The Ground Switcher

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***Abstract*—I propose a new semiconductor device capable of switching between ground or resistance. I use 2 electrodes Anode and Gate respectively. The gate is used to turn the component into a resistor, and without gate voltage, it's a normal ground element. In this paper, we will look at the results of the simulation obtained with Visual TCAD. Every circuit requires a ground element and usually, it's used to complete the circuit, this component acting as a resistor can save some electrons from grounding and we will use these electrons to provide an alternate path so they can flow through a different branch of the circuit this can save from power loss and every little current can be used in some way.**

***Index Terms*—Semiconductor Device, New electrical component, Ground Resistance Switcher, Ground Switcher**

I. Introduction

In this paper I will propose and introduce a new device that has the ability to switch between ground and resistor, you may ask why would we need such a component but as we know in any electrical network we need a ground to complete our circuit topology. And if we have such a device that could help us reuse the current that is left rather than sending it to the ground, don't get me wrong my component acts as ground as well as a resistor, so as long as we don't apply any gate voltage the component acts simply as a ground only when you think you could save some power you can switch it into a resistor.

Now you may think why to use a totally new component rather than using any transistor, please keep in mind transistor acts as an open circuit and a closed circuit while this component acts as a ground and resistor which means while in the steady state or OFF state, the component completes the circuit rather than making it an open circuit. I have tested this component in Visual TCAD software. Refer Fig 1 as we can see we have anode as our first electrode on the structure, you can call it a wire/anode/copper/Aluminum with a mesh size of $0.1\mu m$ anything you want for this paper we will use the word "anode" since it's our input from the circuitry it's connected. And in the middle of our component, we see soil which is an insulating material like SiO_2 or Ceramic. Just around our Anode, we can see $N+$ Region to create resistance behavior but to turn it ON we use a small P region, and it's connected to another electrode which we will call Gate which is a Npoly-silicon with a mesh size of $0.005\mu m$ layer inspired from our MOSFET.

The device structure is of size $0.5\mu m$ in width refer to Fig 1, $0.4\mu m$ in height, and $0.640312\mu m$ diagonally. I have used gaussian doping at the P region of $1e + 12$ which is less concentration of holes, and the whole $N+$ region around the soil is of $1e + 20$ which has more concentration electron. And the whole Ground Switch is Silicon and mesh size of $0.005\mu m$. The soil is made up of SiO_2 layer with a mesh size of $0.1\mu m$. Now that we are done with the doping profile, the materials, and the dimensions, In the next few sections, we will take a look at my device simulation outputs and how my device act in terms of V-I characteristics.

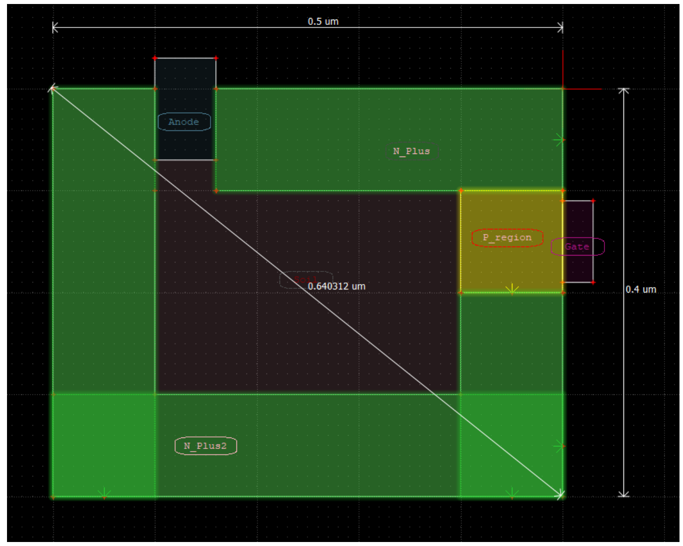

Fig. 1. Full Device structure taken directly from the simulation software, In the middle, we have soil (Insulation material in my case its SiO2) and N+ doping around soil and a P Region connected to the Gate.

II. Literature Survey

For this paper, I looked into many different domains of electronics and watched many lectures including NPTEL and MIT OCW. Read the books mentioned in the reference section. After thoroughly going through my study I decided to sit and think about a component to save electrons/current and I came up with my Ground Switcher. The most difficult task was to get access to any TCAD software to simulate my device and I am glad Visual TCAD gave me 25 days of free trial and I got to work instantly.

The lectures online and books sparked this new device idea, but mostly the main idea came from looking at a Power MOSFET design. I still think that the device can be improved upon since it is the beginning of this component it will go through a lot of changes before it goes commercial.

