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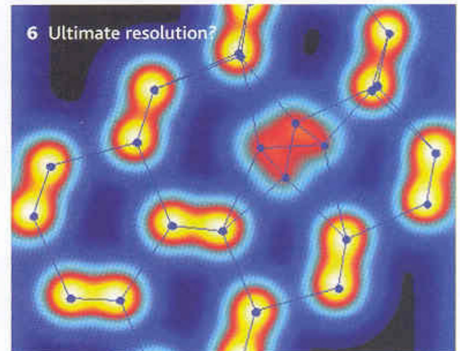

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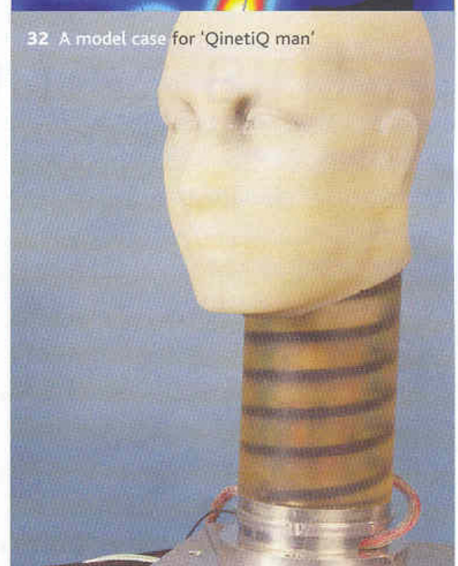

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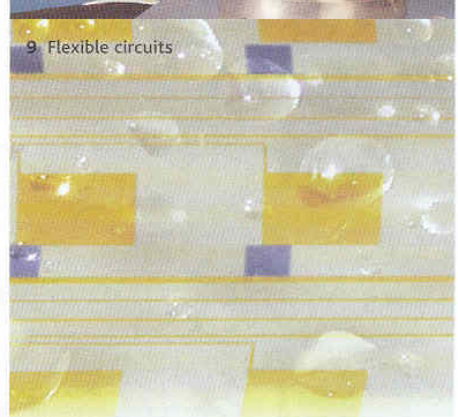

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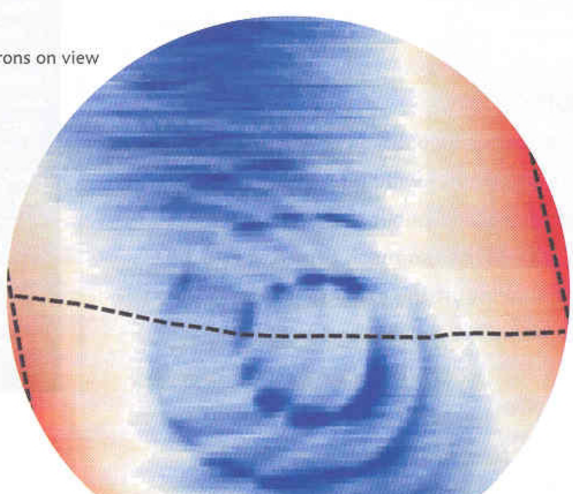


Surprise for spiders

BIOMATERIALS

Silkworm silk could give artificially spun spider silks "a good run for their money" according to new work by Zhengzhong Shao of Fudan University, Shanghai, and Fritz Vollrath of Oxford University [*Nature* (2002) **418**, 741]. Recently, there has been much interest in spider dragline silk because of its stretchable and strong properties. *Nephila* spider dragline has a strength of ~1.3 GPa, a breaking elongation of 40%, and toughness (breaking energy) of 16 x 10^4 Jkg^{-1}. Compare this with the values for typical commercial silk from *Bombyx mori* silkworm cocoons of ~0.5 GPa, 15%, and 6 x 10^4 Jkg^{-1}, respectively. Shao and Vollrath's new results indicate that the properties of silkworm silk can approach those of spider dragline if it is reeled under controlled conditions. Under normal conditions, a silkworm spins a cocoon by moving its head back and forth in arcs. If this acceleration and deceleration is avoided by reeling in the silk from immobilized silkworms, the material's properties can be varied. Like the spider, the silkworm produces stronger, more brittle fibers at high spin speeds and weaker, more extensible fibers at slow speeds, explain the authors. At a spin speed of 13 mms^{-1}, silkworm silks achieved a toughness of 12 x 10^4 Jkg^{-1}. The effect of spin speed on silk strength is also more significant than other effects, such as pre-processing washing. Unlike spider dragline, which is both strong and stretchable, the researchers do concede that silkworm silk can only be one or the other. Nevertheless, Shao and Vollrath suggest that if the spinning habits of silkworms could be changed to become faster and more uniform, with or without genetic modification, threads could be produced that compare well to spider dragline silk.

