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Metal-Graphene-Semiconductor (MGS) Interfaces and Perspectives for Nanodevices

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The present paper deals with the metal-graphene and graphene-semiconductor (MGS) contacts aiming design and implementation of modern electronic devices for analog very high frequencies operations and higher power applications. This is due mainly to the higher electron mobility and power sustainability of graphene material. For metal-graphene MG contacts, MLG (multilayer graphene) are good candidate for Schottky diodes and MESFETs

1. Introduction

Recently, graphene has been widely studied aiming a variety of devices and applications [1] that led to the emerging of Carbon electronics. The graphene electronics very high electron mobility and thermal sustainability characteristics have made it a candidate for future electronic devices. However, understanding of the metal-graphene junction (MGJ) [2] is crucial for improving the transmission from metal to grapheme and vice versa [3]. This will reduce the MG contact resistance and lead to efficient FET (Field Effect Transistor) devices. Moreover, getting thermal stability for the MG contacts can overcome the major concern in conventional MESFETs (Metal Semiconductor FET).

The present paper deals with the metal graphene and graphene semiconductor contacts aiming the design of better FET devices for analog very high frequencies operations and higher power applications

2. Metal-graphene (MG) contact description

Graphene semiconductor contacts are being widely studied [4,5], as they are basics for designing Schottky barrier devices. The MGS semiconductor structure can lead to high performances devices and MEMS.

The present work is meant to study the transport properties in the MGS both MG and GS aspects aiming understanding and modeling of the transport at higher nobilities and under high temperatures.

To achieve this objecyive, we have considered the band structure of the structure and explained the mechanisms of current conductions at higher mobility. The MG contact studies used a GFET and the GS junction based on a HEMT. Some other features are studied based on photoconduction and emission. In addition, the MGS structure can also be used for design of better photovoltaic cells [6]. Figure 1 shows the band structure of the MG and GS contacts illustrating the interface charges at the contact.

The structure shows clearly a transition zone that can be seen as 3D-2D transition region where all the transport phenomena will occur. The electrons transport will automatically depend on the work functions and the Fermi level difference.

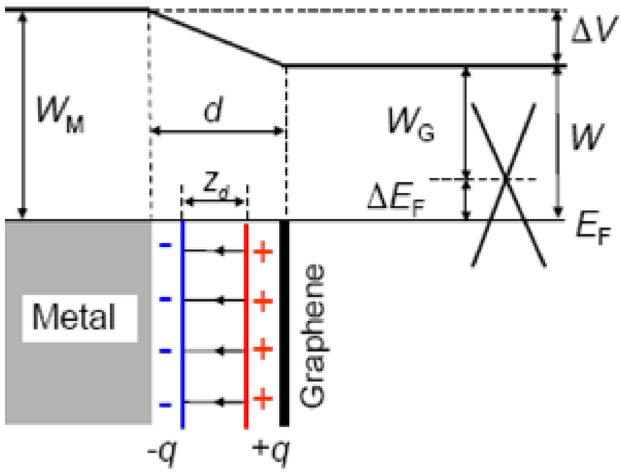

Fig. 1 Band structure of Metal Graphene Contact

The GM contact is mainly used in GFETs (Graphene Field Effect Transistors) as drain source-graphene channel contacts. These contacts should be very low resistance contacts in order to increase the ON/OFF current ratio. Moreover the GM contact is useful for enhanced efficiency solar cells and super-capacitor in energy storage.

In our simulations, we dealt with the MG contact for devices of high mobility and low resistive contacts. We found that the 2D/2D or 2D/3D configuration affects the device performances, especially the charge transport involved (classical or ballistic).

3. Graphene-Semiconductor (GS) contact description

The graphene semiconductor contact can be seen as a pseudo-metal semiconductor contact as shown in Fig.2. The barrier height can be modulated by the applied voltage making a possible Schottky rectifier. The GS contact interface is of better quality as graphene structure has a varying Fermi level and hence capability of lowering the contact resistance [7], which is critical in conventional metal semiconductor contacts. However, there is an inhomogeneous SBH (Schottky Barrier Height) at the GS interface, which may be due to the random impurity distribution at the interface. This may lead to the non-constant Fermi level through the Graphene sheet layer. In order to obtain better electronic and optoelectronic devices, deeper understanding of the SBH variations and 2D/SC and 3D/SC configurations should be taken into considerations.

