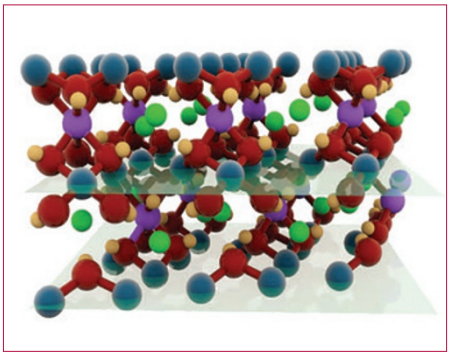
FRUSTRATED ANTIFERROMAGNETS

Spin-liquid ground state

Science **350,** 655–658 (2015)



AAAS

Frustrated antiferromagnetic interactions occur in materials where, due to the lattice geometry, the atomic spins cannot simultaneously minimize the energies of their local interactions. For instance, if the spins are arranged in an equilateral triangle, two of them can be antiferromagnetically coupled, yet the third cannot be similarly coupled to the other two simultaneously. This situation is found in antiferromagnetic materials with kagome lattices. The exact nature of the ground state of these materials — or minimum energy state, achievable by cooling them down — has been under debate. Now, Mingxuan Fu and colleagues report experimental evidence based on nuclear magnetic resonance and magnetic susceptibility characterization, showing that the ground state of the kagome antiferromagnet $ZnCu_3(OH)_6Cl_2$ is a disordered state — namley, a spin-1/2 spin liquid — with a finite gap between this and the excited states. These results clarify the fundamental issue of the ground state of these frustrated antiferromagnets and open up the possibility of experimentally studying this quantum state. *DC*

NANOPOROUS GOLD

Single crystals

Nature Commun. **6,** 8841 (2015)

There is substantial interest in the fabrication of porous Au due to its high catalytic activity. Khristosov *et al.* now demonstrate a new approach for the synthesis of micro-scale nanoporous Au particles devoid of grain boundaries. The approach they adopt is one of depositing Au and Ge at their eutectic composition on an SiO_2 substrate, followed by heating to above the eutectic temperature; the melt dewets the substrate, forming solid spheres with a nanoscale eutectic structure, which is frozen by subsequent cooling. Ge is then etched away, yielding a single crystal of Au with nanoscale pores. The authors discern that the lack of grain boundaries is a result of the timescale for crystallization of one micro-droplet being shorter than the average timescale between two nucleation events. Importantly, the single-crystal structure makes the particles more thermally stable — as compared to dealloyed samples containing grain boundaries — potentially boosting the temperature at which they may be utilized. *JP*

TISSUE ENGINEERING

Paper scaffolds

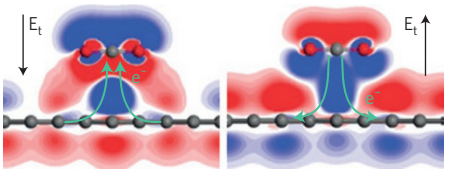
Proc. Natl Acad. Sci. USA http://doi.org/9pr (2015)

When designing tissue scaffolds for regenerating tissues with complex forms, established technologies such as electrospinning and mould-casting are at a disadvantage. Three-dimensional printing approaches are evidently better suited to the task, yet they impose limitations on the choice of materials and can negatively affect cell viability. Su-Hwan Kim *et al.* now show that scaffolds based on paper offer an attractive alternative. By taking advantage of the capabilities of paper origami and of vapour-based thin-film coating methods, the researchers coated tissue-like paper forms with cell-encapsulating alginate hydrogels to make scaffolds with pre-designed shapes and spatially arranged cell patterns (through the use of pre-patterned moulds placed on top of the paper). They also show that a cylindrical hydrogel-laden paper scaffold bearing articular chondrocytes regenerated a trachea defect in rabbits without the need to use sutures, and with no signs of tissue granulation or significant narrowing of the airway four weeks after transplantation. *PP*

VAN DER WAALS COMPLEXES

Tunable charge transfer

Nano Lett. http://doi.org/9pp (2015)



AMERICAN CHEMICAL SOCIETY

The electrical properties of graphene are highly sensitive to the perturbation of carrier concentration that is induced by the physisorption of molecules on its surface. Now, Manoharan Muruganathan and colleagues show that the van der Waals interactions between graphene and CO_2 molecules adsorbed onto it can be tuned by applying an external electric field. By means of first-principle calculations and transport measurements, they demonstrate that the molecules behave as weak electron acceptors when no voltage is applied to the substrate, and that such electron transfer increases under the effect of a positive voltage. In contrast, a negative voltage reverses the charge-transfer direction, causing the CO_2 molecules to behave as donors. This is because the external electric field alters the internal dipole created in the graphene–CO_2 complex together with the bonding distance and the O–C–O angle in the molecule. The researchers suggest that such effects may be useful for the realization of graphene-based gas sensors with improved molecule-recognition capabilities. *LM*

SILICON QUBITS

High fidelity

Nature Nanotech. http://doi.org/9pq (2015)

Bell states feature the maximally achievable degree of entanglement, a necessary resource for the implementation of efficient quantum computation algorithms. In this kind of system, the state of two distinct particles cannot be described as a product of the states of its local constituents. John Bell in 1964 defined the upper limit for such correlations to occur assuming classical properties — locality and realism; violation of Bell's theorem is therefore directly linked to quantum entanglement. Andrea Morello and co-workers now demonstrate entanglement between two-level systems (qubits) in a silicon platform. The researchers prepared a maximally entangled state using the electron and the nuclear spins of a single phosphorus atom as qubits; the two-spin initialization fidelity was shown to reach 97%. Two-qubit state tomography used to map out the density matrix of the entangled states revealed very high, near-unity fidelity of 96% when compared to the ideal states. This demonstration of high-level manipulation of silicon-based qubits constitutes an important step towards real-life quantum computing. *MM*

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