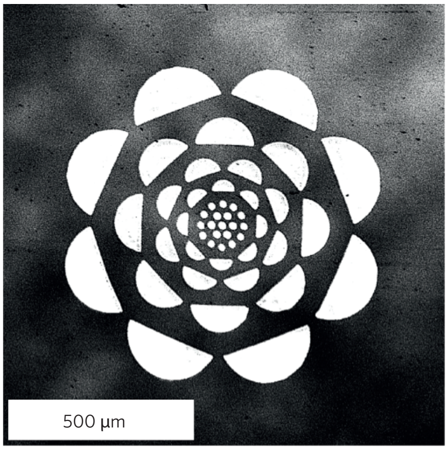
PRINTED ELECTRONICS

Nanotube resolution

Sci. Adv. **2,** e1601660 (2016)



AAAS

Printing electronic devices with very small features in a short time and in a reproducible way over large areas represents a significant technological challenge. Some printing techniques achieve nanoscale structures, yet they are not compatible with high-throughput production. Relief printing, also known as flexography, is one of the most common techniques used in roll-to-roll manufacturing. The smallest feature size that can be obtained by the method is tens of micrometres, which is a serious limitation for applications in flexible electronics.

Now, Kim *et al.* report on a new flexography method with sub-micrometre resolution that works on both rigid and flexible surfaces. The method is based on nanoporous printing stamps comprising vertically grown carbon nanotubes embedded in a polymeric matrix. The pore size is chosen in such a way that it is larger than the ink particles but appreciably smaller than the printed features. Complex printing designs are achieved via controlled nanotube growth on photolithographically pre-patterned silicon substrates. Once loaded with an ink, the stamp coated by mechanically robust carbon nanotube arrays comes into uniform contact with the target substrate and enables the printing of high resolution images. This technique is readily scalable to roll-to-roll manufacturing and offers at least tenfold resolution improvement over current industrial flexographic printing. *OB*

QUANTUM COMPUTATION

Qubits in a row

Phys. Rev. Appl. **6,** 054013 (2016)

Gate-defined quantum dots in semiconductors have been identified as hosts for high-fidelity quantum bits, storing the information in the spin state of the trapped charges. However, reproducing the physical properties of the dots is still a challenging aspect of their fabrication, undermining the realistic prospects for the implementation of quantum-computing tasks based on these devices.

Now, Zajac *et al.* report on the fabrication of nine collinear quantum dots with reproducible properties. The researchers pattern an undoped Si/SiGe heterostructure with aluminium-based screening layers and electrodes defining the dots, whose chemical potential and mutual tunnel coupling are tuned independently. Three additional collinear dots are also defined and used as single-electron charge detectors. By performing measurements of conductance and pulsed-gate spectroscopy, the researchers observe narrow value distributions for the charging and orbital-excited energies of the nine dots considered. Sensitive real-time detection capabilities for tunnelling events, with effective bandwidth up to 30 kHz are also demonstrated.

The researchers perform single-shot readouts of an electron spin trapped in one of the dots, quantifying spin-relaxation times in the order of hundreds of milliseconds. Remarkably, they also demonstrate a strong capacitive coupling between adjacent dot couples — a convenient property in view of the implementation of high-frequency computing tasks. *GP*

ARTIFICIAL PHOTOSYNTHESIS

Adaptable kind

Nano Lett. **16,** 7461–7466 (2016)

In conventional energy harvesting devices, steady power output is achieved via active feedback components such as voltage converters. The same requirement applies to solar cells that are not equipped with any internal regulation mechanism to account for natural variations in the incident solar power. This long standing issue of inefficient energy storage has now been addressed by Arp and colleagues, who propose a model describing a quantum heat engine photocell with an intrinsic mechanism for the suppression of energy fluctuations.

Similar to the case of photosynthesis in green plants, a heat engine with quantized energy levels converts the energy of solar photons into useful work. In the simplest case, a nanoscale light-harvesting photocell consists of two photon-absorbing channels with equal charge transfer probability but different energy input. When exposed to fluctuating solar energy, the quantum heat engine photocell stochastically switches between high and low power channels to yield steady-state output. Simulations reveal that this suppression mechanism is effective over a wide range of the solar spectrum with the exception of the green region, in which the regulatory benefits vanish and the two-channel quantum heat engine essentially behaves as a one-channel photocell. *OB*

BIOFUEL CELLS

What's in store

Angew. Chem. Int. Ed. **55,** 15434–15438 (2016)

A biofuel cell converts chemical energy stored in the chemical bonds of a biofuel, usually glucose, into electrical energy using enzymes. In the anode, glucose is oxidized to produce gluconolactone and give out electrons that are then routed through an external circuit to power a device. In the cathode, the electrons reduce oxygen to form water. When the fuel supply ends, the fuel cell stops working. Now, Pankratov *et al.* describe a charge-storing biofuel cell, a device in which the charges produced at the anode and the cathode form an integrated supercapacitor.

Like a biofuel cell, the device is composed of an anode where glucose is oxidized and a separated cathode where oxygen is reduced. Electrons produced in the anode reduce an osmium(III) compound to osmium(II), whereas the reduction of oxygen in the cathode is tied to the oxidation of the same osmium couple. As a result, a concentration (or, better, an activity) difference and therefore a voltage difference is generated between the two electrodes, akin to a supercapacitor. To discharge the supercapacitor one connects the anode and the cathode through an external circuit when needed.

The device proposed by Pankratov *et al.* can generate an open-circuit voltage of 0.45 V, meaning that virtually all chemical energy is stored as charges in the supercapacitor (no leakage currents). At discharge, the power density generated by this charge-storing biofuel cell exceeds that of the corresponding biofuel cell by a factor of 8. *AM*

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