

Graphene: the future of solar cells

[Business](#)



A trend for developing nations has been working towards greater access of renewable energy. Solar energy has been in the forefront of the innovations sought by nations today, and scientists are constantly searching for new ways of creating effective energy producing processes. A relatively new material that has gained attention for its efficient properties is graphene, a layer of carbon that is an atom thick.

This nanomaterial has astonished scientists with its unique electrical properties, and its discoverers were awarded a Nobel Prize in 2010 as a result. Following its inception, graphene exceeded expectations and shattered previous records as the strongest and lightest material in the world. After working with the material for many years now, scientists have made considerable advancements in the development of graphene, which has spurred numerous methods of producing the material. It is due to the unique features of graphene that this material has attracted attention for its possible application in the development of solar cells. Materials that are currently being used to produce solar cells are indium tin oxide and silicon, which scientists have concluded are inefficient and costly in comparison to graphene (Miao).

Since graphene is a stronger, more conductive, and highly transparent material, it should be used as a replacement for the current substances used to make photovoltaic cells. The most notable methods of producing graphene are through the Scotch Tape Method, CVD, and through newly developed experimental methods that expose the graphene material to various temperatures. The two scientists who discovered graphene did so by using the Scotch Tape Method (Dume). Using pure graphite, the scientists

used regular duct tape to peel off layers of graphene until there was only one layer that remained (Mortelmans). After dissolving the duct tape substance in acetone, graphene could then be observed using a microscope due to the transparency of the material (Mortelmans).

This method is frequented by many scientists today who are doing basic research on graphene, but this process limits the graphene “in sizes of 10s of microns, which are the biggest suits you could end up with” (Guikema). Larger graphene crystals would make the analysis of the material much easier and would provide scientists with greater means of manipulating the material. Although this is the most common method of producing graphene, this process would not be suitable for the production of solar cells. Small, even layers of graphene would be optimal for solar cell production, but this process is useful in allowing scientists to easily experiment with the material to find new ways of advancing its efficiency. A method that appears most suitable for the production of graphene in solar cells is Chemical Vapor Disposition (CVD).

CVD involves the deposition of gaseous reactants onto a metal substrate (De La Fuente). Using a reaction chamber, carbon gas molecules are heated, and when the gases come in contact with the substrate in the chamber, “a reaction occurs that creates a material film on the substrate surface” (De La Fuente). The temperature of the substrate defines the sort of reaction that will occur, and the substrate is usually coated with graphene at slow speeds that adds microns of graphene per hour (De La Fuente). CVD creates high quality graphene that is incredibly pure and involves low costs, but there are some drawbacks when using this process (Guikema). The challenges with <https://assignbuster.com/graphene-the-future-of-solar-cells/>

this process are “ actually getting it to work right and not having wrinkles in the graphene or holes or tears” (Guikema).

Developing a sheet of pure graphene without these miniscule flaws will result in an increase in efficiency due to the greater surface area that can absorb more photons. Other obstacles include successfully removing graphene from the substrate, but research has found that coating graphene with Poly(methyl methacrylate) (PMMA) will make it strong enough to remove the graphene from the substrate without damaging it (Miao). CVD is a promising process for the production of graphene solar cells and is the likely choice for scientists who are developing these devices. There are many experimental methods of producing graphene that have not yet been adopted by many of the scientists working with graphene today. One process involves textile cloned graphene, which begins with silicon carbide.

In this process, silicon carbide is heated to about 2,000 degrees Celsius, which causes the surface silicon to sublime away, leaving carbon atoms that would form graphene on the surface (Guikema). There are some problems being worked out with this method as it often created multiple layers of graphene instead of just one (Guikema). Producing a uniform sheet of graphene rather than multiple layers of various sizes would be ideal when constructing solar cells. A cheap, sturdy method of producing graphene is also through chemical reduction. This approach involves oxidizing graphite to form graphene oxide and then distributing oxygen groups onto each graphene layer (Stankovich). By oxidizing the sheets of graphene, the space between the layers of graphene will begin to separate, and using an

ultrasound, the sheets can be separated to result in individual sheets of graphene (Stankovich).

These methods can be used by scientists to experiment with graphene in order to enhance its properties, and with further research, they may result in more effective methods of producing graphene for solar cells. Graphene contains several key electrical properties that make it suitable for solar cells. The nanomaterial is unique since it possesses a high electron carrier mobility, which is favorable in the production of solar cells (Bolotin). The electron charge carriers in graphene can travel for microns in the graphene material at room temperature without scattering (Fuhrer). The absence of scattering makes the material highly efficient because more of the energy is able to transfer through the graphene and into the solar device.

