ECE 3030
Physical Foundations of Computer Engineering

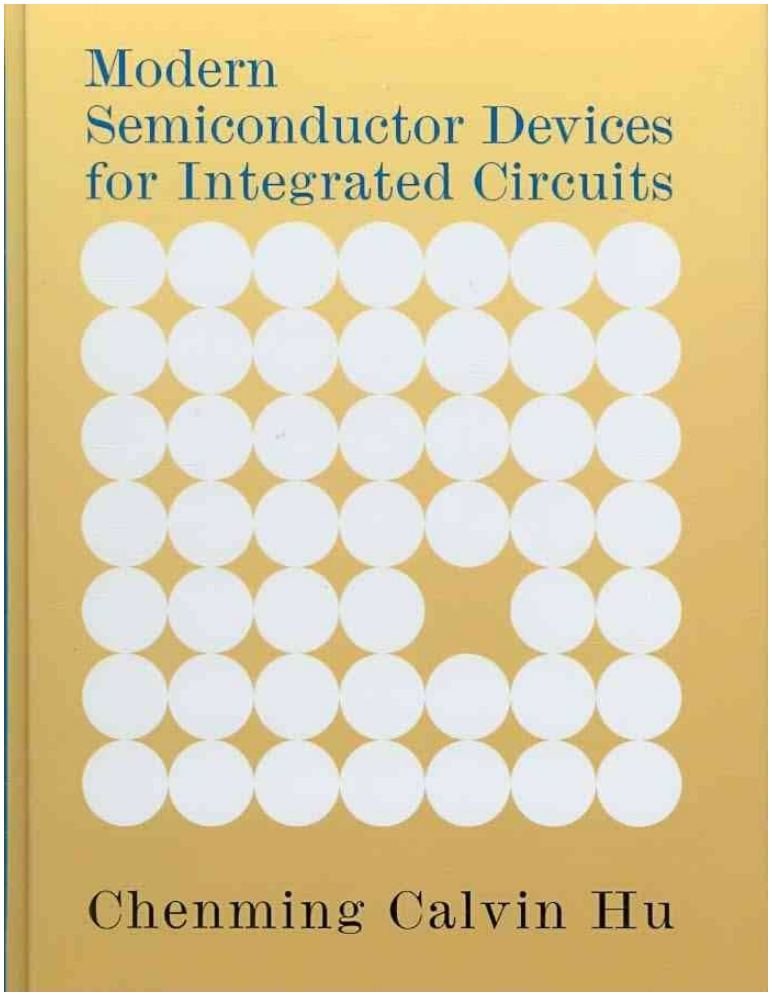
MOS Electrostatics-II

Asif Khan

Department of Electrical and Computer Engineering
Georgia Institute of Technology

Georgia Tech

Reference



Modern Semiconductor Devices for Integrated Circuits

Chapter 5: Section 5.3, 5.4, 5.5

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Resources

Recorded lecture available at https://youtu.be/gU85ggnOClU

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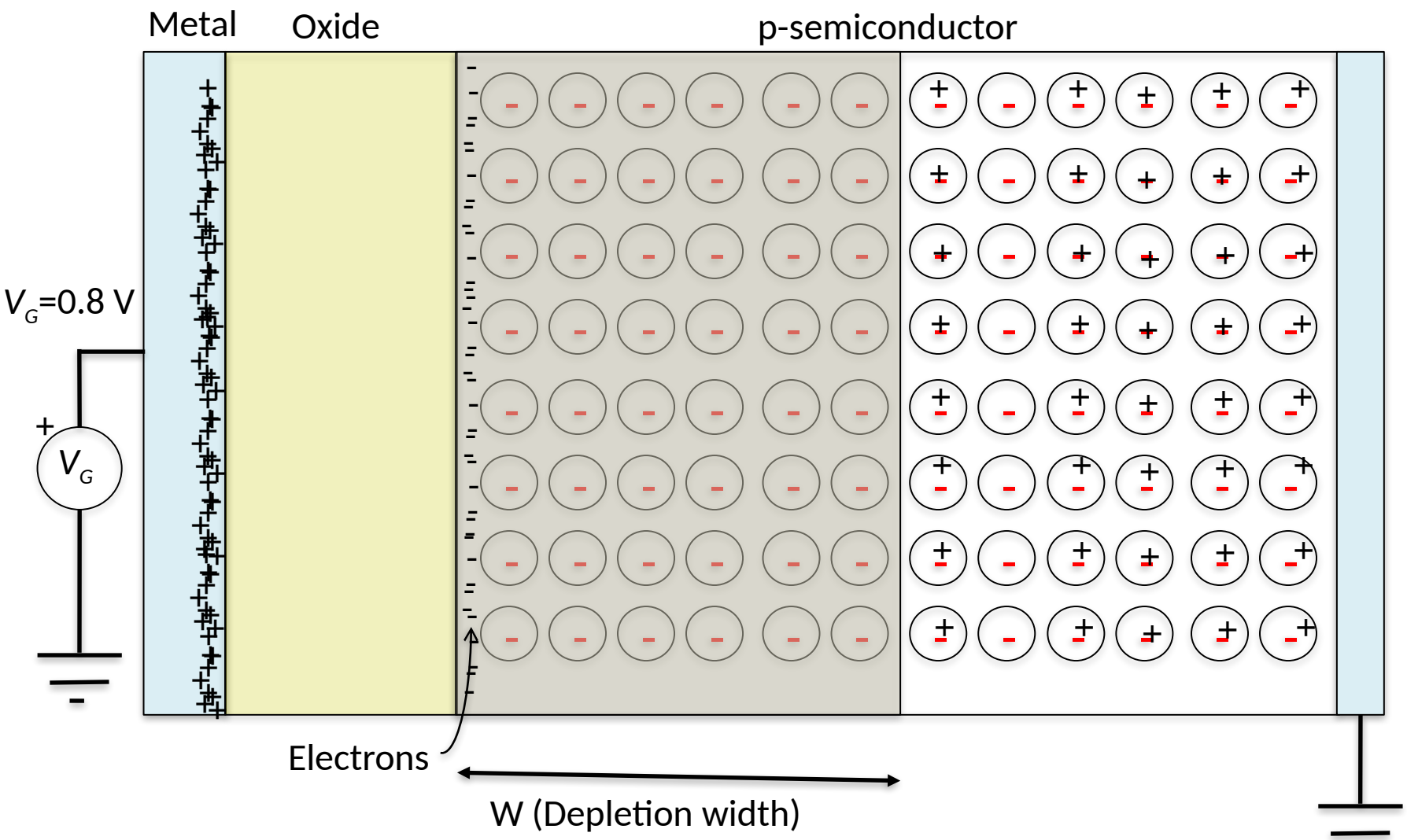
What happens when you apply V_G>Threshold?



