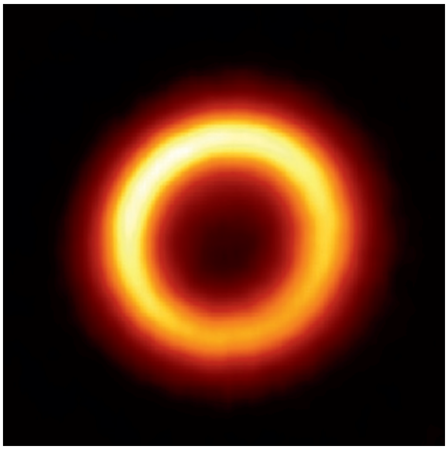
SCANNING PROBE MICROSCOPY

Zooming in on a single atom

Science **348,** 308–311 (2015)



AAAS

In recent years, the atomic force microscope (AFM) has been used to image organic molecules with submolecular resolution by attaching a carbon monoxide molecule to the end of the microscope's tip. This approach has also allowed, for example, different types of chemical bond to be discriminated and for reaction-induced changes in the bonds of single molecules to be followed. Now, Franz Giessibl and colleagues have shown that the technique can be used to image metallic atoms and clusters with subatomic resolution.

The researchers — who are based at the University of Regensburg and Ludwig-Maximilians-Universität München — first examined single copper and iron atoms adsorbed on copper surfaces. The atoms appear as toroidal structures, rather than as single protrusions as would be expected in a typical AFM image. This, they suggest, is due to the electronic structure of the atoms, and, in particular, is the result of electrostatic attraction in the centre of the atoms and Pauli repulsions at the edges. Moreover, the toroidal image depends on the bonding symmetry of the atom to the underlying surface structure. When the approach is used to image small clusters of iron atoms, the structures appear as connected tori with each atom discernible. *OV*

PHOTONIC METASTRUCTURES

Colour change with a stretch

Optica **2,** 255–258 (2015)

Light splits into its component colours when it interacts with a surface composed of periodic features separated by a distance comparable to the wavelength of the incident irradiation. The phenomenon is commonly used in diffraction gratings and an external observer will see a different colour depending on their position relative to the grating. Connie Chang-Hasnain and colleagues at the University of California at Berkeley have now used this principle to make a thin and flexible display device that changes colour as the device is stretched.

The researchers etch silicon ridges of nanometre-thickness in a wafer and then transfer them to a polymeric substrate. The final surface contains ridges of a high-refractive index material (silicon) that are separated by about one wavelength and embedded in a low-index matrix (the polymer). Using this specific design, almost all of the power of the impinging light goes into a diffracted ray, rather than being simply reflected. The upshot of this special case is that under white light illumination and at fixed angle of observation, the colour perceived by an external observer can be modified by changing the separation distance between the ridges. In a striking demonstration (https://youtu.be/ppmx-PlsiT8), Chang-Hasnain and colleagues stretch their photonic material by less than 5% and change the perceived colour from green to red without an appreciable loss of power. *AM*

QUANTUM DEVICES

Turning noise around

Phys. Rev. Lett. **114,** 146805 (2015)

Electrical noise is often an unwanted presence in electronic devices as it can hamper their operation. Fabian Hartmann and colleagues at the University of Würzburg and the University of St. Andrews have now found a way to harness noise, in the form of voltage fluctuations, to produce a direct current in quantum devices. Two semiconductor quantum dots are lithographically defined in an AlGaAs/GaAs heterostructure, separated by a distance of 150 nm. The first one is connected to an electron reservoir in which voltage fluctuations are induced by a noise source. The magnitude of the fluctuations can be controlled by a voltage. The second quantum dot is capacitively coupled to the first one, and connected to two leads in such a way that the flow of electrons from the left lead is unequal compared with that from the right lead.

Random voltage fluctuations experienced by the first quantum dot supply energy, via Coulomb interaction, to electrons in the second quantum dot. Because of the asymmetry in the left and right contacts of the second dot, a direct current — whose magnitude and direction depend on the noise amplitude and that can be controlled by gates — can be measured through the second quantum dot. The maximum current obtained is 10 nA, with a power of up to 24 pW. The researchers suggest that the device concept could potentially be used for energy harvesting at the nanoscale, although at present all measurements have been carried out at 4.2 K. *ED*

MOLECULAR COMPUTING

A logical connection

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Combining DNA- and enzyme-based logic circuits for the clinical testing of infectious and genetic diseases is advantageous because it increases the diversity of disease markers that can be recognized, and enables the processing of complex biological signals. So far, combined DNA–enzyme systems have involved enzymes that act directly on DNA, such as polymerases and endonucleases, but these enzymes cannot detect certain disease markers. Evgeny Katz, Dmitry Kolpashchikov and colleagues have now reported an interface that can connect output signals from enzymatic circuits with DNA computational systems.

The researchers — who are based at the University of Central Florida and Clarkson University — created the interface using two modified graphite electrodes. The first electrode, which communicates with the enzyme system, has a thin film of polyethyleneimine with pyrroloquinoline quinone (PQQ) covalently attached to it. The second electrode contains a DNA entrapped in an alginate thin film crosslinked by Fe^{3+}. PQQ catalyses the oxidation of nicotinamide adenine dinucleotide (NADH) — an output of the enzyme system — to produce a negative potential, which is sufficient to reduce Fe^{3+} to Fe^{2+} on the second electrode. This reduction dissolves the alginate and releases the DNA, which serves as an input for a DNA computing system. Katz and colleagues used two different enzyme systems that produce NADH to create a Boolean AND logic gate, and an OR gate connected to an AND gate. They show that through the electrode interface, the output of these enzyme circuits becomes an input to a DNA AND gate, which could potentially be used to detect cancer markers. *ALC*

Written by Ai Lin Chun, Elisa De Ranieri, Alberto Moscatelli and Owain Vaughan.