Graphene also suppresses backscattering of charge carriers, which involves the reversing of the momentum of the charge carrier, and this also contributes to graphene's large carrier mobility. (Fuhrer) Since electron carriers are able to move quickly through graphene, the material would be a suitable choice for solar cells, which would require the graphene to convert photons into electrons and transport them into the solar cell device. A high electron carrier mobility is a distinctive feature that makes graphene an excellent candidate for its use in solar cells. Since graphene is ambipolar, it can be modified by scientists in order to change the type of charge carrier within it. Scientists can control the type of charge involved in the current that would be passed through graphene by applying a voltage to the material (Tian). Modifying the charge can be useful for scientists who are attempting to tweak graphene to make it suitable for use in electronics.

<https://assignbuster.com/graphene-the-future-of-solar-cells/>

When there is conduction going through a material, such as graphene, it is “really a collective behavior because there is not just a single electron” (Guikema). Multiple electrons are travelling through the graphene crystals, and although the electrons have a negative charge, the materials can behave as if the charges were positive instead of negative (Salisbury). These factors can result in an increase in efficiency in electronics made with graphene. When there is an absence of positive electrons, there are holes in a material which results in a reduction of efficiency, but this problem can be fixed if scientists were to use graphene to introduce more positive electrons (Salisbury). Using graphene, scientists can tune the carrier charges to make them positive in order to eliminate the holes in the material. The feature of modifying graphene’s charge carriers makes the material more accessible for its use in solar cells.

Graphene has the unique property of being able to convert a single photon into multiple electrons in order to create an electric current (Johnson). This characteristic is highly beneficial for energy production. When graphene is exposed to light, the photocurrent for the material has high values of 5 milliamps per watt, which are the result of the photothermoelectric effect (Dume). When light is shone on graphene, the electrons in the layered material would heat up and remain hot, causing a current to be produced (Dume). These properties exhibit graphene’s promising capacity as a material in solar cells.

Graphene’s absorption properties also show that “ graphene holds potential for light-to-electricity conversion...even more suitable than expected” (Johnson). This research highlights another example of graphene’s efficient <https://assignbuster.com/graphene-the-future-of-solar-cells/>

electrical properties that scientists can take advantage of when constructing solar cells. Graphene's physical properties make it an ideal material for solar cells.

Since the graphene sheets are so thin, only a small amount of raw materials are needed to produce the graphene solar cells, which brings down costs considerably. Since graphene is a flexible material, this gives scientists the opportunity to create a wide variety of solar cells that silicon would not be able to produce (Gray). This could lead to innovations in technology that have never been seen before. The transparency of graphene provides the material with applications in electronics and solar technology, and the material could potentially be used as the screen of a phone or a television in order to power the device (Gray). The transparency and flexibility of graphene allow for solar applications in spacecraft and aviation, and these attributes could ease the installation of flexible solar cells (Chandler). The physical and electrical properties of graphene gives scientists a plethora of options when adapting the material to solar cells and its use would be greatly beneficial to those who consume great amounts of energy.

Graphene is also a layered material and can be modified to produce various types of solar cells. Using two layers of graphene, scientists are able to produce incredibly thin solar cells out of this atom-thick material (Team). These devices would only have a 1 to 2 percent efficiency of converting photons to electricity, but these layers can be stacked to boost the efficiency of the material (Chandler). Stacking the graphene could match its efficiency to the 15 to 20 percent efficiency of silicon solar cells, and " pound for pound..

<https://assignbuster.com/graphene-the-future-of-solar-cells/>

. the new solar cells produce up to 1, 000 times more power than conventional photovoltaics" (Chandler). By stacking multiple layers of graphene, solar cells of various thicknesses can be produced so that engineers can choose the size that would fit best in their distinctive production of electronics. Layers of graphene can also combine with iron (III) chloride to increase the number of electron carriers in graphene in order to raise the conductivity of the material (University). In areas where space is not limited, solar cells with thick layers of graphene can be used as a valid source of energy production. Furthermore, Graphene can be coated with a variety of chemicals including TSFA to enhance its efficiency (Miao).

Scientists are constantly progressing chemical coating methods, and the efficiency of graphene continues to rise as these methods improve. The versatility of graphene makes it an ideal source in the creation of a variety of solar cells. Graphene is distinctly superior compared to the current materials used to make solar cells in a variety of ways. Graphene surpasses Indium Tin Oxide in efficiency and functionality as ITO is very brittle, which limits its use on flexible substrates (Wu). The thickness of graphene films are also between 4 and 7 nm whereas ITO is about 130 nm thick (Wu).

The increase in thickness and weight of ITO compared to graphene highlight it's limitations for manufacturers attempting to create large amounts of the material. The sheet resistance of graphene is similar to that of ITO, but scientists have concluded that the overall performance of graphene surpasses that of ITO (Quick). Graphene also outperforms silicon in solar cells. Graphene produced solar cells have displayed a power conversion

efficiency (PCE) of 8.6%, which surpasses the PCE of solar cells made of silicon that were measured to have a PCE ranging from .

1% to 2.86% (Miao). When graphene is chemically coated with TSFA, the graphene possesses a lower cell series resistance and a higher carrier density compared to silicon (Miao). These factors substantially increase the material's performance over silicon. Graphene is also stronger and more flexible than silicon, which allows for sturdier and more effective solar cells (Fuhrer). These factors exhibit graphene's superiority over these materials and reveal the potential for the formation of numerous advancements in solar technology.

