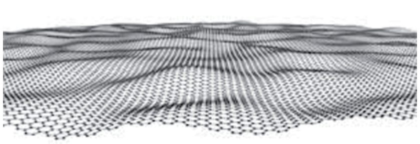
phys. stat. sol. (RRL) **1**, No. 3, A40–A41 (2007) / **DOI** 10.1002/pssr.200750016

Solid state and materials research news

Ultrathin graphene sheets

Researchers at the Max Planck Institute for Solid State Research Stuttgart and the University of Manchester have created the thinnest membranes possible. They consist of only a single layer of carbon atoms: graphene [1]. Despite the thinness of the membranes, they are extremely stable. The reason for this is that the membranes are not perfectly flat, but slightly corrugated – a form that gives the ultra-thin material stability – comparable with corrugated cardboard. "These two-dimensional membranes are completely different to ordinary 3D crystals," says Jannik Meyer from the Stuttgart Institute. "We have just begun to explore the fundamental properties and possible applications."
Since its discovery two years ago, graphene has rapidly become one of the most provocative topics in solid state physics [2]. However, it had remained doubtful whether the materials could exist without the support of a substrate. In order to fabricate graphene, only a pencil is principally needed: By rubbing ordinary graphite onto a surface, flakes of varying thickness break off from the layered material. Some layers are thereby formed that are only a monolayer thick. In order to find these and further process them, a microfabrication method was used. As a base, the researchers used a silicon crystal with an exactly calibrated oxide film. This was the only way that they could make out the graphene monolayer in the microscope by means of its very slight colour change. They then overlaid this with a metallic scaffold made from very fine gold wires. In the next step, the researchers dissolved the Si substrate in various acids. This permitted the graphene to hang freely on the scaffold. Fabricated in this manner, a graphene membrane between the wires has a surface of approximately 1 μm^2.
These ultra-thin membranes may find use, for example, in filtering out gases, to make miniaturized ultrafast electro-mechanical switches or as a non-obscuring support for electron microscopy to study individual molecules. "We have now demonstrated that extremely thin membranes that are only one atom thick can be produced. And we also believe that this technology can be adapted for use in real applications," says Andre Geim from the University of Manchester. "It still remains a challenge, however, to be able to fabricate these membranes economically and on a larger scale."
(Source: Max Planck Society)



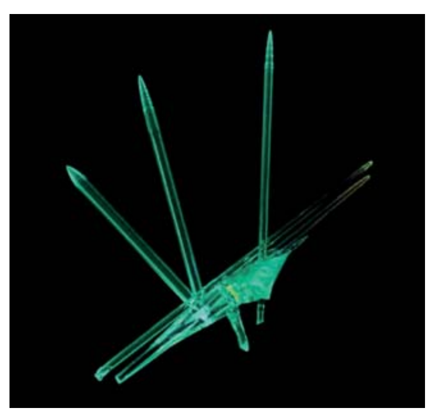
Model of a graphene membrane – only one atom thick

The thinnest material that will ever exist: The arrows point to a monolayer membrane hanging on a scaffold of fine gold wires (marker length: 500 nm) (Figures: MPI-FKF)

[1] Nature **446**, 60 (2007).
[2] See, e.g., phys. stat. sol. (b) **243**(13) (2006).

Workshop on ZnO

The 4th International Workshop on ZnO and Related Materials was held from 3–6 October 2006 at the Justus-Liebig-University Giessen, Germany. The workshop brought together 208 scientists from 24 countries presenting 148 contributions. The workshop covered the diversity of current ZnO research, ranging from optical, electrical and structural characterization over growth to processing and devices of ZnO materials. Latest achievements in p-type conductivity, electronic devices and LED structures were discussed.
Detailed reports on the growth of polar and non-polar ZnO films and ZnO/(Zn,Mg)O quantum well heterostructures were given by J.-M. Chauveau (CRHEA/CNRS), Shengbai Zhang (NREL) and H. Kato (Yokohama). Main issues were homoepitaxial growth and the key technology of making ZnO substrates epi-ready. Progress in ZnO bulk growth and the application of nanostructures for bio-sensors and nanodevices were hot topics in talks by D. Klimm (Berlin), G.-C. Yi (POSTECH) and X. W. Sun (Singapore). A further focus was on stimulated emission (C. Klingshirn, Karlsruhe [3]), ultrafast exciton and biexciton dynamics (C. C. Yang, Taipei), surface-related emission in nanorods (L. Wischmeier, Bremen) and optical characterization of ZnMgO films (H. Shibata, AIST).
The session on the state-of-the-art of p-conductive ZnO covered aspects of N and P doping (J.-P. Mosnier, Dublin), type-conversion from n- to p-type in ZnO : P (A. Allenic, Michigan), the codoping approach in ZnO : N, Ga (Tae-Hwan Kim, Gwangju), and compensation effects in ZnO : N (Xiaonan Li, NREL).
Latest developments on room temperature ferromagnetism and applications for spintronics were presented. Besides Mn as the favorite dopant, J. Dumont (Namur) and E. Schlenker (Braunschweig) demonstrated that ZnCoO and ZnVO may be promising material combinations.
Great progress has been achieved in the field of 2DEG (H. Tampo, AIST) and high mobility transport in ZnO/MgZnO heterostructures (A. Ohtomo, Sendai). In the last session, Zhizhen Ye (Zhejiang) and Y. C. Liu (Changchun) provided insight into the problems of ZnO-based LED fabrication and GaN/ZnO heterostructure



An unusual look at the green luminescence of rod-shaped ZnO crystals under ultraviolet excitation.

diodes (see also [4]). Recent developments in thin film transistors and organic/inorganic hybride structures were finally discussed by J. Phillips (Ann Arbor) and R. Yakimova (Linköping).
Yicheng Lu from Rutgers University, USA, will chair the next workshop to be held at Eagle Crust, Michigan, in 2008.

