Simulation of a Voltage Controlled Resistor Mimicking the Geometry of a MOSFET Device having Graphite Channel

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Outline :

- Introduction
- Geometry of device
- Application COMSOL multiphysics
- Results
- Summary

Introduction :

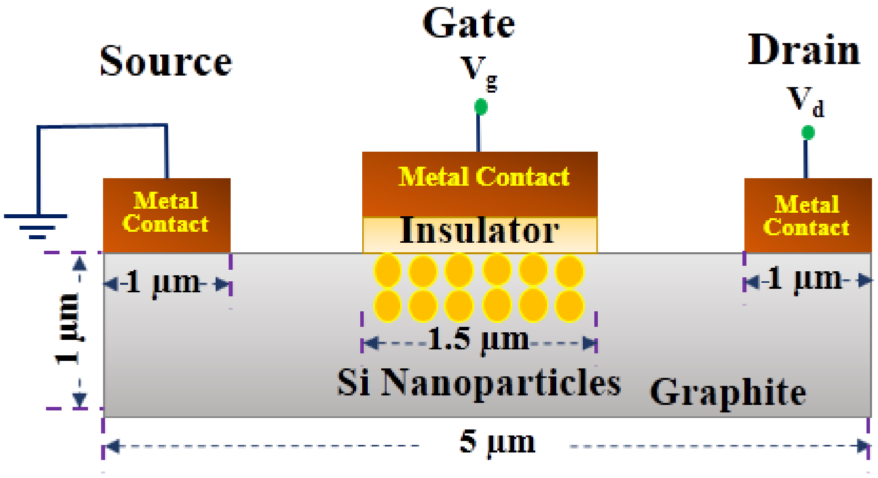
- **Voltage Control Resistor (VCR) :**

  A device where the resistance or conductance depends upon external voltage.

- The device has **3 terminals**.

- Geometry is **similar to MOSFET** device.

Geometry of the Device :



- V_g **(gate voltage)** can be termed as control voltage.
- V_d **(drain voltage)** can be termed as applied voltage.

Governing Equations :

$$\nabla\cdot(\varepsilon_r\nabla V)=q(n-p+N_A^- - N_D^+)$$

Poisson's eqn.

$$\frac{1}{q}\nabla\cdot J_n=-U_n$$

$$\frac{1}{q}\nabla\cdot J_p=U_p$$

Continuity eqns.

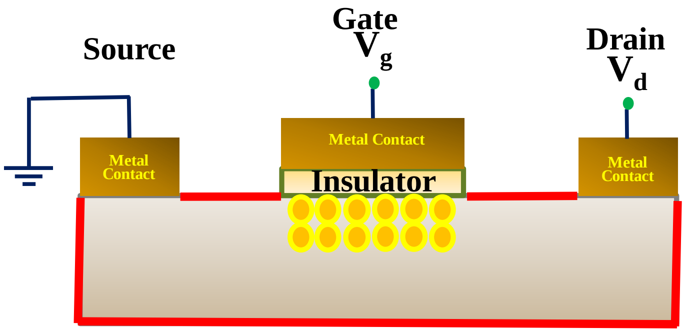
$$J_n=(\mu_n\nabla E_c+\frac{qD_{n,th}}{T_I}\nabla T_I)n+\mu_n k_B T_I G(n/N_C)\nabla n$$

$$J_p=(\mu_p\nabla E_c+\frac{qD_{p,th}}{T_I}\nabla T_I)p+\mu_p k_B T_I G(n/N_V)\nabla p$$

Fermi-dirac carrier statistics

Assumption :

- Insulation at the boundaries.



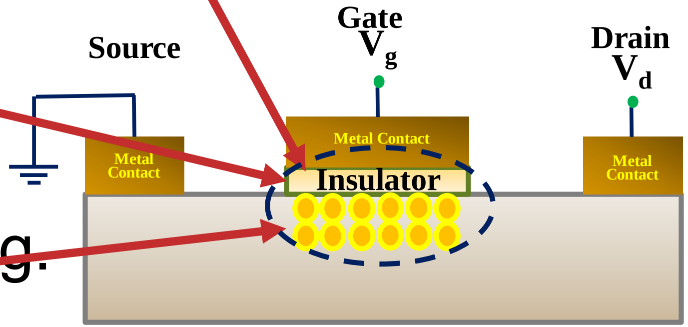
- Ohmic metal contact.
- All the terminals are voltage terminal.

Application COMSOL Multiphysics :

- **Module:** Semiconductor.
- **Method:** Finite volume.
- **Discretization:** Scharfetter - gummel.
- **Carrier Statistics:** Fermi-dirac.
- **Mesh:** Triangular mesh with 29429 domain elements.
- **Study:** Stationary.

