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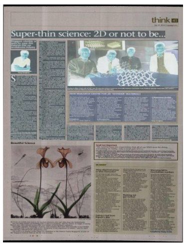

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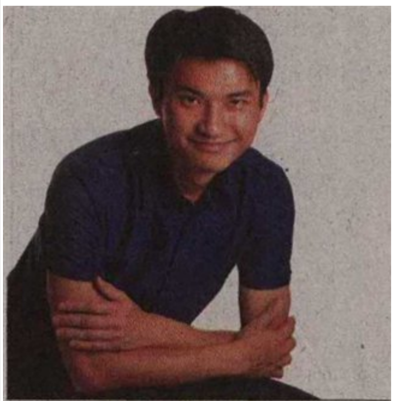
NUS National University of Singapore

Super-thin science: 2D or not to be...

Singapore scientists on quest for super-thin materials that can revolutionise industry



Feng Zengkun

Super-thin materials could soon be created in Singapore. These can make electric cars lighter, medical devices safer and even large touchscreens so thin and flexible they can be folded and put into pockets.

The National Research Foundation has poured $50 million into a new Centre for Advanced 2D Materials at the National University of Singapore (NUS) to look into these wonder materials that have taken the world by storm.

The centre will open on Friday.

The materials are so thin that scientists consider them to have only two dimensions.

Graphene, for example, is made of carbon, the same material found in pencils – except it consists of only a single layer of carbon atoms, making it one million times thinner than paper. European scientists created it in 2004.

Super-thin materials could revolutionise entire industries, from electronics and electric cars to the renewable energy sector.

Last year, the European Union awarded one billion euros (S$1.7 billion) over 10 years to a global group of graphene researchers.

"Graphene is an extraordinary combination of physical and chemical properties," it said. "It conducts electricity much better than copper, is 100 to 300 times stronger than steel and has unique optical properties.

"It is set to become the wonder material of the 21st century, as plastics were to the 20th century."

Electronics giant Samsung is researching graphene because it could make smartphones and other devices more durable and a fraction of their current thickness.

Other scientists have proposed using it to create batteries that can be fully recharged in 16 seconds, and solar cells that are less brittle and can capture more sunlight. It could also be used as a super-smooth coating on medical implants to deter the human body from attacking them after they are implanted.

Singapore institutes have been racing to keep up with their global peers.

Nanyang Technological University (NTU) and the Agency for Science, Technology and Research have graphene researchers, while NUS set up its graphene research centre in 2010.

But one way for Singapore to steal a march on competitors in the 2D field is to look for other materials that could be even better than graphene at meeting some needs, said researchers.

"Graphene is becoming very popular across the world," said NUS deputy president of research and technology Barry Halliwell.

"To stay ahead, you have to ask yourself, what's after graphene? You have to develop new materials with completely new kinds of properties."

NUS Distinguished Professor Antonio Castro Neto, who will head the new 2D centre, pointed to phosphorene, the ultra-thin version of the element black phosphorus.

He and other researchers at the NUS graphene centre were among the first to suggest just six months ago that phosphorene, a semiconductor, may be even better than the metallic graphene for improving electronics.

Prof Neto said the centre will also investigate molybdenum disulfide. The material was highlighted by the US Institute of Physics in April for its "impressive ability to convert light into electricity".

It could improve solar panels, digital cameras, remote controls and a wide range of other devices.

To give the NUS centre a head-start, world-renowned researchers have been recruited to its scientific and industrial advisory board. These include professors Andre Geim and Kostya Novoselov, who won the 2010 Nobel Prize in physics for their work in graphene.

Professor Albert Fert, another board member, won the same prize in 2007 for his discovery of giant magneto-resistance, which led to a breakthrough in creating gigabyte hard disks.

Prof Neto pointed out, however, that there are considerable challenges to making 2D materials useful for industry. "You need very special machines to synthesise them," he said. "If you use a normal machine to inscribe circuitry on graphene, for example, you could punch a hole through the material."

Professor Subbu Venkatraman, chair of NTU's School of Materials Science and Engineering, where some researchers work on graphene and other 2D materials, said scientists also need to find ways to produce very pure versions of the materials in large quantities.

"If you want the material to have certain properties, it needs to be in a certain structure," he said.

"One of the biggest challenges is to produce a specific structure of the 2D material in high yields without contamination by other structures," he added.

In a widely cited paper on the state of the 2D materials field last year, American researchers said that for the field to advance, new techniques are needed to rapidly and safely probe "the atomic structure, defects and properties" of such materials. "Still, new understanding of 2D materials has contributed to entirely new scientific frontiers," they wrote.

"There exists an entire periodic table of materials, each having different electronic and mechanical

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properties," they added. "The possibility to create 2D layers from any material remains. Harnessing them will surely lead to exciting new technological advances."

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NEW RESEARCH CENTRE FOR 2D 'WONDER' MATERIALS

The National University of Singapore (NUS) will open a new research centre on Friday to look into super-thin materials, referred to as "two-dimensional" (2D), that could revolutionise industries. To start, it will have about 50 researchers from multiple disciplines such as biomedicine and engineering. It will receive $50 million in funding over 10 years from the National Research Foundation.

