phase-transition in a three-dimensional multiple charge-density waves solid, PNAS journal, April 2012.

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