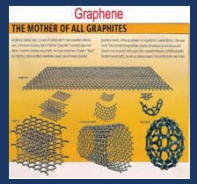
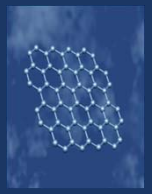


GRAPHENE: MATERIAL THAT WILL CHANGE THE FUTURE

Will Graphene reach the limit to Moore's Law?

JIGAR DESAI AND DARRYL REESE
UNIVERSITY OF NEVADA LAS VEGAS 4505 S MARYLAND PKY LAS VEGAS NV, 89119



Abstract

Graphene is most recent material discovered by scientists and is a star on the horizon of materials science and condensed matter physics. The one atom thick, two dimensional material is an amazing conductor of electricity. Although graphene was not discovered completely until 2004, it has already revealed potential applications and scientists have begun researching ways of developing graphene products for the market. Only two products have been successfully produced so far, but scientists have encountered amazing results. This material has many potential applications in the real world and is about to change the future in a positive way.

What Is Graphene?

Graphene is a flat monolayer of carbon atoms which are tightly packed in a two dimensional honeycomb lattice structure. It is allotrope of carbon and is the basic building block of graphitic materials such as graphene, carbon nanotubes and fullerenes.

One layer of carbon is only about .142 nanometers thick, which means it would take approximately three million sheets of graphene for it to be one millimeter thick!

The History Behind Graphene

Graphene was first theorized in 1947 while a theoretical physicist by the name of Phillip Wallace was conducting carbonic research. The term "graphene" was not coined until a physicist by the on Hanns Peter Boehm described single layer carbon in 1962.

It wasn't until 2004 that graphene was fully discovered in its observational and testable form. Two physicists from the University of Manchester, Andre Geim and Konstantin Novaselov, founded graphene in 2004 and received a Noble Prize in Physics on October 5, 2010 for founding a material known to be one of the most promising and versatile materials ever discovered.

How Was Graphene Discovered?

Andre Geim and Konstantin Novaselov's procedure for discovering graphene was fairly simple. They placed a miniscule amount of graphite on adhesive scotch tape and repeatedly peeled away graphite strips until they were down to a single layer of the atomic plane. Thus graphene was discovered.

Today, scientists use a process called chemical vapor decomposition in order to produce graphene. In this procedure, graphene is grown on top of copper foil. When graphene is produced, a thin layer of adhesive polymer is applied on the top of the graphene and the copper backing is dissolved off of the carbon. Then the scientists peel off the adhesive polymer, resulting in a single layer of carbon.

In order to strengthen the graphene, multiple layers of the material are stacked upon one another.

Why Are Scientists So Crazy About This Discovery?

Well, there are many reasons why. Here are a few reasons why:

•Graphene is the thinnest possible material feasible.

•There is no other material that can compete with attributes of graphene.

•The material is overwhelmingly strong. It is stronger than a diamond and Researchers at Columbia University's Fu Foundation School of Engineering have proven that "It would take an elephant, balanced on a pencil, to break through a sheet of graphene the thickness of Saran Wrap."

•Graphene is extremely flexible. It has the ability to stretch by a quarter of its length, like rubber. It can also be folded like a piece of paper without affecting its structure.

•Graphene has a surface area of that is the largest known for its weight.

•The monolayer carbon has a mass of zero. According to scientists in order for an object to have mass it needs volume; In order for an object to have volume it has to have three dimensions. Since graphene is a two dimensional object, it has is mass less.

•Graphene has off the charts ability to conduct electricity, better than any conductor ever discovered.

•The single layered carbon has a lower resistance than idium, which is used in transparent conductors today. Graphene can function smoother and faster than products which use idium and won't have a dead pixel problem that occurs in idium based products. Also, graphene has a lifespan of a lifetime, contrast to that of idium.

What Can Graphene Do For Us?