Some materials that will come under its microscopes are:

Graphene

Made up of a single layer of carbon atoms, graphene has been the focus of intense research around the world since European scientists created it in 2004.

It is much stronger than diamond, far more conductive than copper and as flexible as rubber. It offers huge promise for applications that include electronics, energy and medicine, for instance, in flexible touchscreens and batteries.

The NUS Graphene Research Centre, opened in 2010, will become part of the new centre.

Phosphorene

The graphene centre researchers were among the first to suggest, just six months ago, that this ultra-thin version of the element black phosphorus could surpass graphene in some uses.

While graphene has charmed scientists, it might not be useful in replacing semiconductor switches for computer circuits – it lacks a natural "band gap" that can be used to switch the flow of electrons on and off.

Phosphorene has this band gap, so it could be more suitable than graphene for making electronics that can be cooled more easily than traditional silicon-based versions.

Molybdenum disulfide

The 2D form of this material, another alternative to graphene, was first produced by scientists in Switzerland in 2011. Before, the material had been used as a liquid for industrial lubrication.

It also has a natural band gap, and researchers at the Massachusetts Institute of Technology say it could be used to make walls that glow. It could also be used to make improved products, such as clothing with embedded electronics and glasses with built-in display screens.

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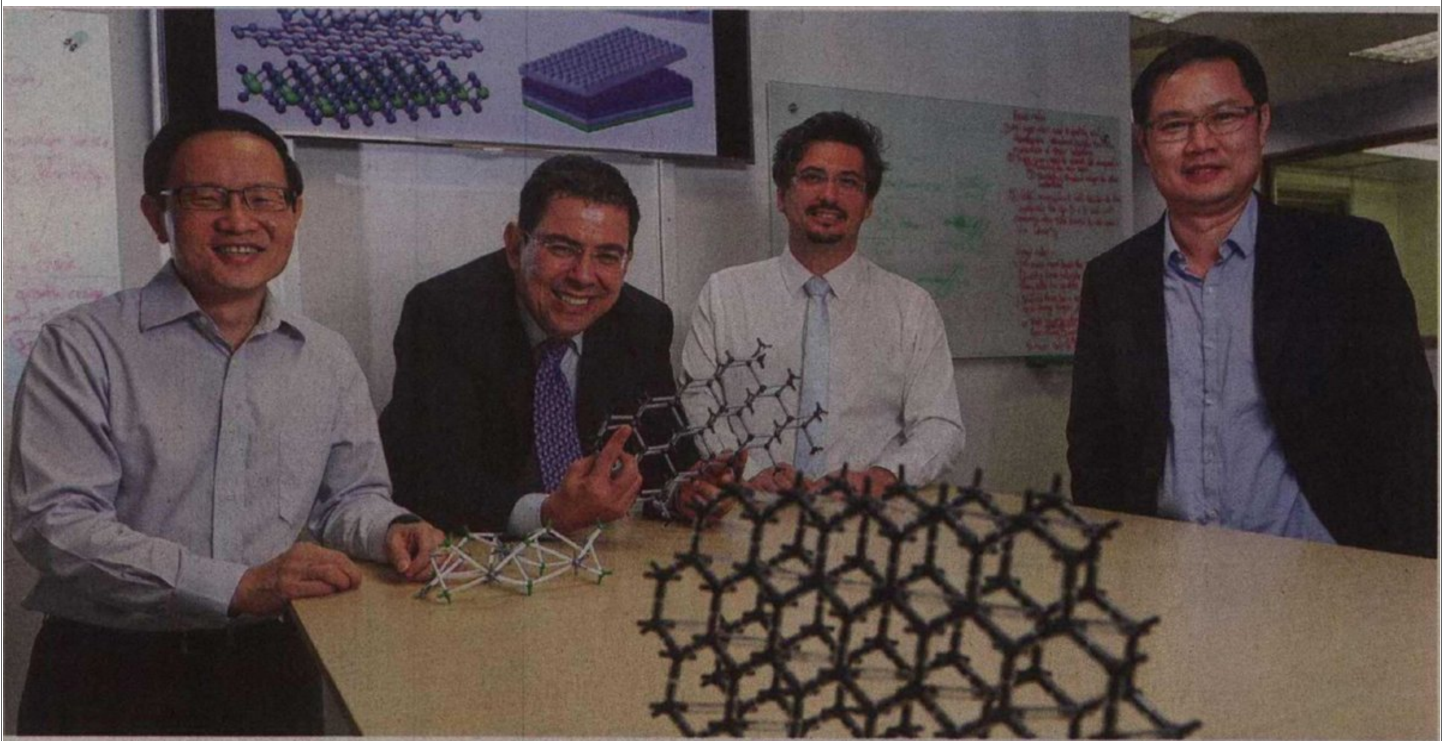

ST PHOTO: DESMOND WEE

Hoping to blaze a new trail at NUS' new 2D materials research centre are (from left) Professor Lim Chwee Teck, Professor Antonio Castro Neto (the centre's director), Professor Barbaros Ozyilmaz and Professor Loh Kian Ping.