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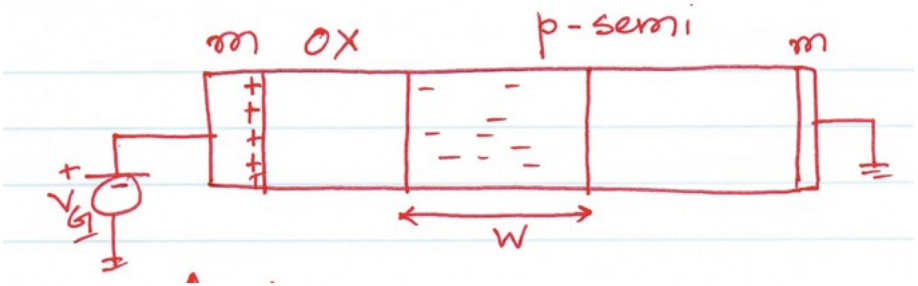
Electrostatics of MOS Capacitors



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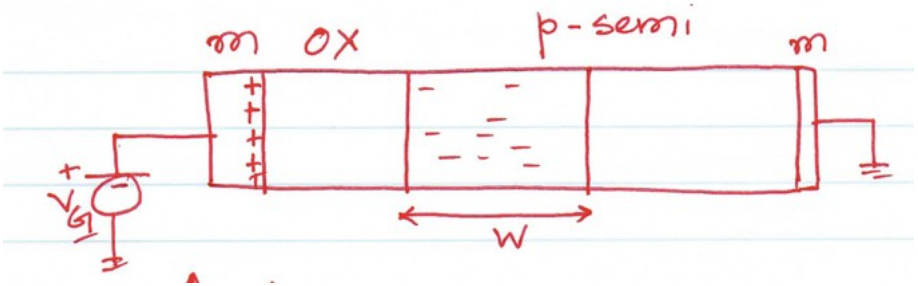

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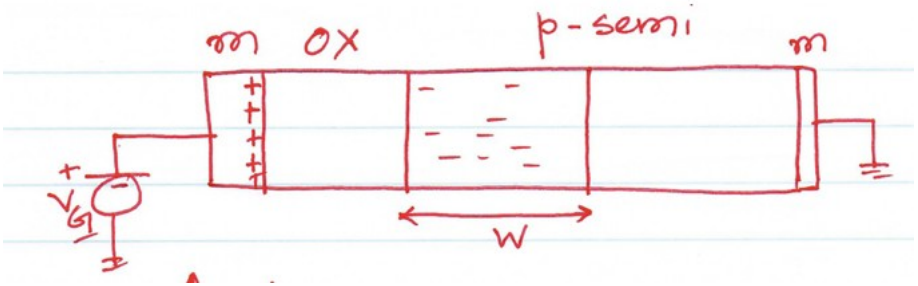
Electrostatics of MOS Capacitors



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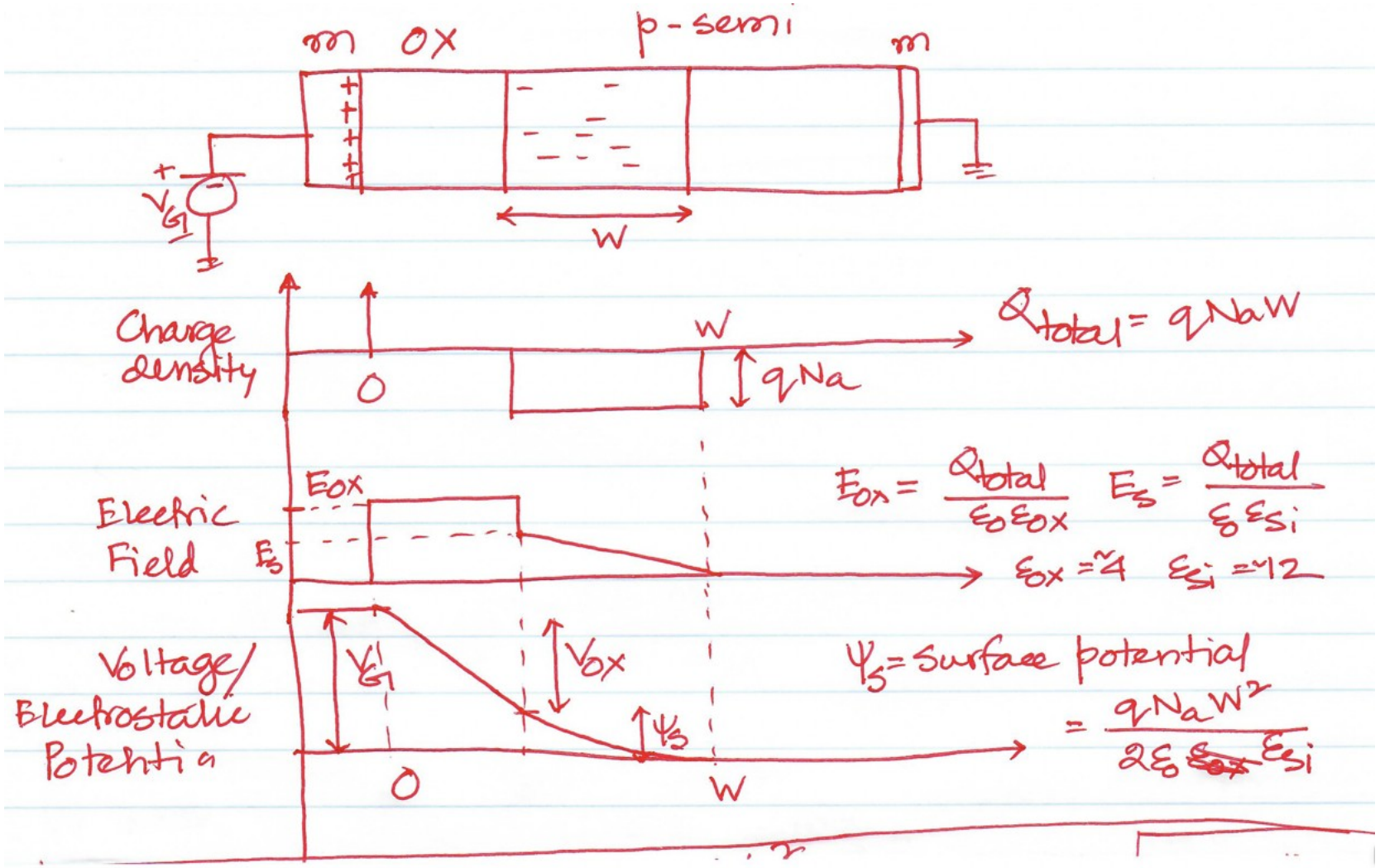

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Electrostatics of MOS Capacitors

$$\psi_s = \frac{qN_a W^2}{2\varepsilon_0 \varepsilon_{Si}} \qquad W = \sqrt{\frac{2\varepsilon_0 \varepsilon_{Si}\,\psi_s}{qN_a}}$$

$$V_G = V_{ox} + \psi_s = \frac{qN_a W}{C_{ox}} + \psi_s = \frac{\sqrt{2\varepsilon_0 \varepsilon_{Si}\, qN_a\, \psi_s}}{C_{ox}} + \psi_s$$

$$V_{ox} = \frac{Q_{total}}{C_{ox}}$$

At threshold, $\psi_s = 2\psi_B \Rightarrow$

$$V_t = V_G(\psi_s = 2\psi_B) = \frac{\sqrt{4\varepsilon_0 \varepsilon_{Si}\, qN_a\, \psi_B}}{C_{ox}} + 2\psi_B$$

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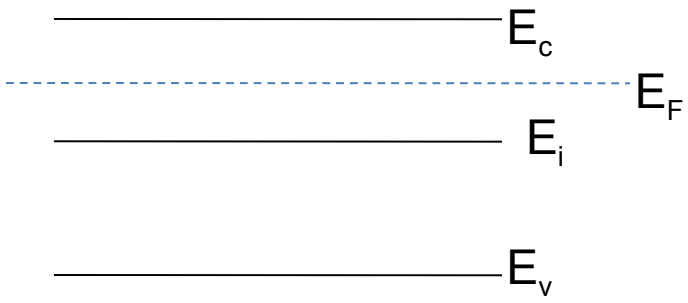
How to create inversion?