III. Results and Discussion

IV. A Ground Switcher as a Ground

In Fig 3 and Fig 4 we can see how the curve indicates that as the gate voltage/Current decreases the Anode Current reaches 0 value. This curve represents how my device acts as a ground when no gate voltage is applied and this linear graph shows everything one needs to evaluate if the component is really in the ground state or not. Same with Fig 4 we can see as the gate current reaches zero the anode current reaches zero or acts as a ground element.

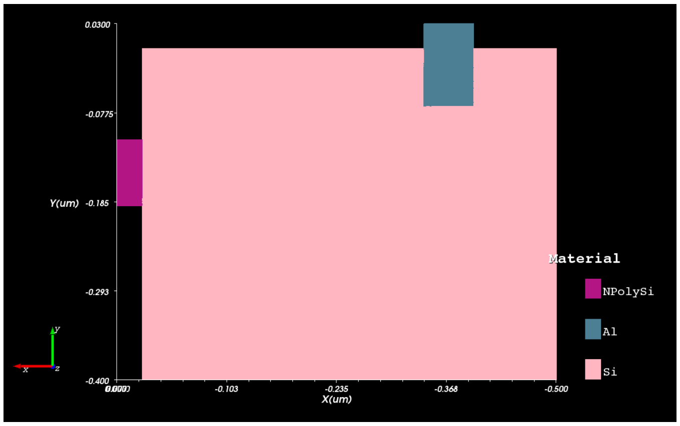

Fig. 2. Device structure with materials specified.

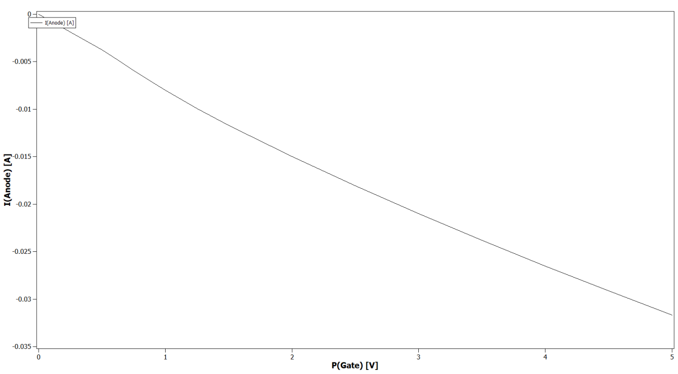

Fig. 3. V-I Characteristics of Ground Switcher as a ground

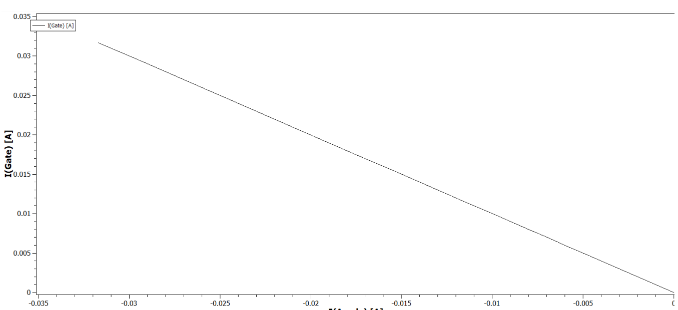

Fig. 4. Gate I-Anode I Characteristics of Ground Switcher as a ground

V. A Ground Switcher as a Resistor

In Fig 5 we can clearly see as the gate current increases the anode voltage increase and as we all know more voltage means low current which means the component is acting as a resistor. As the relationship is linear we can also imply that the vice versa relationship is also true.

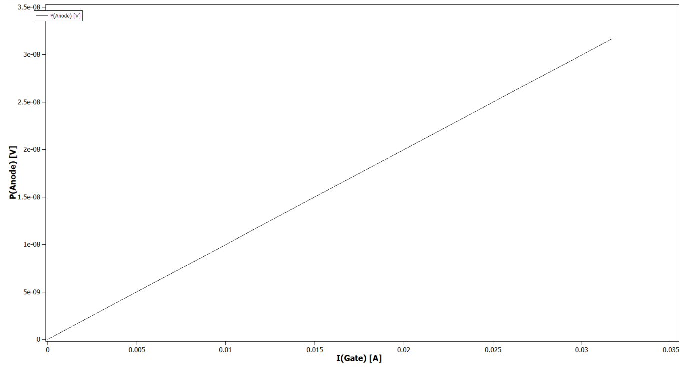

Fig. 5. V-I Characteristics of Ground Switcher as a Resistor

VI. 3D Shapes of Ground Switcher

In this section, we will take a look at my ground switcher with a 3D view taken from the Visual TCAD software. In Figures 6, 7, 8 and 9 we have all the information about the electron density in Fig 6 we can see how equal distribution of our $N+$ region helps in creating a strong presence of an abundance of electrons which creates resistance those high-density spots in the Fig 6 are due to my bad design but that doesn't really matter since the device works totally fine. This can be clarified with our Fig 7 we can see how those high-density hotspots are gone and it is taken as a part of the equal distribution of electrons.

