INCORPORATION OF SILICON P-TYPE &N-TYPE MATERIAL IN CHANNEL BOX FOR ENHANCEMENT OF DRIVING CURRENT AND BREAKDOWN VOLTAGE IN SOI- MESFET

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Abstract: This work reports a novel SOI MESFET including silicon N-type and P-type well inside the drift and buried oxide regions. The drift-diffusion equations along with the main physical models such as impact ionization, Shockley-Read-Hall and self-heating effect are carefully solved inside the structures. Modification of the potential profile occurs in the channel region and results in decrease in peak electric field. Output power density is successfully boosted owing to improved driving current and breakdown voltage, simultaneously. In addition self-heating effect is alleviated in the proposed structure due to decreased effective thermal resistance of the channel region. Comprehensive DC and AC performance comparisons show that the proposed device promises a more reliable candidate than the conventional SOI structure for high voltage applications**.**

Keyword: SOI MESFET, impact ionization, self-heating effect

I. INTRODUCTION

In this SOI-MESFET structure we have added a burie doxide in the dimension of a channel box in order to improve the values of driving current and breakdown voltage in the soi mesfet as a result drain current of the proposed structure reduces slightly , improvement in maximum output power density by 126%. finally the channel boxed SOI MESFET structure has superior electrical performances in comparison with the similar device based on the conventional structure .

MESFET stands for metal–semiconductor field-effect transistor. It is quite similar to a JFET in construction and terminology. The difference is that instead of using a p-n junction for a gate, a Schottky (metal-semiconductor) junction is used.MESFETs are usually constructed in compound semiconductor technologies lacking high quality surface passivation such as GaAs, InP, or SiC, and are faster but more expensive than silicon-based JFETs or MOSFETs.

Production MESFETs are operated up to approximately 45 GHz, and are commonly used for microwave frequency communications and radar. The first MESFETs were developed in 1966, and a year later their extremely high frequency RF microwave performance was demonstrated.

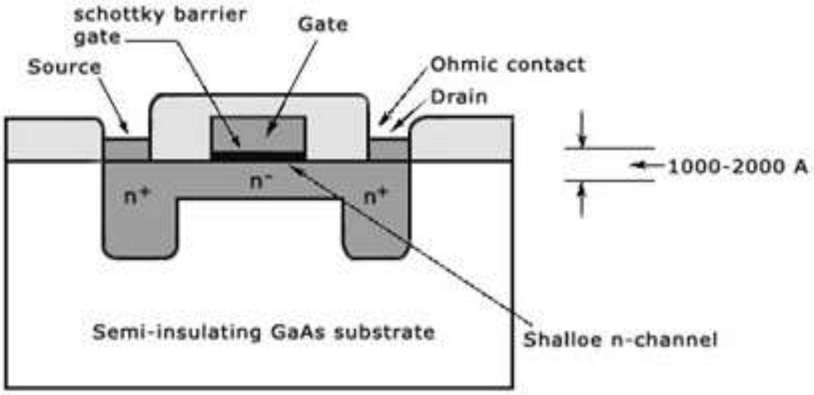

Fig.1.1 Structure of MESFET

II.DEVICE DESIGN & SIMULATION

In simulation part, first the materials and models are defined in order to modify the characteristics of defined electrode as well as change the default material.An electrode in contact with semiconductor material is assumed by default to be ohmic. So to treat the electrode as schottky contact, workfunction of the electrode is defined. The WORKFUNCTION parameter sets the workfunction of the electrode. The CONTACT statement is used to specify barrier and dipole lowering of the Schottky barrier height.

The CONTACT statement also changes an electrode from voltage control to current control. Current controlled electrodes are useful when simulating devices, where the current is highly sensitive to voltage or is a multi-valued function of voltage (e.g., post-breakdown and when there is snap-back).After defining materials, contact and workfunction, the INTERFACE statement is used to define the interface charge density and surface recombination velocity at interfaces between semiconductors and insulators.

This is followed by substrate material declaration. In this part substrate material is defined along with electron affinity, conduction band density as well as valence band density is defined using the MATERIAL statement. Along with that band gap between conduction band and valence band is also defined.After defining the substrate material, physical models are defined using MODELS and IMPACT statement followed by mobility specification. The physical models consist of five classes: mobility, recombination, carrier statistics, impact ionization, and tunneling. All the models are defined using MODEL statement except the impact ionization model. IMPACT statement is used to define the impact ionization model followed by mobility declaration.

