SYNTHESIS AND CHARACTERIZATION OF GRAPHENE BASED ELECTRODES FOR ELECTRICAL AND OPTICAL DEVICES

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ABSTRACT

This Graphene is a upcoming material which able to replace other traditional electrode materials such as Copper, indium tin oxide in electrical and optical devices. It combines several advantageous characteristics including low sheet resistance, high optical transparency and excellent mechanical properties. Recent research has coincided with increased interest in the application of graphene as an electrode material in transistors, light-emitting diodes, solar cells and flexible devices. However, for more practical applications, the performance of devices should be further improved by the engineering of graphene films, such as through their synthesis, transfer and doping. This has several applications of graphene films as electrodes in electrical and optical devices and the essential requirements for applications of graphene films as electrodes.

Keywords:Electrode,Graphene, Indium tin oxide, Raman spectroscopy, sheet resistance.

I. INTRODUCTION

Graphite refers as a plumb ago or black lead . It is an allotrope of carbon consisting of a single layer of carbon atoms arranged in an hexagonal or honey comb lattice. Individual layer can be separated which is graphene. The bonding is a weak vanderwaal′ s force so that the bond can be easily separated. Graphene was first discovered by Philip Russel Wallace in 1946. Graphene is good conductor of heat and electricity. It is more conductive when compared with copper. And it is robust and flexible.Electrodes are used to make contacts with non-metallic parts of the circuits. It is conductors through which electricity can enters and leave the substances. Generally metals are considered as electrode because they are good conductor of heat and electricity. The electrode made up of materials like copper, aluminium, gold, platinum, titanium, brass,silver etc.

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1.1 HISTORY OF ELECTRODE MATERIALS

MATERIAL	MELTING POINT(°C)	RESISTIVITY (Ω m)	CONDUCTIVITY(W/mk)	ADVANTAGE	DIS ADVANTAGE
COPPER	1083	1.7	401	NON CORROSIVE	EXPENSIVE
TITANIUM	1668	41.7	21	STRONG , DURABLE	EXPENSIVE , NOT SUITABLE FOR HIGH TEMPERATURE
BRASS	900	6.3	150	DUCTILE , CORROSION RESISTANCE	BRITTLE , HIGH COST
SILVER	961	1.6	2.5 - 4	SIMPLE , STABLE	SPECIAL EFFORT FOR CLEANING , POLISHING
PLATINUM	1772	4.3	107	DURABLE , STRONG	EXPENSIVE
GRAPHENE	3600	40	3000-5000	TRANSPARENT , LOW COST	LOW CURRENT DENSITY

TABLE 1 COMPARISON OF TRADITIONAL ELECTRODE MATERIAL WITH GRAPHENE

1.2 ADVANTAGE OF GRAPHENE

- Highly transparent and conductive
- No heat loss
- 100% OUTPUT
- Thinnest and strong

II. SYNTHESIS AND CHARACTERIZATION

- **METHODS**

Exfoliation

- **CHARACTERIZATION**

Raman Spectroscopy

2.1 CLEANING OF Si SUBSTRATE

Wafer cleaning means removing contaminations on the substrate. Rinse with Deionized water for 5 minutes to remove dust particles. Ultra sonificate for 5 minutes using acetone and isopropyl alcohol to remove organic and oil residues from the surface of silicon wafers. Piranha etch cleaning is also known as piranha solution. It is a mixture of 3 parts of sulphuric acid and 1 part of 30 % hydrogen peroxide. The mixture is strong oxidizing agent it mostly used to remove organic matter. After that, the substrate was rinsed with distilled water for 1 to 2 minutes. Finally, the substrate was dried with nitrogen flushing and then heats the sample at 120℃which is used to remove moisture.