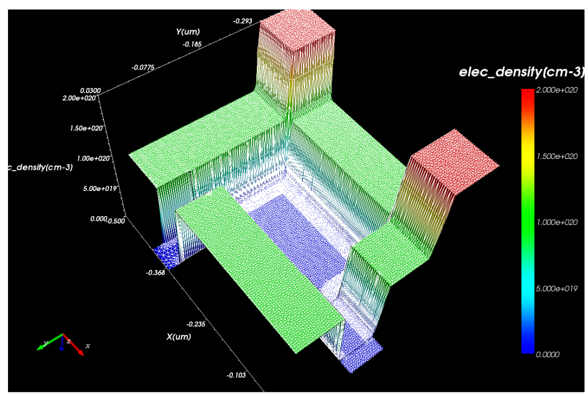

Fig. 6. Electron Density of the Ground Switcher

VII. Different Architecture for Ground Switcher with Boundary Conditions

I propose a different architecture for my Ground Switcher refer to Fig 10 where Gbody and Gbodyex are N+ regions just as before. And we have our SiO2 as soil or grounding. Here I have used the word "wire" and it's connected directly to contacts which are conductors. Please refer to Fig 15 these boundary conditions extracted directly from simulation software, refer to Fig 10 and you can compare each region to understand how the boundary conditions are met.

In Figures 11, 13, 12 and 14 we see hole density, electron density, electron quasi fermi and Potential respectively. The

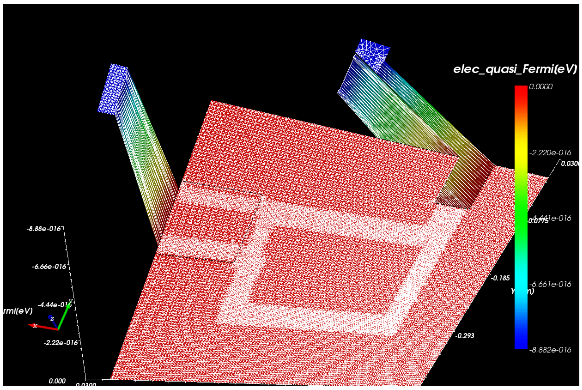

Fig. 7. Electron Quasi Fermi of the Ground Switcher

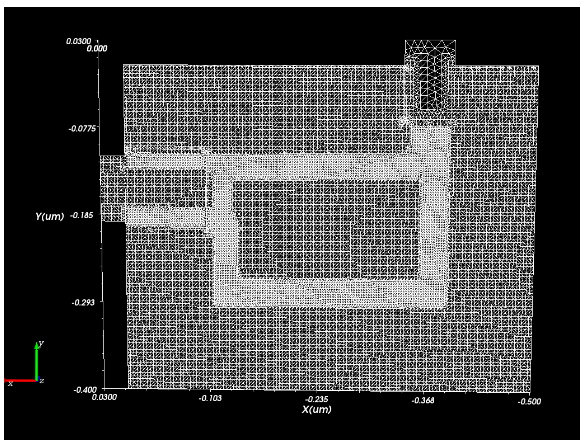

Fig. 8. Ground Switcher Mesh

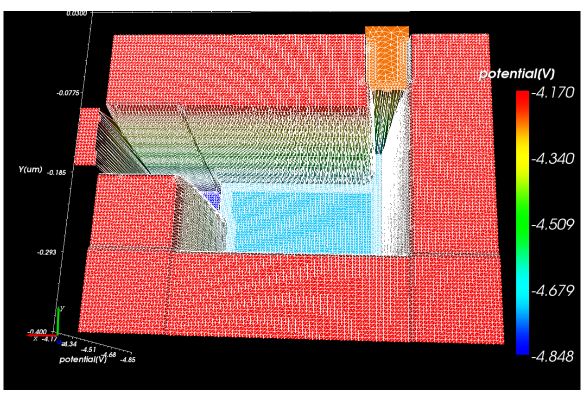

Fig. 9. Ground Switcher Potential V

hole density as displayed in Fig 11 is in the P region and that's what causes the $N+$ region to turn ON.