This is followed by numerical method declaration. Numerical methods are declared using METHOD statement. Different combination of methods is used to solve the output. For equations which are weakly coupled and have linear convergence GUMMEL method is used.For fully coupled or strongly coupled equation having quadratic convergence, NEWTON method is used for calculating the solutions to semiconductor device problems because of isothermal drift-diffusion simulations:

- current boundary conditions
- distributed or lumped external elements
- AC analysis
- impact ionization

Here DC analysis of the device is done. First of all the initial solutions obtained for the device is maid zero bias or thermal equilibrium. The voltage on each electrode is specified using the SOLVE statement. The LOG statements are used to save the Id/Vds curve from each gate voltage to separate file. The same procedure is followed to obtain the output curve at different voltages. The drain voltage is also solved using the SOLVE statement and vstep and vfinal statement is used to define the steps in order to get the curves accurately. The PRINT option is specified within the MODELS statement, the details of material parameters and constants and mobility models will be specified at the start of the run-time output. By following the above steps device is simulated and the output curves for the device is obtained.

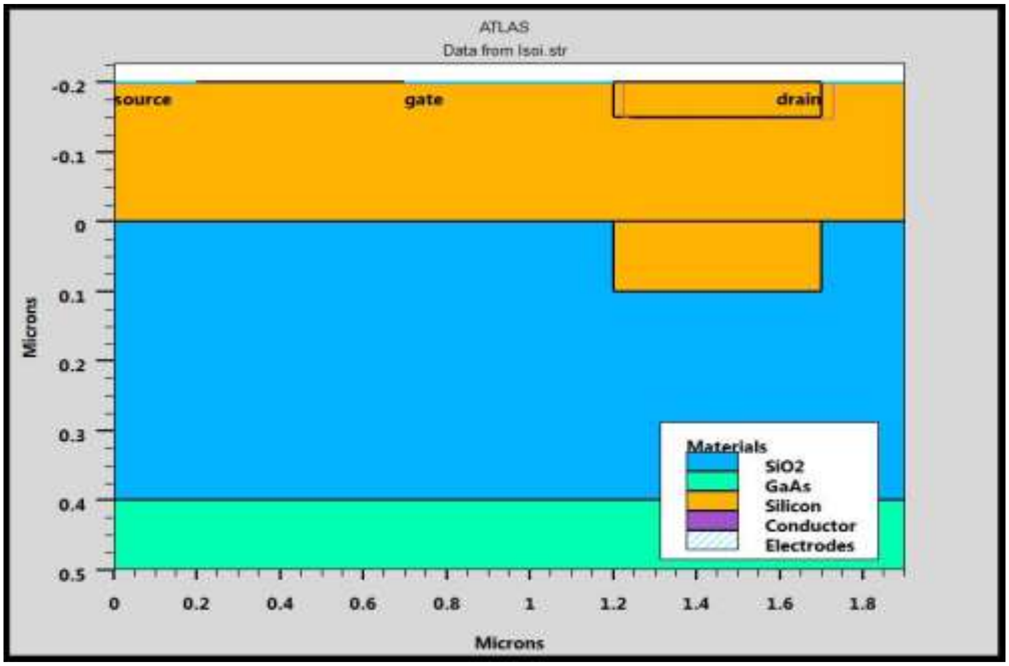

Fig.1.2 MESFET Structure obtained

III.RESULTS AND DISCUSSION

The driving currents of the structures are evaluated at the gate biases increasing from −1 to 0V with steps of 0.5 V. According to the figure, the proposed structure will handle the output devices with a higher power since it has a higher driving current. The N-type well inserted inside the buried oxide increases the channel conduction resulting in improvement of the driving current.