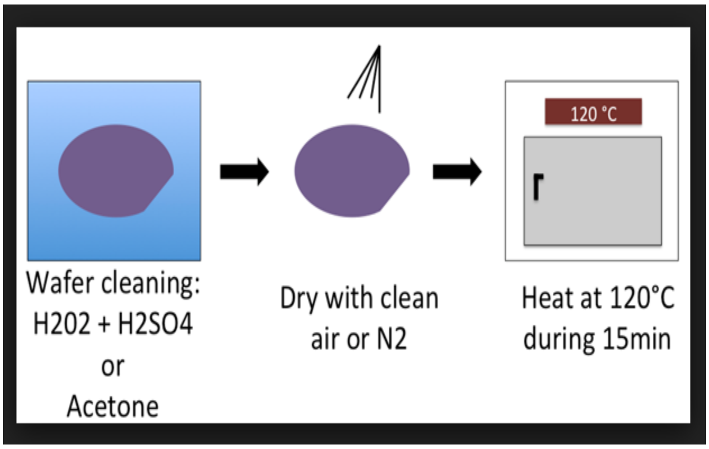

Fig. 2.1Diagram of the Cleaning of Si substrate

2.2 EXFOLIATION

Scotch Tape Method

In this micromechanical exfoliation method, graphene is detached from a graphite crystal using adhesive tape. After, peeling it off the graphite, multiple-layer graphene remains on the tape. By repeated peeling the multiple-layer graphene is cleaved into various flakes of few-layer graphene. Afterwards, the tape is attached to the substrate and the glue solved, e.g. by acetone, in order to detach the tape.

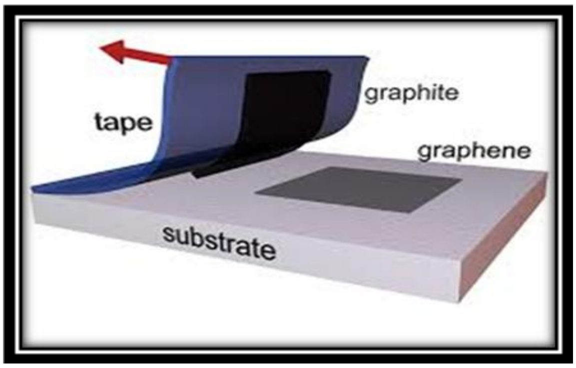

Fig. 2.2 Exfoliation of Graphene layers using scotch tape

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2.3 LITHOGRAPHY

Litho means stone. Graphene means writing. It is a process of producing patterns on semiconductor crystals; Lithography has an important role in the fabrication and mass production of integrated circuits (IC's) in the microelectronics Industry.

Electron beam lithography

(E-beam lithography) is a direct writing technique that uses an accelerated beam of electrons to pattern features down to sub-10 nm on substrates that have been coated with an electron beam sensitive resist. Exposure to the electron beam changes the solubility of the resist, enabling selective removal of either the exposed or non-exposed regions of the resist by immersing it in a developer pattern on a substrate.Silicon wafer is coated by a polymer then exposed to electron beam. Using spinner the uniform thickness of 100nm deposited. Over the polymer hardened by baking at 200 ℃

