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GRAPHENE: THE ADVANCED MATERIAL

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Abstract

Graphene is a rapidly rising star on the horizon of materials science and nanotechnology. This strictly two-dimensional material exhibits exceptionally high crystal and electronic quality, and, despite its short history, has already revealed a new dimension of physics and potential applications, which are briefly discussed here. Whereas one can be certain of the realness of applications only when commercial products appear, graphene no longer requires any further proof of its importance in terms of fundamental physics. More generally, graphene represents a conceptually new class of materials that are only one atom thick, and, on this basis, offers new inroads into low-dimensional physics that has never ceased to surprise and continues to provide a fertile ground for applications.

Keywords **-** External quantum efficiency, Buckyballs, Van Der Waals forces**.**

I. INTRODUCTION

Graphene is a single atomic layer of carbon atoms tightly packed in a two-dimensional honeycomb lattice microscopy. The first graphene was extracted from graphite using a technique called micromechanical cleavage._ This approach allowed easy production of high-quality graphene crystallites and further led to enormous experimental activities. . Graphene has a high electron (or hole) mobility as well as low Johnson noise (electronic noise generated by the thermal agitation of the charge carriers inside an electrical conductor at equilibrium, which happens regardless of any applied voltage) Combination of excellent electrical property and low noise make graphene an ideal material in the electronics. 2D materials display very interesting properties, and are fundamentally different from the 3D materials we encounter everyday. The discovery of 2D materials means that scientists now have access to materials of all dimensionalities, including 0D (quantum dots, atoms) and 1D (nanowires, carbon nanotubes)

II. STRUCTURE

Graphene is a member of the class of 2-dimensional materials. It consists of a hexagonal array of sp^2-bonded carbon atoms, just like those found in bulk graphite.

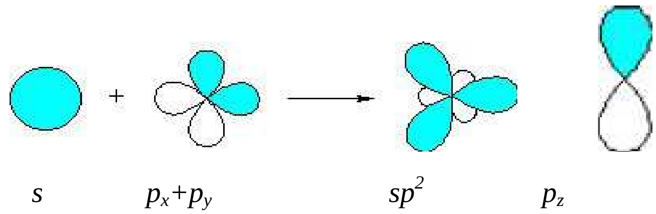

Fig. 1: Atomic structure of Graphene in the form of quantum numbers.

III. SYNTHESIS

A. Exfoliation and Cleavage

Graphite is stacked layers of many graphene sheets, bonded together by weak Van Der Waals force. Thus, in principle, it is possible to produce graphene from a high purity graphite sheet, if these bonds can be broken. Exfoliation and cleavage use mechanical or chemical energy to break these week bonds and separate out individual graphene sheets.

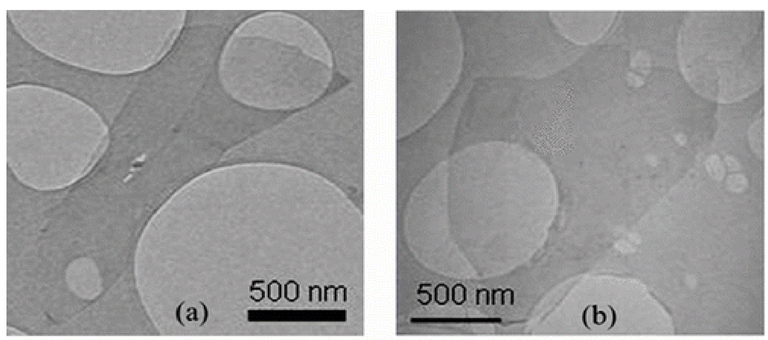

Fig. 2: Separation of Graphene sheets

B. Thermal Chemical Vapor Deposition Techniques

In this work, a natural, eco-friendly, low cost precursor, camphor, was used to synthesize graphene on Ni foils. Camphor was first evaporated at 180°C and then pyrolyzed, in another chamber of the CVD furnace, at 700 to 850°C, using argon as the carrier gas. Upon natural cooling to room temperature, few-layer graphene sheets were observed on the Ni foils.

