Health Services Vocational Collage

Investigation of The Effect of Electron Irradiation on Al-Omic/Graphene (F3O4) Device

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Abstract

This study reports the electrical properties of Al-omic/Graphene (F3O4) devices due to electron radiation. The sample was exposed to 9, 12 and 15 MeV electron irradiations. The sample was exposed to the same radiation dose at different energies. It was observed that the experimental ideality factor also increased with increasing energy levels. It was observed that the I-V curves were distorted. Here, the distortion of the I-V curves is attributed to the change in the device's surface or interface state distribution. Some basic diode parameters such as ideality factor (n), barrier height (Fb) and series resistance (Rs) were calculated from I-V measurements using of Thermionic Emission and Cheung function. The increase in series resistance by electron radiation irradiation was attributed to the decrease in active doping densities.

Keywords: Electron, irradiation, diode, electronic, properties

Introduction

F. Braun first detected the rectification property of metal-semiconductor contacts in 1874. The first metal-semiconductor diodes made were point contact diodes. These structures were first used as frequency converters and microwave detectors. These diodes were not mechanically reliable and could not be reproduced. Therefore, it has left its place to diodes formed by coating a thin metal film layer on a semiconductor surface. Since the metal layer formed on the semiconductor creates an obstacle at its interface, some metal/semiconductor structures show rectifying properties. Metal-semiconductor contacts are also called "Schottky contacts" since Schottky was the first to develop the model for this barrier formed between metal-semiconductors. Mott, on the other hand, proposed a different model for this obstacle. According to this model, In the metal neighborhood of the semiconductor, there is a thin layer devoid of emitters. In this layer, the electric field will remain constant, and the potential will change linearly. Studies on metal-semiconductor contacts gained intensity, especially in the 1960s. In these years, the construction of Schottky diodes has been the subject of many applications. Current conduction mechanisms and basic properties of metal-semiconductor and metal-insulator-semiconductor structures; (Sze 1969; Sharma 1980). A different method was developed by Cheung and Cheung (1986), which allows for obtaining the diode parameters in both ideal and non-ideal cases from the graphs drawn with the help of linear functions of current density. The ease of construction of Schottky contacts and the significant determinability of their characteristics make them widely used in the electronics industry. To make a circuit element suitable for the area in which it is used, the characteristic parameters of the semiconductor must be measured. The current transition mechanism depends on the ideality of the metal-semiconductor, and the current-voltage characteristic determines the ideality. An ideal diode has an ideality factor of 1. Changes in electronic characteristics cause devices to operate in different states. When such power devices work in aerospace, they will not always be directly exposed to cosmic rays, so the energy of the ions penetrating the machines will be variable. Therefore, examining changes in function when devices are under lowenergy irradiation is essential (Wang et al., 2021)

Experimental

The current-voltage measurements of the Al-omic/Graphene (F_3O_4) junction devices have been carried out using KEITHLEY 487 Picoammeter/Voltage Source. The I–V characteristics of Al-omic/Graphene (F_3O_4) junction devices were measured in the temperature range of 80 K to 460 K.

The ideality factor (n) and the barrier height (Φb) from the *I–V* characteristics were calculated.
Calculation of ideality factor of diode used to experimental I-V measurement with Thermoionic Emission (TE) theory.

$$I = I_0\left[\exp\left(\frac{eV}{kT}\right) - 1\right] \qquad (1)$$

Where, saturation current (I_0) is given by;

$$I_0 = AA^*T^2 \exp\left(-\frac{e\Phi_b}{kT}\right) \qquad (2)$$

where k is Boltzmann constant, n is the ideality factor, which is a measure of the consistency of the diode to pure thermionic emission, e is the electron charge, T is the temperature in Kelvin, k is the Boltzmann constant, A^* is effective Richardson constant (112 A/K^2cm^2 for n-Si), A is effective diode area (A=0,00785 cm^2), and Φb is barrier height at zero bias, V is the bias voltage. The ideality factor is calculated according to the current transmission mechanism in the thermionic emission theory.

$$n = \frac{e}{kT}\frac{dV}{d(\ln I)} \qquad (3)$$

The ideality factor is a dimensionless parameter that indicates the deviation from the properties of the diode. This approximate value should be ‘1’ for an ideal diode. Value of the barrier height (BH) is determined as follows:

$$e\Phi_b = kT\ln\left(AA^*T^2 / I_0\right) \qquad (4)$$

The I-V graph of the sample is shown in Figure 2.

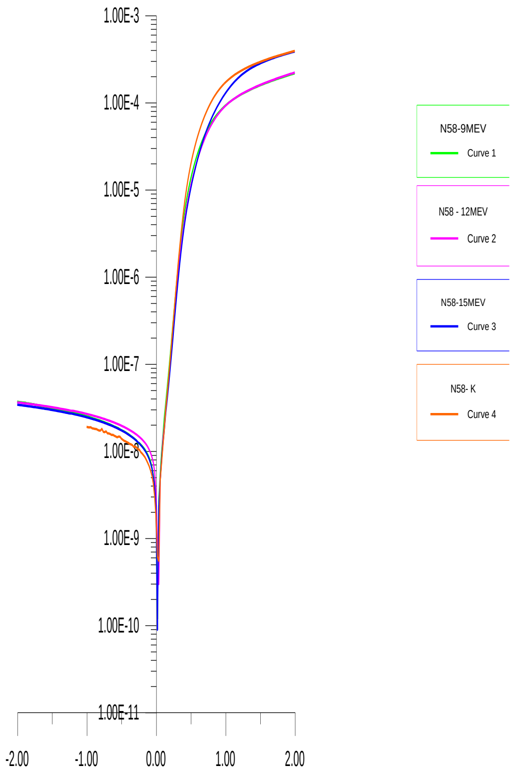

Figure 1 The current-voltage plots of Al-omic/Graphene (F_3O_4)