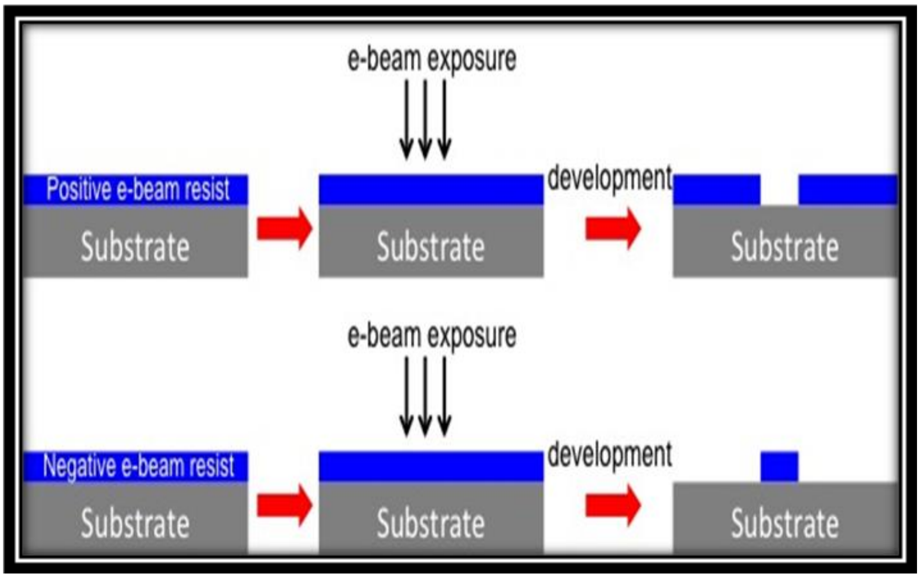

Fig. 2.3 Schematic representation of Positive and Negative Resist

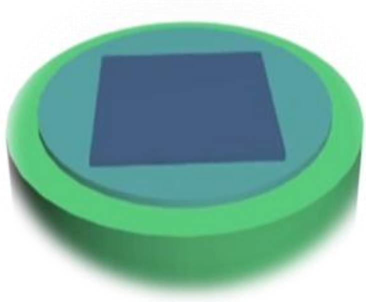

Fig. 2.4 Diagram of E Resist Spin Coating

Fig. 2.5 Schematic representation of E Beam Drawing

Wafer is prepared and inserted into electron microscope

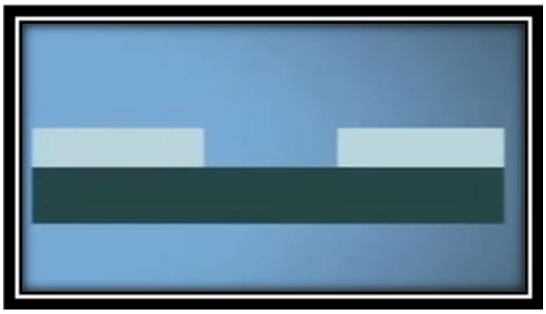

Fig. 2.6 DEVELOPER

Wafer is taken from microscope and put into solvent to develop it. Solvent is choose only to dissolve and remove the part of the polymer which were irradiated by electron beam and leave rest of the polymer intact.After the metal is cleaned then move to the stage of metal deposition.

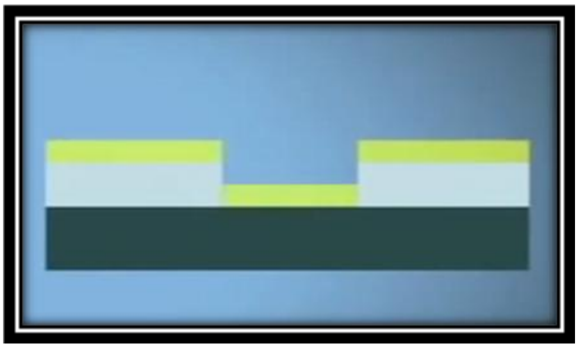

Fig. 2.7 SPUTTERING

Sputtering is used to deposit the thin film on a substrate by creating gaseous plasma and acceleratingions.The wafer placed into sputter this device sputters the metal over whole surface.

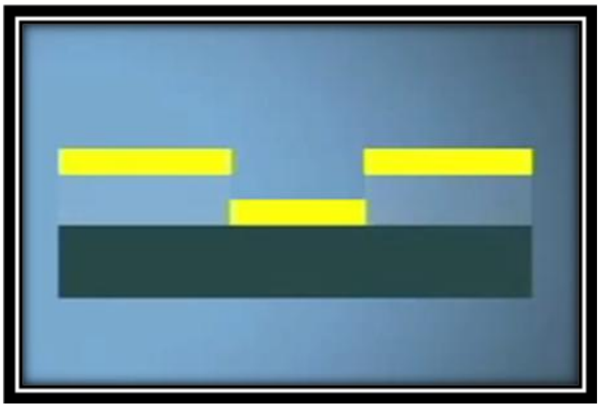

Fig.2.8 LIFT OFF

Lift-off process in **microstructuring technology** is a method of creating structures (patterning) of a target material on the surface of a substrate (e.g. **wafer**) using a sacrificial material (e.g., **Photoresist**). It is an additive technique as opposed to more traditional subtracting technique like **etching**.

An inverse pattern is first created in the sacrificial stencil layer (ex. photoresist), deposited on the surface of the substrate. This is done by etching openings through the layer so that the target material can reach the surface of the substrate in those regions, where the final pattern is to be created. The target material is deposited over the whole area of the wafer, reaching the surface of the substrate in the etched regions and staying on the top of the sacrificial layer in the regions, where it was not previously etched.

When the sacrificial layer is washed away (photoresist in a solvent), the material on the top is lifted-off and washed together with the sacrificial layer below. After the lift-off, the target material remains only in the regions where it had a direct contact with the substrate.

