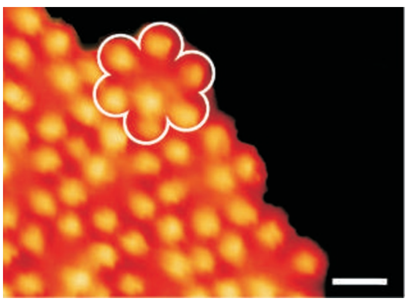
molecules. Now, John Polanyi and co-workers at the University of Toronto in Canada have found that a single surface Si atom — an adatom — switches between low (off) and high (on) conducting states when an adjacent pair of molecules — a dimer — undergoes a change of configuration.

Scanning tunnelling microscopy (STM) showed that on/off currents and switching rates were dependent on whether the adatom was sitting directly above another Si atom (faulted) or not (unfaulted). The switching rate varies with temperature, which means that the activation energy for the process could be calculated. It is suggested that stabilization of the faulted 'on' state by its sub-surface Si atom leads to a high activation energy for 'on' to 'off' switching in this arrangement. Theoretical calculations identified two similar dimer structures that corresponded to energy minima. Simulated STM images of the 'on' and 'off' states using these structures closely resembled the experimental images.

The density of states at the faulted adatom is shifted down by 1 eV when the switch is off. This is consistent with changes in the local electric field induced by variation of the molecular configuration of the dimer. Moreover, the magnitude of this shift is similar to that achieved by doping a semiconductor.

MOLECULAR DEVICES

Rack and roll



Nature Mater. **6,** 30–33 (2007)

Molecules designed to mimic the functions of macroscopic machines are often studied as large ensembles in which their individual characteristics are not observed directly. In this way, the precise atomic-scale motions of the components of such systems remain hidden amongst averaged overall behaviour.

Now, researchers in France and Germany have looked at a molecular 'rack-and-pinion' device in which a single molecule (the pinion) — reminiscent of a six-toothed cog — can be moved along the edge of a molecular island (the rack) comprising many copies of the same compound. Christian Joachim and colleagues from CEMES-CNRS in Toulouse and the Freie Universität Berlin used a scanning tunnelling microscope (STM) to move a molecular cog along the serrated edge of a self-assembled island on a Cu surface. The STM tip was placed above the centre of a single cog, pinning the molecule to the surface while still allowing it to rotate about its central axis. As the tip was displaced along the island's border, the cog moved with it to the next position along the 'rack'.

One tooth of the cog had a different structure to the others so could be distinguished during imaging and from this it could be seen that the displacements along the 'rack' resulted in successive 60° rotations of the cog.

GLUCOSE SENSING

Silicon's sweet spot

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Diabetes is a metabolic disorder that is characterized by the body's inability to regulate blood sugar levels. Considerable effort is expended on the development of fast, reliable and economical glucose sensors. Conventional electrochemical sensors use glucose oxidase — an enzyme — as the sensing element, but these are unstable under physiological conditions. Alternative enzyme-free sensors made using noble metals suffer from other deficiencies, such as electrode poisoning.

Now, Siu-Tung Yau and colleagues from Cleveland State University and the University of Illinois at Urbana-Champaign in the USA have made a high performance enzyme-free glucose sensor using 1-nm-sized silicon particles. Si_{29} particles were synthesized by the electrochemical etching of crystalline silicon and were then deposited on silicon substrates to act as Si_{29}–Si sensing elements. The Si_{29} particles act as catalysts for the oxidation of glucose and relay the electrical signal to the silicon electrode. A linear response for glucose levels up to 50 mM was observed.

The Si_{29}–Si electrode sensors did not suffer from electrode poisoning, were stable after repeated use over a 14-day period, and exhibited a four-fold enhancement response when compared with glucose oxidase based sensors. The superior performance of the silicon-based sensors is thought to arise from enhanced accessibility of the glucose to the Si_{29} particles and shorter electron tunnelling distances than in enzyme-based sensors.

TOP DOWN BOTTOM UP

Making connections

Researchers in robotics and materials science can solder components at the nanoscale.

After presenting at the NanoChina 2005 conference in Beijing, Lixin Dong from the Institute of Robotics and Intelligent Systems (IRIS) at ETH Zurich, Switzerland was approached by Xinyong Tao, a PhD student in materials science at Zhejiang University in Hangzhou, China. Tao was fascinated by the way nanorobots could manoeuvre individual nanostructures so they could be studied, and Dong agreed to characterize the field-emission properties of the copper-tipped carbon nanotubes that Tao had made.

Dong's initial measurements showed that the copper-tipped nanotubes did have better field-emission properties, as expected. But then he noticed something surprising: when a lower voltage was applied to the nanotubes over an extended period of time, it was possible to keep the nanotubes intact while allowing the copper to melt and flow out. Using a nanorobotic manipulator inside an electron microscope, the collaboration went on to show that the copper-tipped nanotubes could solder nanotubes together in a nanosized version of assembly lines found in the automobile industry (*Nano Lett.* **7,** 58–63; 2007).

"Bottom-up collaboration is often more effective than the top-down approach because the motivation is purely for the thrill of science, rather than simply to obtain additional funding", says Bradley Nelson, director of the IRIS lab in Zurich. He adds that this collaboration was not officially funded and relied instead on existing grants at IRIS and Xiaobin Zhang's laboratory at Zhejiang University.

Bradley has started several collaborations as a result of discussions at conferences. "Oral presentations are incredibly important because this is where strong impressions are made on the quality of the work and group," he says. "Don't be afraid to email authors of papers that are of interest, and don't worry about who gets credit, or where the funding will come from. With good work, there will be plenty of credit to go around, and avenues to apply for additional funding."

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.