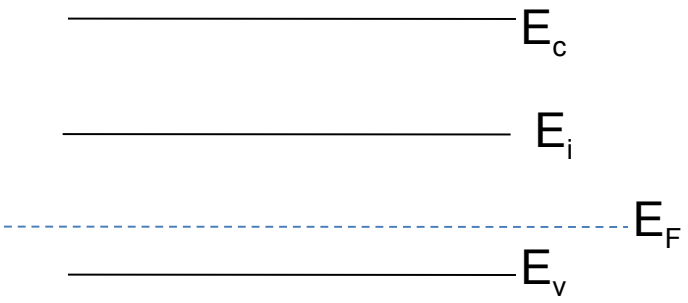
n-type



$$n = N_c e^{(E_F - E_C)/kT}$$

The closer the Fermi level is to the conduction band, the larger is the number of electrons

p-type



$$p = N_v e^{(E_V - E_F)/kT}$$

The closer the Fermi level is to the valence band, the larger is the number of holes

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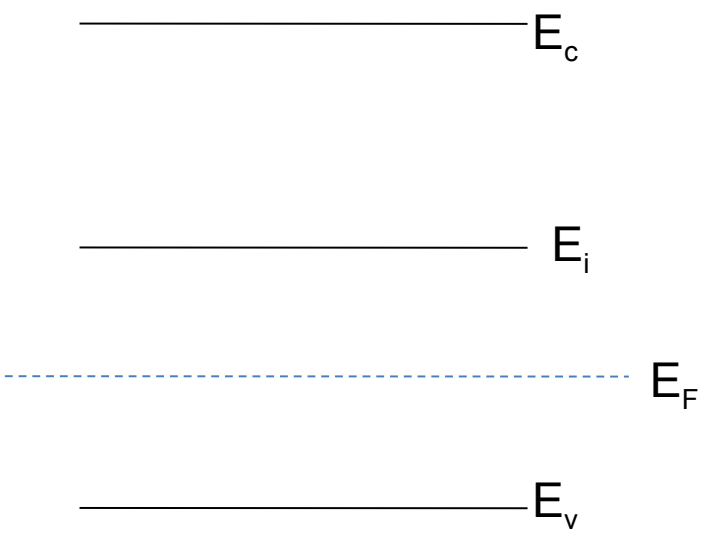
How to create inversion?



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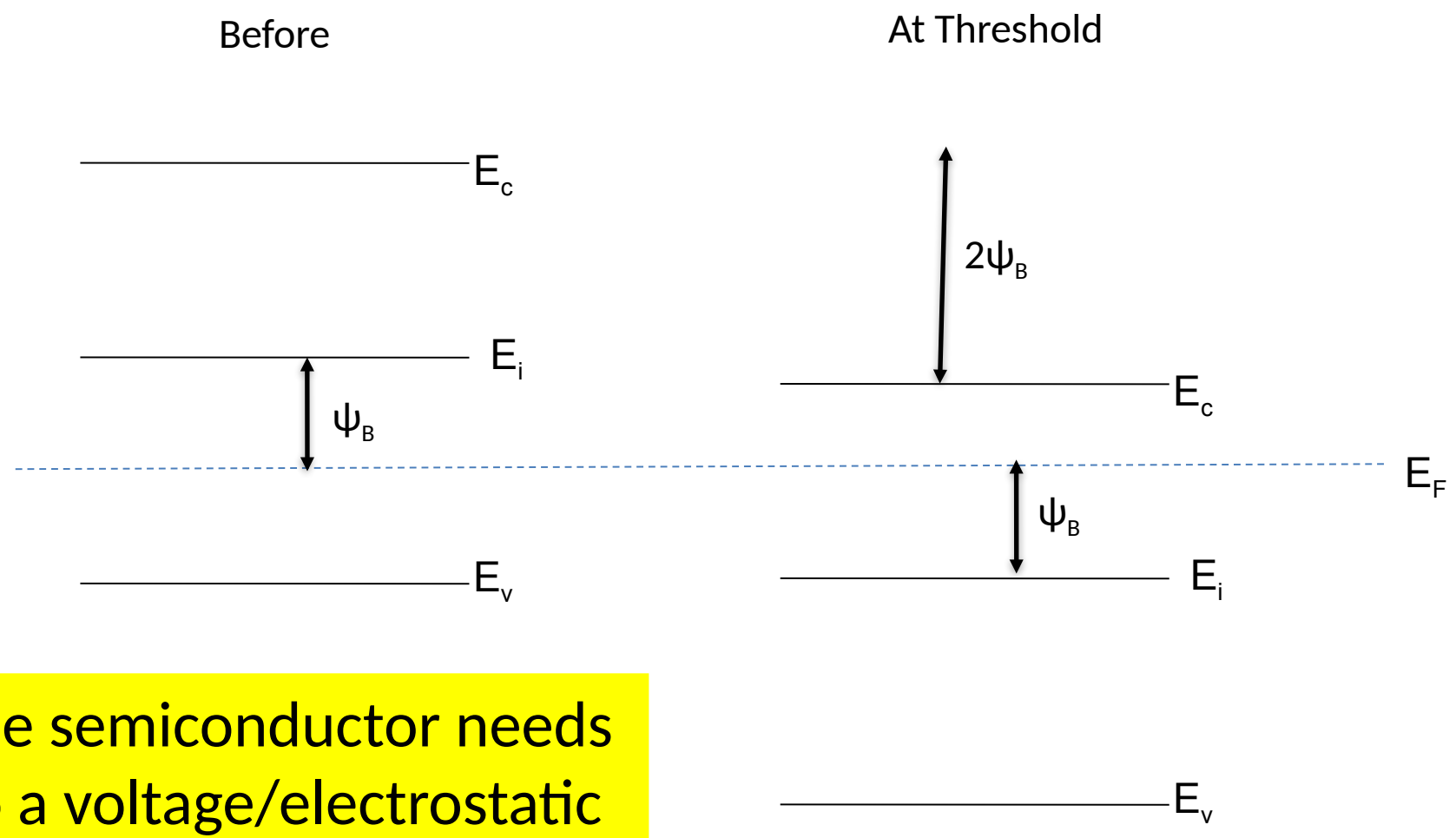
How to create inversion?



