MOLECULAR ELECTRONICS

The strongest link

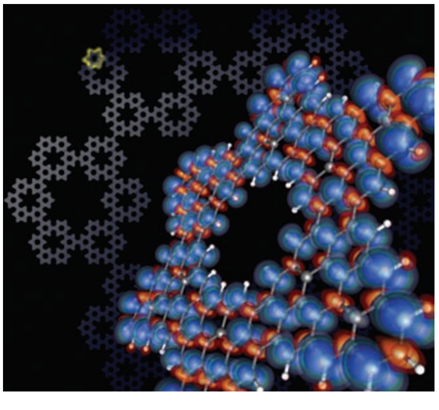
J. Am. Chem. Soc. **129,** 15768–15769 (2007)
Molecules terminated at each end with a chemical group that is capable of binding to a metal surface can be used to form a junction between two electrodes. The conductance characteristics of such molecules can be greatly influenced by factors such as their chemical structure, length and shape. However, little is known about the effect that different molecular end groups can have on the electronic properties of these systems.

Now, Latha Venkataraman and colleagues at Columbia University have compared the conductance of a series of alkane molecules terminated by three different chemical groups — amines, sulphides and phosphines. Junctions were created by moving the gold tip of a scanning tunnelling microscope in and out of contact with the surface of a Au electrode immersed in solutions of the different molecules. As the tip moved away from the electrode, the conductance decreased until the contact was reduced to a single chain of Au atoms. Pulling the tip further broke the contact, but in the presence of the alkanes, conductance was observed beyond this point, suggesting that the molecules were bound across the gap between the two electrodes.

When the different end groups were tested, it was observed that the alkanes terminated by phosphines gave the highest conductance . It is thought that this result stems from the fact that Au–P bonds are stronger than either Au–S or Au–N bonds, but the size and shape of the electron orbitals that interact with the gold surface also play a role.

GRAPHENE

Cut to size



Nano Lett. **8,** 241–245 (2008)
Graphene has a number of electronic properties that make it an ideal material for spintronics applications. The possibilities are all the more interesting for nanoscale graphene strips in which localized spins form along the edges owing to unpaired bonds.

A theoretical study from Efthimios Kaxiras and colleagues at Harvard University now explores the shape-dependent magnetic properties of graphene 'nanoflakes'. On the basis of a graphical analysis of the unpaired bonds of different graphene geometries — from triangles to complex looking snowflakes — the Harvard group predicts which shapes will have a finite spin. With the aid of first principles calculations, they determine how large this spin will be.

The spin on a triangular-shaped graphene flake scales linearly with the length of its side, or at least up to the point when the flake is a few nanometres in size. These flakes assume the properties of an infinite sheet of graphene. One other shape that is particularly interesting is a fractal 'star of David' in which it is shown that the spin state increases exponentially with the complexity — or fractal level — of the star edges.

BIOSENSING

Keeping it renal

Appl. Phys. Lett. **91,** 222101 (2007)
AlGaN/GaN heterostructures are used to produce high-power field-effect transistors, where a gate voltage modulates the source–drain current flowing through a two-dimensional electron gas (2DEG) at the AlGaN/GaN interface. This 2DEG is formed because of polarization effects, and counter positive charges are induced below the AlGaN surface. These positive charges are extremely sensitive to environmental conditions, leading to fluctuations in the source–drain current.

Now, Fan Ren and colleagues from the University of Florida, Gainesville, and Nitronex Corporation in North Carolina have exploited the environmental dependence of the source–drain current in these structures to detect a substance known as kidney injury molecule-1 (KIM-1), an important factor for early diagnosis of kidney disease. KIM-1 antibodies were immobilized on a 5-nm-thick gold gate electrode on top of the AlGaN layer by thiol-group-mediated self assembly. When the Au region is exposed to KIM-1, the carrier concentration of the 2DEG is altered owing to surface charge accumulation, resulting in a decrease in the conductance of the device.

The detection limit of 1 ng ml^{-1} KIM-1 for a 20×50 μm^2 sensing area and the compact size of the sensor should enable the use of AlGaN/GaN heterostructures as arrays for multi-analyte detection, thus overcoming limitations of conventional enzyme-linked immunsorbent assay protocols.

TOP DOWN BOTTOM UP

Give and take

Engineers, geneticists and microscopists have used carbon nanotubes to measure the electrical conductivity of single DNA molecules.

Understanding the electronic properties of DNA has been a controversial issue for a number of years, partly because it is difficult to be sure that you are measuring the DNA itself and not, for example, effects due to the electrodes or the surface that is supporting the DNA. Achieving good contact between the DNA molecule and the electrodes is a major challenge, which is why Wonbong Choi, an engineer at Florida International University in the US, decided to use carbon nanotubes for the electrodes rather than a traditional metal. Choi wanted to measure the electrical conductance of single- and double-stranded DNA, so he recruited experts in atomic force microscopy from POSTECH in Korea and geneticists from the National Institute of Genetics in Japan to work on the project.

The team suspended a single DNA molecule across a tiny trench and bonded each end to a single-walled carbon nanotube electrode that was deposited on a silicon wafer. Because the diameter of a nanotube (~2 nm) is similar to that of a DNA molecule, it was possible to measure electrical signals passing through the DNA molecule more accurately than in previous experiments with much larger metal electrodes. Choi hopes that such a measuring platform will lead to a better understanding of the properties of DNA and therefore help in developing techniques for reversing DNA damage caused, for example, by mutations (*Nano Lett.* **8,** 26–30; 2008).

Choi and his collaborators already knew each other, which helped them to overcome the cultural barriers between the US, Korea and Japan. "Communicating with a person who is in different research area and sending samples to foreign countries were the most difficult parts," Choi recalls, "but the rewarding part was that we could reach our goal in the shortest time. We also learned a lot from working in a multidisciplinary collaboration. The meaning of collaboration is 'give and take.'"

The definitive versions of these Research Highlights first appeared on the *Nature Nanotechnology* website, along with other articles that will not appear in print. If citing these articles, please refer to the web version.