hundreds of coils takes only a fraction of a second.

When a receiver coil has been detected, the nearest sender coil is activated to transmit power. Ideally, each sender coil would be addressed by a transistor. But organic transistors cannot easily handle the large currents required to transmit substantial power. So instead of transistors, the researchers have developed electrostatically activated mechanical switches, one for each sender coil. The switches are composed of two suspended polyimide cantilevers separated by an air gap. The inner surface of each cantilever carries an embedded control electrode and an exposed metal contact. When a voltage is applied between the control electrodes, the electrostatic force pulls the cantilevers together until the metal contacts touch and current flows to the sender coil. When the control voltage is removed, the cantilevers return to their 'switch open' positions.

The complexity of the system is remarkable. The sheet is composed of four arrays: sensing coils, transistors, sender coils and switches (Fig. 2). To keep the manufacturing process manageable, each of the transistor and coil arrays is prepared on a separate sheet of polyimide, and the switch array is made from three polyimide sheets. In the final step, the six sheets are laminated together. The finished sheet is only 1 mm thick, flexible and weighs only 0.1 g per square centimetre.

Where possible, the researchers have made use of printing techniques. The gate electrodes of the transistors and the control electrodes of the switches are made by inkjet-printing and subsequent curing of silver nanoparticles. The insulator layer between the gate electrode and the organic semiconductor of the transistors is made by inkjet-printing and curing of dilute polyimide precursors. The inductors are made from electroplated copper patterned by screen-printing. The cantilevers are cut from polyimide sheets by computer-controlled machining. To create interconnections across all six polyimide sheets, holes are drilled and filled by plating with silver solder. Only the transistors' organic semiconductor and metal contacts are prepared with conventional deposition techniques — evaporation through shadow masks.

Are we going to see power-transmitting wallpaper and carpets in our homes soon? Will my next laptop recharge by drawing power from a ceiling tile? The idea of no longer wading through cords and cables certainly carries a lot of charm. But I am also confident that the materials and methods showcased here in the form of a power-transmission sheet will create a wealth of other exciting opportunities. There is a great future for systems on plastic.

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BIOMIMETIC SYNTHESIS

Double-walled silica nanotubes

Many living organisms contain silica structures. A biomimetic synthesis process that uses a peptide as a template gives an opportunity for making a new kind of silica structure and understanding the details of how it forms.

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Biominerals are outstanding examples of nature's ability to produce intricately complex structures and patterns. Bones, teeth, shells, silica sponges and diatom cell walls all belong to this class of minerals (Fig. 1). Typically they are composites made of inorganic compounds and biomolecules. Their subtle and sometimes enigmatic composition and structure are the reason for their amazing properties. The discovery of some of the basic principles underlying the formation of biominerals has led to the burgeoning field of biomimetic materials synthesis, in which the aim is not simply to imitate nature but to create new classes of materials with unprecedented properties. Following this strategy, Emilie Pouget and colleagues have obtained double-walled silica nanotubes forming centimetre-long bundles, as reported on page 434 of this issue[1].

Silica is found in a number of biominerals, and the biomolecules implicated in its biomineralization have been intensively investigated[2–4]. A wide variety of silica structures such as nanospheres, platelets, nanocylinders and nanotubes have been synthesized by biomimetic approaches. All these studies have contributed to the current consensus that amine moieties in the template (the scaffold that directs the inorganic structure formation) play an important part in the self-assembly of silica structures from silica precursor species.

One of these templates is the peptide lanreotide, the behaviour of which Valery *et al.*[5] have carefully studied.This is a relatively small molecule (if compared with proteins that are involved in natural biomineralization processes) that in water solution self-assembles to form nanotubes with two exposed amine groups. So it would be tempting to assume that these nanotubes could act as templates on which silica could mineralize. However, the details of how mineralization proceeds are not yet established. Pouget *et al.* conducted their experiments with an open mind. It so happens that they discovered a new mechanism by which the silica phase and the lanreotide nanotube grow synergistically, almost in a concerted manner, by mutually neutralizing their charges (positive on the lanreotide and negative on the silica). Pouget and colleagues call this 'dynamical templating' because it requires the kinetic coupling of two chemical processes.

Another intriguing result is that instead of obtaining a single silica tube, Pouget *et al.* consistently find two concentric tubes. The walls of the tubes are separated by 2 nm, neatly corresponding to the thickness of the lanreotide tube. The walls of the silica tubes are unusually

Figure 1 Biominerals set an example of complexity and functionality. Their syntheses are inspirational to material scientists who explore new chemical routes to make materials.

thin (1.4 nm), and their length (up to 3 μm) and homogeneity is extraordinary. The dynamical template mechanism can explain these results: silica deposition occurs on both sides of the lanreotide molecule, and it stops immediately after the neutralization of surface charge. This is a very well-controlled process that yields a hierarchical structure from the nanoscale to the macroscopic level. The double-walled silica tubes form bundles that can be as much as a centimetre long.

The importance of this work does not simply lie in the production of a structurally very interesting material. The 'dynamical template' concept has potential applications in a variety of future biomimetic materials syntheses because it allows the production of superstructures greatly exceeding the size of the original template assemblies. Therefore, Pouget and colleagues' experiments represent an important advance because the current biomimetic approaches still fall far short of nature's perfection with respect to complexity and uniqueness of the materials obtained.

Biomimetic synthesis approaches offer a number of advantages over conventional inorganic synthesis routes. They usually work in 'mild' chemical conditions, which usually also implies lower consumption of energy and reduced release of environmentally unfriendly chemicals. Furthermore, it is hoped that biomimetic approaches will pave the way to synthetic routes that, as in the work of Pouget and colleagues, allow fine control of material structure across different length scales.

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SPINTRONICS

A nanomagnet oscillator

A direct electrical current can drive high-frequency oscillations of the magnetization of a nanomagnet. A current-tunable microwave oscillator has now been demonstrated that shows large-amplitude oscillations.

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The connection between electricity and magnetism has a long illustrative history starting with Oersted who, in 1819, showed that an electrical current passing near a compass needle causes it to rotate and reorient. This is understood as the result of the current producing a magnetic field that acts on the magnet, tending to align its magnetization direction with the field. A remarkable recent discovery is that current flow through a magnetic material may alter its magnetization by a mechanism that has nothing to do with magnetic fields. This new mechanism can cause a persistent oscillation of the magnetization in the presence of a constant current, which is not possible with the 'Oersted' magnetic fields otherwise associated with electric currents. On page 447 of this issue, Dimitri Houssameddine and colleagues show how to use this mechanism to generate large-amplitude magnetic oscillations at low currents without the need for an applied magnetic field[1]. Their oscillator makes use of the flow of electron spin and adds to applications of spin-based electronics, or spintronics.