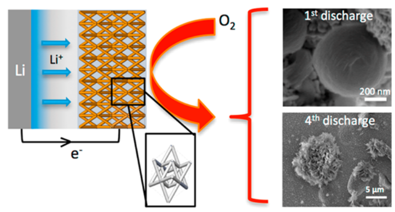
$Li-O_2$ Battery Cathode Gets the Golden Touch

$Li-O_2$ cells have the potential for gravimetric specific energies several times higher than state-of-the-art Li-ion batteries. Consequently, they have attracted increasing attention for their potential to power electric vehicles, which could use these devices to travel more than 300 miles before recharging. However, developing practical $Li-O_2$ batteries has been hampered by a lack of chemical stability among positive electrode materials, along with poor catalytic activity toward the oxygen reduction reaction. Early research in this area focused on carbon-based materials. However, these materials tend to accumulate Li_2CO_3 with cycling, leading to rapid degradation in performance. Alternatively, some researchers have looked to microlattices, cellular materials with periodic structures and tunable densities. Their macroscopic, well-structured pores could potentially accommodate large amounts of discharge products while minimizing transport losses, and their large surface areas could effectively lower discharge currents.

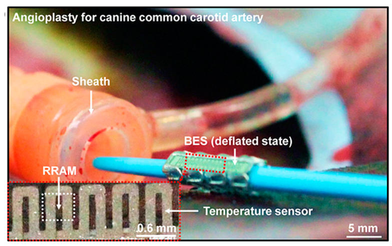
In a new study, Xu *et al.* (DOI: 10.1021/acsnano.5b00443) investigate the feasibility of using one such microlattice, composed of Au, as a $Li-O_2$ battery cathode. Cells with these cathodes were discharged in lithium-bis(trifluoromethane)sulfonamide in a 1,2-dimethoxyethane electrolyte, with lithium metal foil as the anode. Scanning electron microscope images taken after the first discharge showed toroidal-shaped particles covering the cathode, which disappeared after charging. Subsequent analysis showed that these particles were composed mostly of Li_2O_2. After multiple cycles, the discharge product evolved into platelet-shaped particles with higher proportions of Li_2CO_3 and LiOH. The authors suggest that these findings showcase the promise of using a three-dimensional microlattice as a $Li-O_2$ cell cathode, with further optimization possible using alternative fabrication methods and materials.



A New Opening for Treating Endovascular Diseases

Balloon angioplasty and stent placement procedures have revolutionized the treatment of a variety of cardio-, neuro-, and peripheral vascular diseases. While bare metal stents do restore blood flow to ischemic areas, they also come with a host of limitations, including cell migration into and around the stent, which reduce their effectiveness over time. To reduce the risk of in-stent restenosis, researchers have investigated several approaches, including resorbable stents and drug-eluting stents. Despite their utility, these interventions are missing some potentially useful features, such as feedback on blood flow and temperature, controlled delivery of drugs and other therapeutic modalities, onboard sensing, and data storage.

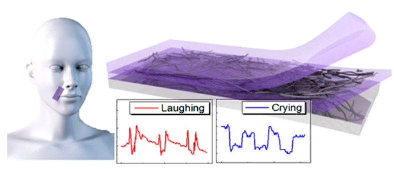
In a new study, Son *et al.* (DOI: 10.1021/acsnano.5b00651) report the development of a new bioresorbable/bioinert stent that incorporates all these functions. The base of the stent is a Mg–Zn–Mn alloy, which is bioresorbable. This base is coated with a polymer containing therapeutic nanoparticles. These include ceria nanoparticles, which scavenge reactive oxygen species and lower inflammation, and gold nanorod core/mesoporous silica nanoparticle shells, which can be loaded with drugs that can be released with directed heat while also providing hyperthermic therapy. This latter therapy can be precisely controlled using incorporated temperature sensors. Blood flow sensing further adds to the device's functionality. Data from these sensors are stored using a resistive random-access memory (RRAM) array and can be exported by using the Mg strut as an antenna for wireless electronics. These functions displayed their utility in both *in vivo* and *ex vivo* animal studies as well as *in vitro* cell studies. The authors suggest that this prototype stent offers significant advantages over current stent technologies.



