

Status and Prospect of Application about the New Materials Graphene

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Abstract. In this paper, the related properties of graphene were described as the new materials. Through the comparison, the advantages and disadvantages about the preparation methods of graphene were analyzed. According to the present situation of its application, application areas, existing products, etc. of the graphene materials, that Graphene materials are widely used in the future. And the possible environmental pollution risk in the process of development and application are put forward.

Keywords. Graphene, application status, preparation method, application prospect, new material.

1 Introduction

Graphene was a new material that is found in the first form of a single atom. In 2004, it was successfully separated from the graphite and confirmed that it could exist alone. Graphene is a nano material, that it has the thinnest, maximum strength and strongest conductive thermal conductivity [1], also known as the “wonder material”, “black gold”, “king of the new materials”. Since the discovery of graphene materials, technical personnel in various countries to make full use of their excellent performance, expected to be applied in many industrial areas [2], but so far there is still not a large-scale industrial production and application.

Graphene is separated from the graphite material. It is a two-dimensional crystal consisting of carbon atoms with only one layer of atomic thickness (two-dimensional carbon material). Its thickness is about 1/300 million mm [3].

2 Characteristics

2.1 Physical and chemical properties

Graphene has perfect two-dimensional crystal structure. It is the hexagonal lattice surrounded by six carbon atoms. They are bonded with each other to form a honeycomb between carbon atoms by strong conjugated bond to SP² hybrid method. This unique stable structure makes graphene with excellent mechanical strength and structural rigidity [4]. Each carbon atom of graphene has a p orbital electron, which can move freely in the crystal, and moving speed up to 1/300 times the speed of light, so that graphene has excellent electrical conductivity [5].

2.2 Performance analysis

The mechanical strength of graphene can be made into various kinds of graphite carbon materials, such as coiled carbon nanotubes or globular material, and pencil graphite is equivalent to countless graphene stacked together. The layered graphene includes monolayer graphene, double-layer graphene (two layers of hexagonal honeycomb structure stacking), few-layer graphene (3-10 layer hexagonal honeycomb structure stacking), multi-layer graphene (thickness more than 10 layers below 10 nm) and a variety of materials.

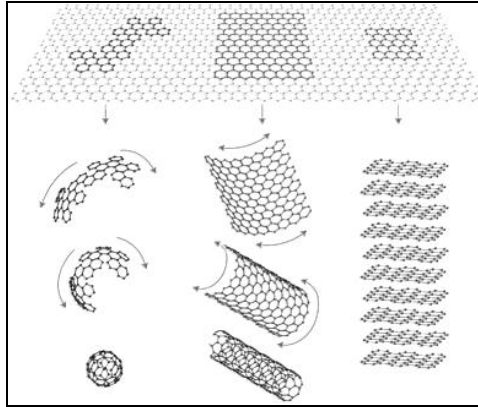


Fig. 1. Structural relationships of spherical, tubular, and tabular carbon materials [4]

The conductivity of graphene is closely related to the electronic band structure. Because there is only one layer of atoms, the motion of electrons is restricted to a plane, which is much faster than the speed of motion of electrons in a general conductor.

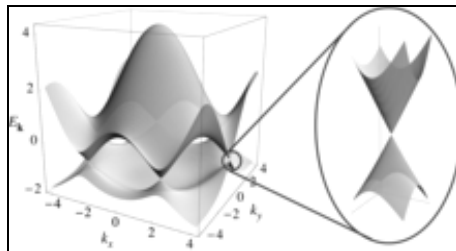


Fig. 2. Schematic diagram of graphene electronic energy band structure [5]

2.3 Possible application areas

According to the strength characteristics of graphene, graphene is the thinnest material, but also the strength and toughness of materials, good elasticity, than steel high fracture strength of 200 times. It can provide a thin, light, strong and tough new material for industrial manufacturing industries, such as automobiles, aircraft and satellites.

Graphene resistivity is only about $10^{-6}\Omega\cdot\text{cm}$, is the smallest resistivity material. Due to its low resistivity, electron migration is extremely fast, so the future can replace silicon, to develop the thinner and the faster conduction velocity that new generation of electronic components or ultra micro transistor. It will make the speed of the computer processor running several hundred times. In the future, it can be used to produce super computer.

Graphene is almost completely transparent, and very dense, even the smallest gas atoms (helium atoms) cannot penetrate it. Therefore, it is very suitable as raw materials for transparent electronic products, such as transparent touch control display, light emitting plate, etc. And in combination with its flexibility, it can be used to produce curved screens.

3 Application status

3.1 Preparation method

The production and preparation of graphene materials are the most important issues in the development and utilization. Initially, the two sides of the graphite sheet is stuck on a special adhesive tape, tear tape, can be divided into two pieces of graphite, and constantly operate, finally, it is only a layer of carbon atoms of graphene. So far, the commonly used methods of preparation are mechanical stripping, chemical stripping, chemical synthesis, catalytic generation (chemical vapor deposition, epitaxial growth method), graphite intercalation method, high temperature quenching method, etc.^[6]

Mechanical stripping method is the most simple and direct method, the use of friction and relative motion between the object and the graphene, mechanical stripping to prepare graphene. The method has higher quality, the majority of graphene has a complete crystal structure, but the film layer is small, the production efficiency is low, and the cost is high.