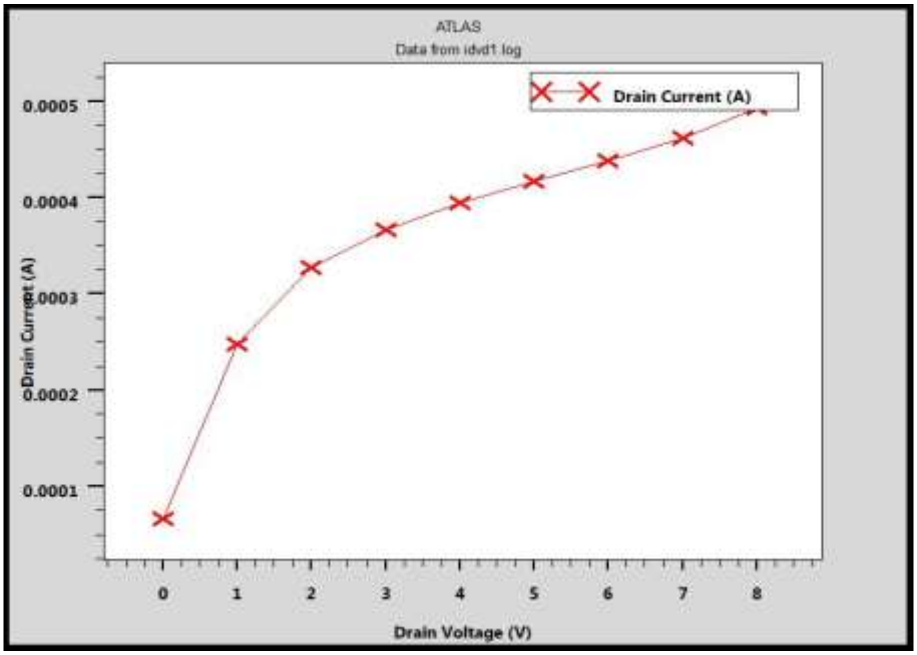

Fig.1.3 Drain Current vs Drain Voltage

The breakdown voltage, which is one of the main parameters in high voltage applications, is related to the critical electric field at gate edge near the drain region. Fig. 3 shows the drain current versus the drain voltage at the bias VG=−2.5 for the structure.

As can be seen from the figure, the breakdown voltage BV=12.3 V has been extracted for structure. Inserting the P-type well leads to the improvement of the breakdown voltage as it is expected.

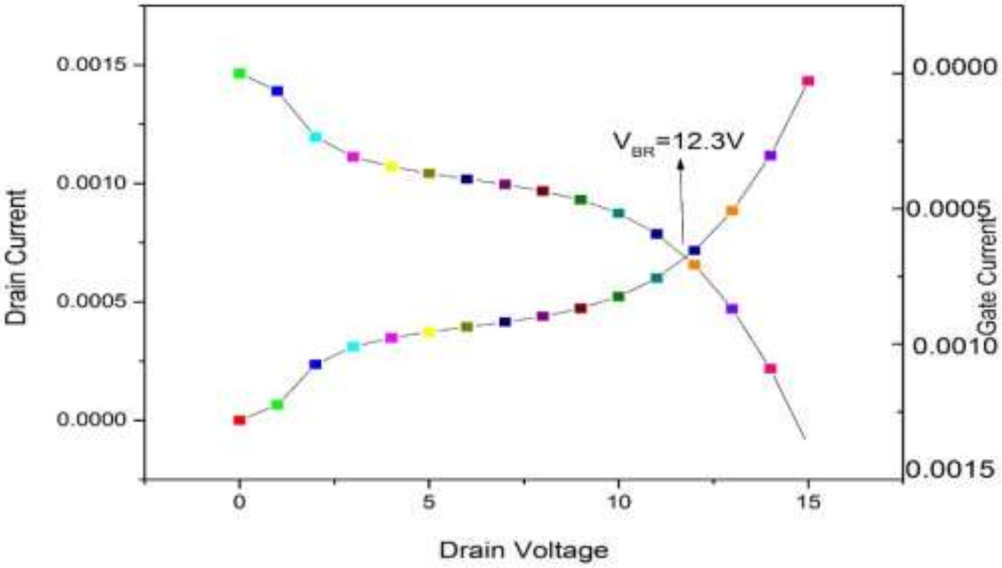

Fig.1.4 Breakdown voltage curve

For equipotential contours the bias conditions are set to be the values VG=−2.5 V for gate voltage and VD=8 V for drain voltage. As shown in the figure, the rate of crowding in the potential lines for the structure is more even and accurate. The P-type well modulates the potential distribution along the channel region and therefore distances between the potential lines will be evener.