•Promises to revolutionize the electronic industry

•Produce lighter weight and cheaper aircrafts

•Lighter weight and cheaper satellites

•Produce clothing that can power and charge electrical devices efficiently

•Produce eco-friendly components because graphene is easier to recycle than any other material

•Produce higher efficiency as well as cheaper batteries that charge in the fraction of the time as state of the art batteries produced today

•More durable and efficient credit card machines which would last a life time

•Make electronics faster

•Make electronics smaller

•Produce leak tight containers which can keep food fresh for weeks

•Cheaper and higher efficiency solar panels

•Cheaper gas prices

•Stronger medical implants

•Better sports equipment

•Produce processors with speeds up to 1Thz

•Will become common place substance such as plastic but will eliminate recycling problems since graphene is very easy to recycle

•Capability of producing computers as small as cellular devices, yet functions as well as a desktop

•Flexible touch screens

•Replace rare and expensive metals such as platinum and idium and perform the same tasks with greater efficiency and a fraction of the cost

•Graphene will solve the global warming problem because it has the ability to produce alternative ways of fueling a vehicle with zero emissions and with high efficiency

•Just use your imagination!

Real World Applications

•Cheaper and more efficient transparent conductors

•Replacement for silicon in transistors which are used in every electronic device. This will make the product cheaper, smaller and reach the limit to Moore's Law.

•Potential production on light weight, stronger than steel materials.

•Replace carbon fibers in composites

•Embed in plastics to conduct electricity.

•Graphene based sensors capable of sniffing out dangerous molecules

•Use graphene powder in batteries to increase efficiency

•Higher efficiency optoelectronics

•Stiffer, stronger, lighter plastics

•Transparent conductive coating for solar cells and displays

•Stronger wind turbines

•Super-capacitors which store much more charge than regular capacitors.

•Improved conductivity for materials

•High power, high frequency electronic devices

•Computer revolution

•Cheaper and more efficient than nanotubes

•Has the ability to send radio waves 100x farther than silicon based transmitters

Graphene In Action

Scientists and researchers have been hard at work ever since the discovery of graphene. Within six years, two graphene products have already been created and have showed amazing results.

First of all, in 2008, Manchester team created a one nanometer graphene transistor only one atom thick and ten atoms wide; this is smaller than the smallest possible silicon transistor and could have possibly reached the limit to Moore's Law.

The second invention is also mind blowing. Researchers in Korea and Japan engineered a large film of graphene, seventy six centimeters diagonally, were doped by treating it with nitric acid which enabled the sheet to act as a large transparent electrode and were demonstrated to work as a touch screen device.

Difficulties

Although there has been a few successful products produced using graphene, mass production is still an issue. The future defiantly looks bright but right now the main goal for scientists is to devise more ways to produce graphene quickly, cheaply and in high quantity.

Bibliography

1. Ahn Et Al, J. H. "First Graphene Touchscreen." *Royal Society of Chemistry, the Largest Organisation in Europe for Advancing the Chemical Sciences*. N.p., 20 June 2010. Web. 22 Mar. 2011. <http://www.rsc.org/chemistryworld/News/2010/June/20061001.asp>.

2. Carmody, Tim. "Why Graphene Won Scientists the Nobel Prize | Gadget Lab | Wired.com." *Wired.com*. N.p., 5 Oct. 2010. Web. 22 Mar. 2011. <http://www.wired.com/gadgetlab/2010/10/graphene/>.

3. Kaku, Michio. "Graphene Will Change the Way We Live | Dr. Kaku's Universe." *Big Think*. N.p., 6 Oct. 2010. Web. 21 Mar. 2011. <http://bigthink.com/ideas/24381>.

4. Liao, Lei, and Xiangfeng Duan. "The Promise and Challenges for Graphene Electronics." *Http://www.sciencedirect.com*. © 2011 Elsevier B.V, 22 Nov. 2010. Web. 21 Mar. 2011. <http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6TXH-50R63J3-1&_user=516213&_coverDate=11%2F22%2F2010&_alid=1685597209&_rdoc=1&_fmt=high&_orig=search&_origin=search&_zone=rslt_list_item&_cdi=5591&_sort=r&_st=13&_docanchor=&view=c&_ct=8729&_acct=C000023038&_version=1&_urlVersion=0&_userid=516213&md5=17d951930f9689260280c152bf36c21a&searchtype=a>.

5. Service, Robert F. "Graphene Finally Goes Big." *Science Now*. © 2010 American Association for the Advancement of Science., 20 June 2010. Web. 20 Mar. 2011. <http://news.sciencemag.org/sciencenow/2010/06/graphene-finally© 2010 American Association for the -goes-big.html>.

6. Unknown. "Graphene." *Wikipedia, the Free Encyclopedia*. N.p., 18 Mar. 2011. Web. 22 Mar. 2011. <http://en.wikipedia.org/wiki/Graphene>.