In this study we showed that, by simulation, the MGS structure can be of higher importance in designing field effect devices both transistors and sensors as well as very high frequency Schottky diodes. It is important to point out that the GS Schottky contact is not the same as the classical one, new equation should be derived accordingly. In addition a new physical model should be proposed to include the SHB inhomogeneous behavior in the graphene layer. However, understanding the nature of the GS interface is important in the current-voltage expressions of the structure.

It has been found that the semiconductor doping is critical in tuning the Schottky diode barrier. Bromine has been used [8] and found that the structure can be used for sensor applications for atoms detection.

Figure 2a

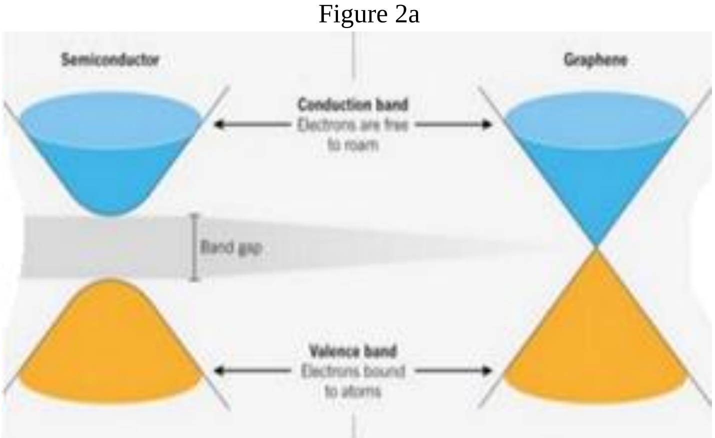

Figure 2b

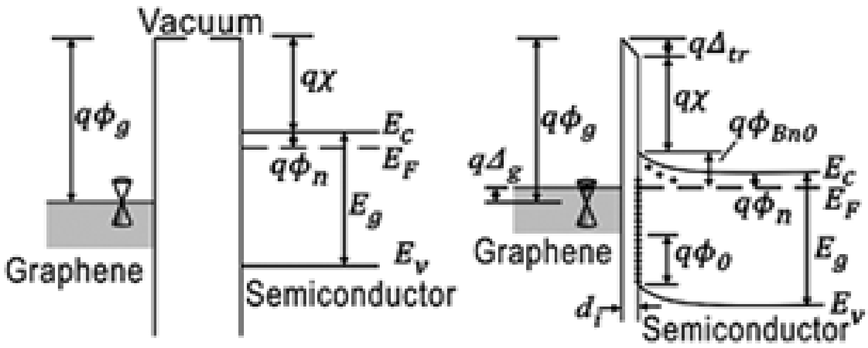

Fig. 2a showing the zero bandgap graphene and the semiconductor and Fig. 2b Showing the contact and filling of the Graphene bands including the behavior of the interface states.

4. Conclusion

The MGS contacts behave differently at different side of the grapheme. M-G is more likely to be a resistive contact or non-rectifying junction but of very high charge transfer. Applications in GFETs contacts are foreseen to improve the graphene transistor performances in different configurations. Also nanotransistors are very high frequency and high power transistors. Sensing with MG structures can be investigated. Effort should be made in understanding the metal-graphene junction and the mechanism of charge transport .

Moreover, the GS contact can be made as very high frequency tunable SBH Schottky diode and sensors. Last, combination of the MGS structure can be of great help in designing new high power and higher frequencies devices and sensors. Due to the transparent type of graphene and the photo transmission, it can be used to improve the photo and optoelectronic devices.

In the coming works, we will apply the models to simulate a first MESFT based on GMS structures.

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