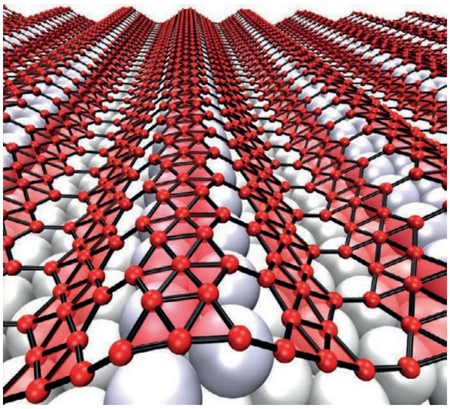
FLEXIBLE ELECTRONICS

Twists and turns

Nano Lett. **16,** 6622–6627 (2016)



AMERICAN CHEMICAL SOCIETY

Stretchability and conductivity rarely go hand in hand in the same material and finding exceptions to this rule remains a challenge. Two-dimensional materials offer a wide range of electronic properties, notably graphene, a conductor with outstanding transport properties. Being atomically thin, 2D materials are highly bendable, but their limited ability to sustain in-plane deformations precludes their immediate incorporation into flexible devices.

Boris Yakobson, Mark Hersam, Nathan Guisinger and colleagues at Northwestern University, Argonne National Laboratory and Rice University now report on a new class of highly stretchable and compressible 2D sheets of boron, or borophenes. At elevated growth temperatures, borophene, epitaxially deposited on a Ag(111) substrate, adopts an unusual corrugated structure. Steps on the Ag substrate surface act as nucleation centres resulting in the formation of the undulating pattern of the borophene. Theoretical analysis shows that the observed borophene phase with periodic nanoscale waves is energetically favourable. The wavy borophene sheet exhibits record small bending stiffness while its metallicity remains well preserved, which potentially makes borophene an alternative to flat and stiff graphene. The researchers suggest that the undulated borophene could be successfully separated from the Ag(111) substrate and subsequently transferred onto elastomeric substrates without compromising its electronic properties and keeping the periodic buckling intact. *OB*

INORGANIC MATERIALS

Semiconductors in a spin

Adv. Mater. http://doi.org/f3rfh7 (2016)

Helices are well-known secondary structures in biology, the canonical example being the DNA double helix, and have since been found in numerous organic and polymeric materials. LiP has been predicted computationally to adopt stable double helices, but although templated examples exist, stable inorganic helices have yet to be realized. Now, Tom Nilges and colleagues at the Technical University of Munich and other institutions in Germany have synthesized the first inorganic compound with an atomic-level double helical structure.

The researchers prepared crystalline SnIP in a single phase by a solid-state annealing reaction. The unit cell contains twisted P^- and SnI^+ chains wrapped around one another to form a double helix around 1 nm in diameter. Coordinative interactions of the Sn and P lone pairs stabilize the two helices and, along with van der Waals forces, these attractive interactions between the two interlocked helices are stronger than typical hydrogen bonding (for example in DNA). This leads to interesting mechanical properties; bulk crystals can be fully folded without breaking. The material has a direct bandgap of 1.86 eV and shows photoluminescence, leading the authors to suggest these semiconducting helices for flexible electronics applications. Bulk SnIP can also be delaminated to form nanorods ~15 nm in diameter with a moderately larger calculated bandgap (2.28 eV). *BLB*

VAN DER WAALS HETEROSTRUCTURES

On-chip single photons

Nat. Commun. **7,** 12978 (2016)

The extension of information technologies to the quantum realm has motivated recent efforts towards the development of optoelectronic devices that are able to generate single photons with controlled quantum correlation properties. In view of possible applications, the dimensions of these devices should be scalable to the nanoscale, while the stimulus required to trigger single-photon generation should be electrical. However, devices simultaneously satisfying these requirements are rare.

Now, Mete Atatüre and colleagues at the University of Cambridge in the UK and the National Institute for Materials Science in Japan report an electrically driven single-photon generator based on stacked 2D materials. Here, electrons are injected from graphene to p-doped WSe_2 or WS_2, where positive and negative charges recombine radiatively. A boron nitride layer acts as a barrier against this process, and biasing the device electrically leads to an increased tunnelling probability for the injected charges. Remarkably, the single-photon emission is associated with spatially localized regions and can be switched on and off by tuning the intensity of the tunnelling current.

The reported phenomenon is effective at low temperatures, but suffers from a spatially homogeneous background emission with no appreciable quantum correlation. Still, these results offer exciting prospects for scalability and on-chip integration of single-photon emitters. *GP*

NANOMATERIALS

Silky but tough

Nano Lett. **16,** 6695–6700 (2016)

Silkworm silk is popular because it is strong, easy to mass produce and is attractive in textiles. Many of the current methods to enhance the performance of silk through incorporation of metals, conductive polymers and other materials require toxic chemicals and complex procedures. Now, researchers in China show a simple way to produce silk fibres reinforced with carbon nanotubes or graphene.

Yingying Zhang and co-workers at Tsinghua University fed the larvae of *Bombyx mori* silkworms with mulberry leaves that had been sprayed with different concentrations of either single-walled carbon nanotubes (SWNTs) or graphene. The silk fibres obtained from these silkworms were tougher than control silkworms (as measured by fracture strength and elongation at break). Raman spectroscopy showed that some of the SWNTs were incorporated into the silk fibres while others were excreted. Using infrared spectroscopy, the researchers found that the modified silk contained more α-helix and random coil structures and fewer β-sheets than the control silk. This suggests that the SWNTs and graphene may hinder the transition from α-helices to β-sheets, a process that naturally occurs in the silk-spinning process of silkworms. Furthermore, this compositional difference is thought to contribute to the observed toughness. This feeding strategy offers a scalable approach for the production of tough silk fibres for both research and the textile industry. *ALC*

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