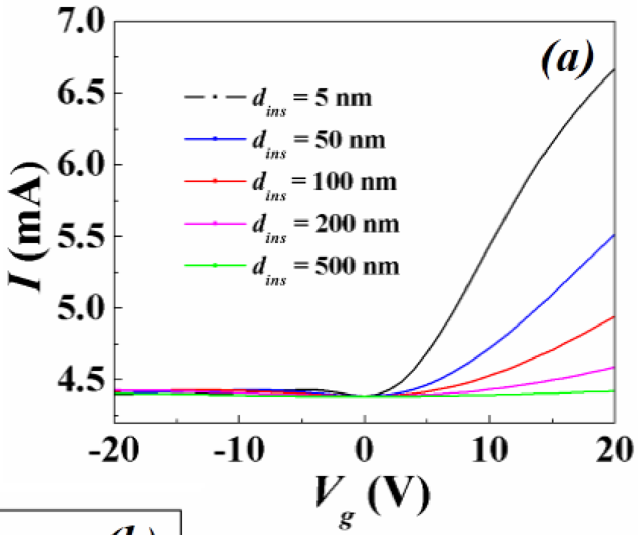
Parameters that Effects Channel Current :

- Dielectric constant of insulator layer ($\mathcal{E}_r$).
- Thickness of insulator (d_{ins}).
- Effect of Si nanoparticle loading.

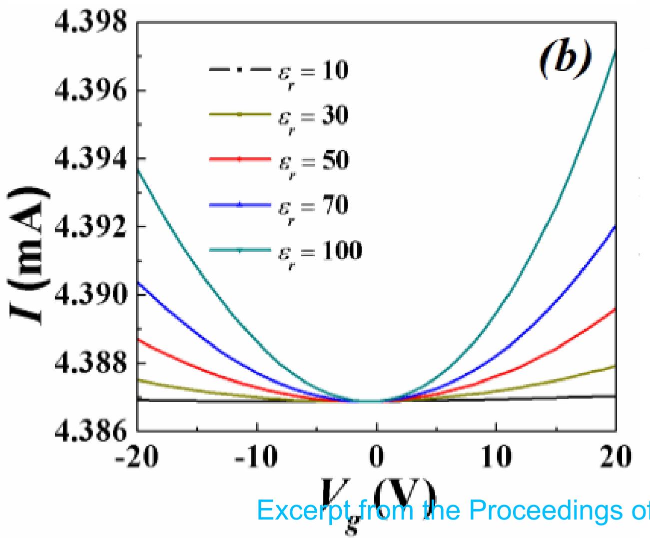


Results :

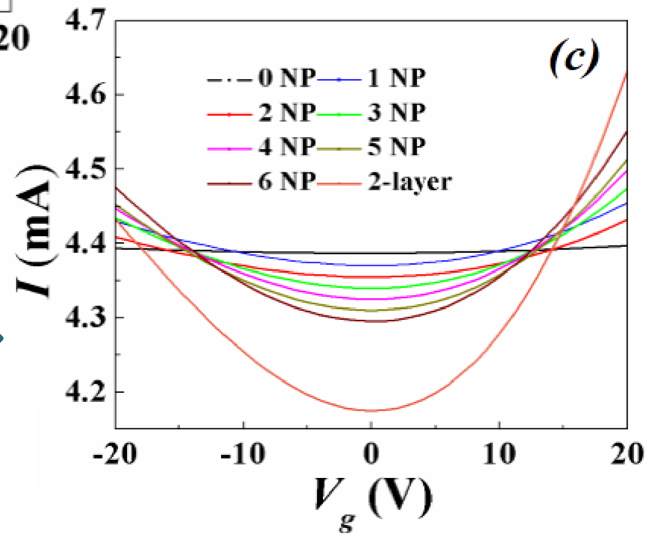
Effect of dielectric constant of insulator layer



