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Performace Analysis of Germanium Source Double Gate TFET Based Biosensor

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Abstract:- The current research delivers a review of the performance of a dielectric modulatedbased Ge-source dual material double gatetunnel field effect transistoras a label-free biosensor. To widen the biosensors' capture area, a cavity is put in this particular case at both the source and drain ends of a fixed SiO^2 dielectric. HfO^2 layer is an additional dielectric layer that is placed there to enhance the dielectric strength. Silicon fills up the drain and channel, although germanium functions as the source material. Since the cavity is filled with a number of dielectric materials, sensitivityis extracted for neutral and charged biomolecules. Moreover, these biosensors' ION/IOFF ratio, transfer characteristics whichtakes into account either charged or neutral biomolecules. In this analysis, the response time of the Ge-source DMDG-TFET is raised.

Keywords*:* Biosensor, TFET, Biomolecules

1. Introduction

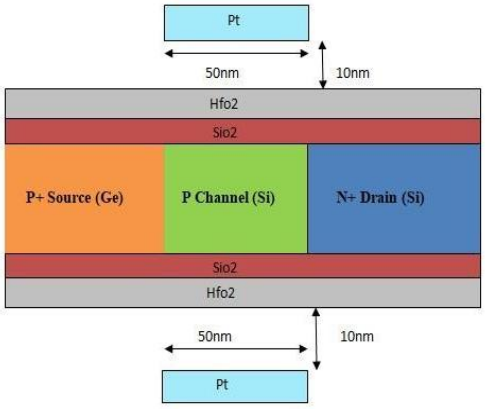
The current pandemic and health hazard era demands quick, inexpensive biosensor equipment with higher selectivity and sensitivity. Sensing sensitivity and speed are key aspects to biosensing applications. Devices based on zero-dimensional nanoparticles have been extensively employed in biosensor platforms. Field effect transistors have emerged as possible sensing devices owing to their straightforward manufacturing process and rapid flexibility. To raise the biomolecules' detection sensitivity, the size of the instrument must be minimized. Scalability of MOSFETs is limited, nevertheless, by their low ION/IOFF, vital sub-threshold swingand short channel effect. Scalability of MOSFETs is impeded by their enormous sub-threshold swing and low ION/IOFF.Biosensing applications need to have the quickest achievable detection time.The TFET, which is unaffected by SCE when its dimension is lowered is a strong contender for handling every single issue. The TFET has an average ON-current but an extremely low OFF-current when compared to the MOSFET. Therefore, numerous device designs such as double-gate TFETshave been created. The device's performance is assessed in several simulation circumstances.

2. Literature Survey

The TFET performance analysis has been the subject of numerous investigations. The number of studies that are currently available is displayed in the reference list [1] TO [5]. This research paper [1] focuses on tunnel field-effect transistor-based biosensors and covers recent and possible future developments in device sensitivity and architecture. They discussed the growing significance of biosensors to human life in this era of fast expanding technology.Their primary objective was to reduce the size of the biosensors to increase sensitivity and guarantee precise biomolecule detection. From this review paper it is studied that how various structures of TFET based biosensors has worked and its performance is analyzed and compared with traditional FETs. A detailed review about development and working of TFET based biosensor and its uses in current biosensing applications are found in this review paper [2]. This review paper states that TFET based biosensor has several exceptional features like high sensitivityand label free sensing that has made it to gain huge attention in modern biosensing applications.Another review conducted by Suneet kumar Etal [3] explains about a specific structure of TFET that is dielectrically modulated TFET which is used for biosensing applications. In their proposed work gate

engineered function was used and the structure has a dual gate source electrode and dual metal source electrode. From this review paper it is studied that the proposed structure in this paper has high sensitivity and has the ability for label free detection.This paper describes the usage of a junction less tunnel field-effect transistor fitted with a triple material gateas a biosensor to distinguish between various protein molecules. described the idea of diagonal tunneling in [5]. For label-free biosensing applications, a dielectrically controlled tunnel field effect transistor device is developed. Numerical device simulations were used to comprehensively analyze the performance of this sensor architecture.In [6]label-free biosensors with MOSFETs attained a high level of detection sensitivity. Unfortunately, these sensors' subthreshold swing is capped at 60 mV Dec-1 by the thermal electron emission physical mechanism. Moreover, the effect of various dielectric constants on a certain density of charges is investigated. Within [7] This paper includes a numerical evaluation of the energy band, electric field, drain current, sensitivity, and other characteristics of a proposed Ge-source and pocket-based tunnel-field-effect transistor-based dielectrically modulated label-free biosensors. Inside [8] according to their explanation in that study, the dielectric modulated double source trench gate tunnel FET based on biosensors was recommended for the detection of biomolecules. In order to generate a bidirectional current and raise the on-state current, the DM-DSTGTFET employs a double source and trench gate. They came to the conclusion that the DM-DSTGTFET biosensor is an effective instrument for a variety of applications due to its remarkable sensitivity and low power consumption.