A. Hoffmann, Tech. Univ. Berlin, and B. K. Meyer, Univ. Gießen

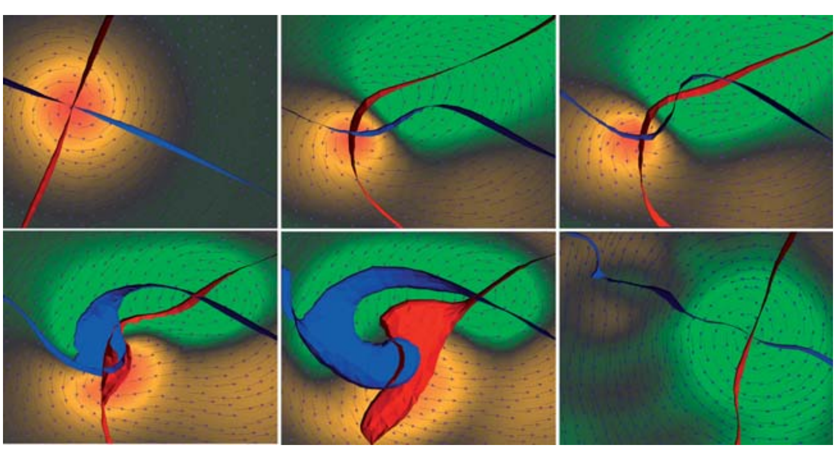
www.zno-giessen.de

[3] Chem. Phys. Chem. **6**, 782 (2007).
[4] phys. stat. sol. (b) **244**, 1439 (2007).

Ultimate speed record for magnetic switching predicted

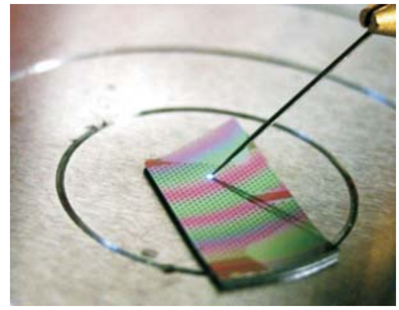
Scientists have found a fundamentally new magnetic switching method which achieves the fastest speed ever reported by applying an external magnetic field [5].
In µm-sized disk-shaped magnets the magnetization can naturally align to form vortex structures. In the vortex core the magnetization points perpendicular to the surface, either up or down. This naturally lends itself to applications in binary data storage, especially as the magnetization direction is very stable caused by exchange interaction. Only by exploiting this strongest magnetic force does it become possible to flip the core without applying very strong fields.
Using state-of-the-art computer simulations, the group of Riccardo Hertel at the Institute of Solid State Research (IFF) of the Research Centre Jülich has demonstrated a way to flip the core with very short and relatively weak pulses. Owing to the strength of the exchange force the processes are extremely fast: “The main result of the study is that the magnetic core can be flipped from ‘up’ to ‘down’ and vice versa by applying a magnetic field pulse that can be as short as 5 ps – nearly a hundred times faster than the fastest computer processor”, Hertel explains. “Within a few picoseconds, the field pulse distorts the magnetic structure to the point where a vortex–antivortex pair is created in addition to the already existing vortex. This is followed by an annihilation process which leaves only one vortex behind, pointing down if the original vortex was up.” This mechanism appears to be the most complex reversal presently known in nanomagnetism.
Besides its extremely high speed, a remarkable aspect of this finding is that it unfolds automatically: The applied field only perturbs the magnetization, which then undergoes these complicated changes as it recovers equilibrium. “These findings represent a promising leap towards smaller length scales and shorter time scales in magnetic data storage applications”, affirms co-author Claus M. Schneider, director at the IFF.
(Source: Research Centre Jülich)

[5] Phys. Rev. Lett. **98**, 117201 (2007).



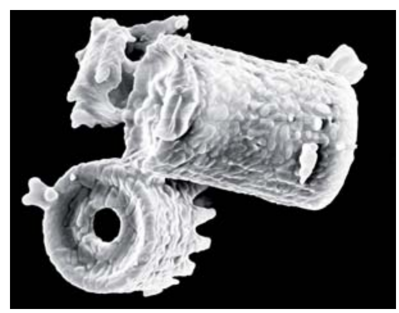
Reversal of a vortex core: a vortex–antivortex pair is created (top right) and annihilated (bottom left, middle). The centres of the (anti-)vortices are at the crossings of the red and the blue ribbons. The orientation of the vortex core: changes from „up“ (orange) to „down“ (green) (Figure: FZ Jülich).

News in brief



➔ **Armin Dadgar**, Institut for Experimental Physics of the Otto von Guericke University Magdeburg has won the **Gaede Prize** sponsored by the German Vacuum Society. He received the honour for his outstanding achievements in the growth of crack-free GaN layers on Si and progress based thereon, especially for the development of LEDs [6].

[6] phys. stat. sol. (c) **4**, 41 (2007).



➔ Zhihao Bao et al. from Georgia Institute of Technology have demonstrated a low-temperature magnesiothermic reduction process for converting three-dimensional nanostructured silica micro-assemblies into **microporous nanocrystalline silicon replicas** [7]. The diatom microshells were converted while retaining their outer fine structure. Earlier, the group of Kenneth H. Sandhage had already produced zinc silicate-coated microparticles with biologically well-controlled 3D shapes (figure) [8]. These simple and scalable methods may be used to synthesize functional microparticles with a variety of shapes and tailored silicate chemistries. A first application for NO gas sensing was suggested.

[7] Nature **446**, 172 (2007).
[8] phys. stat. sol. (a) **202**, R105 (2005).