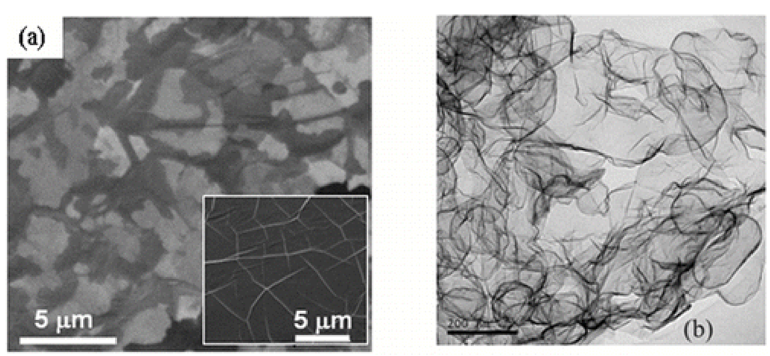

Fig. 3: Vapors containing Graphene being deposited.

C. Plasma Enhanced Chemical Vapor Deposition Techniques

Interest in synthesizing graphene through plasma enhanced chemical vapor deposition (PECVD) is contemporary to that of exfoliation. The earliest report had proposed a DC discharge PECVD method to produce so called nanostructured graphite-like carbon (NG). Simplicity of the process immediately attracted attention of the scientific community and the same kind of process was followed by many research groups, worldwide.

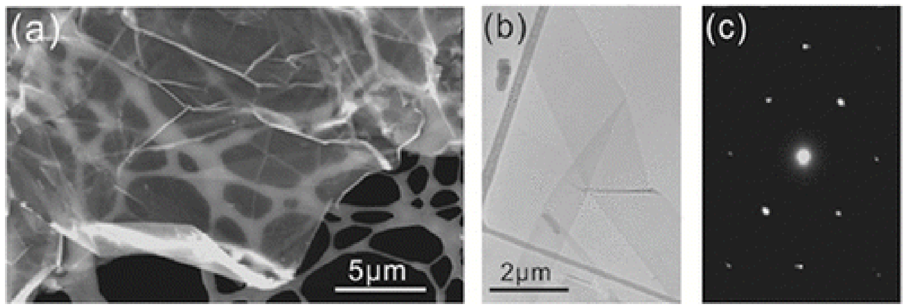

Fig. 4: Graphene deposited on Plasma.

PECVD method has shown the versatility of synthesizing graphene on any substrate, thus expanding its field of applications. Future developments of this method should bring out better control over the thickness of the graphene layers and large scale production.

IV. PROPERITES

Graphene has several good properties. It conducts heat readily, so it can be easily cooled. It can withstand temperatures of several thousand degrees. Graphene doesn't melt easily. It is, however quite flammable. If there is any oxygen, it will burn up. In addition to its exceptional electrical conductivity, graphene is the strongest known substance. By creating holes within a sheet of graphene, then "doping" those holes with desired impurities, semiconductors can be made that are nearly unbreakable and highly flexible. As a bonus, graphene is a superb heat conducting material, so heat would not be the problem it is with current semiconductor materials. Yet, optimism must remain guarded until tangible results have been produced. This novel material is atomically thin, chemically inert, consists of light atoms, and possesses a highly ordered structure. Graphene is electrically and thermally conductive, and is the strongest material ever measured. These remarkable properties make graphene the ideal material. One photon can be converted into multiple electrons.

A paradigm shift in the materials industry is likely within the near-future as a variety of unique materials replaces those that we commonly use today, such as plastics. Among these new materials, graphene stands out. The single-atom-thick sheet of pure carbon has an enormous number of potential applications across a variety of fields. Its potential use in high-efficiency, flexible, and transparent solar cells is among the potential applications.