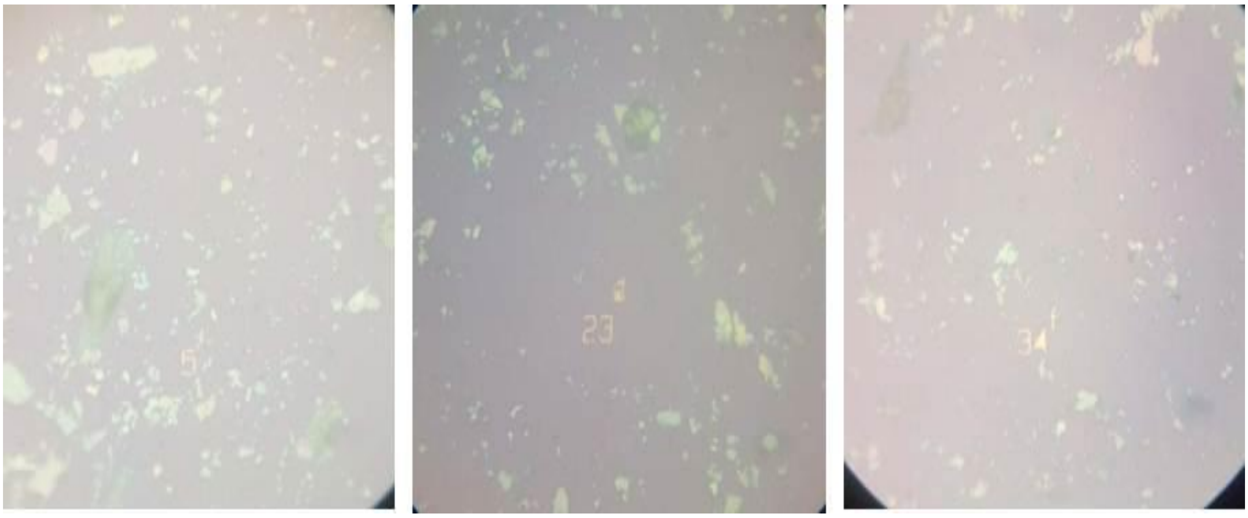

Fig. 2.9 OPTICAL MICROSCOPE IMAGES OF GRAPHENE FLAKES

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III. CHARACTERIZATION

3.1 RAMAN SPECTROSCOPY ANALYSIS

Spectroscopy is a interaction of light and matter. The scattering of radiation with change of frequency is Raman scattering. It is used to observe vibrational, rotational, and other low frequency modes in a system Raman spectroscopy is a spectroscopic technique used to observe vibrational, rotational, and other low-frequency modes in a system. The energy of the scattered radiation is less than the incident radiation for the Stokes line, and the energy of the scattered radiation is more than the incident radiation for the anti-Stokes line Rayleigh scattering, is an elastic scattering process in which a photon bounces off a molecule like a billiard ball, emerging with the same energy as it entered. Raman scattering, is an inelastic scattering process in which the light scattered by a molecule emerges having an energy that is slightly different (more or less) than the incident light. This energy difference is generally dependent on the chemical structure of the molecules involved in the scattering process.

