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Graphene and its Dopants used as a Transistor in VLSI Circuits

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ABSTRACT

Graphene, a sheet of carbon atoms arrayed in a honeycomb pattern, could be a better semiconductor than silicon.Due to many such properties graphene has been under study as a alternative substance used, rather then graphite and silicon in transistors.But the main function of a transistor is to perform the operation of switching, i:e on and off.The problem that arises here is that graphene has no energy band gap and therefore in this paper i review the various possibilities with which a band gap can be induced in graphene and with all the possible alternatives of use of graphene in LSIs.

Key words : Graphene**,** nano ribbon**,** Triazine-based graphitic carbon nitride (TGCN) , DNA , LSIs.

INTRODUCTION

In recent years, the increase in power consumption associated with the spread of mobile information terminals and the progress in IT devices has become a concern. Societal demand for reduction of the power consumed by electronic information devices is increasing. Although attempts at reducing the power consumed by large-scale integrated circuits (LSIs) have been advanced, the conventional transistor structure is considered to have inherent limits. Meanwhile, electron mobility of graphene, which represents the ease of electron movement, is at least 100 times larger than that of silicon. It is also expected that graphene can be used to resolve the problems of the inherent limits of silicon and other materials. Therefore, graphene has the potential to remove the obstacle to reducing the power consumed by LSIs, and it is expected that graphene will be used as a material for ultra-low-power-consumption transistors of the post-silicon age that utilize new functional atomic films.

Graphene when used in a switching transistor, electric current cannot be sufficiently interrupted, because graphene has no band gap. Also, although there is technology for forming band gaps,electron mobility decreases when the band gap required for switching is formed. Therefore, a graphene transistor with a new operating principle that can perform the switching operation effectively with a small band gap is required.

Researchers have developed a graphene transistor with a new operating principle.

In the developed transistor, two electrodes and two top gates are placed on graphene and graphene between the top gates is irradiated with a helium ion beam to introduce crystalline defects. Gate biases are applied to the two top gates independently, allowing carrier densities in the top-gated graphene regions to be effectively controlled. An electric current on/off ratio of approximately four orders of magnitude was demonstrated at 200 K (approximately “73 °C). In addition, its transistor polarity can be electrically controlled and inverted, which to date has not been possible for transistors. This technology is expected to contribute to the realization of ultra-low-power-consumption electronics by reducing operation voltage in future. In order to create a transport gap in graphene of the channel between the two top gates, a helium ion microscope was used to irradiate helium ions

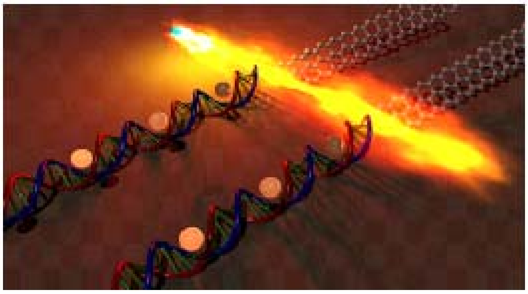

Fig.1:

conventional transistor (Figs. 1(d) to 1(f)) is in an off state, carrier transport is blocked by a barrier formed on the source- or drain-side end of the channel having the transport gap. However, as shown in Fig. 1(e), the leak current of the transistor in the off state is large, because only a small barrier is formed. Meanwhile, as Fig. 1(b) shows, the transport gap in the developed transistor works as a barrier larger than that of conventional transistors (Fig. 1(e)) and blocks charge transfer. As a result, it is possible to obtain a superior off state to that of conventional transistors.

DNA used for graphene assemblage

For assembling mechanism of grapheme nano-ribbons of 20 to 50 atom corpulence DNA molecule is used. Since ,the molecular length of DNA strands are of the same dimension as graphene ribbons and DNA molecules contain carbon atoms, the material that forms

at a density of 6.9 x 10^{15} ions/cm^2 to introduce crystalline defects.

The operating principle of the newly developed graphene transistor is shown in Figs 1(a) to 1(c).The energy band of the graphene on both sides of the channel can be modulated by electrostatic control by applying biases to the top gates. The polarity of the carriers in graphene can be changed between n-type and p-type, depending on the polarity of the biases applied to the top gates. When the polarities on both sides of the channel differ, the transistor is in an off state (Fig. 1(b)). When the polarities are the same, the transistor is in an on state (Fig. 1(c)). When a

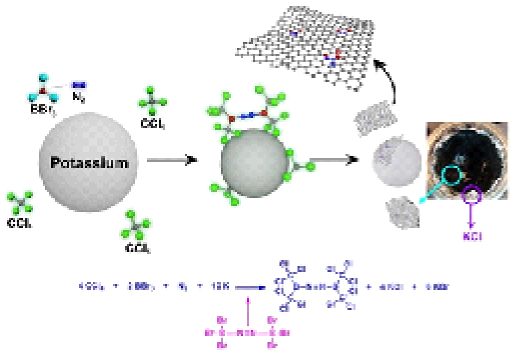

Fig. 2:

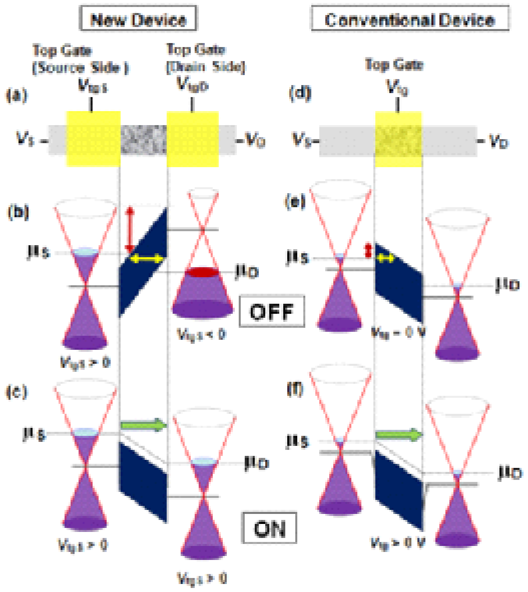

Fig. 3:

graphene, this can be taken as a thought under consideration and here's the experiment we've compiled on it.

The analysis is carried with tiny silicon platter as a substrate .This platter is dipped into DNA derived from bacteria,which is then combed into DNA strands of relatively straight lines.Next, the DNA on the platter is exposed to a copper salt solution. The chemical properties of the solution allowed the copper ions to be absorbed into the DNA.

The platter is then heated and bathed in methane gas, since it has carbon as a constiuent .The platter on getting heated sparked a chemical reaction that freed some of the carbon atoms in the DNA and methane. These free carbon atoms quickly joined together to form stable honeycombs of graphene. The loose carbon atoms stayed close to where they broke free from the DNA strands, and so they formed ribbons that followed the structure of the DNA.

This derived grapheme assemblage from DNA performed electronic tasks and thus transistors were made with carbon ribbons DNA-based fabrication method is highly scalable, offers high resolution and low manufacturing cost, thus this method seems to be v attractive for industrial applications fig(2) To the right is a honeycomb of graphene atoms. To the left is a double strand of DNA. The white spheres represent copper ions integral to the chemical assembly process. The fire represents the heat that is an essential ingredient in the technique.

BBr2 used with graphene for controlling the band gap

Another method for making graphene-based FET is tailoring grapheme made nano ribbons using boron nitride was a support. Not only the band gap can be controlled bit also the properties like high specific surface area, good thermal and electrical conductivities can also be improved.

The need for controlling the band gap of graphene arises because of the vanishing band-gap for semiconductor application. As a result, it is not suitable for logic applications, because devices cannot be switched off. Therefore, graphene must be modified to produce a band-gap, if it is to be used in electronic devices.

Though boron can be added into the graphitic framework but since atomic size of boron (85 pm) is larger than that of carbon (77 pm), it is difficult to accommodate boron into the graphitic network structure. The solution can thus be obtained by co-doping boron/nitrogen with carbon tetrachloride (CCl4) when treated with boron tribromide (BBr3) and Nitrogen gas (N2) 70 pm.Pairing two nitrogen atoms and two boron atoms can compensate for the atomic size mismatch. Thus, boron and nitrogen pairs can be easily introduced into the graphitic network. The resultant BCN-graphene generates a band-gap for FETs. The approach is simple synthetic and economically viable ,but fine -tuning of band-gap to improve the on/off current ratio is still a challenge.

Transistor using TGCN

This approach too, deals with changes involved in graphene structure for appropriate band gap required to facilitate switching operation.Triazine-based graphitic carbon nitride (TGCN) is a new material that has a two dimensional structure and an electronic band gap.

The procedure involves preparing crystals of graphitic carbon nitride ,a two-dimensional layered material that is similar to graphene that contains nitrogen along with molecule of dicyandiamide. The above materials were combined in a quartz tube and then heated for 62 hours at up to 600°C. A liquid was obtained of TGCN along with flakes that can be removed by filtering or peeling them off the quartz tube.

The material still needs to be scaled up for performance in electronic devices but due to its strong heat and electricity conduction its highly efficient.

CONCLUSION

The article concludes that Graphene the first known one atom thick material with excellent electrical and heat conduction can be effectively used along with proper dopants and material insertions in large scale integrated circuits effectively.The thesis proposed above even solves the problem of absence of band-gap required for switching operation in a transistor. The use of graphene with Helium also helps in solving the problem of high power consumption in LSIs thus proposing in the gen-next material to be used in FETs

REFERENCES

1. Guanxiong Liu, Sonia Ahsan, Alexander G. Khitun, Roger K. Lake, *Journal of Applied Physics,* **114**, 154310 (2013)
2. Frank Schwierz, *Nature Nanotechnology* **5**, 487–496 (2010)
3. Sun-Min Jung, Eun-Kwang Lee, Min Choi, Dongbin Shin, In-Yup Jeon, Jeong-Min Seo, Hu-Young Jeong, Noejung Park, Joon Hak Oh, and Jong-Beom Baek. ”Direct” Synthesis of Boron/Nitrogen Co-Doped Graphene through the Solvothermal Reaction of Carbon Tetrachloride, Boron Tribromide, and Nitrogen. Angewandte Chemie International Edition, (in press)
4. Prof Andrew Cooper,Angewandte Chemie (2013).
5. Professor Zhenan Bao, Anatoliy Sokolov and Fung Ling Yap,Stanford University press (2013)