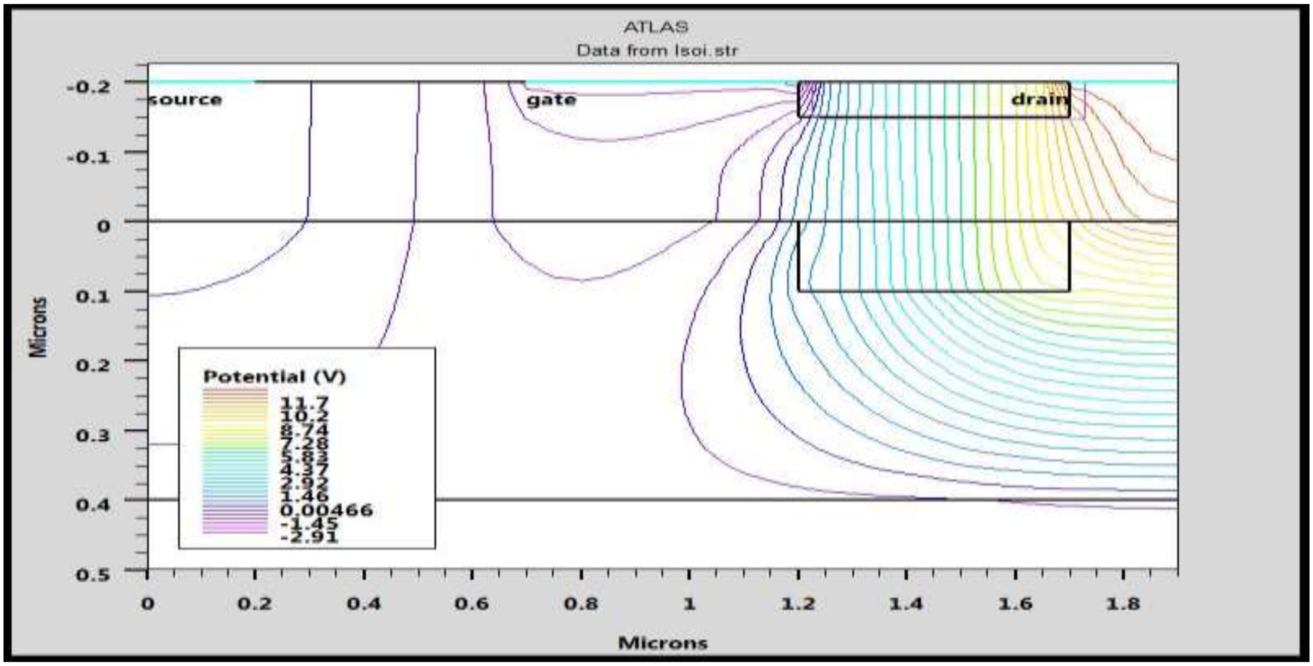

Fig.1.5 Potential Cureve

The modulation of channel region by the P-type and N-type well causes the peak electric field reduced at the gate edge near the drain thus decreasing the breakdown voltage, finally. The modulation of the channel region occurs by pushing the potential lines toward the drain region through the P-type well. Therefore, the crowding of the potential lines degrades and the peak electric field will decrease, successfully.

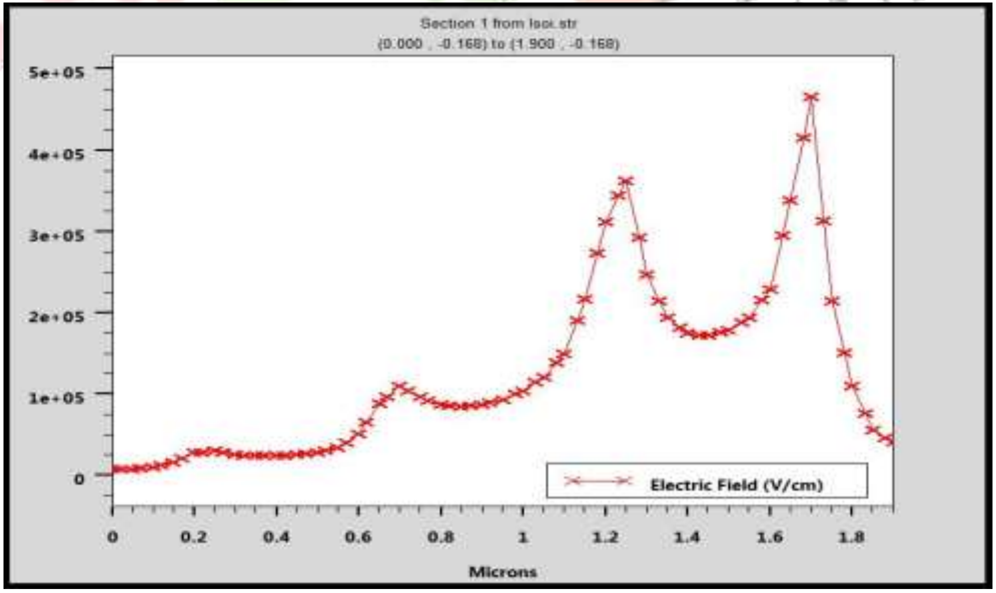

Fig.1.5 Potential curve

IV.CONCLUSION

In this work we have designed a novel SOI MESFET device and simulated it using appropriate models. The incorporation of p-type material in channel and a n-type material in BOX region has a significant impact on the device performance especially the breakdown voltage and on drive current. The breakdown voltage is the main significance of SOI MESFET. In our work we got the V_{BR}=12.3V which is more than in comparison to previously available `device. Also the on drive current for the device is 0.5mA at the gate voltage of 1.1V. Further investigation needed to get more breakdown voltage by modifying the proposed device structure.

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