A new discovery by researchers has revealed that graphene is even more efficient at converting light into electricity than previously known. Graphene is capable of converting a single photon of light into multiple electrons able to drive electric current. The discovery is an important one for next-generation solar cells, as well as other light-detecting and light-harvesting technologies. In most materials, one absorbed photon generates one electron, but in the case of graphene, it is seen that one absorbed photon is able to produce many excited electrons, and therefore generate larger electrical signals. It was known that graphene is able to absorb a very large spectrum of light colors. However now it is known that once the material has absorbed light, the energy conversion efficiency is very high. Our next challenge will be to find ways of extracting the electrical current and enhance the absorption of graphene. Then we will be able to design graphene devices that detect light more efficiently and could potentially even lead to more efficient solar cells

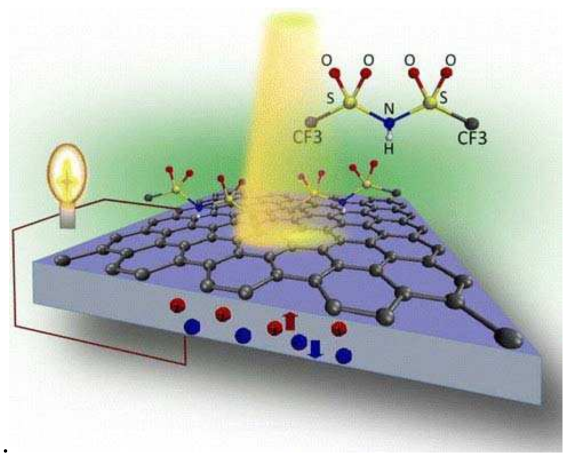

Fig. 5: Graphene as substrate in Solar cell.

V. APPLICATIONS AND USES

A. Electrodes with very high surface area.

Researchers have developed electrodes made from carbon nanotubes grown on graphene. The researchers first grow graphene on a metal substrate then grow carbon nanotubes on the graphene sheet. Because the base of each nanotube is bonded, atom to atom, to the graphene sheet the nanotube-graphene structure is essentially one molecule with a huge surface area.

B. Lower cost solar cells:

Researchers have built a solar cell that uses graphene as a electrode while using buckyballs and carbon nanotubes to absorb light and generate electrons; making a solar cell composed only of carbon. The intention is to eliminate the need for higher cost materials, and complicated manufacturing techniques needed for conventional solar cells

C. Transistors that operate at higher frequency.

The ability to build high frequency transistors with graphene is possible because of the higher speed at which electrons in graphene move compared to electrons in silicon. Researchers are also developing lithography techniques that can be used to fabricate integrated circuits based on graphene.

D. Lower cost of display screens in mobile devices.

Researchers have found that graphene can replace indium-based electrodes in organic light emitting diodes (OLED). These diodes are used in electronic device display screens which require low power consumption. The use of graphene instead of indium not only reduces the cost but eliminates the use of metals in the OLED, which may make devices easier to recycle.

E. Storing hydrogen for fuel cell powered cars.

Researchers have prepared graphene layers to increase the binding energy of hydrogen to the graphene surface in a fuel tank, resulting in a higher amount of hydrogen storage and therefore a lighter weight fuel tank. This could help in the development of practical hydrogen fueled cars.

F.Sensors to diagnose diseases.

These sensors are based upon graphene's large surface area and the fact that molecules that are sensitive to particular diseases can attach to the carbon atoms in graphene. For example, researchers have found that graphene, strands of DNA, and fluorescent molecules can be combined to diagnose diseases. A sensor is formed by attaching fluorescent molecules to single strand DNA and then attaching the DNA to graphene. When an identical single strand DNA combines with the strand on the graphene a double strand DNA if formed that floats off from the graphene, increasing the fluorescence level. This method results in a sensor that can detect the same DNA for a particular disease in a sample.

VI. DRAWBACKS

Graphene’s "external quantum efficiency" is low – it absorbs less than 3% of the light falling on it. Furthermore, useful electrical current can only be extracted from graphene-based devices that have electrical contacts with an optimized "asymmetry" – something that has proven difficult to achieve. Graphene-related materials existed only as conductors or insulators, never as semi-conductors. Graphene has a low energy band gap, so graphene continues to conduct a lot of electrons even in it’s off state. If there were billions of graphene transistors on a chip, a large amount of energy would be wasted

VII. CONCLUSION

Although graphene has shown exceptional electrical, optoelectric, and chemical properties and thus, has excellent potential be used as transparent electrode, field effect transistor, sensors and energy applications, synthesis of graphene films on arbitrary substrates, with desired energy band gap, still remained to be achieved. It is expected that after complete development of graphene films, on a large scale, with desired electrical properties, graphene may become more attractive and thus provide future electric devices.

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