Motion Sensor as Emotion Sensor

The increasing interactivity between humans and smart systems requires human–machine interfaces that can perform a variety of functions, including detecting a person's surrounding environment, physical activities, health status, intentions, and emotions and then transmitting these collected data. Many of these services require wearable sensors and thus must incorporate functionalities such as flexibility, stretchability, stability, and optical transparency. On-body patchable strain sensors have previously been developed from highly stretchable piezoresistive materials. However, few sensors developed thus far have the stretchability, high strain sensitivity, and transparency necessary to detect the minute facial movements required to sense human emotion.

In a new study, Roh *et al.* (DOI: 10.1021/acsnano.5b01613) report the development

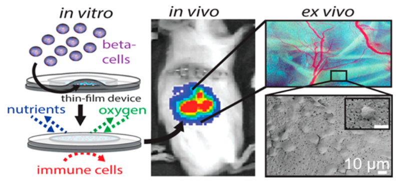


of a transparent, stretchable, ultrasensitive, and tunable strain sensor capable of detecting and differentiating between human emotions. The sensor is composed of two layers of the conductive elastomer poly(3,4-ethylenedioxythiophene) and a polyurethane dispersion (PU-PEDOT:PSS) with a layer of single-wall carbon nanotubes (SWCNTs) sandwiched between. The result was a strain sensor with 63% optical transparency, a high gauge factor, and stretchability above 100%. The new sensor was hardy, with stable performance after 1000 stretching cycles at 20% strain. Tests showed that when placed strategically on the face at locations including the forehead, under the eye, near the mouth, and on the neck, readouts from the sensor could readily distinguish between laughing and crying, as well as blinking and direction of eye movements. The authors suggest that integrating this sensor with others that detect skin temperature, sweat, and heartbeat could provide more detailed emotion detection.

Published online June 23, 2015
10.1021/acsnano.5b03625

Polycaprolactone for Sequestering Cells

Cell replacement therapy has the potential to transform treatment of many common diseases, particularly diabetes mellitus, in which islet cell transplantation is already showing promise for achieving insulin independence. However, this therapy has several challenges that must be overcome before widespread implementation, most notably the lifelong systemic immunosuppression required to prevent transplanted cells from being rejected. To prevent the need for immunosuppressive therapies, several cell encapsulation strategies have been explored. The key goals of encapsulation devices are creating environments that allow cells to secrete products, such as insulin, in a responsive way while maintaining cell viability through nutrient and waste exchange and shielding from the immune system. Thus far, cell encapsulation technologies have suffered from several challenges, including retrievability, control over pore dimensions, biocompatibility, scalability, and reproducible fabrication methods.

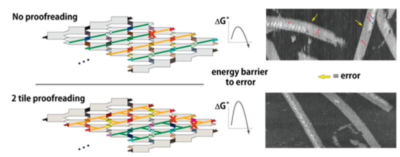


Seeking a way to overcome these challenges, Nyitray *et al.* (DOI: 10.1021/acsnano.5b00679) fabricated cell encapsulation devices made of polycaprolactone, a material already used in FDA-approved medical devices that has demonstrated long-term biocompatibility in multiple animal models. The researchers created microporous and nanoporous films from this material, using two pancake-shaped films to trap cells between. Using MIN6 cells, a mouse insulinoma cell line, they showed that both the micro- and nanodevices maintained cell viability, with encapsulated cells producing insulin in response to glucose stimulation for more than 20 days *in vitro*. However, only the nanodevices were able to maintain viability *in vivo* and protect against immune cytokines. The authors suggest that these devices might eventually be used to treat type 1 diabetes.

Reducing Self-Assembly Errors, Bit by Bit

The transfer of complex molecular information with low error rates is common in biological systems. However, chemical computational systems are often plagued with high error rates. One system that could be used as a model for such molecular computation is the algorithmic self-assembly of DNA tiles. This process has been demonstrated in both one and two dimensions to create complex, aperiodic patterns. However, the error rate inherent in this method limits its applicability.