The semiconductor needs to a voltage/electrostatic potential=$2\psi_B$ for carrier inversion

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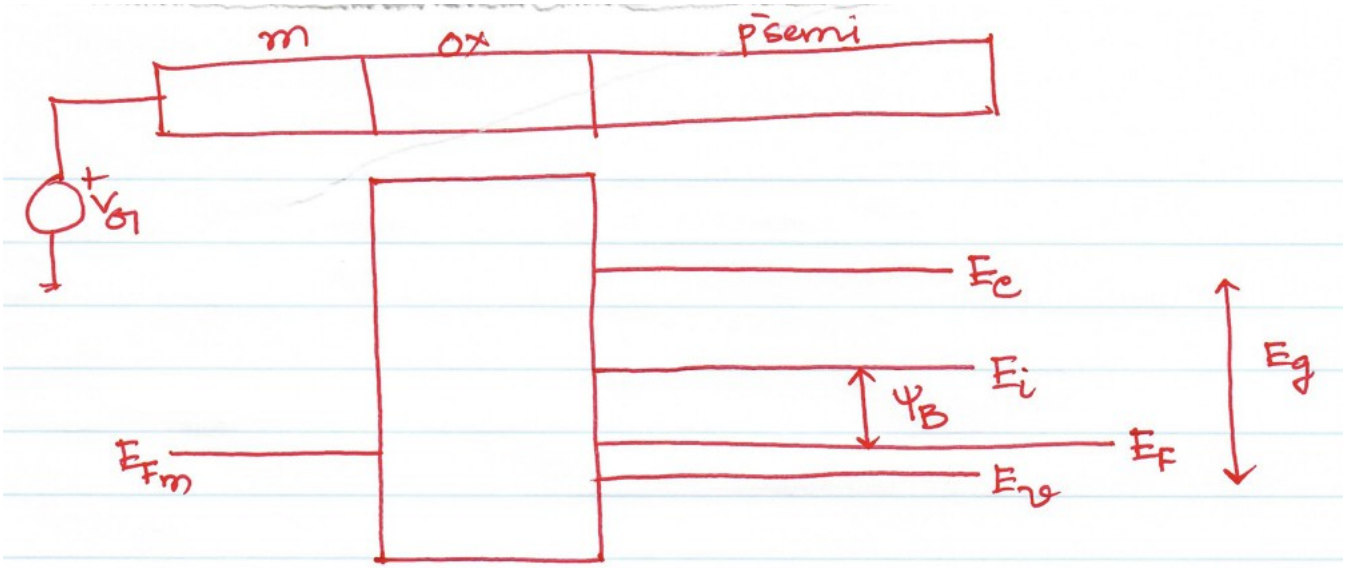
Band Diagram with VG=0



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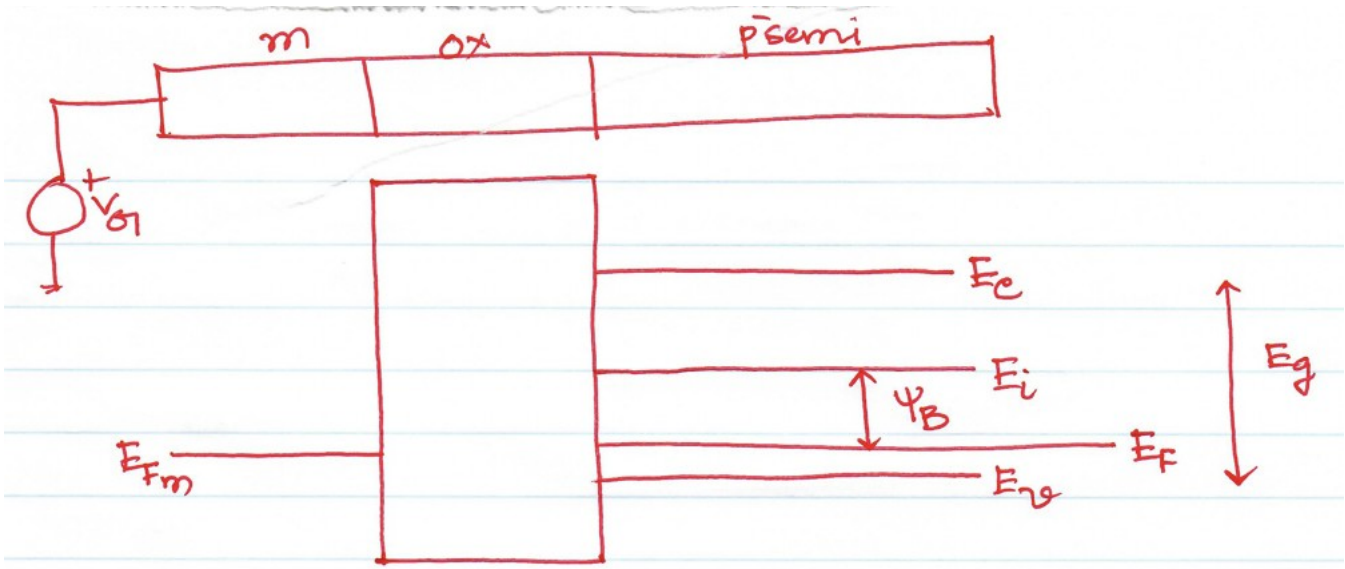
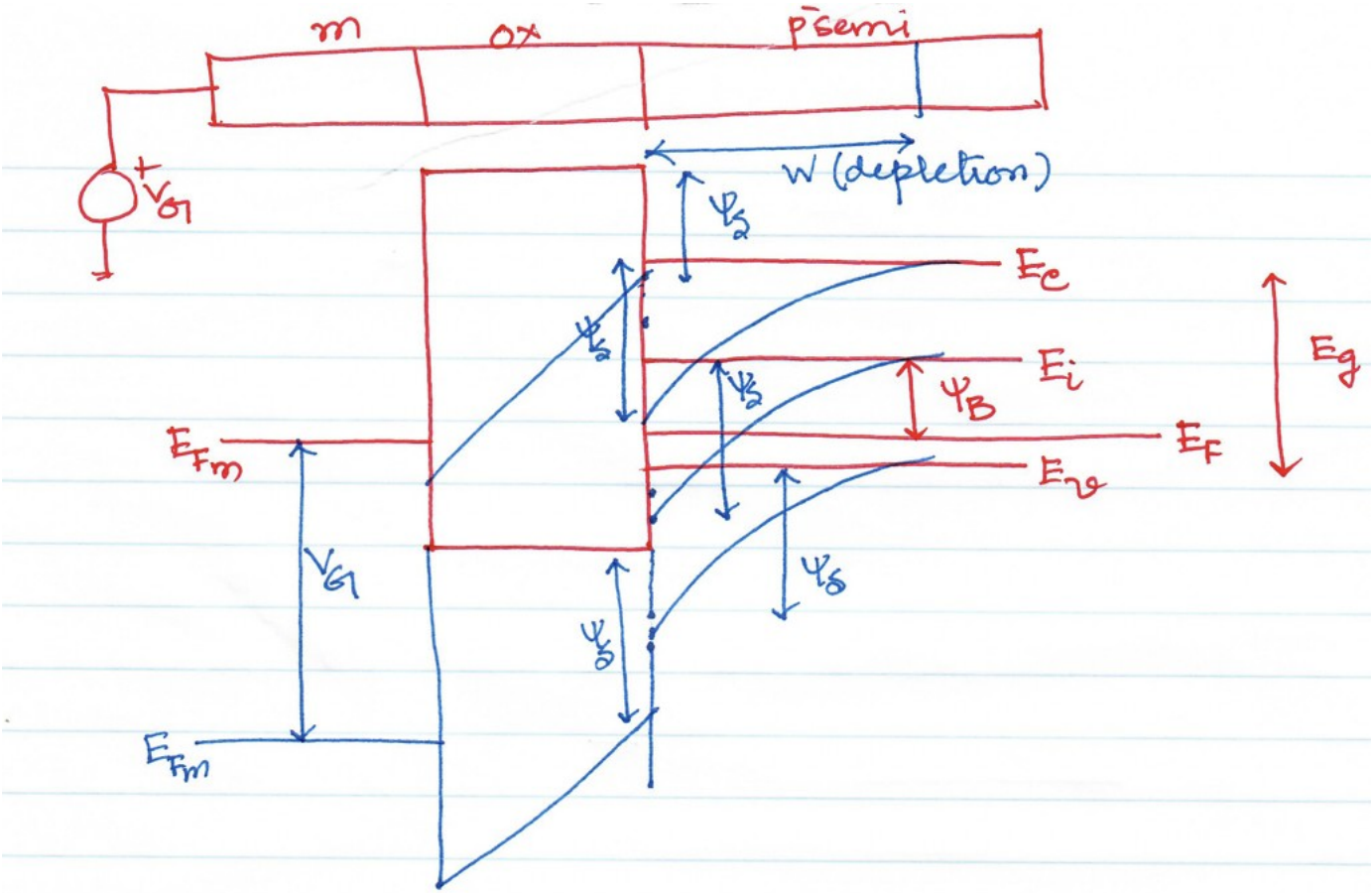
Band Diagram with VG>0



