FORCE MICROSCOPY

Ferroelectrics come alive

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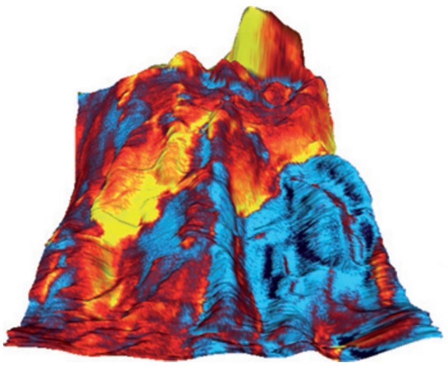

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Ferroelectric materials, which are used to make memories and sensors, exhibit a spontaneous electric polarization that can be reversed by applying an electric field. This property has been observed in numerous inorganic and synthetic substances, and is accompanied by piezoelectric and pyroelectric abilities in which polarization behaviour can be altered by mechanical forces or temperature, respectively. However, whilst piezoelectricity and pyroelectricity have been observed before in soft biological tissues, evidence of ferroelectricity in such materials has remained elusive. Jiangyu Li and colleagues at the University of Washington and Boston University have now shown that mammalian tissue can be both piezoelectric and ferroelectric.

The researchers used piezoresponse force microscopy — a scanning probe technique that detects local piezoelectric deformations of a material induced by an external electric field — to examine the walls of a pig aorta. To measure the piezoelectric effect at an aortic wall, the tip of the microscope was placed in contact with the sample and an a.c. bias was applied through the conducting tip to excite the piezoelectric vibration of the wall. To explore whether the walls were also ferroelectric, a sequence of d.c. voltages with a triangular saw-tooth profile were applied to try to switch the polarization of the material. An a.c. voltage was simultaneously applied to measure the corresponding piezoresponse. Phase–voltage hysteresis loops and amplitude–voltage butterfly loops, which are characteristic of polarization reversal, were obtained.

Li and colleagues suggest this biological ferroelectricity could have implications for cardiovascular and other diseases. *OV*

TITANIUM DIOXIDE NANOPARTICLES

A prevalent additive

Environ. Sci. Technol. http://doi.org/fx2g7b (2012)

Titanium dioxide is a common pigment added to paints, plastics, foods, pills and various cosmetic products, and its increasing use in the nano form has raised safety concerns. Until now, most toxicity studies have used the P25 variant, used in non-foodstuffs, but little is known about the E171 food-grade TiO_2 that is used as an anti-caking ingredient. Now, researchers at Arizona State University, ETH Zurich and the Norwegian University of Science and Technology have examined the nanoscale TiO_2 content of several foods and personal care products.

Using inductively coupled plasma mass spectrometry and other analytical methods, Paul Westerhoff and colleagues measured the titanium content of 89 different foods and 24 different personal care products that either listed TiO_2 on the label or had a white appearance. Of all the foods tested, sweets (including chewing gums, chocolates, white icing and powdered sugar toppings) had the highest titanium content per serving, and greater than 90% of the titanium was associated with the outer shell of the sweet. Scanning electron micrographs showed that the aggregates of TiO_2 isolated from chewing gum had a mean size of between 100 and 300 nm. No significant differences were seen in the titanium contents of generic and brand-name products. Although many white products contained titanium, dairy products such as cheeses, yoghurts, mayonnaise and whipped cream had low titanium contents.

Modelling suggested that children could be more exposed to TiO_2 than adults through eating sweets. Because of the prevalence of TiO_2 in foods, the researchers called for more environmental health and safety tests to be done on E171. *ALC*

GRAPHENE ELECTRONICS

Switching transistors

Science http://doi.org/hqc (2012)

Graphene transistors tend to draw power even when they are off, because large-area graphene does not have a bandgap. However, graphene can be modified to introduce a bandgap, for example, by cutting it into ribbons or functionalizing it, but this tends to interfere with other aspects of its performance. Kostya Novoselov and colleagues in the UK, the Netherlands, Russia, Portugal and the US have now demonstrated that graphene is well suited to an alternative architecture known as a tunnelling transistor, for which a bandgap is not necessary.

This device consists of two graphene monolayers separated by an atomically thin insulator. A bias voltage between the monolayers produces a tunnel current across the insulator, and a gate voltage between one monolayer and a gate electrode changes the carrier concentration in both monolayers, thereby controlling the size of the tunnelling current.

Novoselov and colleagues found that a boron nitride barrier led to an on/off ratio of 50 at room temperature. The control over current in this device depended on changes in the density of states available for tunnelling as carrier concentration changed. Higher ratios should be possible if current were instead limited by the tunnelling energy barrier. A prototype device operating in this regime was demonstrated using a molybdenum disulphide insulator, and achieved an on/off ratio of 10,000. *MS*

TWO-DIMENSIONAL MATERIALS

Let there be magnetism

ACS Nano http://doi.org/fx2ct5 (2012)

Two-dimensional materials such as graphene and molybdenum sulphide have mechanical and electronic properties that are useful for a variety of applications, but they are non-magnetic. These materials can be made magnetic by, for example, introducing transition metal atoms or point defects, but the resulting materials lack the stability and controllability needed for application. Now Ying Dai and co-workers at Shandong University have predicted that single layers of vanadium disulphide and vanadium diselenide should be magnetic.

Dai and co-workers used density functional theory to predict the electronic and magnetic properties of these materials, which contain a hexagonal layer of V atoms sandwiched between two layers of S or Se atoms. According to their calculations, pristine monolayers of both materials exhibit ferromagnetic ordering, with both the V and the S or Se atoms carrying a small magnetic moment. Moreover, they find that the magnetic moments and the strength of the magnetic coupling in VS_2 and VSe_2 increase as the strain in the monolayer is increased from −5% to 5%.

The Shandong researchers report that a combination of through-bond and through-space interactions is responsible for the ferromagnetic behaviour they predict. However, they caution that the introduction of local defects and strains during the growth of real samples will complicate the experimental detection of ferromagnetism in monolayers of VS_2 and VSe_2. *PR*

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