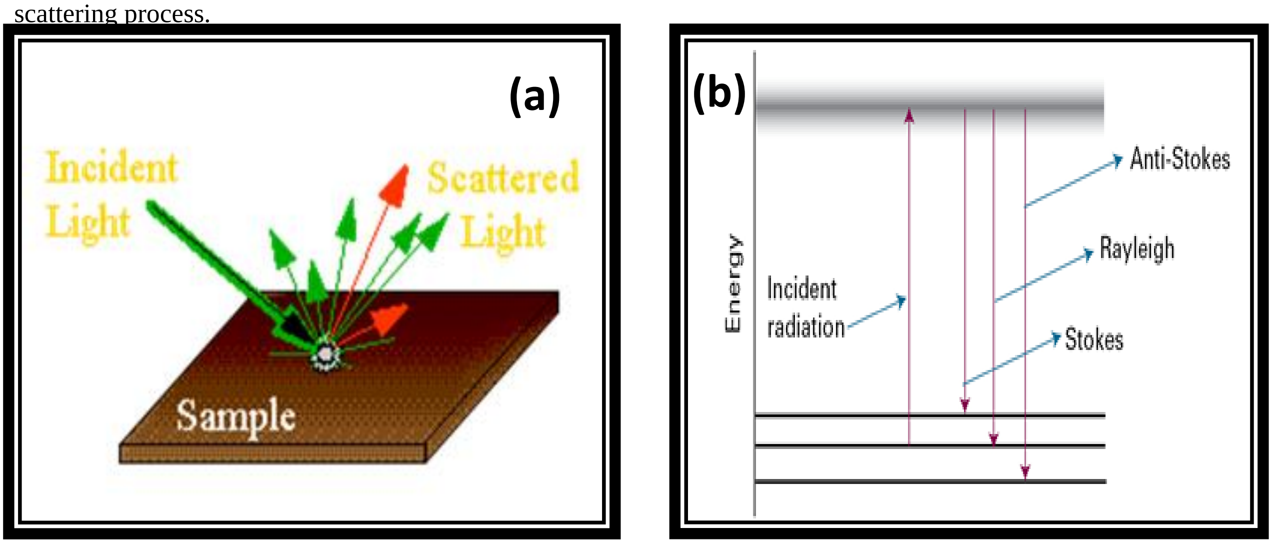
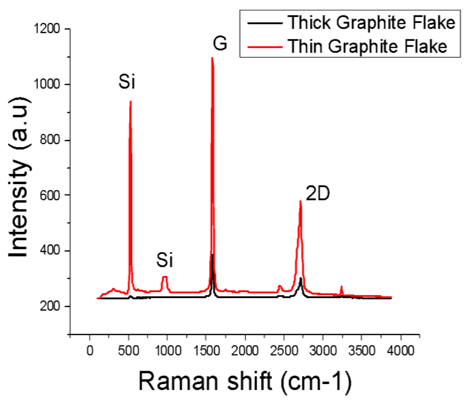


Fig. 2.10 (a) Schematic representation of Light Interaction on the sample (b) Energy level Diagram of emission of the stokes & Anti stokes lines



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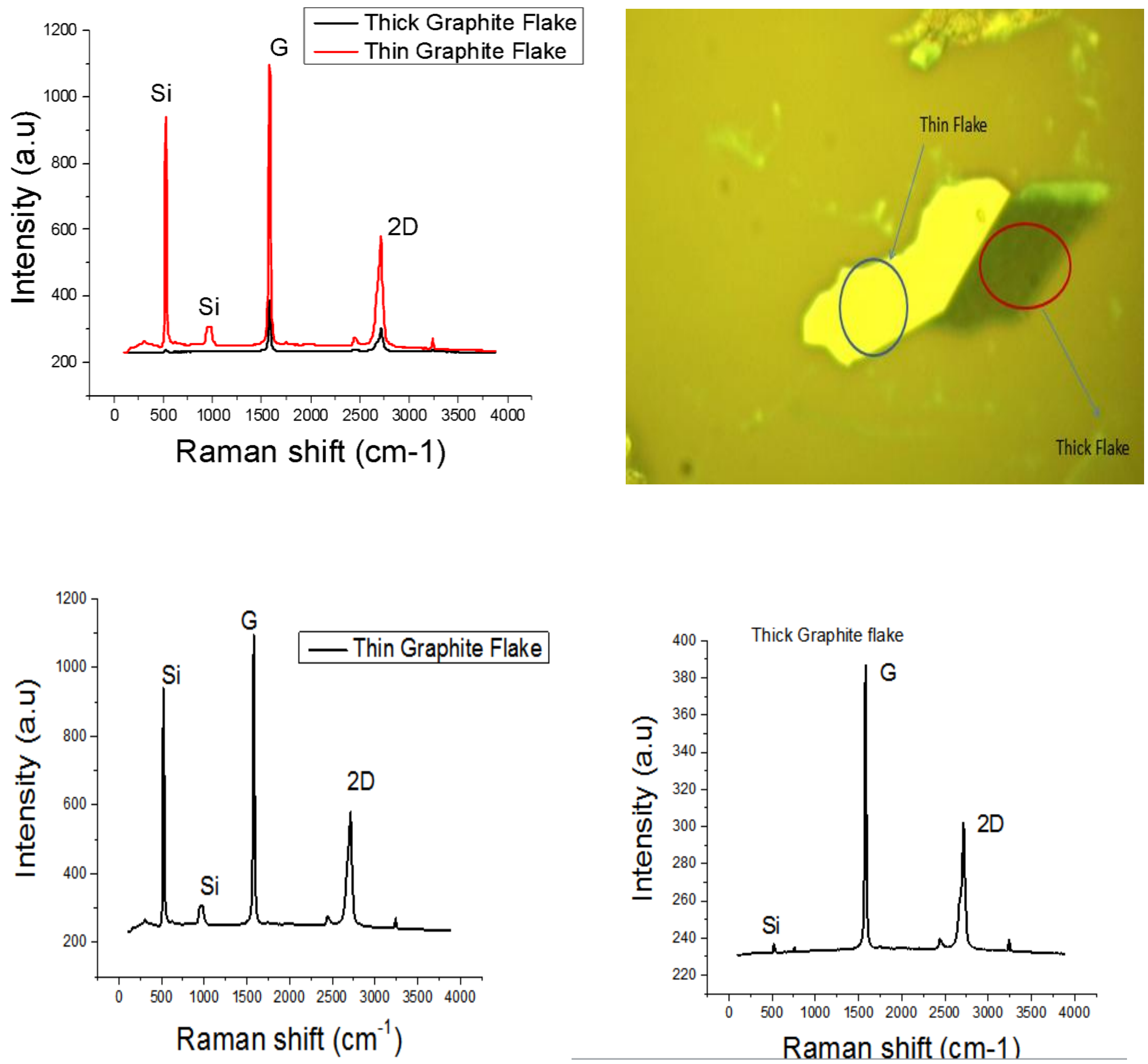

