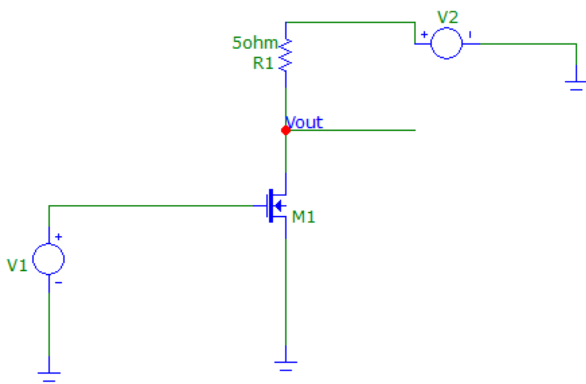


Fig.3. Circuit Diagram of simple inverter circuit.

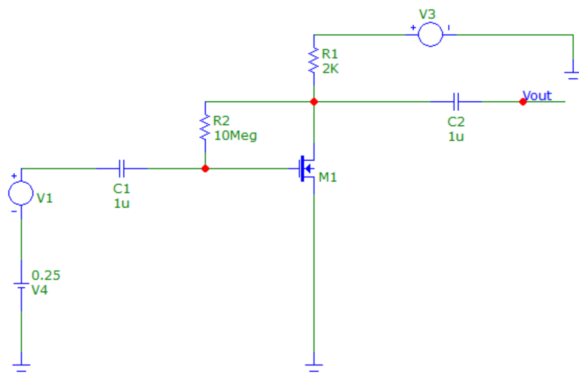


Fig. 4. Self-biasing circuit for frequency response analysis.

The inverter circuit shows accurate results, providing 0V at the output when input is given as 1V and vice-versa. Figure 5 shows the output of the inverter circuit for both models.

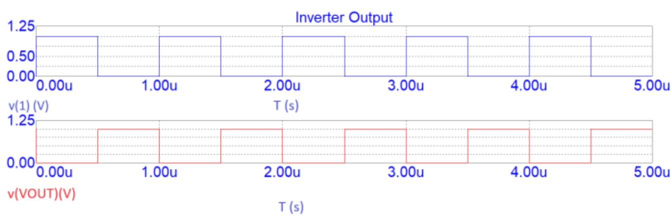
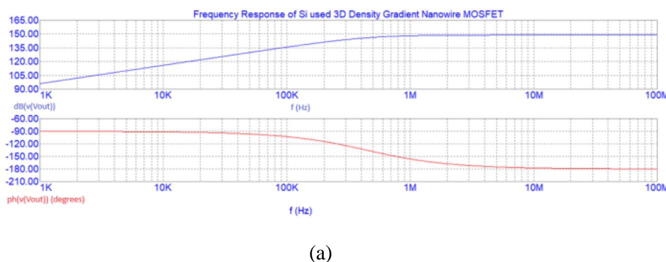
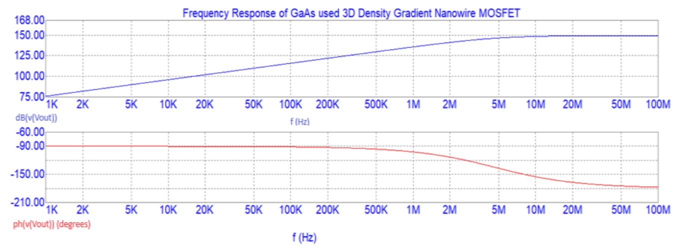


Fig. 5. Inverter circuit output of both Si and GaAs used models.

Lastly, the frequency response curve in dB and phase change curve have been generated for both models. The results are shown in Figures 6 (a) and (b).



(a)



(b)

Fig.6. (a) Frequency response curve of Si used model. (b) Frequency response curve of GaAs used model.

From Figure 6 (a) and (b), the used model has a cut-off frequency at 1MegaHz while that of the GaAs used model is at 10MegaHz.

Si has been there since the start as a major material in the semiconductor industry. However, with the reduction in the size of the devices, few limitations are coming up and researchers are going for newer materials to take the place of Si. From the analytical results, it can be said that GaAs can be a better material, impacting the performance and features of devices in the semiconductor industry.

V Comparison with Previous Works

A comparison table has been shown for differentiating the designed model from available research papers. The comparing parameters have been limited to the channel length, oxide thickness, and threshold voltage.

TABLE IV. COMPARISON WITH PREVIOUS WORKS

Research Works	Channel Length[nm]	Oxide Thickness [nm]	Threshold Voltage [V]
[19]	30000	7	0.125
[20]	10	3-10	0.2
[21]	7-10	2.82	0.7
[6]	4	0.8	0.7
Designed Model	3.2	0.5	0.7

Table IV shows that the value of threshold voltage increases with the decrement of channel length and oxide thickness. Moreover, the designed model has the lowest values of channel length and oxide thickness among the mentioned papers.

VI Conclusion

The paper analyzes the impact of semiconductor materials in designing the 3D density gradient nanowire MOSFET. The models having the same channel length and oxide thickness of 3.2nm and 0.5nm, respectively, have been designed using varied materials, namely Si and GaAs. I_d-V_g, I_d-V_d, gm-Id curves, and the electron concentration along the x and z coordinates have been analyzed and compared. The analysis showed the drain current, potential-well depth, and transconductance values are higher by approximately 10, 10^4, and almost double in range, respectively, in the case of the

model designed using GaAs as a material compared to the Si-used model. The higher drain current can provide switching losses, which can be controlled if kept within a safe operating area. In addition, a higher drain current is suitable for application in analog circuit designs like amplifiers. Moreover, the extracted data have been utilized to generate model and library files to create a component model. A simple inverter circuit and biasing circuit have been designed with the models to get a digital application-level comparison. The inverter circuit worked accordingly, and the frequency response curve provided the cut-off frequency of both models. It is found that the Si-used model has a cutoff frequency of 1MHz while that of the GaAs-used model is 10MHz, which means the used model can provide faster performance. So, it can be said that the GaAs used model can offer faster performance and more energy than the Si one. From the theoretical and analytical comparison from analysis to application level, it can be concluded that the model using GaAs as the material would give better and faster performance than the model using Si material. Further work might include designing low-power analog application circuits to get analog application-level analysis of the designed nanowire MOSFET.

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