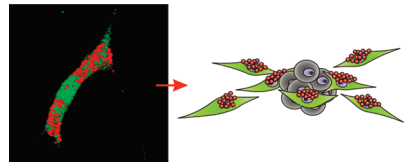
Cancer Therapy in a Patch—For Cells

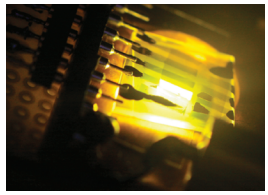
Nanostructures are potential tools for targeted cancer therapy. Previous studies have shown that nanoparticles can target tumors passively and be taken in by the leaky vasculature of the tumor. More importantly, nanostructures can be used as vehicles for the directed delivery of chemotherapeutics. However, many barriers remain to fully realizing this tool, such as the potential for rapid clearance of nanostructures by the liver, kidney, and immune system. To bypass these barriers, some researchers have sought to take advantage of stem cells, which possess tumoritropic properties in some systems. Stem cells have already been shown to internalize Au nanoparticles and to deliver them to tumor spheroids.



In a new study, Cheng *et al.* (p 625) suggest that delivering nanostructures to the outsides of stem cells might have advantages over having the cells carry nanostructures internally, such as more effective delivery of drug payloads and reduced toxicity to carrier cells. To test this idea, the researchers developed adhesive nanoscale patches treated with NeutrAvidin, which binds to biotinylated cell membranes. These patches demonstrated long-lasting adhesion, remaining firmly bound to cells after 2 days in media. Further examination with human mesenchymal stem cells showed that the patches did not affect the cells' tumoritropic properties; cells with and without patches oriented equally well toward tumor spheroids. Experiments with human umbilical vein endothelial cells indicate that the patches also do not affect other functional properties, such as the ability to form multicellular structures. The authors suggest that this construct could offer a novel way to deliver cancer therapeutics to cells.

Light-Emitting Devices Go All Organic

Organic light-emitting diodes (OLEDs) have progressed quickly from concept to application in the past two decades, bringing low-voltage, ultrathin, and energy-efficient lighting and displays to market in the form of displays in televisions, cameras, and mobile phones. These devices are typically built in a "sandwich" structure, with two charge-injecting electrodes surrounding an organic light-emitting layer. Though these devices have demonstrated remarkable efficiency, they still require at least one metal electrode, a factor that complicates manufacturing.

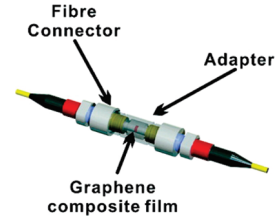


Seeking a way to develop light-emitting devices that operate without metal electrodes, Matyba *et al.* (p 637) developed the light-emitting electrochemical cell (LEC). The structure of this device is similar to OLEDs, but the light-emitting polymer is blended with an electrolyte. The mobile ions in the electrolyte rearrange when a potential is applied between the electrodes, forming high charge-density layers at each electrode interface, allowing efficient and balanced injection of electrons and holes into the polymer. The researchers designed their new device using chemically derived graphene as a cathode, a screen-printable conducting polymer as a partially transparent anode, and a micrometer-thick active layer solution-deposited from a blend of a light-emitting polymer and a polymer electrode. Tests showed that their device displayed quantum efficiency and power conversion efficiency values close to state-of-the-art for conjugated polymer LEC devices, though the researchers suggest considerable room for improvement. These findings suggest that low-voltage, inexpensive, and efficient light-emitting devices can be made truly organic, without the need for metal electrodes.

Graphene and Lasers Become Ultrafast Friends

Ultrafast laser sources have garnered considerable attention for their many potential applications, ranging from meteorology to telecommunications, medicine, and materials processing. Most of these lasers employ a mode-locking technique in which a nonlinear optical element, called a saturable absorber, turns the laser's continuous wave output into a train of ultrashort optical pulses. Currently, semiconductor storable absorber mirrors (SESAMs) dominate passive mode-locking, but these have a narrow tuning range and require complex fabrication and packaging. Single-walled carbon nanotubes (SWNTs) have been suggested as a simpler and cost-effective alternative. However, when operating at any specific wavelength, nanotubes not in resonance are not used and give insertion losses, leading to suboptimal device performance.

In a new study, Sun *et al.* (p 803) suggest that graphene could offer an ideal solution for passive mode-locking. The researchers tested this idea by designing an ultrafast fiber laser mode-locked at 1.5 μm, the most common optical telecommunications wavelength, using single-layer graphene and few-layer graphene flakes. The graphene was incorporated into a polyvinyl alcohol (PVA) composite, which served as the saturable absorber. Tests show that the composite can be used over a broad spectral range, unlike SESAMs. Also, further investigation indicated that wideband operation could be achieved with the as-prepared material with no need for special procedures, such as the chirality or diameter selection needed for SWNTs. For a given wavelength, the graphene mode-locked laser displayed performance comparable to that previously achieved with SWNTs. The authors suggest that this new laser extends the practical potential of graphene from nanoelectronics to optoelectronics and integrated photonics.



