# An overview of Graphene and its application

**G Mohanty[1],[*]**

**[1]Department of Physics, School of Chemical Engineering and Physical Sciences**

**Lovely Professional University, Phagwara, Punjab-144411, India. [*]Corresponding author: smilegoutam@gmail.com**

**Abstract: Graphene, called shining star in material science, is a 2D and $sp^2$- bonded C-atoms with hexagonal crystal lattice structure. It has amazing thermal, mechanical, optical and electrical properties, which attract researchers and recently plays a key role for different applications. In this short review, authors intend is to emphasize on fundamentals of graphene, unique properties, it's biomedical applications.**

**Keywords: Graphene, properties, biomedical application**

## 1. Introduction

Graphene is a single atomic thick, two-dimensional sheets of $sp^2$ hybridized C-atoms packed in a hexagonal lattice [1-2]. The structure of graphene and its three dimensional band structure is shown in Fig 1. In 2010, Geim and Novoselov have got nobel prize award for their ground breaking research 2D-material. Graphene has potential application in wide range of areas because of its amazing properties such as high surface area to volume ratio, high electron mobility, high tensile strength, high thermal conductivity, good biocompatibility and an opacity high enough that it can be seen on a suitable substrate with a standard optical microscope (see Table 1) [3-8]. Hence, it would make a good option for the development biosensor. Present scenario suggest that still we need to understand its biocompatibility for many biological applications. In this section, the fundamentals of graphene and its use for bio-molecular detection is briefly discussed.

## 2. Structure and properties of Graphene

A graphene is a 2D sheet forms honeycomb crystal lattice with a primitive cell contains 2-atoms (A and B). The lattice structure of graphene and its first Brillouin zone is shown in Fig 1. The structure of graphene and its three dimensional band structure is shown in Fig 2. The electron configuration of free carbon atoms is $1s^2 2s^2 2p^2$. For the 2-atoms in the basis, there are 4-valence orbitals, yielding eight extended orbital basis functions for the graphene. Because of its planar structure, atoms undergo bonding with four hybridized $sp^2$-wave functions. The unique properties of graphene is summarized in Table 1[3-8]
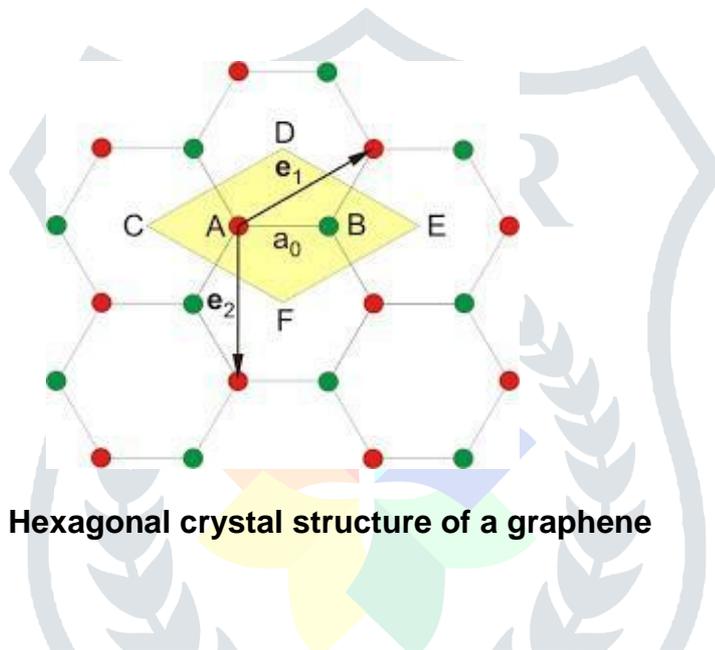


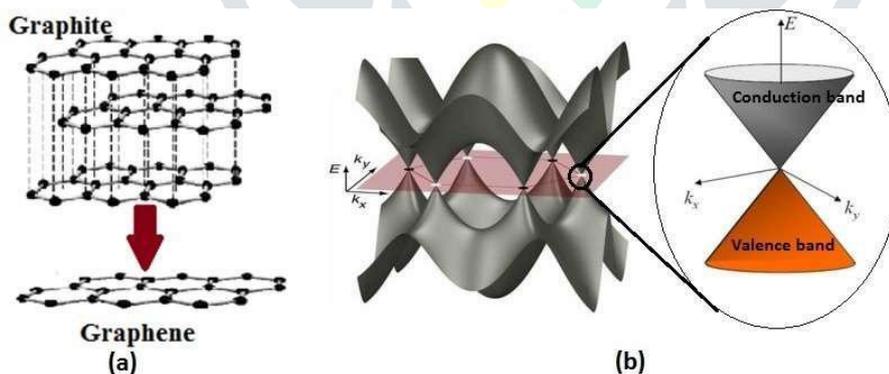**Fig 1: Hexagonal crystal structure of a graphene**