Considering graphene is a conductive, sturdy, and highly transparent material, it should be used as a substitute for the present materials used to make photovoltaic cells. The development of graphene has opened up innumerable possibilities of applying this wonder material to areas of energy and electronics, most notably in the development of solar cells. Graphene can be developed using the Scotch tape method, through experimental methods using low temperatures, and through the most functional process, CVD (Guikema). Graphene possesses remarkable electrical properties, and its high carrier mobility allows for the rapid displacement of electrons (Fuhrer). Graphene is also distinguished for its changing charge carriers and its high electron conversion efficiency (Guikema).

The physical properties of graphene provide scientists with a number of ways of improving solar cells. The material is extremely thin, but it is also robust and economical to produce. Furthermore, the flexibility and transparency

properties of the material open up the possibility of the widespread use of solar cells. In comparison to indium tin oxide and silicon, studies have shown that graphene has superior absorption properties, and its economical advantage gives it a clear dominance (ICFO). Moreover, since graphene is a layered material, it can be used to create a wide variety of solar cells that cannot be produced by other existing materials (Flexi).

The adoption of graphene in the production of photovoltaic cells will allow for the highly efficient collection of energy that surpasses that of current materials; therefore, companies should make graphene their primary material in the production of solar cells. Works Cited Bolotin, K. I. " Ultrahigh Electron Mobility in Suspended Graphene." Pico.

phys. columbia. edu. N. p., 6 Mar.

2008. Web. 4 Feb. 2014. Chandler, David L.

" New Graphene Treatment Could Unleash New Uses." MIT's News Office. N. p., 15 Dec. 2013.

Web. 18 Dec. 2013. De La Fuente, Jesus. " CVD Graphene – Creating Graphene Via Chemical Vapour Deposition." Graphenea. com. 2013. 13 Nov. 2013 .

Dume, Belle. " Electrons Heat up in Graphene." Physicsworld. com. N. p.

, 6 Oct. 2011. Web. 11 Dec. 2013. . " Flexi Cells May Provide New Opportunities." Energy Next 31 Jan. 2013: n. pag. Gale Science in Context.

Web. 23 Oct. 2013. Gray, Richard. “ Graphene Paint Could Power Homes of the Future.

” Telegraph. co. uk. N. p., 3 May 2013.

Web. 9 Oct. 2013. Guikema, Janice. “ Graphene Interview.

” Telephone interview. 4 Dec. 2013. ICFO-The Institute of Photonic Sciences.

“ Graphene: A material that multiplies the power of light.” ScienceDaily.

ScienceDaily, 24 February 2013. .

Johnson, Dexter. “ Graphene Can Create ‘ Hot Carrier’ Cells for Photovoltaics.” Spectrum. ieee. org/.

N. p., 26 Feb. 2013. Web.

9 Oct. 2013. Miao, Xiaochang. “ High Efficiency Graphene Solar Cells by Chemical Doping.” Nano Letters (2012): 1-14. Pubs.

acs. org. Web. 22 Jan. 2014.

. Mortelmans, Koen. “ Andre Geim: Graphene Is Only the Beginning.

” Youris. com. N. p., 15 Oct.

2013. Web. 3 Feb. 2014. Quick, Darren.

“ Graphene-based transparent touchscreens and solar panels a step closer.”

Gizmag. com. 1 Aug. 2011. 06 Nov.

2013 Salisbury, David F. “ New Study Confirms Exotic Electric Properties of Graphene.” News. vanderbilt. edu/.

N. p., 17 Nov. 2009. Web. 6 Feb.

2014. Stankovich, Sasha. “ Synthesis of Graphene-based Nanosheets via Chemical Reduction of Exfoliated Graphite Oxide.” Bucky-central. me. utexas.

edu/. N. p., 6 Mar. 2007. Web.

5 Feb. 2014. “ Team Creates a Low Cost Thin Film Photovoltaic Device with High Energy Efficiency.” Phys. org. N.

p., 26 Dec. 2014. Web. 23 Mar.

2014. Tian, J. F. “ Ambipolar Graphene Field Effect Transistors by Local Metal Side Gates.” Arxiv. org/.

N. p., n. d. Web. 6 Feb.

2014. “ University of Exeter Researchers Have Improved Graphene as a Transparent Conductor to the Point That It Can Beat the Transparent Conductive Coating Used in Most LCDs, Indium Tin Oxide (ITO), Writes Steve Bush.” Electronics Weekly 16 May 2012: n. pag. Gale Student Resources in Context.

Web. 23 Oct. 2013. Wu, Junbo. “ Organic Solar Cells with Solution-Processed Graphene Transparent Electrodes.” Applied Physics Letters (2008): n.

pag. Scitation. aip. org/. Web. 22 Jan.

<https://assignbuster.com/graphene-the-future-of-solar-cells/>

2014.