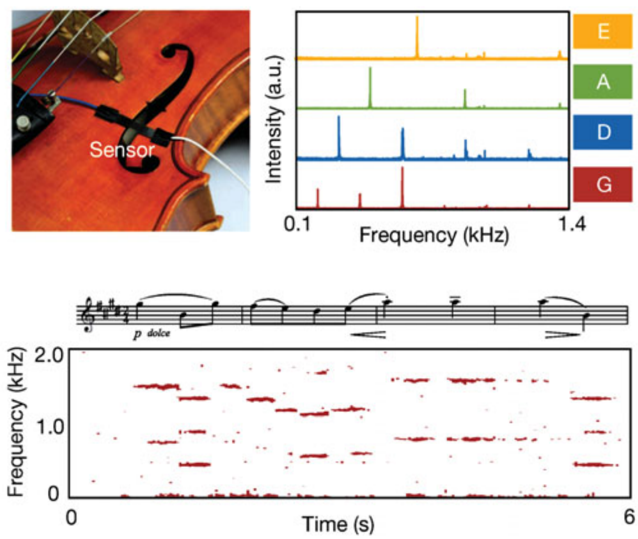
Bio Focus

Spider-inspired vibration sensor detects music

Spiders use crack-shaped slit organs near their leg joints to detect minute mechanical vibrations. This inspired Mansoo Choi and his team from Seoul National University to design their own version of a mechanical sensor based on nanoscale crack junctions. As the researchers describe in their December 2014 *Nature* publication (DOI: 10.1038/nature14002), they fabricated their sensors by depositing a stiff 20-nm thin film of electrically conductive platinum on a flexible polymer (polyurethane acrylate). The material is then wrapped around glass rods of different diameters to induce controlled directional cracking with different spacing between the individual zigzag cracks. While signal transductions through the spiders' neurons are responsible for the extraordinary vibration sensitivity of their slit organ, changes in electrical resistance as the zigzag crack edges of the platinum gaps pull apart or reconnect are the underlying cause of the artificial sensor's operation. It is the gap geometry both devices have in common, which is crucial to achieve the remarkably high sensitivity to mechanical stress.



Nanoscale crack junction-based sensor attached to a violin for sound wave recognition (top left), recorded wave functions of E (yellow, fundamental frequency of 659 Hz), A (green, 440 Hz), D (blue, 294 Hz), and G (red, 196 Hz) strings (top right), measured sound waves of music playing ("Salut d'Amour"; excerpt shown in the bottom panel). Reproduced with permission from *Nature* **516** (7530) (2014), DOI: 10.1038/nature14002; p.178. © 2014 Macmillan Publishers Ltd.

Among other tests to prove the functionality and reversibility of their mechanosensor, the research team attached it to a violin (see Figure). Not only were they able to register sound waves, but they could also observe unique sensor responses to different frequencies. Additionally, the flexible sensor was mounted on skin and successfully detected speech or heartbeats with superior signal/noise ratios. The publication's supplementary information includes a real time–peak spectrogram of Elgar's "Salut d'Amour" played on the violin, a special treat for music lovers.

Throughout their study the researchers show that their sensor pixel array outperforms other mechanosensors in the 0–2% strain range, including recently reported sensors based on graphene platelets, carbon nanotubes, or organic semiconductors. "Precise engineering of crack formation" says Choi, "might be the future of ultrasensitive mechanosensing."

Birgit Schwenzer

Bio Focus

Spinning artificial spider silk remains a challenge

Although spider webs can be torn apart with one well-aimed sweep of a broom, the silk that forms them is, by weight, one of the strongest materials found in nature. It's also lightweight, biodegradable, sticky, and slightly stretchy—all properties that make it desirable for a variety of applications.

Humans have been collecting silk from silkworm colonies for thousands of years to create textiles. However, using the same strategy to harvest natural spider silk—which is stronger and lighter than that of silkworms—isn't a practical option. Spiders can become territorial and even cannibalistic when kept in close proximity to each other, and the labor required to harvest their silk is too great to make the process commercially viable. Instead, scientists are studying the molecular basis for spider silk's valuable properties with the hopes of eventually creating a commercially viable biomimetic synthetic silk fiber.

"One of the main obstacles to synthesizing true, biomimetic spider silks was, and still is, a lack of understanding about the natural material and processes by which it is created," said Cameron Brown of the University of Oxford and an author of a review paper on synthetic silk in the January 14 issue of the *Journal of Materials Research*. "We are getting much better at making proteins similar to the natural proteins, yet our processing capabilities lag behind."

The two main proteins believed to be responsible for silk production are large molecules called Spidroins, but over a hundred secondary proteins might help finesse the silk's properties. Researchers have turned to a variety of organisms, from bacteria to goats, to recombinantly express these relevant proteins. None, however, has yielded synthetic fibers on par with natural ones in strength. Recombinant silk protein expression has suffered from