Major advance made in imaging of a single-molecule switch

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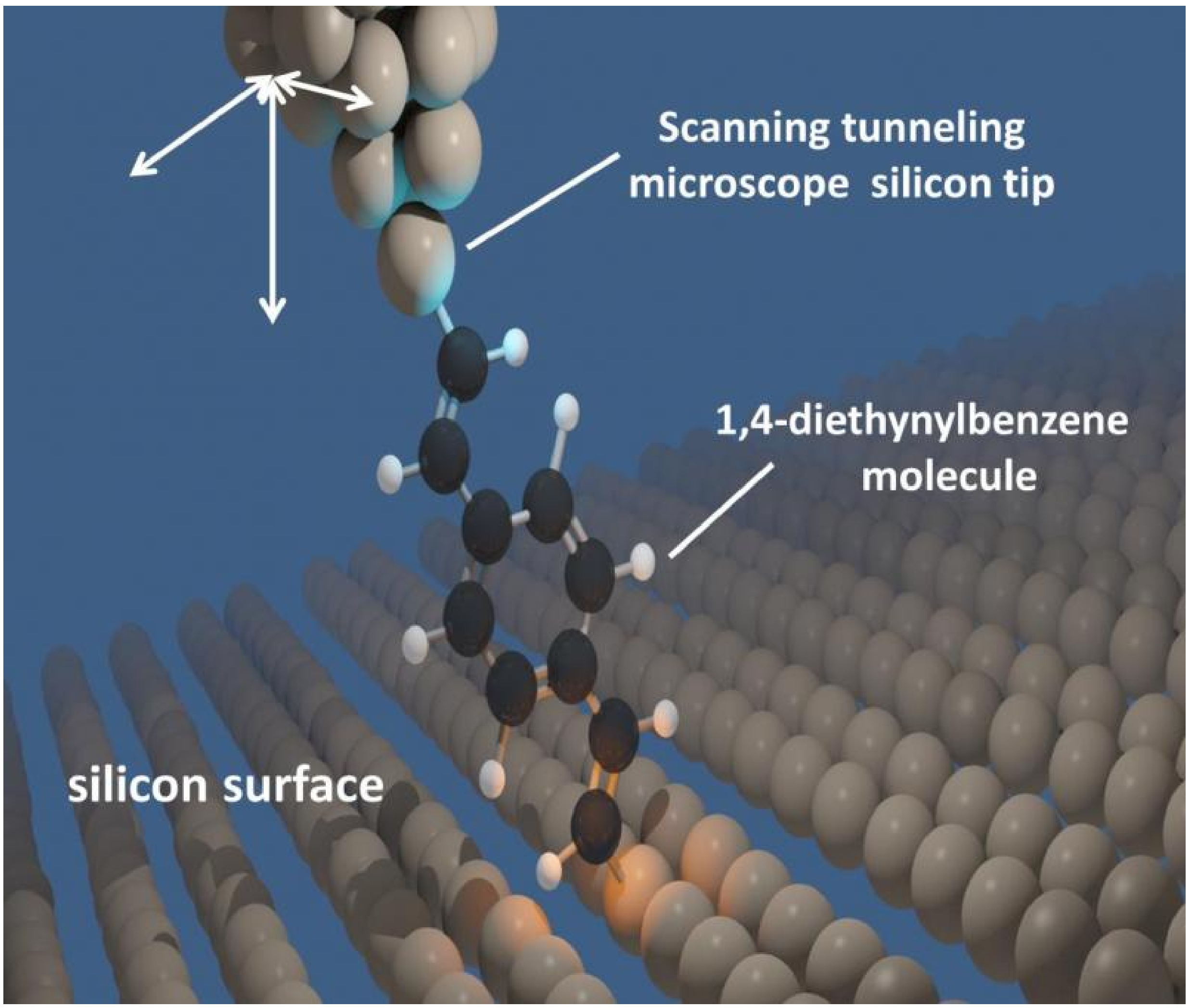

Molecular conductance

Development of future technologies will be greatly aided by understanding and extracting molecular-level characteristics. A University of Tsukuba research group has established a three-dimensional probe that can depict the switching of a single molecule between two different conformations, induced by a mechanical force.

This achievement is particularly encouraging because of the markedly different levels of conductance of electrical charge by the molecule in these different conformations, which could be used in molecular-sized devices.

This study involved binding individual molecules between two silicon electrodes, creating a robust "molecular junction." Altering the distance between these electrodes—in other words, applying different levels of mechanical force to the individual molecules attached between them—showed that the electrical current conducted by these molecules changed. For one molecule tested, the electrical current changed gradually as the distance decreased or increased, as would be expected. However, for another molecule, there was an abrupt change in the conductance, which was shown to correspond to a switch in this molecule's overall conformation.

"We created such molecular junctions for divinylbenzene and diethynylbenzene," explains lead author Miki Nakamura of the Graduate School of Pure and Applied Sciences in the University of Tsukuba. "Using our dynamic probe based on scanning tunneling microscopy, we were able to show that applying a mechanical force to the former resulted in a gradual change in the conductance of the molecule. However, for diethynylbenzene, we saw the conductance dramatically change, which we modeled as a switch from a cis to a trans conformation and back again."

This work builds on earlier studies that successfully characterized the specific properties of individual molecules, such as flexibility, and spin properties. There were also previous suggestions that abrupt switching in the level of conductance of a molecule is related to its ability to transition rapidly between two different, stable conformations. However, the Tsukuba team are the first to directly image these changes.

Group leader Dr. Shigekawa of the University of Tsukuba Faculty of Pure and Applied Sciences is excited about the potential for this new development. "Our work could have widespread implications for basic research on the electronic properties of molecules, as well as for the development of molecular machines," he says. "The ability to combine solid state semiconductor electrodes with organic molecules into this type of junction boosts the potential for further advances in molecular computing."

More information: Miki Nakamura et al. Mechanically activated switching of Si-based single-molecule junction as imaged with three-dimensional dynamic probe, *Nature Communications* (2015). DOI: 10.1038/ncomms9465

Provided by University of Tsukuba