Single molecule electronics and 'chemical soldering'

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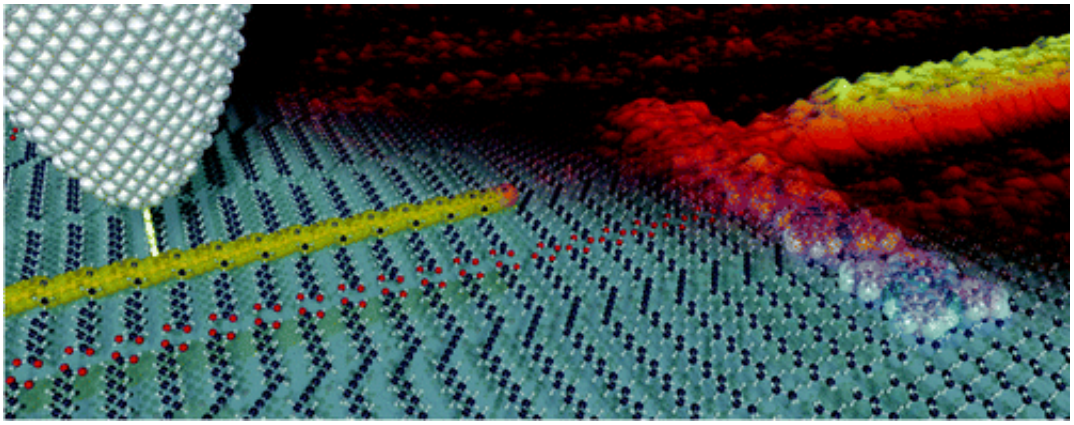

(PhysOrg.com) -- Single molecule electronics is a division of nanotechnology utilizing single molecules as electronic components and its study has the ultimate goal of reducing the size of common electrical circuits. Since 1974, when Mark Ratner and Arieh Aviram from IBM first described how a single molecule was capable of working as a diode in passing current in one direction, research has moved forward in trying to develop a way to use single molecule electronics.

However, the biggest obstacle has been how to wire up this molecule to begin with. Researchers have tried connecting metal electrodes directly, as well as attempting to connect them with conductive polymers, both with little success.

However, according to a study published in the Journal of the American Chemical Society, it appears there may be a breakthrough. Yuji Okawa from the National Institute for Materials Science in Japan and his team have developed a way to bond and wire single molecules. Starting with a monomolecular film of diacetylene on graphite substrate, they deposit phthalocyanine to form nanoclusters. With a tip of a scanning tunneling microscope, they apply a pulsed voltage across the tip and the phthalocyanine surface which initiates a chain polymerization of the diacetylene, forming a polymer nanowire which then bonds to the phthalocyanine molecule.

Okawa now plans to test these phthalocyanine molecules as diodes, with the ultimate goal of creating a single molecule electronic circuit. While the idea of single molecule electronics hitting the market is still a long way off, this new discovery is a breakthrough and gives one step closer to its possibility.

More information: Chemical Wiring and Soldering toward All-Molecule Electronic Circuitry, *J. Am. Chem. Soc.,* Article ASAP. DOI: 10.1021/ja111673x

Abstract
Key to single-molecule electronics is connecting functional molecules to each other using conductive nanowires. This involves two issues: how to create conductive nanowires at designated positions, and how to ensure chemical bonding between the nanowires and functional molecules. Here, we present a novel method that solves both issues. Relevant functional molecules are placed on a self-assembled monolayer of diacetylene compound. A probe tip of a scanning tunneling microscope is then positioned on the molecular row of the diacetylene compound to which the functional molecule is adsorbed, and a conductive polydiacetylene nanowire is fabricated by initiating chain polymerization by stimulation with the tip. Since the front edge of chain polymerization

necessarily has a reactive chemical species, the created polymer nanowire forms chemical bonding with an encountered molecular element. We name this spontaneous reaction “chemical soldering”. First-principles theoretical calculations are used to investigate the structures and electronic properties of the connection. We demonstrate that two conductive polymer nanowires are connected to a single phthalocyanine molecule. A resonant tunneling diode formed by this method is discussed.

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