In a new study, Schulman *et al.* (DOI: 10.1021/nn507493s) significantly improved the reliability and error rate of algorithmic DNA tile self-assembly by harnessing a tool used in electronic circuit design to reduce error rates during computation—redundancy. The researchers used four different types of DNA tile-based zigzag ribbons. Each ribbon had six rows, with the middle four rows encoding a bit sequence that was copied during assembly. The ribbons grew through tiles attaching to a ribbon both at a binding site that encodes the correct row information and at a second binding site that matched a "0" or "1" value of the tile in the previous column. One tile set employed no redundancy, but the three others incorporated increasing amounts of redundancy, with increasingly fewer distinct bits than the nonredundant tile set. Both simulations and experiments showed that each level of redundancy resulted in a multiplicative reduction in the error rate, with the most redundant set having an error rate of less

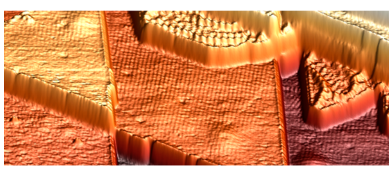


than 0.1% per bit copied. The authors suggest that redundancy can play an important role in significantly reducing the number of defects in self-assembling systems.

The Nano-Skyrmion Is the Limit

Magnetic skyrmions, quasiparticles with a whirling configuration, have a specific rotational sense that cannot be deformed to a ferromagnetic or other magnetic state without overcoming an energy barrier. This robust nature has made skyrmions exciting prospects for spintronic applications, such as encoding digital information. Interface-stabilized nano-skyrmion lattices in metal films have traditionally only been studied on bulk metallic single-crystal substrates. However, an important prerequisite to their use in future spintronic applications is mass-producing skyrmionic devices in multilayer configurations.

In a new study, Schlenhoff *et al.* (DOI: 10.1021/acsnano.5b01146) show the feasibility of this approach by growing Fe epitaxially

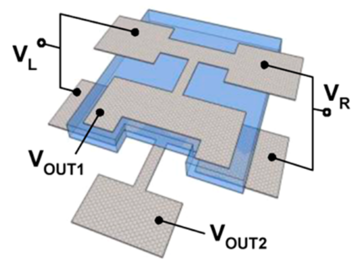


onto an Ir surface layered on an yttria-stabilized zirconium (YSZ) buffer layer on a Si(111) wafer. They then tested this system for a magnetic nano-skyrmion lattice. After depositing 0.8 atomic layers of Fe on this multilayer substrate, the researchers used spin-polarized scanning tunneling microscopy to examine the sample after cooling it to a measurement temperature of 26.4 K. Their initial examination showed that the electronic properties of a submonolayer coverage of Fe on Ir/YSZ/Si(111) are equivalent to those on the Ir(111) surface, raising the question of whether the multilayer system also exhibits a magnetic nano-skyrmion lattice like the simpler bulk single-crystal system. Further investigations revealed that this lattice does indeed exist in the multilayer system, present even in the presence of structural point defects. The authors suggest that this work promotes nano-skyrmions for spintronic applications on materials fully compatible with standard semiconductor technology.

Rectifiers and Inverters Go All-Graphene

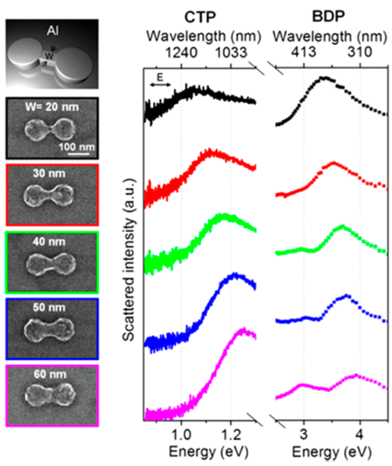
Graphene field-effect transistors' many advantageous qualities, including transparency, flexibility, and high carrier mobility, have made them among the most studied device structures for future electronic applications. These devices have recently surpassed the gigahertz limit on both conventional rigid substrates, such as Si, as well as flexible substrates. However, their performance as switches or rectifiers has been limited because of graphene's zero band gap.