3. Proposed Work

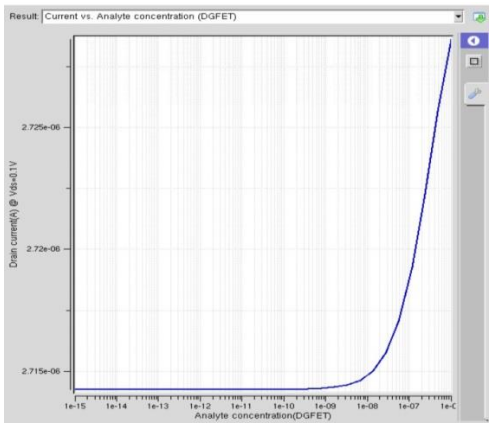


A Ge source DMDG-TFET basedbiosensor is proposed in this study. We look into potential biosensing applications for the Ge source DMDG TFET. The performance of this sensor architecture is thoroughly examined using numerical device simulations.More specifically, proteins are identified using the architecture's diagonal band to band tunneling component. The effects of the cavity height of the nano gapfor biomolecules and the dielectric constanton the SS, ION/IOFF ratioand transfer characteristics are investigated and evaluated for the proposed structure. The results of the experiment indicates that the cavity contains both neutral and charged biomolecules.

4. Results and Discussions

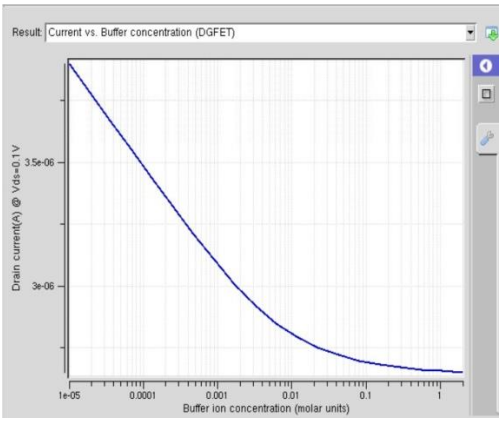
The following graphs are the results obtained from the simulation of double gate TFET based biosensor where the bio - molecule that is to be detected is DNA. The following parameters are considered into account for the simulation such as drain current, buffer concentration,analyte concentration, pH of the bio-molecule etc.

1. Plot between Current vs Analyte concentration



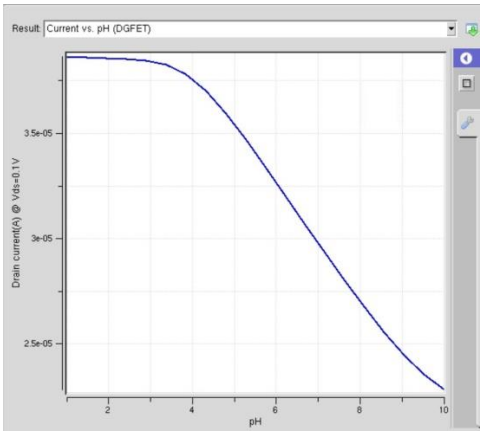
The above figure depicts the relationship between the drain current of DG-TFET with the Analyte concentration of the biomolecules of DNA.

2. Plot between Current vs Buffer concentration



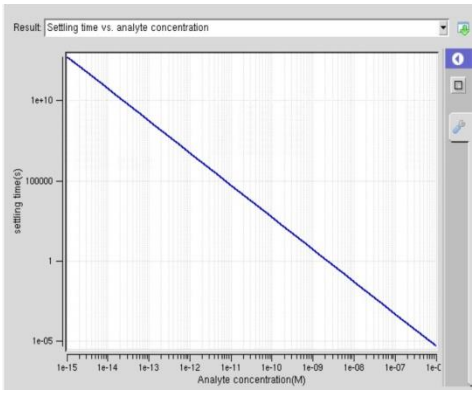
The above figure gives the relationship between the drain current of DG-TFET with the buffer concentration of the biomolecules of DNA.

3. Plot between Current vs Ph



The comparison between the Drain current of DG-TFET with various pH values are depicted in the above figure.

4. Plot between Settling time vs Analyte concentration



The above figure shows the plot of Settling time and analyte concentration.

Refrences

[1] N. Nagendra Reddy & Deepak Kumar Panda, A Comprehensive Review on Tunnel Field-Effect Transistor (TFET) Based Biosensors: Recent Advances and Future Prospects on Device Structure and Sensitivity (2021).

