Graphene

A.N. Author: Christos Paspalides
ph4744@edu.physics.uoc.gr

Graphene is one of the most important and well-studied materials of the modern technological era. It is the forerunner of a new family of materials, known as "two-dimensional materials". Its special set of mechanical, optical and electrical properties constitutes a powerful weapon for technological applications. This project is aimed at focusing on the unique lattice structure of graphene, its extraordinary properties and how do scientists try to control the performance of current graphene-based devices.

Back in 2004 Andre Geim and Konstantin Novoselov manage to extract via mechanical exfoliation the first 2D graphene layer and characterize it. Their work resulted in winning the Nobel Prize in Physics "for groundbreaking experiments regarding the two-dimensional material graphene", in 2010. The lattice structure of graphene consists of a single layer of carbon atoms, which are connected via covalent bonds creating a hexagonal formation. Some of its properties are shown in Table 1.

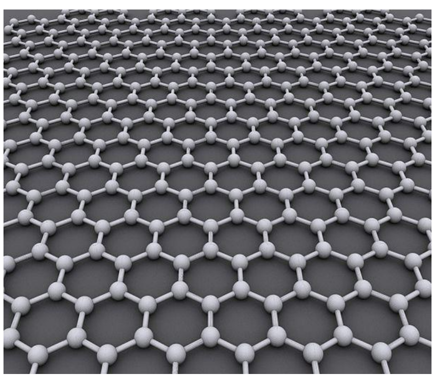

Fig 1: Hexagonal lattice structure of graphene

Charge carrier mobility	~200 000 $cm^2/V{\cdot}s$
Thermal conductivity	~5000 $W/m{\cdot}K$
Transparency	~97.4%
Specific surface area	~2630 m^2/g
Young's modulus	~1 TPa
Tensile strength	~1100 GPa
Band gap	Zero

Table 1: Properties of graphene

Ref: Sang Kyu Lee et al, 2013. Graphene: an emerging material for biological tissue engineering. Carbon letters 14(2)

A very important fact is that graphene's properties are exceptional considering its size, but still cannot substitute the performance of common semiconductors (Silicon, GaAs). Also, the greatest disadvantage of graphene is the absence of energy gap which results in poor I_{on}/I_{off} ratio. [1]. This parameter is crucial for any electro-optical device and that's why scientists have drawn their attention towards graphene nanoribbons (GNRs). [2].

Nowadays, a wide range of graphene-based devices such as MOSFET transistors are being put to the test. According to Gaurav Gupta et al. a dual-gate graphene nanoribbon

SBFET is proposed for succeeding silicon based MOSFET. [3]. Different types of contacts have been examined, as well as their performance in terms of I_{on} to I_{off} ratio. Apart from MOSFET transistors there is a variety of other new age devices that rely on graphene such as sensors, supercapacitors and batteries.

In conclusion, the unique structure and the extraordinary properties of graphene have been presented. A huge interest has rapidly risen towards graphene-based devices. Some practical difficulties and disadvantages considering the absence of energy gap in graphene remain a challenge to solve. These challenges led to the introduction of graphene nanoribbons as an alternative for silicon semiconductors. Graphene is a promising material, which can excel in many technological fields and should be exploited in the best possible way.

References

[1] Frank Schwierz, 2010. Graphene transistors. Nature Nanotechnology, volume 5, pages 487–496.

[2] https://en.wikipedia.org/wiki/Graphene nanoribbon

[3] G Gupta et al, 2016. Applications of Graphene-Based Materials in Electronic Devices. Graphene Science Handbook, CRC Press

Abbreviations

MOSFET: Metal Oxide Semiconductor Field Effect Transistor

SBFET: Schottky barrier Field Effect Transistor