Band Diagram with an applied VG



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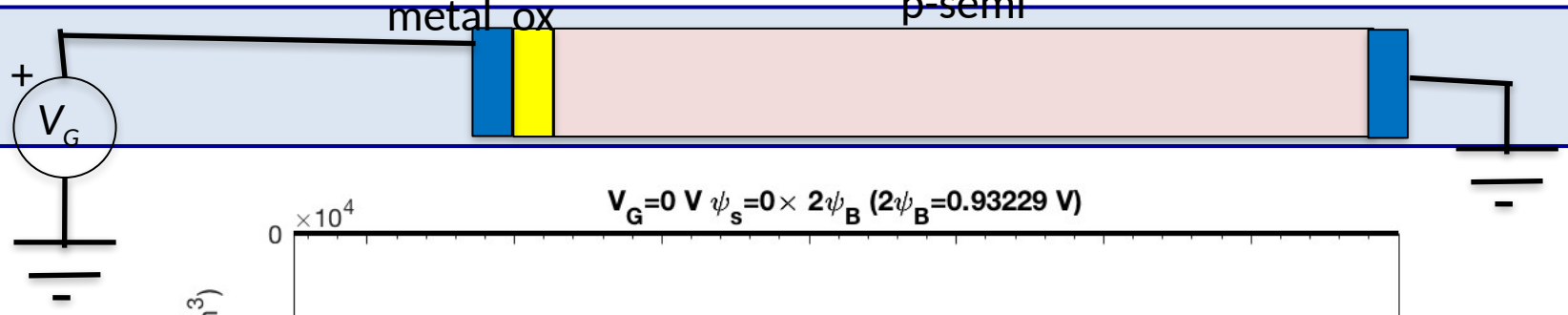

