Graphene researchers make a layer cake with atomic precision

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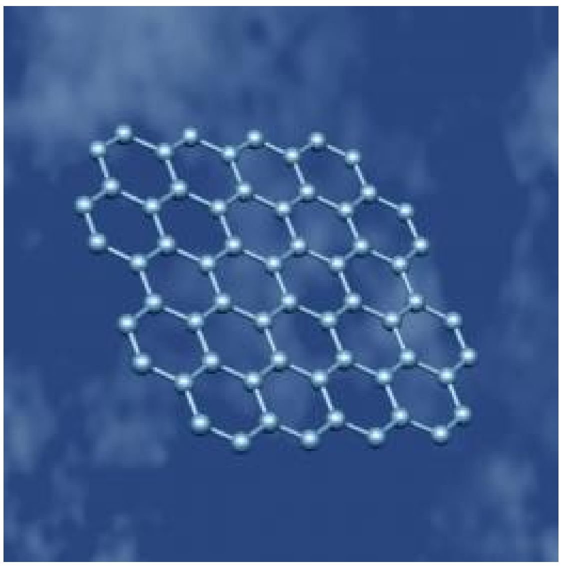

Artistic impression of graphene molecules. Credit: University of Manchester

Graphene and associated one-atom-thick crystals offer the possibility of a vast range of new materials and devices by stacking individual atomic layers on top of each other, new research from the University of Manchester shows.

In a report published in *Nature Physics*, a group led Dr Leonid Ponomarenko and Nobel prize-winner Professor Andre Geim has assembled individual atomic layers on top of each other in a desired sequence.

The team used individual one-atom-thick crystals to construct a multilayer cake that works as a nanoscale electric transformer.

Graphene, isolated for the first time at The University of Manchester in 2004, has the potential to revolutionise diverse applications from smartphones and ultrafast broadband to drug delivery and computer chips.

It has the potential to replace existing materials, such as silicon, but the Manchester researchers believe it could truly find its place with new devices and materials yet to be invented.

In the nanoscale transformer, electrons moving in one metallic layer pull electrons in the second metallic layer by using their local electric fields. To operate on this principle, the metallic layers need to be insulated electrically from each other but separated by no more than a few interatomic distances, a giant leap from the existing nanotechnologies.

These new structures could pave the way for a new range of complex and detailed electronic and photonic devices which no other existing material could make, which include various novel architectures for transistors and detectors.

The scientists used graphene as a one-atom-thick conductive plane while just four atomic layers of boron nitride served as an electrical insulator.

The researchers started with extracting individual atomic planes from bulk graphite and boron nitride by using the same technique that led to the Nobel Prize for graphene, a single atomic layer of carbon. Then, they used advanced nanotechnology to mechanically assemble the crystallites one by one, in a Lego style, into a crystal with the desired sequence of planes.

The nano-transformer was assembled by Dr Roman Gorbachev, of The University of Manchester, who described the required skills. He said: "Every Russian and many in the West know The Tale of the Clockwork Steel Flea.

"It could only be seen through the most powerful microscope but still danced and even had tiny horseshoes. Our atomic-scale Lego perhaps is the next step of craftsmanship".

Professor Geim added: "The work proves that complex devices with various functionalities can be constructed plane by plane with atomic precision.

"There is a whole library of atomically-thin materials. By combining them, it is possible to create principally new materials that don't exist in nature. This avenue promises to become even more exciting than graphene itself."

More information: 'Strong Coulomb drag and broken symmetry in double-layer graphene', by L Ponomarenko, R Gorbachev and A Geim, *Nature Physics*, 2012.

Provided by University of Manchester