VIII. Proposed Uses For My Ground Switcher

I would like to propose that we use my ground switch in VLSI fabrication and CMOS circuit design like in Fig 16 as we can see how single gate current provided to PMOS and NMOS is used for ground switcher gate as well and how ground switcher is used between the PMOS and NMOS. I estimate that we could prevent the excess/remaining current

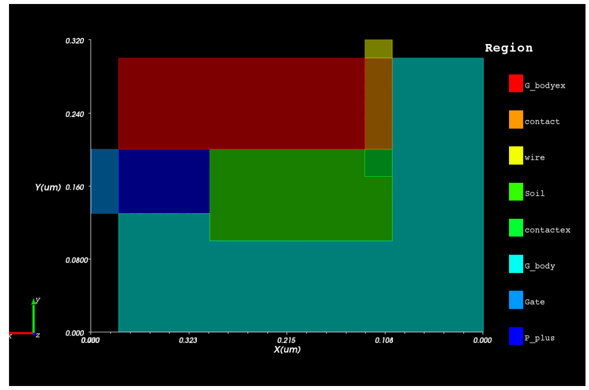

Fig. 10. A Different take and design on my Ground Switcher.

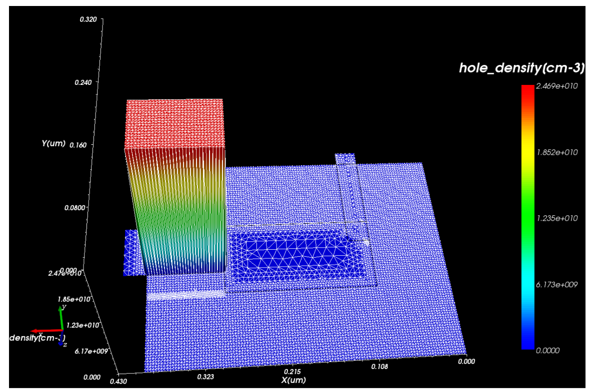

Fig. 11. Ground Switcher Hole Density

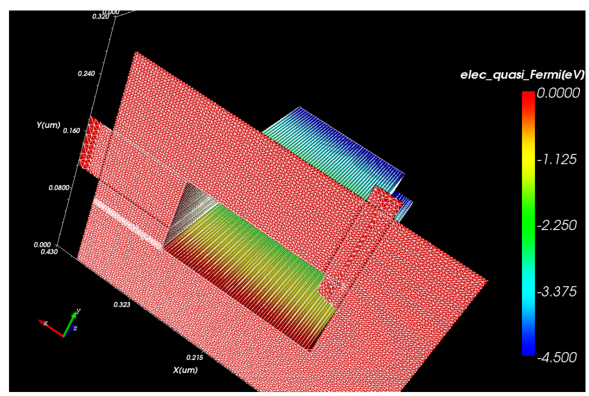

Fig. 12. Ground Switcher electron Quasi Fermi

from grounding by my device to reuse this current for a different branch of the circuit.

IX. Mathematical Expression For Ground Switcher with Ohm's Law

In Equation 1 as we know Current(I) = 0 in the case of ground.

And As for Equation 2 We already know my ground switcher acts as a resistor so the resistors equation is valid here.