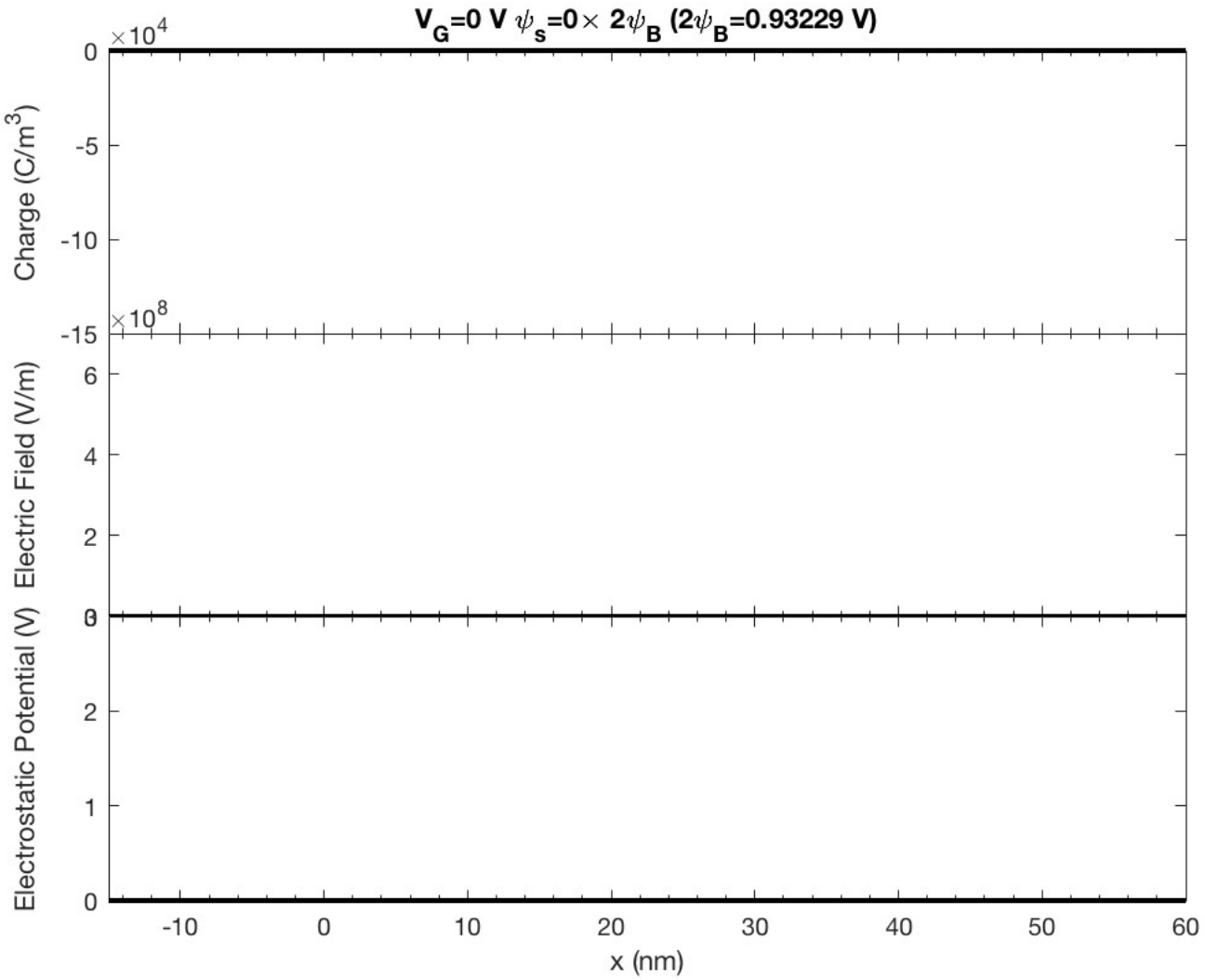

N_A=1e24 /m^3

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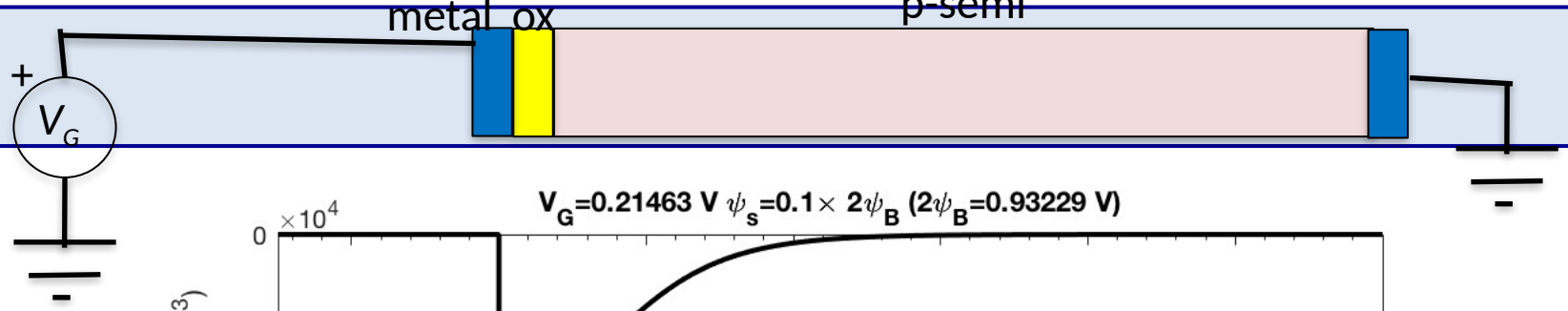

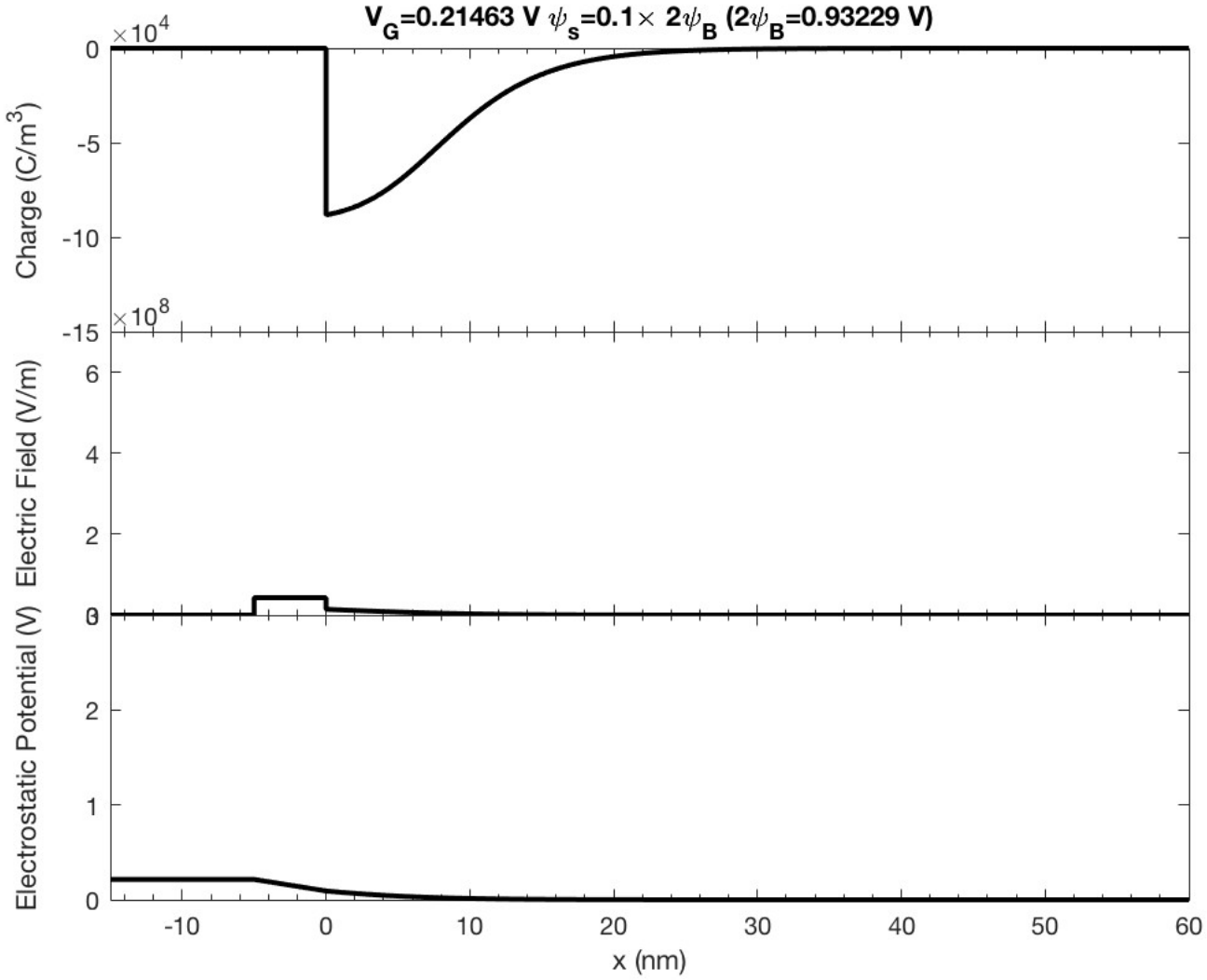

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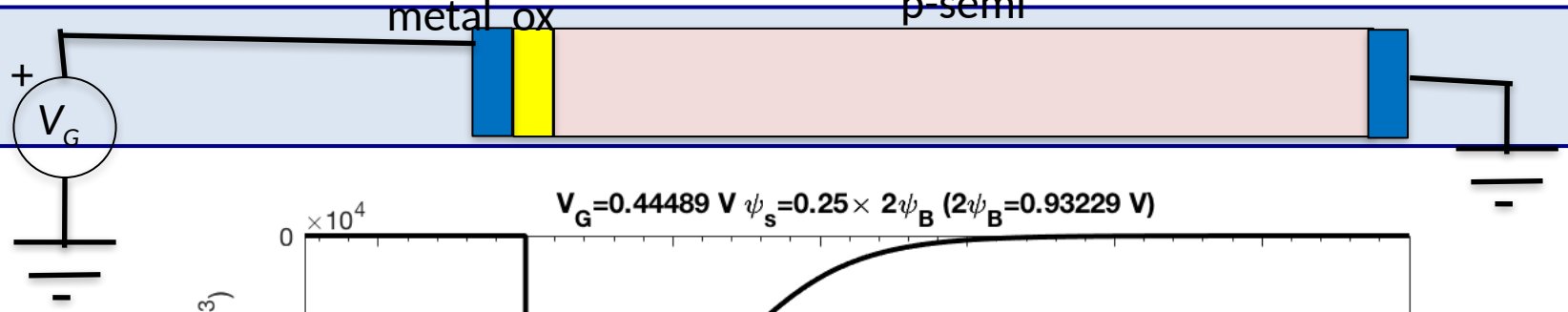