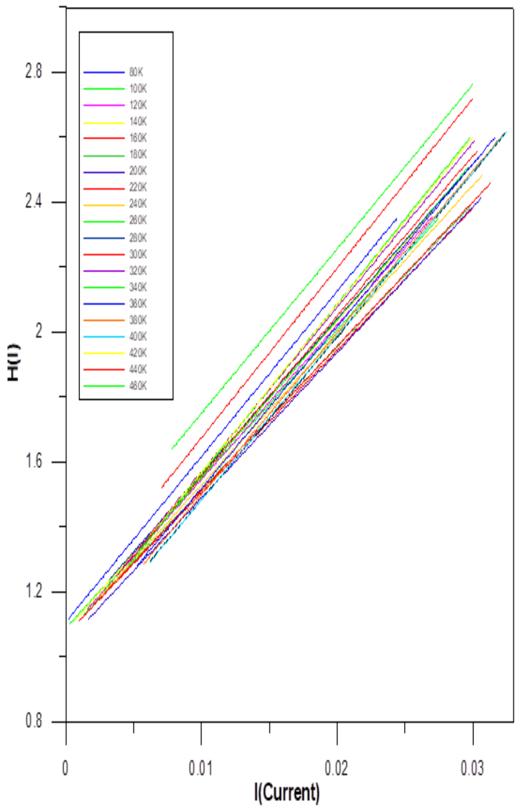

Figure 2 The plots of HI/(I) versus I obtained from forward bias currente voltage characteristics of the Al-omic/Graphene (F_3O_4) diode

The increase in series resistance can be explained by this decrease in carrier concentration (Aydoğan et al., 2011) (Vieira et al., 2021). It is seen that the Φb values obtained from the H(I)- (I) graphs first decrease and then increase depending on the irradiation in accordance with the values obtained from the I-V graphs.

Result and Discussion

The effect of electron radiation on the current-voltage characteristics of the Al-omic/Graphene (F_3O_4) device was investigated between varying energies of 9,12,15 MeV. It was found that the coupling parameters changed as a function of the irradiation dose. In general, the defects caused by electron radiation irradiation and the redistribution of organic layer interfaces have been considered as the reason why the junction parameters are dependent on irradiation. As a result, it has been seen that electron irradiation has a significant effect on the electronic properties and performance of Al-omic/Graphene (F_3O_4) device.

References

1. Sze, M., 1969. Physics of Semiconductor Devices. John Wiley and Sons, New York. Tataroğlu, A., Altındal, Ş., 2007. The effects of frequency and γ-irradiation on the dielectric properties of MIS-type Schottky diodes. Nuclear Instruments and Methods in Physics Research B, 254, 113-117.
2. Cheung, S. K., ve Cheung, N. W., 1986. Exraction of Schottky Diode Parameters From I-V Characteristics. Appl. Phys. Lett, 49, 85-87.
3. Sharma, B. L. ve Gupta, S. C., 1980. Metal-semiconductor Schottky barrier junctions-1: Fabrication. Solid State Technol., 23 (5), 97.
4. Sharma, B. L. ve Gupta, S. C., 1980. Metal-semiconductor Schottky barrier junctions- 2: Fabrication. Solid State Technol., 23 (6), 90..A. Kraft, A.G. Grimsdale, A.B. Holmes, Angew. Chem., Int. Ed. 37 (1998) 402.
5. R.T. Tung, Electron transport at metal-semiconductor interfaces: general theory, Phys. Rev. B, 45 (1992), p. 13509
6. Çaldıran, Z., Deniz , A.R.; Şahin,Y.; Şınoforoğlu,M.; Metin,Ö.; Meral, K.; Aydoğan,Ş. The Synthesis of the Fe_3O_4 Nanoparticles and the Analysis of the Current–Voltage Measurements on Au/Fe_3O_4/p-Si Schottky Contacts in a Wide Temperature Range, Metallurgıcal and Materıals Transactıons A.
7. Aydoğan, Ş., Şerifoğlu, K., & Türüt, A. (2011). The effect of electron irradiation on the electrical characteristics of the Aniline Blue/n-Si/Al device. *Solid State Sciences*, *13*(7), 1369–1374. https://doi.org/10.1016/j.solidstatesciences.2011.03.02
8. Vieira, D. H., da Silva Ozório, M., Nogueira, G. L., Fugikawa-Santos, L., & Alves, N. (2021). UV-photocurrent response of zinc oxide based devices: Application to ZnO/PEDOT:PSS hydrid Schottky diodes. *Materials Science in Semiconductor Processing*, *121*, 105339. https://doi.org/10.1016/j.mssp.2020.105339

9. Wang, D., Hu, R., Chen, G., Tang, C., Ma, Y., Gong, M., Yu, Q., Cao, S., Li, Y., Huang, M., & Yang, Z. (2021). Heavy ion radiation and temperature effects on SiC schottky barrier diode. Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms, *491*, 52–58. https://doi.org/10.1016/J.NIMB.2021.01.019