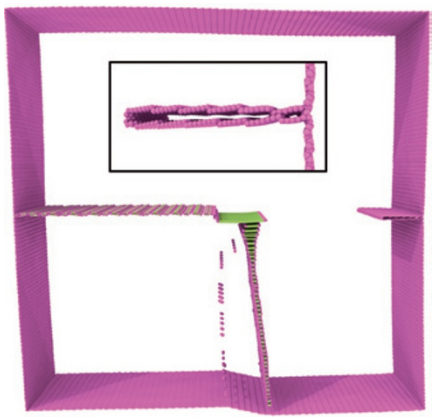
Crack healing by disclinations

Phys. Rev. Lett. **111,** 145501 (2013)



Metals with nanocrystalline structure are strong — in particular if the average grain size is below 100 nm. However, because they do not tolerate plastic deformation, they can fracture at high loads. Now, using molecular dynamics simulations and finite-element-method calculations of a model bicrystal with a pre-existing nanocrack, Xu and Demkowicz show that in nanocrystalline metals stress-driven tilt-grain-boundary migration can be used to completely heal nanocracks and therefore make the metals more ductile. The researchers describe the mechanism of crack healing (which involves the creation of wedge disclinations), and designed microstructures that lead to the closing of cracks under external tensile load (which typically causes crack opening) by placing an impenetrable precipitate that blocks the motion of part of the moving tilt grain boundary. They also show that the amount of grain-boundary migration necessary for crack healing is lower than that needed for crack propagation, making the mechanism more likely to close nanocracks than advance them. *PP*

Frustrating helium

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One of the more widely quoted theorems in condensed-matter physics, ascribed to David Mermin and Herbert Wagner, is broadly taken to mean that long-range magnetic order cannot be sustained in a two-dimensional system as long as the interactions between the spins are short-ranged and isotropic. Alas, reality isn't quite so straightforward. As the enormous experimental literature on systems with reduced dimensionality suggests, long-range order — magnetic or otherwise — can be stabilized in two dimensions, provided the smallest perturbation to the highly idealized scenario considered by Mermin and Wagner is present. The helium isotope ^{3}He physisorbed on graphite is a case in point. The origin of the helium's ferromagnetism is due to nuclear, rather than electronic, spin interactions, and as Andrew Casey and colleagues now confirm experimentally, the system represents an ideal realization of a frustrated two-dimensional magnet. Using a combination of nuclear magnetic resonance and sensitive magnetometry measurements, they show that its ferromagnetism is stabilized by the additional presence of subtle 'multi-site' ring exchange interactions. *AT*

Corona creation

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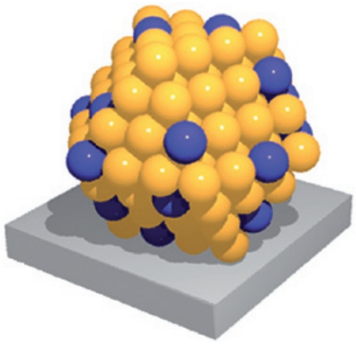
Biomolecules stick to the surface of nanomaterials in biological environments and, as a consequence, alter the nanomaterials' biodistribution, efficacy and toxicity. Most often, it is proteins that bind, forming a protein corona. Now, Stefan Tenzer, Roland Stauber and colleagues have investigated the composition and dynamic changes of protein coronas coated on nanomaterials when mixed with human plasma. Silica and polystyrene nanoparticles of differing sizes and with various surface charges and chemical modifications were incubated in human plasma for a range of time periods. Following centrifugation, the protein–nanoparticle complexes were analysed using mass spectrometry. Even for the shortest incubation time of 30 seconds, over 250 different proteins were detected in the corona. With longer incubation times, the concentration of specific proteins changes with time. The identity of the proteins, however, remains largely unchanged. These rapidly formed, corona-coated nanoparticles were shown to have different pathobiological effects compared with pristine nanoparticles in human-cell models, for example, the corona-coated nanoparticles prevent the rupture of red blood cells and the aggregation of thrombocytes. *AS*

Aerobic oxidation

ACS Nano http://doi.org/n52 (2013)



Titanium dioxide has been shown to be suitable for photocatalytic oxidation with molecular oxygen, but one of the main issues for its practical applicability is its modest catalytic activity under visible light irradiation. Now Yasuhiro Shiraishi and colleagues report that platinum–copper bimetallic alloy nanoparticles supported on anatase TiO_2 exhibit enhanced photocatalytic behaviour for aerobic oxidation under visible light irradiation. The improved photocatalytic activity (17% apparent quantum yield under 550-nm monochromatic light) results from the electronic excitation of Pt atoms followed by the transfer of activated electrons to the anatase conduction band. Copper alloying with platinum lowers both the Schottky barrier height and work function of nanoparticles created at the particle/anatase heterojunction. The photocatalytic activity is also found to be related to the size of the alloy particles: those in the 3–5-nm-diameter range exhibit improved photocatalytic performance for selective and efficient aerobic oxidation of alcohols at ambient temperature. *VD*

Shake to order

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Very fast charge transport can be achieved in small semiconducting molecules arranged in single crystals, because the absence of positional and energetic disorder in these structures reduces the number of trap states detrimental for conduction. For this reason, researchers are developing large-scale-oriented approaches based on direct deposition from solution that can produce conducting layers with high structural order. Peter Diemer and collaborators now show that mechanical vibrations can be the key to boost the performance of solution-deposited thin films. They use two audio speakers transmitting low-frequency sounds to gently shake small molecules drop-casted on a dielectric substrate; this additional mechanical energy provided during crystallization allows the molecules to reach a stable packing configuration that minimizes positional displacements. Transistors based on the obtained conducting layers show improved mobility, as well as reduced threshold voltage and hysteresis. The researchers suggest that this room-temperature strategy can prove particularly useful for organic materials that are sensitive to thermal-induced degradation. *LM*

Written by Vincent Dusastre, Luigi Martiradonna, Pep Pàmies, Alison Stoddart and Andrea Taroni.