Seeking further uses for graphene, Kim *et al.* (DOI: 10.1021/nn507199n) developed all-graphene three-terminal junction field-effect devices that can function as both rectifiers and inverters. To test the three-terminal-based operation, the researchers first constructed graphene T-branch junction (TBJ) devices with graphene as the right and left terminals and metal as a center probe, with graphene also serving as a gate electrode. Experiments demonstrated that this device displayed clear rectification. By connecting one of the terminals to the power source and the other to the ground, they showed that these devices could also become logic inverters. Then, after replacing the metal center probe with a patterned center line, the researchers created all-graphene circuits. Tests showed that these devices displayed similar rectification to the metal-containing devices and could also behave as inverters. By combining two of these all-graphene TBJ devices, the researchers fabricated a novel cascading structure in which the second TBJ is stimulated through the gate voltage generated by the first TBJ to deliver clear and stable rectification. The authors suggest that these results pave the way for all-graphene thin-film applications and seamless flexible electronics.



Bridging the Knowledge Gap for Charge Transfer Plasmons

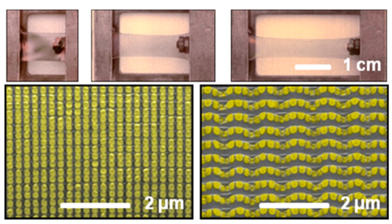
Two metallic nanoparticles separated by a small gap, or plasmonic dimers, have hybridized plasmonic resonances from the coupling between the plasmon modes of each nanoparticle. When these dimers are connected by a conductive junction, enabling direct charge transfer from one member of the pair to the other, the plasmons supported by this structure allow the addition of a charge transfer plasmon (CTP) at energies lower than the hybridized plasmons supported by unconnected dimers. The presence of a CTP is distinguished by an oscillating electric current through the junction, which changes both the near- and far-field properties of the plasmonic structure. Thus far, the only direct experimental studies of CTPs have focused primarily on quantum tunneling or optical frequency molecular charge transport.



Seeking better understanding of CTPs, Wen *et al.* (DOI: 10.1021/acsnano.5b02087) performed a systematic study of CTP properties in matching or mixed Au and Al nanoparticle dimers joined by nanowires, controlling the junction conductance by varying the width, length, and material of the nanowire bridges. The researchers found that a thin nanowire generated a narrow CTP with near-infrared resonance. By decreasing the nanowire's width, this spectral response can be tuned into the mid-infrared region. Similarly, increasing the nanowire's length for a fixed width had the same result. The authors suggest that these results could lead to more effective ways to engineer near- and mid-infrared plasmonic substrates for surface-enhanced infrared spectroscopic and sensing applications.

Plasmonic Nanostructure Arrays Do the Wave

Several recent studies have reported the results of combining hard electronic nanomaterials with soft elastomers, with the potential through optimized designs to yield high-performance integrated circuits with linear elastic responses to large strain deformations. These systems are particularly intriguing for possible future applications in biomedical devices that might be affixed to the curved and moving surfaces of the human body in ways impossible with current electronics technologies. Other recent work suggests that similar concepts might be useful for combining optical nanomaterials and elastomers to create novel metamaterials and plasmonic structures with properties that might be tunable with mechanical deformation.



In a new study, Gao *et al.* (DOI: 10.1021/acsnano.5b00716) add to this body of knowledge by creating large-scale arrays of plasmonic nanodisks on elastomer materials that can accommodate strains of up to 100%. The researchers used transfer printing to deposit multimaterial stacks composed of 40 nm of plasmonic gold, 5 nm of titanium as an adhesion promoter, and 40 nm of silicon dioxide onto a highly stretchable soft silicone substrate. Experiments and simulations showed that at high levels of strain, the attached gold nanodisks displayed buckling behavior that led to wavy conformations. These conformations had significant effects on the plasmonic behavior of these materials, with increasing levels of strain leading to red shifts of the plasmon resonance peak caused by both sheet deformation and buckling geometry. The authors suggest that these novel materials offer strong potential toward realizing different types of three-dimensional optical structures that might one day be used as epidermal photonic sensors with properties that can reversibly shift with changing levels of strain.