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Issue 49

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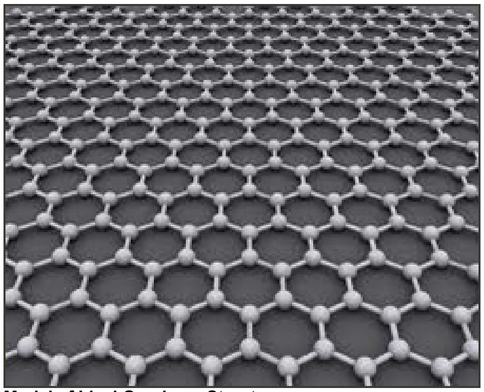


Model of Ideal Graphene Structure

Photo courtesy of AlexanderAIUS, CORE-materials

Graphene – The Miracle Material?

Graphene, a two-dimensional solid comprising a one-atom thick sheet of carbon, has recently overtaken carbon nanotubes as the research material of the moment. Graphene was first isolated in 2004 by scientists at the University of Manchester in England, but the focus for some years has been on developing ways to manufacture graphene sheets of sufficient size and quality to enable effective research into its properties. These efforts have paid off and recent research studies have established graphene as the strongest material in existence. It also has very high thermal and electrical conductivity. These properties are stimulating the imaginations of researchers worldwide and may lead to the development of new generations of mobile electronics, computers, and even nano-sensors used for oil exploration.

Graphene has long been known to exist. Graphite, such as that used in pencil leads, consists of layers of graphene; carbon sheets stacked together like a deck of cards. The molecular forces holding each card to its neighbors are weak, but researchers had not developed the techniques needed to slide a single card out of a graphite deck.

In September 2004, researchers led by Professor Andre Geim, a physics professor at the University of Manchester in England, isolated layers of graphene with a technique that is now scientific folklore. They placed a graphite flake on a piece of adhesive Scotch tape, folding the tape over and pulling it apart, cleaving the flake in two. Folding and unfolding repeatedly caused the graphite to become thinner and thinner. Then they stuck the tape to a silicon wafer and rubbed it. Some graphite flakes stuck to the wafer, and some of those flakes were one atom thick. It has become known as the "Scotch tape" method of graphene production.

Graphene is now typically created using a chemical vapor deposition process, in which carbon-containing gases are made to decompose on a copper foil substrate. Until recently, the process was plagued by problems of poor crystal consistency, but a new production method utilizing hydrogen gas is reportedly capable of producing graphene sheets with perfectly hexagonal, single-crystal grains. The researchers claim it could lead to the large-scale production of higher-quality graphene.

Graphene's carbon atoms are arranged in a hexagonal lattice and, although the substance is chemically very simple, it has astonishing properties. Graphene is light, flexible, and stronger than steel. It conducts heat 10 times faster than copper and can carry 1,000 times the density of electrical current of copper wire. Graphene is proving to be a revolutionary material that could change the technology of semi conductors, LCD touch screens and monitors; create super-small transistors and super-dense data storage; increase energy storage and solar cell efficiency; and transform many other applications.

Researchers at Columbia University, New York, have evaluated the strength of graphene using the diamond tip of an atomic force microscope to apply loads and measure its deformation and rupture strength. They estimate that graphene has a breaking strength of 55 newtons per meter. Scaling that up into everyday terms, it would require a force of 2000 kg to puncture a sheet of graphene that is as thick as ordinary plastic food wrap making graphene the strongest material measured.

University of Maryland researchers have shown that electrons travel over 100 times faster in graphene than in silicon. Their results, published online in the journal *Nature Nanotechnology*, indicate that graphene holds great promise for replacing conventional semiconductor materials such as silicon in applications ranging from high-speed computer chips to biochemical sensors.

Graphene also possesses superior optical and thermal properties that could make it less expensive and use less energy inside portable electronics like smartphones. The University of California recently has created a miniature optical device that could enable the large data files for 3D movies to be downloaded to a smartphone in seconds.

Research institutes, universities, and companies around the world are investigating ways to build devices such as touchscreens, ultrafast transistors, and photo detectors using graphene. In April, IBM demonstrated a graphene transistor that can perform 155 billion cycles per second, which is about 50% faster than previous experimental transistors shown by the company's researchers.

One of the most exciting recent discoveries related to graphene is that water flowing over the surface of a graphene sheet will generate electricity. Led by Professor Nikhil Koratkar of the Rensselaer School of Engineering, researchers investigated how the flow of water over surfaces coated with graphene could generate small amounts of electricity. The research team demonstrated the creation of 85 nanowatts of power from a sheet of graphene measuring .03 millimeters by .015 millimeters. This amount of energy should be sufficient to power tiny sensors that are introduced into water or other fluids. One of the areas where this property could be highly advantageous is oil exploration.

