the substrate may be aided by displacement of the hydrogen terminal groups on SiC by nitrogen atoms, which then bond with the GaN layer and passivate it. Because of the weak coupling between graphene and GaN, the graphene layers can be easily etched away while preserving the ordered structure of GaN on SiC. After graphene removal, the 2D GaN layer is exposed to the ambient. In spite of this, there is no evidence of oxidation or change in the chemistry of the 2D GaN.

Al Balushi and co-workers also probe the electronic and optoelectronic properties of 2D GaN using both experimental and theoretical means[4]. They report that buckled structures of 2D GaN possess a direct bandgap of ~5 eV, which is much larger than for bulk GaN (3.42 eV), probably owing to quantum confinement in two dimensions.

Experimental realization of 2D GaN on technologically relevant substrates such as SiC opens up the possibility of device applications ranging from power electronics to topological insulators and single-photon emitters. Before reaching broad applications, however, surface coverage of the 2D GaN on the SiC substrate must be further improved. For this, it may be possible to defect-engineer[5] the graphene capping sheet so as to induce better intercalation of Ga, possibly leading to more uniformly distributed and larger 2D GaN islands, with the ultimate objective of coalescing the patchwork of islands into a continuous film. It will also be exciting to extend this approach for the experimental realization of other 2D nitrides and other hitherto unexplored compounds. It is conceivable that the MEEG approach could prove to be a powerful engine for future 2D materials discovery. ❐

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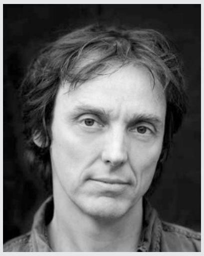
References

1. Novoselov, K. S. *et al. Science* **306,** 666–669 (2004).
2. Naguib, M. *et al. Adv. Mater.* **23,** 4248–4253 (2011).
3. Jariwala, D. *et al. ACS Nano* **8,** 1102–1120 (2014).
4. Al Balushi, Z. Y. *et al. Nat. Mater.* **15,** 1166–1171 (2016).
5. Zandiatashbar, A. *et al. Nat. Commun.* **5,** 3186 (2014).

MATERIAL WITNESS

SEARCHING THE WEB



PHILIP BALL

"No one", wrote the great ethologist Karl von Frisch, "would call spiders dim-witted"[1]. Were they not, after all, the descendants of the skilled but boastful human weaver Arachne, who was transformed into a spider for unwisely provoking the goddess Athena into a weaving contest — and then, worse, making superior work?

The legend shows how the architectural genius of the spider's web has always drawn admiration. Scientific study has only enhanced that response. What is less often recognized is that the web is not just an intricately wrought trap for prey, but a sensing mechanism that enables the spider to locate it. The spider's eyes are of little use there; it is her sense of touch that does the job. Vibration sensors in her feet enable the spider to deduce the whereabouts of the victim from the vibrations of the threads.

If the prey is still, she plucks the converging radial threads to betray its location. The spider then picks her way delicately along those threads, avoiding the connecting 'capture' threads laden with glue.

This suggests that the web might be engineered to optimize its sensing properties, permitting effective vibrational communication between the periphery and the central locus where the spider sits and waits. Mortimer *et al.* have examined that idea by measuring the vibrational characteristics of the web of the garden cross spider *Araneus diadematus*[2]. They have used a combination of laser vibrometry and finite-element modelling to test whether there is evidence for active tuning of the silk-thread properties to transmit vibrations.

It's the radial threads that are crucial here. As the capture threads are under no tension, they cannot sustain transverse (side to side) waves. However, those bridging threads do affect damping of radial-thread transverse waves. The spiders seem to introduce 'pre-stress' into the radial threads, which are the ones constructed first. But if (and only if) the capture threads are present, these pre-stresses can vary along the radial threads. Such stress gradients can amplify a transverse vibration as it travels from a region of high to low stress. In other words, the web architecture might include a built-in vibration amplifier.

The capture threads also couple radial threads and so induce dispersion of both transverse and longitudinal (along-axis) waves. The latter, however, are dispersed less, and so they are likely to transmit more precise directional information about the prey's location. What's more, longitudinal waves are more sensitive to the size of the impact causing them, and so can provide more information about prey size and might help to distinguish genuine prey capture from, say, wind gusts.

Mortimer *et al.* say that another way the spider might tune the vibrational features of the web, beyond active control of tension, is via supercontraction of the radial threads: a dramatic shrinkage at high humidity levels[3]. This significantly lowers the silk modulus, and thus, via changes in the propagation speeds of both transverse and longitudinal waves, alters the frequency filtering of the web.

There are probably tradeoffs here between vibrational (sensing) and mechanical (capture and robustness) performance of the web. But there are always tradeoffs in life. The wonder of silk is that it is multifunctional enough to accommodate them. ❐

References

1. von Frisch, K. in *Animal Architecture* 30 (Hutchinson, 1975).
2. Mortimer, B., Soler, A., Siviour, C. R., Zaera, R. & Vollrath, F. *J. R. Soc. Interface* http://doi.org/bq8g (2016).
3. Liu, Y., Shao, Z. & Vollrath, F. *Nat. Mater.* **4,** 901–905 (2005).