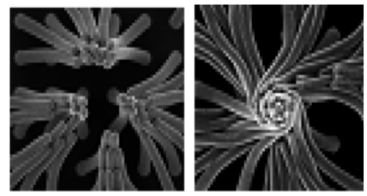
Tuning In to Nanofiber Assembly

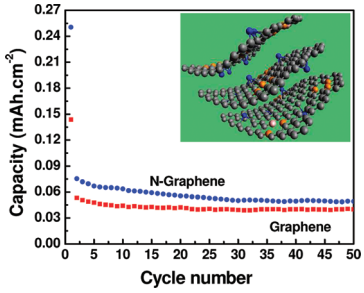
Synthetic nanofibers created by evaporation-induced assembly are a topic of growing interest because of their many potential applications, including in particle trapping, structural color, and adhesives that mimic those used in the natural world by geckos and insects. Despite several reports detailing self-assembly of synthetic nanofibers, researchers still know little about what factors influence size and growth kinetics.

To investigate how geometry, mechanical properties, and surface chemistry work together to influence nanofiber self-assembly, Kang *et al.* (p 6323) undertook a comprehensive study using nanopillars with tunable characteristics. They fabricated these nanopillars using negative elastomeric molds of fibrous arrays, assembling polymeric nanopillars after evaporation of applied liquid. The researchers altered various characteristics of these structures in each iteration of the nanopillars. For example, they changed resulting nanofiber size by coating the pillars with a metal film to increase thickness or etching pillar surfaces with oxygen plasma to decrease diameter, or changed modulus by adding a softener or stiffener to the polymer. Importantly, they also varied adhesion by treating polymeric samples with plasma to activate reactive surface functional groups. Microscopy showed that organization of the fibers into bunches or unique chiral formations depended not only on their size and shape but also on their surface chemistry. While previous studies have suggested that capillary-induced self-assembly relied only on competition between capillary and elastic forces, adhesion also appears to play a critical role. The authors suggest that the interplay among each of the forces they studied could be exploited to create a diverse array of tunable structures.



Building a Better Lithium-Ion Battery

Ever since Li-ion batteries were commercialized by Sony Laboratories in the early 1990s, these carbon-based rechargeable batteries have become the energy storage device of choice for numerous electrical devices. To help increase the energy density and specific capacity of these batteries, researchers have tested various versions of carbon electrodes. Dopants such as phosphorus, boron, and boron–nitrogen have been shown to raise specific capacity significantly compared to pure carbon. The single-atom-thick sheets of carbon known as graphene have also been suggested for use in electrodes due to their unusual electrical properties, including extraordinarily high conductivity. However, early versions of Li-ion batteries incorporating graphene electrodes have suffered from weak adherence between the electrode and current collector, leading to poor electron transport and loss of electrical contact with extended cycling.

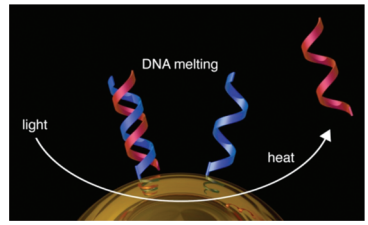


Seeking a way to combine chemically doped carbon with an improved use of graphene, Reddy *et al.* (p 6337) synthesized N-doped graphene films applied directly to copper current collectors. The researchers used chemical vapor deposition to grow either N-doped graphene or pristine graphene onto the copper substrates. Cyclic voltammetry measurements showed that Li could reversibly intercalate and deintercalate into the N-doped graphene electrodes, and further tests showed that the reversible discharge capability of the doped graphene was nearly twice as high as pristine graphene, a property probably due to the doped graphene's surface defects. The authors suggest that these properties, as well as the ability to grow N-doped graphene directly onto current collector substrates, could make this material a useful addition to current battery technology as well as future flexible thin-film batteries.

Nanoparticles: The Golden Ticket for DNA

Gene therapy and antisense therapy could be boons for patients with cancer, Huntington's disease, and numerous other genetic diseases. However, designing vehicles to deliver the selected genes or oligonucleotides into the cells has proven challenging. The best-studied candidate vehicles are viral vectors, but these have been difficult to manufacture and are associated with serious health risks. Gold nanoparticles, which can release attached DNA or nucleic acid when heated with certain wavelengths of light, have been proposed as a potential solution. However, using pulsed laser irradiation to break the Au–S bond that anchors thiolated single-strand DNA to the particles' surfaces can destabilize particles. On the other hand, using continuous-wave lasers to denature double-stranded DNA, releasing one strand, can be prohibitively slow.

Seeking a method that harnesses the benefits of pulsed lasers without the negative consequences, Poon *et al.* (p 6395) evaluated the use of various levels of pulsed laser power and salt content solutions containing nanoparticles decorated with double-stranded DNA. To see whether their methods favored Au–S bond breaking or thermal denaturing, the researchers used two different types of DNA in which either strand attached to the nanoparticle or the complementary strand was fluorescently labeled. If the labeled strand detached, the tags would emit fluorescence. The researchers found that by irradiating the decorated nanoparticles with a low intensity laser combined with supplementing the solutions with salt highly favored thermal denaturing by a ratio of 6:1. The authors suggest that these results could shed much-needed light toward advancing gold nanoparticles as delivery vehicles for genes or oligonucleotides.