Chemical stripping method is the strong oxidizing substances reaction between graphene and strong acid to produced the graphite oxide, after ultrasonic dispersion made precursor graphene oxide, increasing the spacing of the layers, then to separated it through physical methods. Add reducing agent to remove the oxide oxygen gene of graphene surface, then it can obtain graphene by chemical reduction and thermal reduction method. The method is simple in operation and high in yield, but the product quality is low.

Catalytic generation method includes chemical vapor deposition method, epitaxial growth method and so on. The chemical vapor deposition method is to put the transition metal film in the hydrocarbon gas, transition metals as catalysts, in the container to the hydrocarbon pyrolysis, and deposited on the substrate to form graphene film. Epitaxial growth method using growth matrix of atomic structure, under ultra high vacuum in the high temperature environment, silicon atoms sublimed from material, residual C atoms self remodeling group. Namely high temperature carbon dissolved in the metal phase, forming interstitial impurities and low temperature carbon segregation at the surface, in a metal substrate surface grown monolayer or double-layer graphene. This method can obtain high quality graphene, but the equipment requirements are higher.

Graphite intercalation method using natural flake graphite as raw material, between the layers and insert some atoms and molecules of non carbon, to form a new layered compounds, increase the spacing between the layers of the graphene, so as to achieve the stripping.

High temperature quenching method is to heat up to 1000 degrees, quickly into the mass fraction of 1% of ammonium bicarbonate solution, high temperature quenching, 5min cooling to room temperature, then it can obtaine the graphene material.

3.2 Application status of graphene

In 2013, the researchers of University of California at Los Angeles developed a micro super capacitor based on graphene, it is 1000 times the rate of charge faster than ordinary batteries.

China also has a unique advantage in the application of graphene. At present, researchers have successfully made the first 15 inch single layer graphene, and successfully applied to the resistance touch screen graphene transparent electrode, made a 7 inch graphene touch screen. The flexible composite thin film with high conductivity and high thermal conductivity is developed, which is of thin thickness, high thermal conductivity and high tensile strength. Researchers from Chinese University of Science and Technology for the first time found that graphene can be used as a good proton conducting membrane. The world's first batch of graphene phone has been released in China, opened a new era of graphene industry applications.

3.3 Major problems

The main problem of the current application of graphene is how to increase the production of graphene materials, and reduce production costs^[7]. Generally the method for preparing graphene with high yield, such as chemical vapor deposition method, output of graphene on edges tend to be disrupted into five membered or seven membered ring, does

not guarantee complete alignment, so that in the interior of the graphene exist structural weakness, easy to fracture and fracture has been extended, to reduce the intensity of the graphene.

4 Application prospects

Graphene application prospects are very broad, many countries and regions have established graphene technology research and development center, to promote the industrialization and commercialization of graphene.

The European Commission will take the graphene as the future flagship technology project, set up special research and development plans. The British government has also invested in the establishment of the national graphene research institute, to promote the material can be from the laboratory into the production line and the market in the future. Spain Graphenano company plans to develop graphene electric vehicles. South Korean researchers successfully synthesized a wafer level high quality multilayer graphene, making it closer to the commercial application, and achieved the cross of graphene from potential materials to the actual application.

Following the implementation of the integration strategy about "graphene global mergers and acquisitions" in China, Beijing-Tianjin-Hebei Industrial Development of graphene alliance was established in 2015. In the future it will be set the graphene industry cluster of research and development, production, inspection, financial services and others.

5 Conclusions

New nano materials graphene with the high strength, conductivity and other excellent properties to get people's attention, although the current application is subject to material production and its costs, but it is broad prospects for future applications. And we should pay attention to the risk of environmental pollution when we are committed to graphene application technology research and development.

References

1. K. S. Novoselov, V. I. Fal'ko and L. Colombo. A roadmap for grapheme: Nature Vol. 490 (2012), p. 192-200
2. Z. G. Song, VI. Artyukhov, and BI. Yakobson. Pseudo Hall-Petch Strength Reduction in Polycrystalline Graphene: Nano Lett. Vol. 13 (2013), p. 1829-1833
3. Yang L., Liu D. and Chen A. Y. The New Star Nanomaterials-Grapheme: G.Z. Chem. Ind. Technol. Vol. 43 (2015), p. 9-11
4. Huang H. D., Ni Z. F. and Huang G. D. Preparation of Graphene Oxide and Property of Its Composites: J. S.X. Univ. (Nat. Sci. Ed.) Vol. 38 (2015), p. 675-680
5. A. Schinwald, F. A. Murphy and A. Jones. Graphene-Based Nanoplatelets: A New Risk to the Respiratory System as a Consequence of Their Unusual Aerodynamic Properties: ACS Nano Vol. 6 (2011), p. 736-746
6. Xiao S. J., Yu S. W. and Tan X.Y. Properties Characterization of Graphene and Its Preparation: Plas. Sci. Technol. Vol. 43 (2015), p. 30-34
7. Zhou H., Piao M. X. and Li Q. Preparation and properties of graphene oxide nanosheets/epoxy composite: Acta Mater. Comp. Sin. Vol. 32(2015), p. 1309-1315