$$V = 0 \tag{1}$$

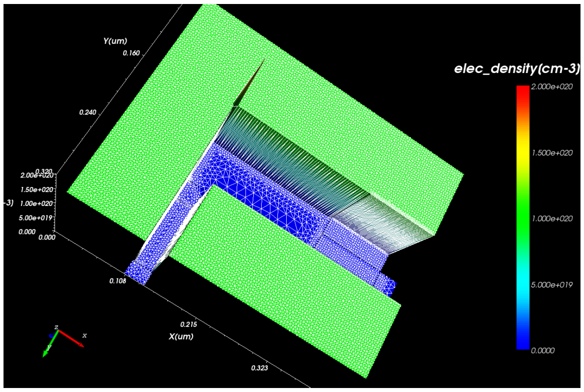

Fig. 13. Ground Switcher Electron Density for new architecture

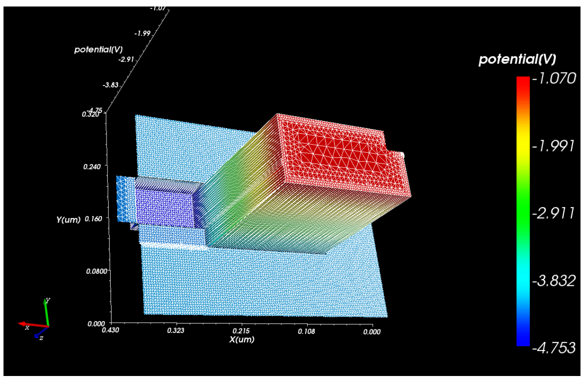

Fig. 14. New Architecture Ground Switcher Potential V

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Bulid boundary conditions on all processors...
  Initializing "Gate_Neumann" as Neumann BC...
  Initializing "G_body_Neumann" as Neumann BC...
  Initializing "wire_Neumann" as Neumann BC...
  Initializing "G_bodyex_Neumann" as Neumann BC...
  Initializing "G_bodyex_to_Soil" as Insulator Semiconductor Interface...
  Initializing "G_body_to_Soil" as Insulator Semiconductor Interface...
  Initializing "G_bodyex_to_P_plus" as Semiconductor Homo Junction...
  Initializing "G_body_to_contactex" as Resistance Ohmic Contact BC...
  Initializing "Soil_to_contactex" as Resistance to Insulator BC...
  Initializing "G_body_to_contact" as Resistance Ohmic Contact BC...
  Initializing "contact_to_contactex" as Resistance Resistance Interface...
  Initializing "G_bodyex_to_contact" as Resistance Ohmic Contact BC...
  Initializing "contact_to_wire" as Resistance Resistance Interface...
  Initializing "P_plus_to_Soil" as Insulator Semiconductor Interface...
  Initializing "G_body_to_P_plus" as Semiconductor Homo Junction...
  Initializing "Gate_to_P_plus" as Resistance Ohmic Contact BC...
Boundary conditions finished.

Buliding Geometry Relationship...ok.
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Fig. 15. Boundary Condition for this new Ground Switcher Architecture. Refer to Fig 10 and compare each name to get an idea of these Boundary Conditions.

$$R = \frac{V}{I} \tag{2}$$

X. Conclusion

In this paper, we have discussed my new semiconductor devices which act as ground or resistor. I thought about this idea when I was searching for a way to solve power consumption and wastage though I have never worked inside a fabrication plant or any other electronics industry, I just had a thought experiment and then I thought about how important ground is in any circuit. And that's what sparked to investigate a way to create a switchable ground element, and just before this idea came about in my previous semester I had Power electronics as a subject which introduced me to Power

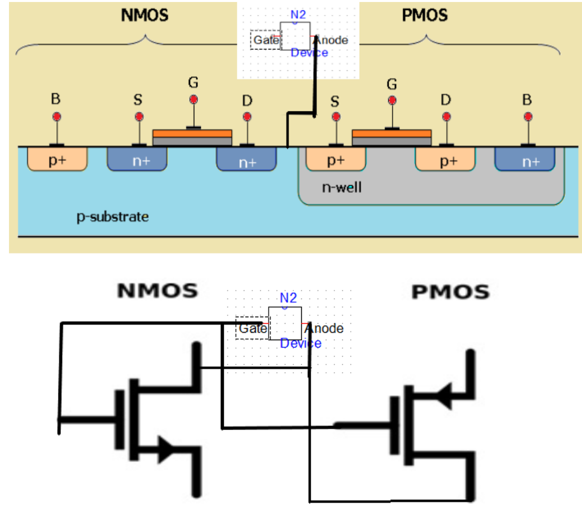

Fig. 16. GS Integrated with CMOS Fabrication and individual MOS Circuits. To Save power and reduce power consumption.

MOSFET and how $N+$ region plays a role in semiconductor technology. My brain instantly thought of keeping an insulated material in between, but what's next? How can we switch an element so static, I used that $N+$ region as a reference I thought that these excess electrons will create a resistance effect. That's 2 puzzles solved next was to make it switchable, how can we do that? that's when I added a P region and connected it to a NpolySilicon material to make my device switchable.

In my estimation, we might get a 3-4 times reduction in VLSI fabrication/Chip design, since we know how my component behaves as per Fig 16 my component connected to these CMOS, we would just keep my component in resistance state and at will, we can switch to Ground and until then we can reuse these excess electrons moving in the circuit that wouldn't have been there if not I had invented this component.

I also estimate that this component can be used in the commutation of SCR or flyback of inductor or even turning off of any electrical component abruptly but these are only vague claims. Applications range widely and are still unknown but since this is only the birth of this component we can never know its capabilities by just me thinking once you as a reader work more on this. It will reach perfection and applications will emerge that I can't even think of right now.

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