Effect of image-charges on electron transport better understood

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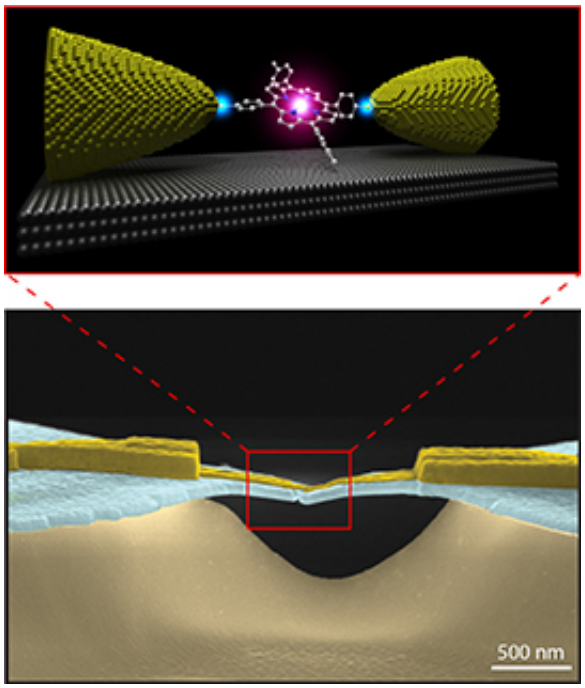

Diagram (top) of a molecule that has been attached to two gold electrodes (yellow in the figure). Electron microscopy image (below) of a break junction. The golden metal strip is broken in the middle; in the opening created a molecule is placed on which measurements can be performed.

Electron transport through a single molecule offers a highly promising new technology for the production of electronic chips. However it is difficult to make a good conducting connection between the molecule and the metal contacts. Researchers from the FOM Foundation, Delft University of Technology and Leiden University have discovered an effect that plays a major role in this: the so-called 'image-charges' in the metal contacts strongly influence the electron transport through the molecule. The molecular conduction can differ by several orders of magnitude as a result of this.

FOM workgroup leaders professor Herre van der Zant and professor Jan van Ruitenbeek published these results with their team online on 17 March in the renowned journal *Nature Nanotechnology*.

Molecular electronics

Molecules are very small and typically just several nanometres in size. A single molecule between two electrodes could be used as a highly sensitive sensor or extremely small transistor. However the problem in developing these 'molecular electronics' is that it is difficult to make electrical contact with a single molecule. This research has resulted in a better understanding of the fundamental physical behaviour of single molecules. This has led to ideas for using image-charges to realise electronic molecular components.

Alignment of energy levels

Image-charges occur in a metal due to the proximity of charge, such as that on the single molecule. The image-charges in the metal in turn influence the energy levels of the molecule. It was already know that this is how image-charges play an important role in charge transport through molecules. The image-charges can strongly shift the alignment of the molecular energy levels compared to the energy levels in the metal. That is how they cause an enhanced or diminished conduction. Now for the first time the researchers have systematically described this effect for a single molecule.

Combination of expertise makes measurement possible

By combining their unique areas of expertise, researchers from Delft and Leiden jointly developed a new technique to measure the molecular conduction. The method is based on the 'mechanically guided break junction' technique, invented by Van Ruitenbeek. In Delft, the technique has been expanded by incorporating it into a transistor. This technique makes it possible to vary

the distance between the electrodes and therefore the proximity of the molecule, so that the image-charge can be influenced. As a result of this the researchers acquired a unique mechanical and electrical control over the energy levels of the molecule. That allowed them to experimentally determine and quantify the role of the image-charges.

More information: Perrin, M. et al. Large tunable image-charge effects in single-molecule junctions, *Nature Nanotechnology* (2013). www.nature.com/nnano/journal/v … l/nnano.2013.26.html

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