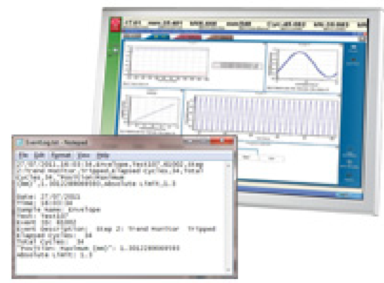
Hydrocarbon exploration is an expensive process that involves drilling deep down in the earth to detect the presence of oil or natural gas. Oil and gas companies envisage enhancing this process by sending out large numbers of nanoscale sensors into drilled wells. These sensors, carried by pressurized water pumped into the wells, would travel horizontally through the network of cracks and fissures that exist underneath the earth's surface.

It’s not possible to power these micro-sensors with conventional batteries, as the sensors are just too small. However, a coating of graphene around the sensor may capture enough energy from the movement of water over the sensors to provide a reliable source of power for the sensors to transmit collected data and information back to the surface. Oil companies would no longer be limited to vertical exploration, and the data collected from the sensors would arm these firms with more information for deciding the best locations to drill.

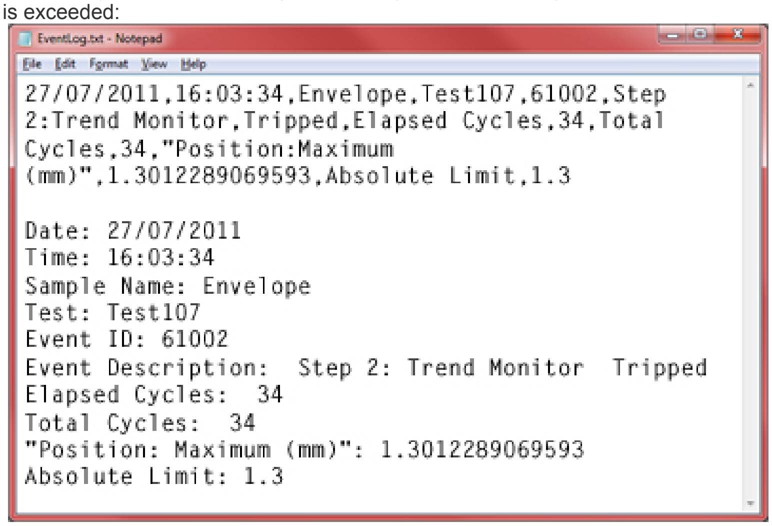
About 200 companies and start-ups are now involved in research around graphene. In 2010, it was the subject of about 3,000 research papers. However, amidst all this excitement, many scientists, including Dr. Geim who, with Dr. Konstantin Novoselov, won the Nobel Prize for physics in 2010 based on their graphene work, recommend caution. Some are certain that graphene will not do everything that has been thought up for the material because the properties have only ever been demonstrated on a very small scale. Graphene seems to have great potential, but there are few examples so far of it working in our macro world.

Event Log Files

Many WaveMatrix™ customers are unaware of the existence of an event log file that is created each time you run a test. The log file, named [testname].log, details each separate event that occurs from the moment the test starts and contains useful information such as how many cycles have run, test values, and more. It is a great resource for troubleshooting problems such as why the test stopped unexpectedly. The file is stored alongside the other results for that test.



Here is a typical line from a log file showing the test stopping when the position limit is exceeded:



EventLog.txt - Notepad

File Edit Format View Help

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27/07/2011,16:03:34,Envelope,Test107,61002,Step
2:Trend Monitor,Tripped,Elapsed Cycles,34,Total
Cycles,34,"Position:Maximum
(mm)",1.3012289069593,Absolute Limit,1.3

Date: 27/07/2011
Time: 16:03:34
Sample Name: Envelope
Test: Test107
Event ID: 61002
Event Description:  Step 2: Trend Monitor  Tripped
Elapsed Cycles:  34
Total Cycles:  34
"Position: Maximum (mm)": 1.3012289069593
Absolute Limit: 1.3
```

Q. Some Bluehill calculations don’t show a result when I think they should. Where can I find information on the calculations?

A. Bluehill contains a comprehensive online document - Calculations Library - that has details of every calculation in the Bluehill suite. It details the calculation algorithm, any calculation dependencies (some calculations cannot work until other results are calculated), and the reasons that a calculation may fail to work. You can open the Calculation Library document using the Help menu in Bluehill.

All of the online calculation information is also available on your software media as a PDF file entitled Calculation Reference.

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