Fig. 2.12 Thick and Thin Flakes

G BAND - Sharp band appears around 1587 cm-1 in spectra of graphene

D BAND -It is called as defect or disorder band.

This D band is weak Intensity of D band is α level of defect in sample

2D BAND-second order of D band sometimes referred as an overtone of D band. It is always strong. It appears around 2658 cm -1.

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MATERIAL	T(%)	R_s(Ω/□)	STATUS	ISSUE
ITO	>85	15-30	Standard	Cost, brittle, corrosion by salts or acids, slow vacuum process
Ag nanowire	>80	0.4-116	Commercialized, Emerging	Roughness , environmental stability , haze
CNT	90	50	Emerging	High resistance, doping stability
Graphene	85	400 or more	Emerging	High resistance, doping stability

TABLE 2 COMPARISON OF THE SHEET RESISTANCE WITH DIFFERENT MATERIALS

IV. APPLICATIONS

OPTICAL DEVICES

- Photodetectors,Touch screen , LED, Solar cell.

ELECTRONIC DEVICES

- Transistors
- Memory devices

V .CONCLUSION

- Many fascinating properties of graphene and its applications provide the opportunityto substitute graphene for ITO in transparent and flexible technologies. In electrical devices with graphene electrodes, it is possible to achieve high-performance OFETs, good resistive switching devices and highly reliable molecular junction devices due to its favorable interfacial contact with organic materials and electrochemical functionalization at the graphene/active layer interface. In addition, transparent electronics is one of the most advanced research topics that features a wide range of device applications, where the key components (i.e. electrodes, active and passive components) should be invisible.

- In optoelectronic devices (such as touch screen, LCDs, LEDs and solar cells), ITO is still the most widely used material for transparent electrodes. However, there is an increasing demand for the development of new transparent electrode materials that can challenge ITO due to ITO's cost fluctuation and brittle nature, suggesting that flexible optoelectronic devices will be an attractive market for ITO substitutes.

REFERENCES

[1] Synthesis, Characterization, and Selected Properties of Graphene C.N.R. Rao, Urmimala Maitra, and H.S.S. Ramakrishna Matte.

[2] The application of graphene as electrodes in electrical and optical devices Gunho Jo, Minhyeok Choe, Sangchul Lee, Woojin Park, Yung Ho Kahng and Takhee Lee.

[3] Eda G, Fanchini G, and Chhowalla M. Large-area ultrathin films of reduced graphene oxide as a transparent and flexible electronic material. Nature Nanotechnology

[4] Preparation of Graphene: Physics of Nanoscale Carbon NilsKrane.

[5] Graphene–MoS2 hybrid structures for multifunctional photoresponsive memory devices Kallol Roy, Medini Padmanabhan, Srijit Goswami , T. Phanindra Sai, Gopalakrishnan Ramalingam, Srinivasan Raghavan and Arindam Ghosh

[6] Application of Graphene within Optoelectronic Devices and Transistors F.V. Kusmartsev, W.M. Wu, and M.P. Pierpoint.