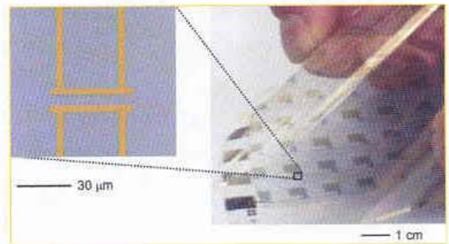
Flexible circuits by lamination

PLASTIC ELECTRONICS

Researchers at Bell Laboratories and the University of Texas at Austin, led by John A. Rogers, have developed a new method to fabricate plastic circuits with organic semiconductors using 'soft', conformable electrical contacts and a lamination process [*PNAS* (2002) 99, 10252-10256]. The printed circuits have excellent flexibility and are able to withstand stirred, soapy water for long periods. Low cost, flexible, durable, and lightweight plastic circuits have great potential for many devices, including electronic paper, wearable sensors, and smart cards.

The key aspect of the approach is the fabrication of different parts of the circuit on different substrates. The two substrates are then bonded together. "A thin elastomeric substrate supports the electrodes and interconnections. Laminating this substrate against another plastic substrate that supports the gate, dielectric, and semiconductor levels establishes effective electrical contacts and completes the circuits," explain the authors. The electrical properties of these laminated transistors are similar to other organic semiconductor devices produced using more standard techniques.

The laminated circuits have two advantages over other fabrication technologies. The embedded circuits have much better mechanical flexibility than circuits deposited in the usual way on the surfaces of substrates. The flexibility arises because the circuit lies near the neutral mechanical plane (0% strain) at the center of the device. The embedded circuits are also naturally encapsulated, providing protection from the environment. Negligible changes in the transistor properties after 15 minutes in stirred, soapy water were observed.



A laminated circuit. Inset shows source/drain electrodes (gold) laminated against a pentacene layer (blue). (Courtesy of PNAS.)

The researchers hope that their work will provide a general method for providing non-invasive electrical contacts to fragile or ultra-thin organic materials, and will be useful for measuring charge transport in these systems.

Glad to be different

SUPERCONDUCTIVITY

Acclaimed as the new hope of superconductivity, magnesium diboride (MgB_2) has also been a puzzle. Until now, that is, thanks to new theoretical work by researchers at Lawrence Berkeley National Laboratory and the University of California at Berkeley [*Nature* (2002) **418**, 758-760]. Conventional models fail to predict MgB_2's unusually high transition temperature and its other differences from ordinary metallic superconductors. "It was like the blind men looking at the elephant," says Marvin Cohen, who led the work with Steven Louie. "Everybody who looked at MgB_2 saw a different picture." The researchers calculated the properties of MgB_2 from first principles, using basic atomic data and physical laws. "When we looked at the elephant," says Cohen, "we saw that almost everybody had been right!"

The simple structure of MgB_2 – honeycombed planes of B atoms separated by Mg atoms – made the calculations possible, and is also crucial to understanding its behavior. Using Bardeen-Cooper-Schrieffer (BCS) theory to examine the properties of MgB_2, the researchers found that its electrons form two distinct populations because of its bond structure. "Partially occupied sigma bonds driving superconductivity in a layered structure is one of the new concepts that appeared from the theoretical studies," explains Louie. They also found that not all the B electrons are needed in strong pair formation for high transition temperature. This means that MgB_2 is a 'two-band' superconductor – a different breed of superconductor that has long been predicted, but not seen until recently. Crucially, this also means, say the researchers, that other intermetallic superconductors might also superconduct in the same way.