MULTIFERROICS

All in one

Nature Mater. doi:10.1038/nmat2185 (2008)

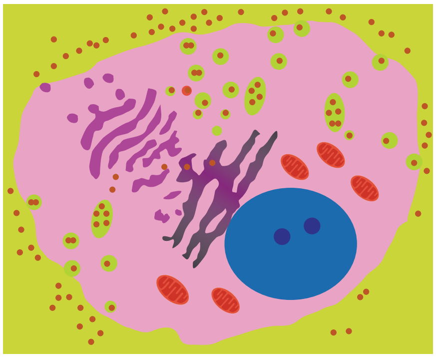
Materials that exhibit both ferroelectricity and ferromagnetism could have applications in data storage and spintronics. However, despite significant advances in our understanding of the physical properties of these multiferroic materials, difficulties in combining them with semiconductor electronics limits their use. Now, Igor Stolichnov of the EPFL in Lausanne and co-workers in Europe and New Zealand show that ferromagnetism in (Ga,Mn)As — a well-known magnetic semiconductor — can be controlled by applying voltages to a ferroelectric gate electrode[1].

This group made devices comprising a 7-nm-thick conducting channel made of (Ga,Mn)As and a 200-nm-thick gate made of a copolymer (polyvinylidene fluoride with trifluoroethylene). The combination of a magnetic semiconductor and a copolymer — which produced good polarization characteristics when annealed at the relatively low temperature of 140 °C — was critical to the success of the devices.

Applying a voltage to the polymer gate changed its polarization state, which in turn changed the Curie temperature — the temperature above which a ferromagnetic material is no longer ferromagnetic — of the (Ga,Mn)As channel. These results could lead to the development of ferroelectric-gate field-effect transistor devices.

NANOBIOREACTORS

It takes three


© 2008 ACS

Nano Lett. **8,** 1368–1373 (2008)

Polymers have been used to deliver drugs, enzymes and a host of diagnostic agents into cells as they can be easily engineered to have useful properties such as specificity and stability. Now, researchers from the University of Basel have shown that certain blends of polymers are stable enough to be used as nanoscale bioreactors that could act as functional components of the cell.

Patrick Hunziker and colleagues made the vesicles by joining three types of polymer chains together to form a tri-block copolymer. The vesicles (typically less than 200 nm in size) were loaded with trypsin — an enzyme that cleaves certain peptide bonds — and functionalized with a ligand so that they targeted macrophages, which are specific cells of the immune system known to be important in various diseases. Fluorescent staining shows that the vesicles enter the macrophages and remain stable for a long time, and that the trypsin inside the vesicle is able to process peptide substrates added to the cell culture. The vesicle membrane protects the trypsin from the external environment while allowing the peptides to enter, thereby forming a nanoreactor inside the cell.

The authors suggest that vesicles made with various combinations of polymers, ligands and enzymes may be targeted to cells to modify functions involved in diseases such as cancer and atherosclerosis.

OPTICS

Liquid lasers

Nano Lett. doi: 10.1021/nl080661a (2008)

Quantum dots are routinely used in imaging applications, especially in the life sciences, but researchers are still developing a more detailed understanding of their optical properties in order to make lasers based on quantum dots. One problem is that as the quantum dots get smaller, transitions that do not contribute to lasing become more likely. However, Lijun Wang and co-workers at the University of Erlangen and the Ludwig Maximilians University in Munich have shown that liquid droplets containing nanocrystal quantum dots can lase at densities some two orders of magnitude lower than previously reported or predicted by theory.

Wang and co-workers dissolved quantum dots with a cadmium selenide core and a zinc sulphide shell in a solution of water — with glycerine added to avoid evaporation — and then used a home-built device to generate droplets with diameters ranging between 10 and 50 μm. The quantum dots had a core radius of 2.6 nm, which gave a peak in the photoluminescence at a wavelength of 625 nm. Because the droplets were charged, they could be trapped by electric fields, which allowed the Erlangen-Munich team to excite them with a laser and stimulate laser action.

Dots without a shell did not lase because, the authors argue, the ZnS coating reduced photo-oxidation of the CdSe core. Why the system lased at such a low quantum-dot density is not clear, but the authors suggest it may be because the dots accumulate near the surface of the droplet, rather than being distributed uniformly throughout it.

TOP DOWN BOTTOM UP

Bridging two cultures

Self-assembled nanofibres have been used to promote the growth of neuronal cells in mice after spinal cord injuries.

It was over a sushi lunch that John Kessler, a neurobiologist in the Medical School at Northwestern University, learned about self-assembling peptide amphiphiles from Sam Stupp, a materials scientist at Northwestern. In aqueous solutions these amphiphiles — which have hydrophilic, hydrophobic and peptide segments — self-assemble into cylindrical nanofibres, with the peptides displayed at very high densities on the outside. After *in vitro* testing of various samples from Stupp's lab, Kessler and co-workers showed that amphiphiles containing the IKVAV peptide fragment could support the growth of neuronal cells while keeping the cells that make scar tissue at bay.

Reckoning that it might be possible to treat spinal cord injuries with the nanofibres, Kessler's team injected the amphiphiles into the spinal cords of mice that had been compressed to simulate an injury. They found that the treatment led to regeneration of motor and sensory fibres at the site of the lesion. Furthermore, the treatment reduced cell death in the area and encouraged the growth of oligodendroglia (the cells that form the insulating sheaths around neuronal cells). The behaviours of the mice also improved considerably compared with those treated with saline solution or a solution in which the IKVAV peptides were not part of the self-assembled nanofibres (*J. Neurosci.* **28,** 3814–3823; 2008).

"The most rewarding part of the collaboration was our ability to merge technologies to, we hope, eventually impact on the treatment of human disease," says Kessler. "The most difficult part was convincing the different cultures of our professional fields of the potential of nanotechnology in medical research. I had to learn at the very beginning how the density of peptides presented to a cell can change the properties of the materials. Most medical researchers do not fully appreciate this point."

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.