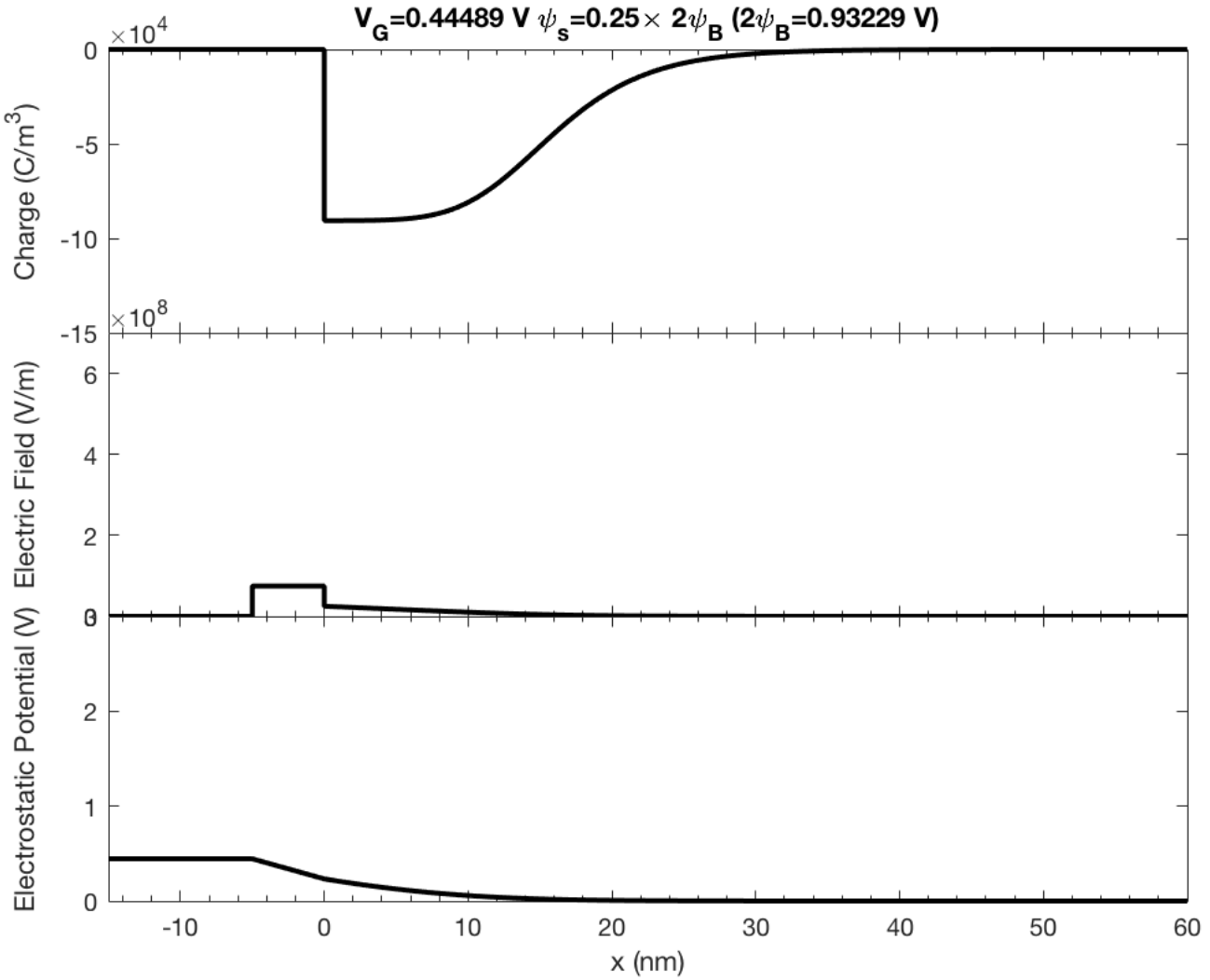

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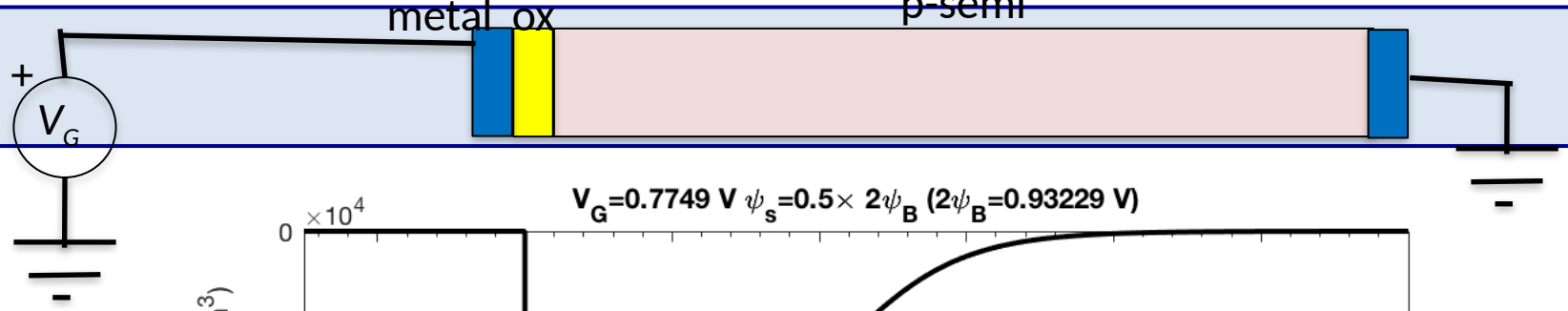

