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Diversity of Graphene in Applied Engineering

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Abstract:

The world of materials research is currently engulfed by research focusing on the mass production, characterization and real-world applications of ultra-thin carbon films the thinnest of which is graphene. Nearly a decade of graphene research has promised potential applications including longer-lasting batteries, more efficient solar cells, corrosion prevention, circuit boards, display panels, and medicinal technologies such as the point-of-care detection of diseases; so it comes as no surprise that there are many scientists eager to make the significant breakthrough which could be commercially exploited and implemented into everyday life. It was the combination of the simple isolation strategy and the discovery of the unique properties which kick-started the engine that is now graphene research for futuristic technologies. It would not be surprising if the first graphene-based commercially available technologies arrive within the next decade. Several approaches have been utilized to produce graphene sheets, but still there remains the question of robustness and reproducibility of the methods. Considering the current infrastructure of the semiconductor industry, the electronics technology is very dependent on silicon. Any approach should be able to adapt itself to the current silicon-based technology.

Keywords: *Graphene, Properties, Applied Engineering, Experiment, Future perspective.*

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Introduction

Aluminum alloys are common lightweight materials that are known to have good thermal conductivity. However, the thermal conductivity of aluminum alloys may not be high enough for use in the manufacture of compact heat exchangers for specific applications including fuel cells. One method to enhance the thermal conductivity of aluminum alloys while maintaining their light weight is fabricating metal matrix composites (MMC) using materials with extremely high thermal conductivity as reinforcement.

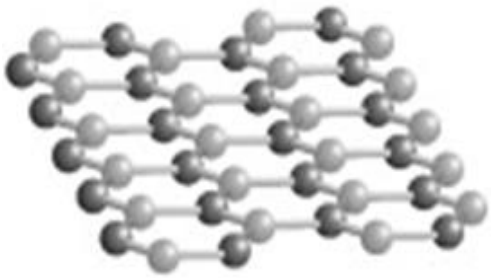

Fig. 1. Crystallographic structure of graphene.

Carbon is the sixth element of the periodic table and the first element of the group 14. Graphene is a two-dimensional (one-atom-thickness) allotrope of carbon with a planar honeycomb lattice. In contrast to carbon, silicon does not catenate readily because the steric effects .The minor size of carbon and its electronic assembly makes carbon as an exceptional element capable of generating versatile structures with tempting properties (Mazdak Taghioskoui, 2009). Graphene, which was experimentally demonstrated in 2004, is building unit for numerous graphitic materials. Graphene shows excellent thermal conductivity (~5.30×103 W/mK), 3 intrinsic strength (~130 GPa), 2 charge carrier mobility (~2×105 cm2 / Vs), and surface area (~ 2600 m2 /g).5 Due to its excellent thermal conductivity, graphene is a good candidate for the corroboration of an aluminum matrix to improve the thermal conductivity (Jeon et al., 2014).

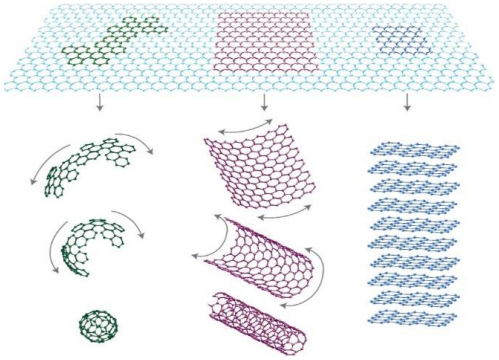

Figure 2. Graphene (top) and related structures: fullerene (bottom left); carbon nanotubes (bottom centre); and graphite (bottom right).

Review of Literature

Katsnelson and Novoselov (2007), basically worked on the limit of zero doping; the concept of Klein paradox (tunneling of relativistic particles) which provides a vital understanding into electron propagation through potential barriers; vacuum polarization around charge impurities is essential for understanding of high electron mobility in graphene; an index theorem which eventually explains the anomalous quantum Hall Effect. It was concluded in the paper that single-layer graphene provides first experimental realization of a two-dimensional massless Dirac fermion system. The analogy with the quantum field theory proved that it is crucial for the understanding of graphene's unusual electronic properties.

Mazdak Taghioskoui (2009), in his paper discussed graphene as possible substitutes for the next generation of faster and smaller electronics because of its unique nano-scale properties it is paving the way to in 21st century. Post processing of graphene sheets, its production, its application and challenges of graphene uses in engineering field and market was further added in the article.

The Royal Swedish Academy of Sciences (2010), described every bit of the details of graphene in their article such as Optical transparency, Density, Strength, Electrical conductivity and Thermal conductivity. From being new to class of materials to its different forms of carbon, discovery and future applications. It eventually concluded that spectacularity of graphene makes it interesting both for fundamental science and for future applications.

Edward P.Randviir et al. (2014), discussed in his paper about the proponent of graphene. He primarily focused upon dissemination of graphene research with a more applicatory approach of graphene and its

perspectives in the future outlook. Along with structure, synthesis and properties of graphene his review also aims to offer a basic background of graphene and some existing research regarding graphene. He concluded his words with need of overcoming obstacles in defect-free and quality mass production of graphene along with government funding in graphene research.