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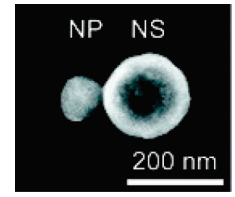
Nanoparticle Heterodimers: A Perfect Mismatch for Unusual Plasmonic Properties

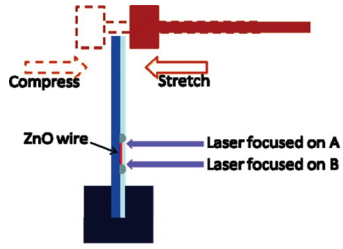
Studies have demonstrated that, when two metal nanoparticles are placed in close proximity, the properties of their surface plasmons, or collective electron oscillations, are dramatically modified. These variations are the basis for numerous applications, including sensors. Homodimers, or pairs of nanoparticles with indistinguishably identical properties, have been studied extensively in this regard. However, pairs of metallic nanoparticles with differing properties, or heterodimers, are not nearly as well-studied or understood. These structures are anticipated to give rise to new physical effects not seen in matched nanoparticle pairs.

To gain insight into these novel properties, Brown *et al.* (p 819) coupled solid nanoparticles of various sizes with each other or with silica–Au nanoshells, creating six types of heterogeneous pairs. They then examined the optical properties of individual plasmonic heterodimers using polarization-dependent dark-field microspectroscopy, correlating their findings with scanning electron microscopy images of each dimer. For these mismatched pairs, the researchers found that size disparity between nanoparticles results in significantly more complex plasmon mixing behavior than in the case of homodimers. The smaller nanoparticle of the pair can couple to the dipolar and higher-energy multipolar modes of the larger nanoparticle. Further examination suggests that plasmon hybridization, combined with energy shifts due to phase retardation, allows modes to couple to an even greater extent, creating the Fano resonance sometimes seen in heterodimer pairs. The authors suggest that, as studies of plasmonic structures extend to more complex geometries, it is likely that these, or analogous, effects will be seen in the properties of more structures.



Customizing ZnO Wire Devices with Light and Strain

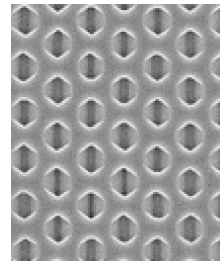
Semiconductor nanowires serve as the principal components for fabricating a wide range of nanodevices, with ZnO nanowires and nanobelts widely studied as key one-dimensional (1D) oxide nanomaterials for numerous applications. Researchers have taken advantage of the unique piezoelectric and semiconducting properties of ZnO to create numerous novel nanodevices based on this oxide, including nanogenerators, piezoelectric field-effect transistors, piezoelectric diodes, and strain sensors. The ZnO direct band gap of 3.4 eV and a large exciton binding energy at room temperature also make this material a promising candidate in optical applications, such as ultraviolet detectors, optical pumped lasers, and light-emitting diodes. Despite considerable progress into the possibility of these various applications, very limited research has been conducted on the localized and quantitatively controlled coupling of the piezoelectric effect and photoexcitation on a ZnO nanowire device.



To overcome this deficit, Hu *et al.* (p 1234) fabricated various devices using a single ZnO micro/nanowire. They then studied electric transport characteristics while introducing a controllable stepping strain and using a focused laser beam. The piezoelectric effect tends to raise the height of the local Schottky barrier at the ZnO–metal contact, and photoexcitation using a light that has higher energy than the band gap of ZnO lowers the Schottky barrier. The researchers found that, by tuning the relative contributions of these effects, the local contacts could be tuned stepwise or transformed from Schottky to ohmic, or ohmic to Schottky. The authors suggest that this tunable property could eventually serve as the basis for fabricating piezo-photoelectronic nanodevices.

Making Tunable Waves with Rhombic Plasmonic Crystals

Periodic metallic nanostructures, such as plasmonic crystals in two dimensions (2D), have been considered as potential plasmonic components for thin-film photovoltaics, light-emitting devices, optical switches, label-free sensors, and negative-index metamaterials. Most work on these crystals has focused on highly symmetric lattices, such as square and hexagonal lattices. However, three other types of lattices exist in 2D: oblique, rectangular, and rhombic. Because of the difficulty in creating large-area, subwavelength plasmonic crytals with arbitrary lattice symmetries, the effects of lattice symmetry on the optical properties of these crystals is not well understood. Additionally, the angle of incidence and the azimuthal angle relative to the lattice direction are complicated and affect the surface plasmon polariton-light coupling process. Few systems have been investigated out to large angles because the patterned areas were not sufficiently large.



To understand these properties better, Zhou *et al.* (p 1241) used a variation of soft interference lithography to produce rhombic plasmonic crystals having areas in the range of square centimeters. Optical examinations of these structures showed that the rhombic crystals generated more plasmon modes compared to more symmetric lattices within a fixed wavelength range. Excitation directions along low-symmetry lattice directions were able to lift degeneracies in the dispersion diagrams to form more resonances. The researchers also observed anti-crossings resulting from coupling between different plasmon modes in dispersion diagrams. These corresponded to regions of slower surface plasmon polariton propagation and further concentration of the localized fields. The authors suggest that their versatile fabrication method may provide new opportunities to design plasmonic crystals with arbitrary 2D lattices so that plasmons can be easily tuned over a broader spectrum.