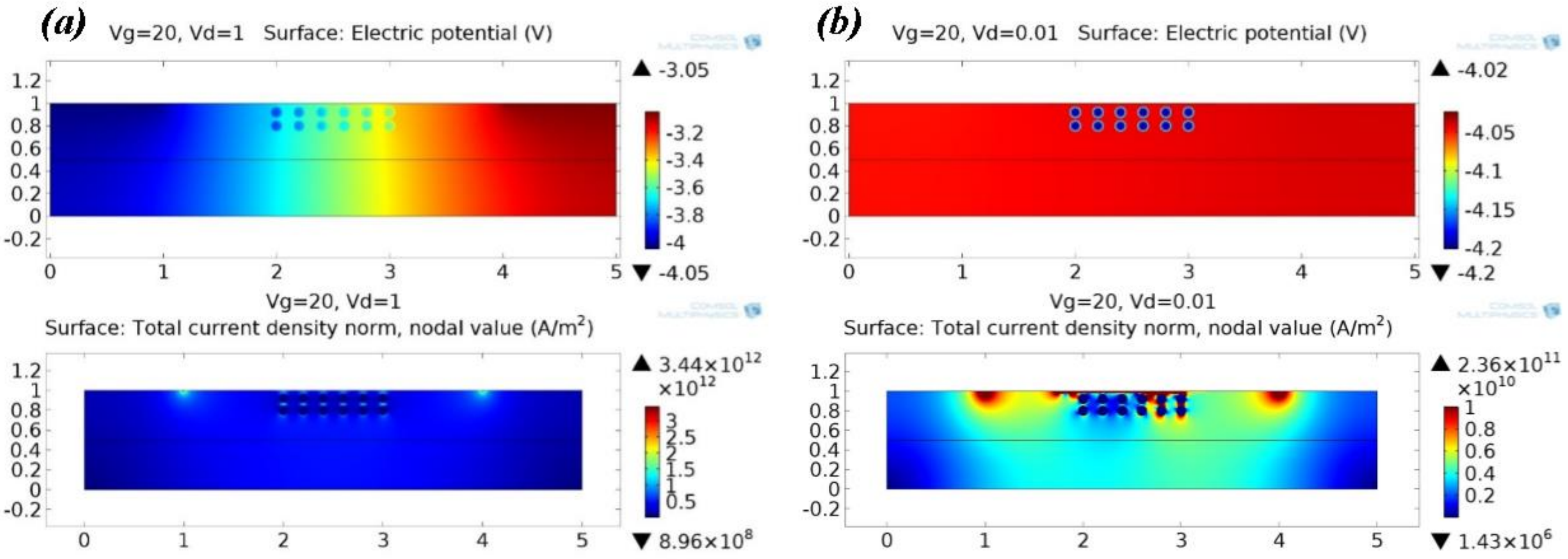
Effect of thickness of insulator layer



Effect of Nanoparticle loading in channel



Surface Potential and Current Density :



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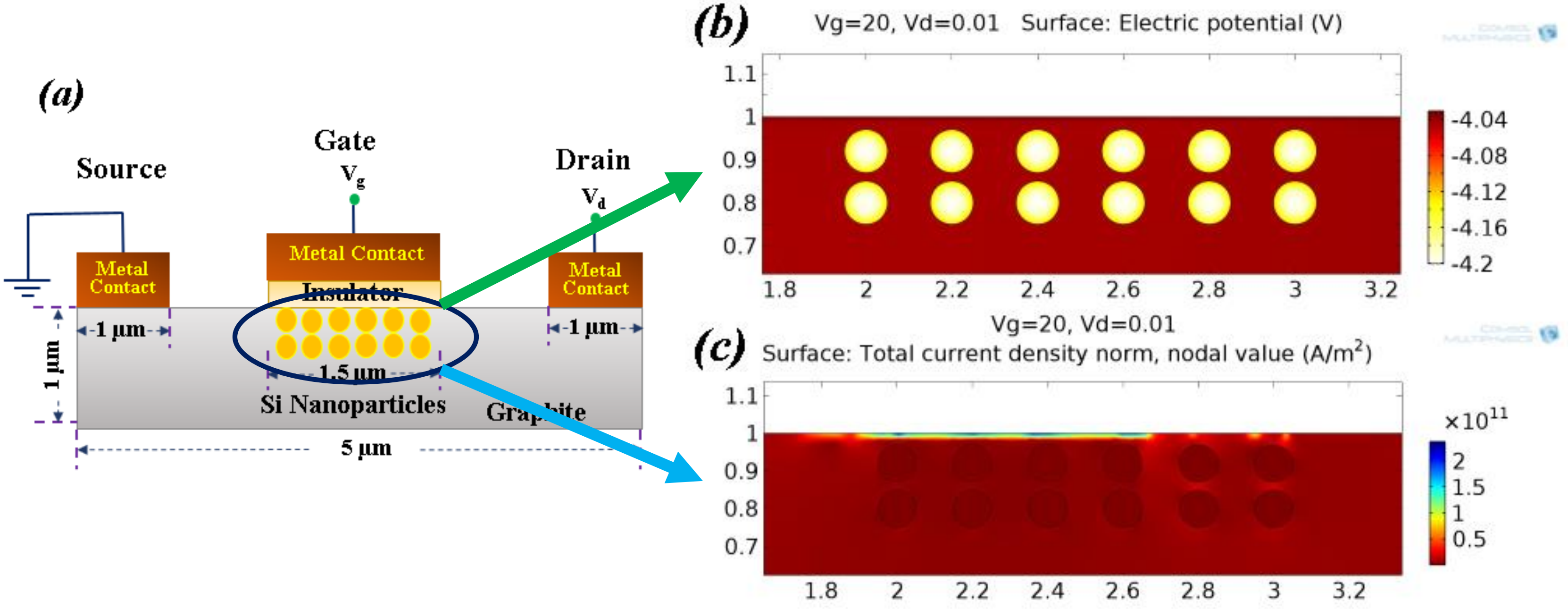
At Channel Region :



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Summary :

- Channel is made of graphite.
- Current through the channel depends on the external control voltage (V_g).
- Channel current depends on d_{ins} and Si nanoparticle loading but depends very less on ε_r .

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Thank You