Daniels et al., (2015) their paper aims at summarizing current research involving the responses of graphene and graphene materials to applied stress at the nano-scale as atomic details govern the functionalities of the materials, and to categorize them by stress–strain behavior. Their paper considers reversible functionalization of graphene and graphene materials through elastic deformation and strain engineering. The formation of defects as a response to stress under high temperature annealing or irradiation conditions, and the properties that affect how, and mechanisms by which, pristine, defective, and polycrystalline graphene fail catastrophically during fracture. And concluded by sharing that significance on potential for the use of existing knowledge, especially that of strain engineering, as well as potential for additional research into the fracture mechanics of polycrystalline graphene.

Taleb and Farías (2016), explained the surface phonon dispersion curve of graphene on metals.

They described further that in the case of graphene, additional drive comes from the fact that thermal conductivity is controlled by assistances from acoustic phonons. Their work was based on the two main experimental techniques usually employed are high-resolution electron energy loss spectroscopy (HREELS) and inelastic helium atom scattering (HAS). The different dispersion branches provide a detailed understanding into the graphene–substrate interaction. Article was concluded discussing Kohn anomaly and future perspective of its application.

Atif and Inam (2016), worked majorly on fractography along with topography of multi-layered graphene meticulous examination of topographical features of fractured patterns, various important features related to fillers can be approximated such as dispersion state, interfacial interactions, existence of agglomerates, and overall influence of the combination of filler on the mechanical properties of nano-composites. In their paper it was concluded that monolithic epoxy possess straight bamboo-like fracture pattern representing the existence of typical epoxy brittle fracture because of the absence of crack bridging mechanisms in monolithic epoxy.

Atif and Inam (2016), worked on graphene based polymer, on their modelling and simulation. They explained that stiff and fragile structure of monolithic polymers indicates to the innate cracks to cause fracture and therefore the engineering presentations of monolithic polymers, requires robust damage tolerance and high fracture toughness which is not universal. They discussed simulation and modelling of graphene in terms of structure, topographical features, interfacial interactions, dispersion state, aspect ratio, weight fraction, and trade-off between variables and overall performance.

Conclusion

The single-layered atom-thick flatbed structure has revolutionized the nanotechnology platform since its discovery. Attempts have been made to manufacture graphene on a hefty scale to address the requirements of numerous industries, mainly the composite industry, in which the use of graphene has dramatically converted the global market for the production of state-of-the-art composite materials (Dhand et al., 2013). Graphene reveals a number of interesting physical properties, which were previously not observed at the nano-scale. The observation of room-temperature quantum Hall Effect, ultrahigh electron mobility and ballistic transport, superior thermal conductivity, great mechanical strength, long electron mean free paths, and remarkable flexibility are among the outstanding properties of graphene. Hence, it's alluring to engineering and more specifically in electronics (Mazdak Taghioskoui , 2009) . There are a variety of graphene production methods each of which carry their respective paybacks, whilst at the same time producing different kinds of graphene (monolayer, multi-layer, etc.) which have different tenders depending on the properties revealed by each type of graphene (Randviir et al., 2014).

References:

"Graphene." Nobelprize.org, 2010, www.nobelprize.org/

Atif, Rasheed, and Fawad Inam. "Fractography Analysis with Topographical Features of Multi-Layer Graphene Reinforced Epoxy Nanocomposites." Scientific Research, vol. 05, no. 04, 2016, pp. 166–177., doi:10.4236/graphene.2016.54014

Atif, Rasheed, and Fawad Inam. "Modeling and Simulation of Graphene Based Polymer Nanocomposites: Advances in the Last Decade." Elsevier, vol. 05, no. 02, 2016, pp. 96–142., doi:10.4236/graphene.2016.52011

Daniels, Colin et al. "Elastic, Plastic, and Fracture Mechanisms in Graphene Materials." Journal of Physics, 27, Sept. 2015. 37, iopscience.iop.org

Dhand, Vivek, et al. "A Comprehensive Review of Graphene Nanocomposites: Research Status and Trends." Journal of Nanomaterials, vol. 2013, 2013, pp. 1–14., doi:10.1155/2013/763953

Katsnelson, M.i., and K.s. Novoselov. "Graphene: New Bridge between Condensed Matter Physics and Quantum Electrodynamics." Elsevier, vol. 143, no. 1-2, 2007, pp. 3–13., doi:10.1016/j.ssc.2007.02.043

Randviir, Edward P., et al. "A Decade of Graphene Research: Production, Applications and Outlook." Materials Today, vol. 17, no. 9, 2014, pp. 426–432., doi:10.1016/j.mattod.2014.06.001

Seo, Chi-Hoon JeonYong-Ha JeongJeong-Jin, and Huynh Ngoc Tien,Sung-Tae Hong,Young-Jin Yum,Seung-Hyun Hur,Kwang-Jin Lee. "Material Properties of Graphene/Aluminum Metal Matrix Composites Fabricated by Friction Stir Processing." SpringerLink, Springer, Dordrecht, 5 June 2014, link.springer.com/article/10.1007/s12541-014-0462-2

Taghioskoui, Mazdak. "Trends in Graphene Research." Materials Today, vol. 12, no. 10, 2009, pp. 34–37., doi:10.1016/s1369-7021(09)70274-3

Taleb, Amjad Al, and Daniel Farías. "Phonon Dynamics of Graphene on Metals." Journal of Physics: Condensed Matter, vol. 28, no. 10, 2016, p. 103005., doi:10.1088/0953-8984/28/10/103005