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Bendy gadget future for graphene

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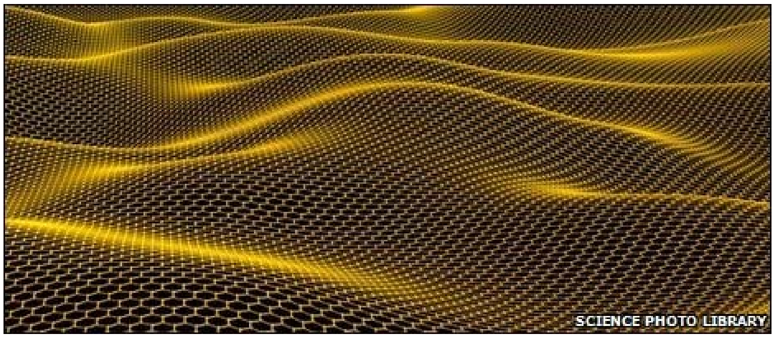

A remarkable material called graphene could soon be used to make flexible and transparent high-speed electronics, researchers say.

Graphene's incredible mechanical and electronic properties are well known, but it is difficult to make in bulk.

It consists of one-atom-thick layers of carbon atoms arranged in hexagons.

A report in the journal Nature is the third in recent efforts that have seen the production of centimetre-scale samples of graphene.

The transparent samples can be fixed to any surface and bent or twisted without damaging them.

When the technique is perfected, such films could be used in solar cells as well as any number of bendy, thin, transparent gadgetry, such as crystal-clear, flexible displays.

Getting lead out

First discovered in 2004, graphene is a close cousin of carbon nanotubes, which are in effect graphene rolled up.

Tiny, high-quality samples of graphene can be sourced by using sticky tape to simply pull them off graphite - the same stuff that is in a pencil lead.

Transistors made from such samples have been shown to operate at gigahertz frequencies - comparable to the speed of modern computers. The material could theoretically operate near terahertz frequencies, hundreds of times faster.

The samples also have remarkable mechanical strength, because the bond that carbon atoms form between themselves is one of the strongest known.

And it gets even better: because they are so thin, the sheets are practically transparent.

Under the sheets

However, for wider application, graphene must be made in larger sheets while maintaining the high quality of the smaller samples.

A suggestion first proposed a few years ago is now coming to fruition: evaporating a mixture of large carbon-containing molecules and firing it over a heated metal surface.

The molecules break down, releasing carbon that re-organises on the surface in neat graphene sheets. The precise conditions of the experiment determine how many sheets are produced.

While growth of such films on metal surfaces has been known to happen for decades, no one had been able to remove the films from the metal, and no one knew if graphene, once removed, would maintain its spectacular potential.

Now, Byung Hee Hong at Sungkyunkwan University in Seoul, South Korea, and colleagues have applied the technique to produce films of up to 12 sheets on extremely thin pieces of nickel.

By dissolving away the nickel with chemicals, the researchers were left with graphene films they could stick to a flexible polymer called PET.

The researchers went on to show that because the films are so robust, they maintain their striking electronic properties even when bent and twisted.

Great minds

The work confirms that the approach is the most promising path towards bendy, practically invisible electronics. In December, Jing Kong of the Massachusetts Institute of Technology (MIT) published the first account of successfully producing graphene films using the nickel technique.

They showed that the precise structure of the graphene films they produced could be controlled by putting a nanometre-scale pattern on the thin nickel plates.

Earlier in January, Yong Chen led a group from Purdue University, US, that published a paper on the arXiv website detailing the approach.

After production, their films were deposited onto silicon-based substrates, showing a potential means to supplement existing microelectronics with the terrifying speed of graphene components.

Andre Geim, whose group first discovered graphene and demonstrated its potential for electronics, is impressed with the recent flood of demonstrations.

"It's a really important development," Professor Geim, who is based at the University of Manchester, told BBC News.

"It took five years from our demonstration of the beautiful properties of isolated graphene and now, at last, three groups have demonstrated that it's possible."

However, he notes that the samples produced using the new technique are so far relatively disordered and made of regions of differing numbers of graphene layers.

For the speediest electronics, only a single layer like that acquired with sticky tape will do.

"Until now, everyone has been using our so-called 'pencil technique' (the sticky-tape method) but the disadvantage is that the graphite crystals are quite small - it's really painstaking research," Professor Geim explained.

Widespread availability of larger, high-quality graphene films will vastly speed up research into the material's properties, putting researchers ever closer to real applications.

"This technique shows the missing element for the whole story, from finding graphene to making real transistors because it shows that industrial scale production is possible," Andre Geim said.

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