SELF-ASSEMBLY

Push to organize

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The bottom-up fabrication of materials relies on the assembly of molecules into large, ordered structures. Although molecules can be designed to self-assemble into organized structures, achieving this in technologically relevant environments, such as on surfaces or in thin films, has been difficult.

Researchers at the Instituto per lo Studio dei Materiali Nanostrutturati in Italy and the University of Edinburgh in the UK can now trigger molecules to self-assemble on a surface, and form structures with long-range order, by using an atomic force microscope (AFM) tip. Fabio Biscarini and colleagues deposited a thin film of rotaxanes — mechanically interlocked molecules in which a ring component is trapped on a dumbbell-shaped one — on a graphite surface and scanned an AFM tip across the film. The mechanical stimulus from the tip triggered the rotaxanes to self-organize into regularly spaced dots that could coalesce to form lines under the right conditions.

The researchers found that film thickness determined the size and spacing of the dots. Interestingly, this ability to self-assemble was not seen with other molecules and it worked only for certain types of rotaxanes. It was proposed that the mechanical perturbation from the tip provides energy for the molecules to reorganize themselves. This phenomenon could be exploited to produce dense arrays of organized dots for information storage applications.

COMPOSITES

Anti-fouling films

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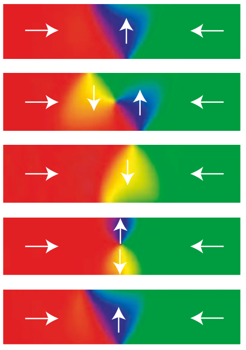
Protein adsorption, known as fouling, is a significant problem for implantable materials and surfaces prone to contamination, such as ship hulls and bioreactors. Incorporating the types of enzymes that break down proteins (proteases) into different polymer matrices can reduce fouling, but it is often difficult to add them at sufficiently high density or keep them active.

Now, researchers at the Rensselaer Polytechnic Institute in the US have overcome this problem by conjugating proteases onto single-walled carbon nanotubes to make a composite that effectively eliminates surface fouling. Jonathan Dordick, Ravi Kane and colleagues created the composite by attaching protease onto the nanotubes and dispersing them in a poly(methyl methacrylate) polymer matrix.

The protease activity was 30 times higher in this composite than in the control, where the enzymes were conjugated to a non-nanoscale graphite support. Composites incubated with proteins showed up to 95% less protein adsorption when compared with films without the enzymes or those on other supports. Moreover, the films were 'self-cleaning' — enzymes broke down proteins that adsorbed onto the films. Furthermore, surfaces coated with paint that contained the composite were able to resist protein binding.

NANOWIRES

Domain walls



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On a microscopic length scale, the magnetization of a ferromagnet is uniform. However, over macroscopic length scales, uniform magnetization is energetically unfavourable and domain walls — regions where the magnetization rotates — will form.

When the domain-wall width corresponds to one of the spatial dimensions of the ferromagnet itself, the wall shape may be confined, even if it is forced to move by an external magnetic field or current. Stuart Parkin and colleagues from the IBM Research Division in the US studied domain-wall formation and propagation in permalloy nanowires with diameters of 200 nm — narrow enough to permit a single domain wall — to better understand how magnetic field and current affect domain-wall shapes and dynamics.

The wires are indented on one edge so that when a domain wall forms and is forced to propagate along the wire length, it becomes pinned at the notch. The type of domain wall — essentially, the precise pattern of how the magnetization flips from one direction to the other — is determined by measuring the resistance along the wire. Importantly, the authors can monitor domain dynamics in real time and find that although currents affect domain-wall velocity, they have little effect on their precessional frequency.

TOP DOWN BOTTOM UP

Opposites attract

A hand-held magnetic probe made by physicists could find a place in cancer surgery.

Determining the spread of breast cancer at present involves locating, removing and microscopically examining the sentinel lymph node. However, a new device developed by Endomagnetics — a spinout company from the University of Houston and University College London (UCL) — could put the detection of the lymph nodes entirely in the hands of the surgeons. All the surgeon has to do is inject the tumour with a magnetic nanoparticle dye, wait ten minutes for the dye to accumulate in the lymph nodes, and then run the SentiMAG probe over the patient.

Quentin Pankhurst of UCL first met fellow physicist Audrius Brazdeikis of Houston through an initiative called the UK–Texas Bioscience Collaboration in 2003. They later teamed up with Simon Hattersley, a systems engineer, and co-workers to design and build the probe, which exploits the ability of a device known as a SQUID to detect extremely weak magnetic fields, such as those produced by the nanoparticles in the dye, even in busy and unshielded environments, such as operating theatres.

How did they know what surgeons wanted? "There is no substitute to getting out there, knocking on doors, and talking one-on-one to the people you think are going to benefit from what you want to do", says Pankhurst. "However, the medics and surgeons we really needed to talk to were precisely those who had hardly any time to talk to us."

A turning point, says Pankhurst, was a meeting with a famous breast cancer surgeon in London. "It took me five weeks to get a 15 minute slot with him, but once we were in his office, he immediately put me in touch with exactly the right person for us — an innovative breast cancer surgeon called Michael Douek who has been our champion and guide in the development of the probe".

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.