[2] Rishika Sen, Cherry Bhargava, Tunnel Field Effect Transistors Based Biosensors for Detection Biomolecules (2021).

[3] Suneet Kumar Agnihotri, Dip PrakashSamajdar Chithrajan, Ankam Srujan Yadav,GowriGanesh,Performance Analysis of GateEngineeredDielectricallyModulated TFET Biosensors. (2020).

[4] Sagarika Choundury, Krishna Lal Baishnab, Koushik Guha,Zoran Jaksic,Olga Jaksic, Jacopo Iannacci Modelling And simulation of TFET-Based Label-Free Biosensor with enhanced Sensitivity (2023).

[5] Sangeeta JanaMukhopadhyay, BudhadityaMajumdar, Karumbaih Chappanda, Subhas C. MukhoPadhyay, Performance Analysis of The DiagonalTunneling Based Dielectrically, Modulated Tunnel FET ForBiosensing Application(2021).

[6] Haiwu Xie, Hongxia Liu, Study of An Asymmetry Tunnel FET Biosensor Using Junction less Heterostructure and Dual Material Gate, (2020).

[7] Karabi Baruah, Srimanta Baishya,Performance Assessment of Ge-Source Double-Gate PNPN TFET Based Biosensor (2022).

[8] Chen Chong, Hongxia Liu, ShupengChen, Simulation and Performance Analysis of Dielectric Modulated Dual Source Trench Gate TFET Biosensor (2021).

[9] Seabaugh, A. C., & Zhang, Q. (2010). Low-voltage tunnel transistors for beyond CMOS logic.Proceedings of the IEEE, 98(12), 2095–2110. Sharma, D., Singh, D., Pandey, S., Yadav, S., & Kondekar, P. N. (2017). Comparative analysis of full-gate and short-gate dielectric modulated electrically doped Tunnel-FET based biosensors. Superlattices and Microstructures (2010).

[10] Gautam, R., Saxena, M., Gupta, R. S., & Gupta, M. (2012). Numerical model of gate-all-around MOSFET with vacuum gate dielectric for biomolecule detection. IEEE Electron Device Letters, 33(12), (2012).

[11] E. B. Bahadır and M. K. Sezgintürk, “Applications of commercial biosensors in clinical, food, environmental, and biothreat/biowarfare analyses,” Anal. Biochem., vol. 478, pp. 107–120, Jun. (2015).

[12] Ajay, R. Narang, M. Saxena, and M. Gupta, “Investigation of dielectric modulated double gate junction less MOSFETs for application as a biosensor,” Superlattices Micro struct., vol. 85, pp. 557–572, Sep (2015).

[13] Ajay, R. Narang, M. Saxena, and M. Gupta, “Modeling and simulation investigation of sensitivity of symmetric split gate junction less FET for biosensing application,” IEEE Sensors J., vol. 17, no. 15, pp. 4853–4861, Aug. 2017.

[14] A . Chakraborty, D. Singha, and A. Sarkar, “Staggered heterojunctions-based tunnel-FET for application as a label-free biosensor,” Int. J. Nanoparticles, vol. 10, nos. 1–2, pp. 107–116, 2018.

[15] Y. Pratap, M. Kumar, S. Kabra, S. Haldar, R. S. Gupta, and M. Gupta, “Analytical modeling of gate-all-around junction less transistor-based biosensors for detection of neutral biomolecule species,” J. Comput. Electron., vol. 17, no. 1, pp. 288–296, Mar. 2018.

[16] S. Singh, B. Raj, and S. K. Vishvakarma, "Analytical modeling of splitgate junction-less transistor for a biosensor application," Sens. Bio-Sens. Res., vol. 18, pp. 31–36, Apr. 2018.
[17] B. Singh, D. Gola, K. Singh, E. Goel, S. Kumar, and S. Jit, "2-D analytical threshold voltage model for dielectric pocket double-gate junction less FETs by considering source/drain depletion effect," IEEE Trans. Electron Devices, vol. 64, no. 3, pp. 901–908, Mar. 2017.
[18] D. Gola, B. Singh, and P. K. Tiwari, "A threshold voltage model of trigate junction less field-effect transistors including substrate bias effects," IEEE Trans. Electron Devices, vol. 64, no. 9, pp. 3534–3540, Sep. 2017.
[19] B. Purohit, P. R. Vernekar,N.P.Shetti, and P.Chandra, Biosensor Nano engineering Design, operation, and implementation for biomolecular analysis (2020).
[20] D. Singh and G. C. Patil, Performance Analysis of Feedback Field- Effect Transistor-Based Biosensor (2020).