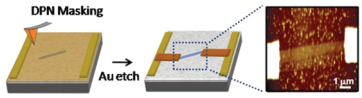


Published online November 23, 2010.
10.1021/nn102953q

Penning a Graphene Electrode Masterpiece

Due to its high room-temperature mobility, graphene has attracted increasing attention as a next-generation material for nanoelectronics, including field-effect transistors, chemical sensors, and as an electron acceptor in photovoltaic devices. Electron-beam lithography (EBL) is the usual method of creating graphene-incorporated nanodevices. However, electron-beam irradiation can damage graphene and affect device performance.

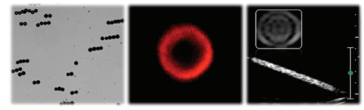
Seeking a new method for creating graphene-incorporated electrodes without EBL, Wang *et al.* (p 6409) turned to dip-pen nanolithography (DPN), a scanning probe-based technique that combines the nanoresolution of EBL with the direct writing abilities of microcontact printing. The researchers fabricated devices by thermally evaporating Au onto graphene exfoliated on a layer of SiO_2. They then used DPN to apply a masking layer of 16-mercaptohexadecanoic acid to monolayer graphene only, leaving the multilayer graphene to be etched away by O_2 plasma after Au etching. A second Au etching revealed the isolated monolayer graphene. Using DPN again, the researchers patterned macroscale Au electrical contacts to the graphene on the substrate using parylene-C masks. Tests showed that resistance measurements for these devices were comparable to those previously reported for graphene electrodes. However, closer inspection showed that Au deposition and subsequent etching damaged some pieces of graphene, introducing cracks and leaving Au nanoparticle residue. By introducing a sacrificial polymer layer between the graphene and Au thin film, the researchers were able to mitigate graphene cracking but not the nanoparticle residue. These findings suggest that DPN is a viable way to create graphene-incorporated electrodes, with possible improvements on sheet resistance with further troubleshooting.



Better Ultrasounds with Nanoparticle-Coated Bubbles

Ultrasound imaging has proven its worth for a variety of medical applications, ranging from viewing tissue injuries to pregnancies. However, this type of imaging is relatively low contrast, a factor that can be improved through the use of microbubbles that provide a difference in echogenicity in comparison with soft tissue. If such microbubbles were coated with nanoparticles, they could also be used to enhance contrast in other imaging modalities such as magnetic resonance imaging (MRI) or fluorescence. Although nanoparticle-loaded microbubbles have been synthesized in earlier research, production has been challenging, expensive, and time-consuming.

Looking for a better way to create nanoparticle-coated microbubbles, Park *et al.* (p 6579) developed a single-step approach that relies on microfluidics. The researchers fed CO_2 with minute amounts of N_2, O_2, He, and Ne under pressure into a microfluidic aqueous solution containing a mixture of lysozyme, alginate, and metal oxide, metal, or semiconductor nanoparticles. Upon entering the stream, the CO_2 rapidly dissolves and creates an acidic environment, leading the lysozyme to adsorb to the bubble surface. The nanoparticles and alginate then layer themselves onto the bubbles due to electrostatically mediated attraction. This process, which takes place within 3 s, produces nanoparticle-coated bubbles with a narrow size distribution and the ability to remain stable in storage for at least 3 months. Ultrasound tests showed that the NP-coated microbubbles produced a significantly stronger signal enhancement compared to nanoparticle-free bubbles. Similarly, the metal oxide bubbles produced an enhanced negative contrast in MRI. The authors suggest that their microbubbles could eventually serve as a versatile, single contrast agent in medical diagnostics where multiple imaging modalities are required.



Laying a Trap for Prion Proteins

Prion diseases, caused by interaction between a conformationally altered form of the membrane-bound prion protein and its normal form, can be genetic, infectious, or sporadic. These neurodegenerative diseases have been well-studied in both humans and animals. However, researchers have yet to discover curative treatments for these diseases or an *ante mortem* assay since the low infectious concentration of prion particles limits the use of standard techniques such as ELISA or Western Blot. Because prions' folding and stability are thought to be influenced by environmental factors and the effect of local confinement, having a way to immobilize this intrinsically disordered protein could lead to new ways to study it and the potential for developing diagnostic tests.

In a step toward these goals, Sanavio *et al.* (p 6607) used nanografting, an atomic force microscopy-based technique, to immobilize prions in two different orientations on a flat surface. On a thin gold film covered by a protein-repellant self-assembled monolayer, the researchers nanografted metal chelating thiols. They then functionalized these "nanopatches" with two histadine-tagged antigen-binding fragments of antibodies (Fabs) that bound different residues of recombinant mouse prion protein. After challenging these surfaces with a saturating solution of the protein, contact mode atomic force microscopy measurements showed that the different Fabs captured the prion protein in two different orientations. This was evident in a discrepancy in heights between proteins bound to the two Fabs. The authors note that this successful system may also be useful for studying other intrinsically disordered proteins, such as α-synuclein and β-amyloid peptide.