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Researchers works on single molecular diode

March 7 2006

Researchers from the University of South Florida, the University of Chicago and the Russian Academy of Sciences (Moscow) have recently developed the principles of operation and completed an experimental testing of a single molecule for use as a diode. A paper explaining their research has just been accepted for publication in *Physical Review Letters* by the American Physical Society.

"Single molecule diodes are the fundamental building blocks of an emerging technology called 'nanoelectronics,' a field that holds promise for application in all kinds of electronic devices, from cell phones to sensors," said Ivan Oleynik, a physics professor at USF and coauthor of the paper. "Molecular diodes could be built a thousand times smaller than diodes in use now."

Computer industry execs might start breathing easier because their biggest fear - that smaller and faster devices will eventually come to an end because silicon microchips will get so small that eventually they will contain too few silicon atoms to work - might be lessened as advancements in molecular electronics come to the rescue.

"Molecular electronics is enabling an area of nanoscience and technology that holds promise for the next generation of electronic devices, said Oleynik. "Single molecular electronic devices rely on organic molecules with electronic responses tailored through synthetic organic chemistry."

Functioning at under several nanometers (a nanometer is a billionth of a meter), the molecular diode studied by the team of researchers acted as a rectifier (diode) because of the chemical asymmetry in different parts of an organic molecule comprised of both thiophene and thiazole. As a major component of electric circuitry, a diode is responsible for conducting electrical current by working something like a light switch, but allows current to flow only forward. The first diodes were large vacuum tubes, and most modern diodes are based on solid-state semiconductors.

“Molecular nanoelectronics is an exciting area of science not only because of its potential but because it is highly interdisciplinary, combining physics, chemistry, materials science, computational science and engineering,” explained Oleynik.

The team’s most recent finding and the basis for their publication was an explanation of how the intrinsic chemical asymmetry of “designer” molecules results in rectification of electrical current. The left and right parts of the organic molecule interact differently with electrons that “tunnel” through the molecule. Importantly, the electronic interactions with the left and right parts of the molecule respond differently to the change of the polarity of applied voltage.

The potentially bright future of molecular electronic technology is calculated on an ability to control molecular structure. Much of the work is yet empirical and involves “chemical intuition” as a driving force in molecular design as well as the applications of molecular devices.

“The next step is in developing the virtual integrated prototyping of molecular devices and optimizing their electronic functionalities by choosing the most appropriate chemical composition that has desirable electronic properties,” explained Oleynik. “This will require the development of a scientific understanding of electron transport through molecules as well as the introduction of new concepts and new language to explain such transport.”

Success in pioneering the field of molecular electronics would mean new life could be breathed into Moore's Law, the prediction made by Intel's Gordon Moore in 1965 that the density of transistors on a chip would double very 18-24 months. While Moore's observation has been true, everyone in the industry knows that there has always been a limit to the number of atoms that would render a device smaller, cheaper, faster but still operable. New technology that would expand the limits of microelectronics has been a continuing quest.

"Molecular electronics is a viable alternative that may reach the ultimate limit of miniaturization – one molecule per transistor, diode or switch," concluded Oleynik.

Source: University of South Florida, by Randolph Fillmore

Citation: Researchers works on single molecular diode (2006, March 7) retrieved 24 April 2024 from https://phys.org/news/2006-03-molecular-diode.html