**Fig 2 (a) Structure of graphene, (b) 3D band structure of graphene with Dirac cone [9]**
**Table 1 Properties of graphene**

| Property | Value with units |
|---|---|
| Charge carrier mobility | $\approx 200{,}000 cm^2/V.s$ |
| Thermal conductivity | $\approx 5000 W/m.K$ |
| Transparency | $\approx 97.4\%$ |
| Specific surface area | $\approx 2630 m^2/gm$ |

| Young's modulus | ≈ 1 TPa |
| Tensile strength | ≈1100 GPa |
| Band gap | Zero |

## 3. Application of Graphene

The graphene is a potential candidate for many promising application due to its unique properties. A few promising applications of graphene has been discussed here. Graphene-enhanced composite materials can find uses in aerospace, building materials, mobile devices, and many other applications. This material is extensively used in microelectronics (for example to make LED lighting more efficient and longer lasting). This can be used in batteries and supercapacitors. This material can be used for anti-corrosion coatings and paints, efficient and precise sensors, faster and efficient electronics, flexible displays, efficient solar panels, faster DNA sequencing, drug delivery, and more.

In this section, Author has reviewed in detail how graphene is useful for the detection of biomolecular agents/ targets. Wu et al. reported that graphene-on-gold SPR biosensor (with L graphene layers) is $(1 + 0.025 L) \times \gamma$ (where $\gamma > 1$) times more sensitive than the conventional gold thin film SPR biosensor [10]. The improved sensitivity is due to increased adsorption of biomolecules on graphene (represented by the factor $\gamma$) and the optical property of graphene. Taking advantage of the high impermeability property of graphene and the sharp surface plasmon resonance (SPR) curve of silver, Choi et al. demonstrated that SPR imaging biosensors with a graphene-on-silver substrate can be used to achieve the dramatically high sensitivity as well as to prevent silver oxidation [11]. Their numerical result showed that a silver substrate with a few graphene layers can significantly increase the imaging sensitivity, compared to the conventional gold film based SPR imaging biosensor. Mohanty et al. reported that performance of SPR sensor is significantly improved by using graphene layer over metal surface [12]. Wijaya et al. demonstrated that sensitivity and signal-to-noise ratio of a SPR sensor is significantly increased by incorporating a graphene layer to the conventional gold thin film SPR structure [13]. Salihoglu et al. fabricated a graphene based surface plasmon resonance sensor integrated with a microfluidic device to study nonspecific physical interaction between graphene

layer and proteins [14]. Lange et al. reported that graphene/ PdNP nanocomposite deposited on gold electrode can recognize $H_2$ and $NO_2$ in more sensitive manner [15]. They also reported that only graphene covered sensor was more sensitive towards $NO_2$. As Graphene is a single atom thin planar sheet of $sp^2$ carbon atoms perfectly arranged in a honeycomb lattice, graphene and graphene oxide are good supports for biomolecules because of their large surface area and rich π-conjugation structure, making them suitable dielectric top layers for SPR sensing. Graphene modified SPR surfaces are believed to have several advantages [16]:

Graphene has a very high surface-to-volume ratio which is expected to be beneficial for efficient adsorption of biomolecules compared with gold.

Graphene should increase the adsorption of organic and biological molecules because their carbon-based ring structure enables π-stacking interaction with the hexagonal cells of graphene.

The presence of graphene on the top of silver passivates the surface against oxidation, making possible the use of silver as plasmon-active interface.

Controlling the number of graphene layers transferred on to the metal interface enables control of the SPR response and the sensitivity of SPR measurements.

## 4. Conclusion

The 2D graphene structure offers several advantages over conventional nano-particles owing to its unique properties. In this review, it has been discussed its structure, properties and a few applications. The graphene for bio-molecular detection has been discussed. The successful application of graphene materials will pave a new way for building a nano-platform in different domain of research.

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