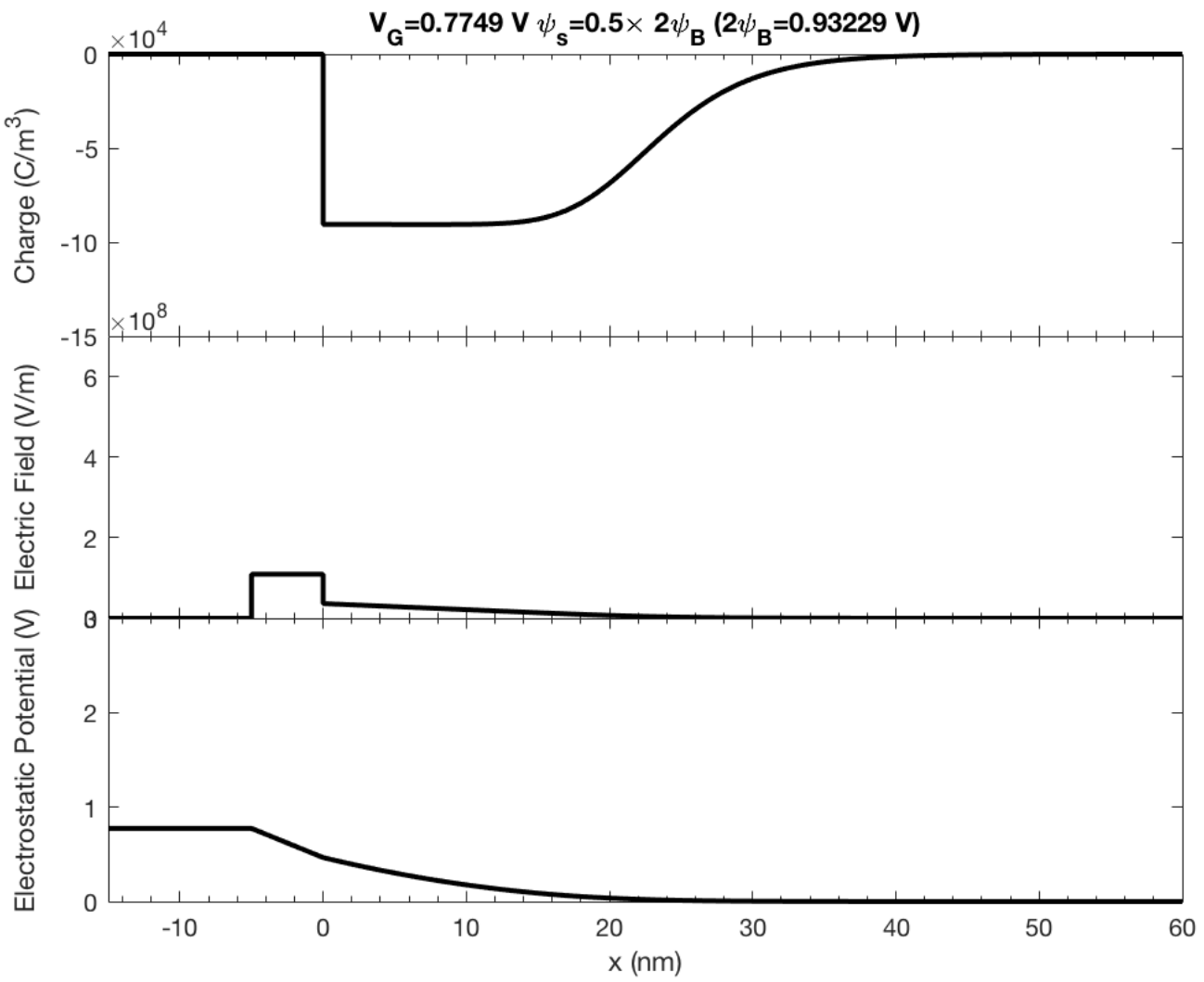

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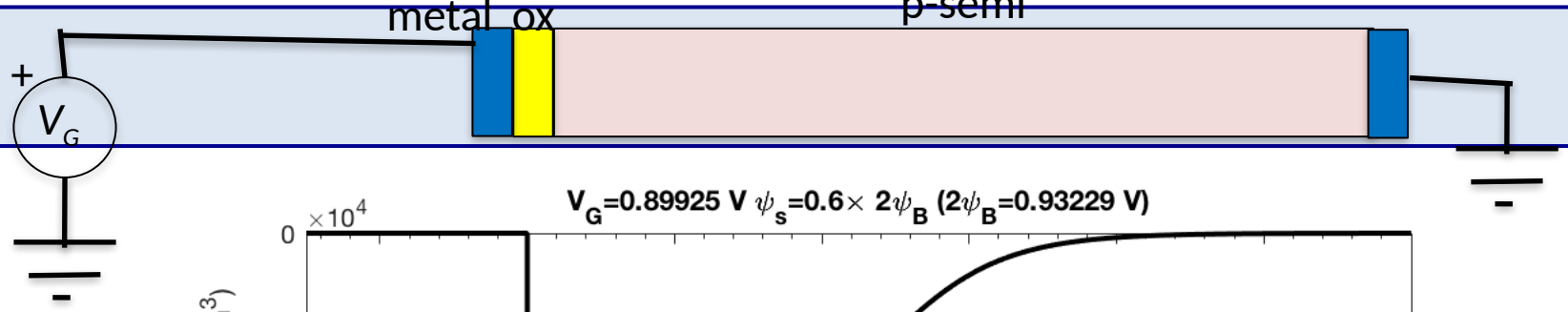

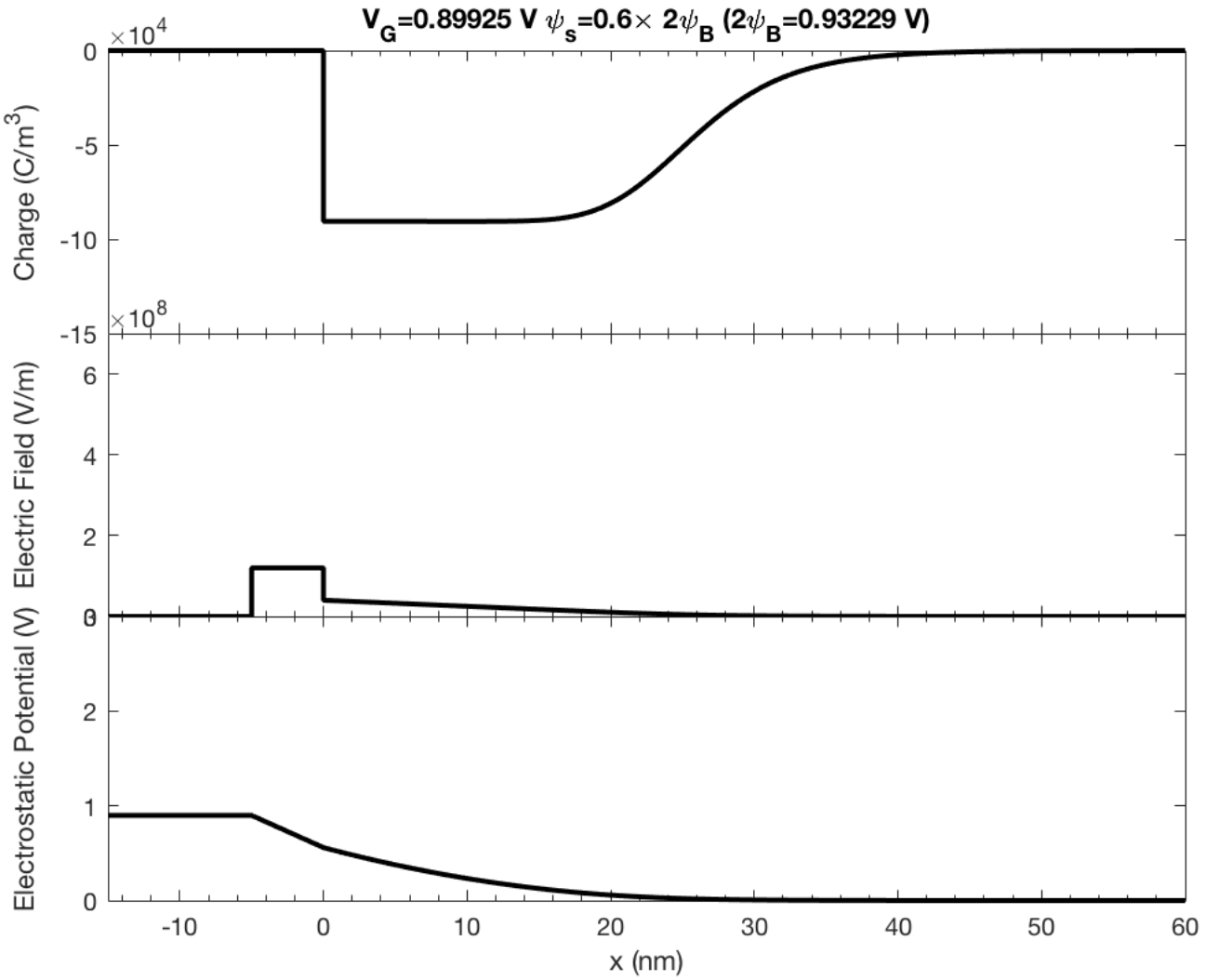

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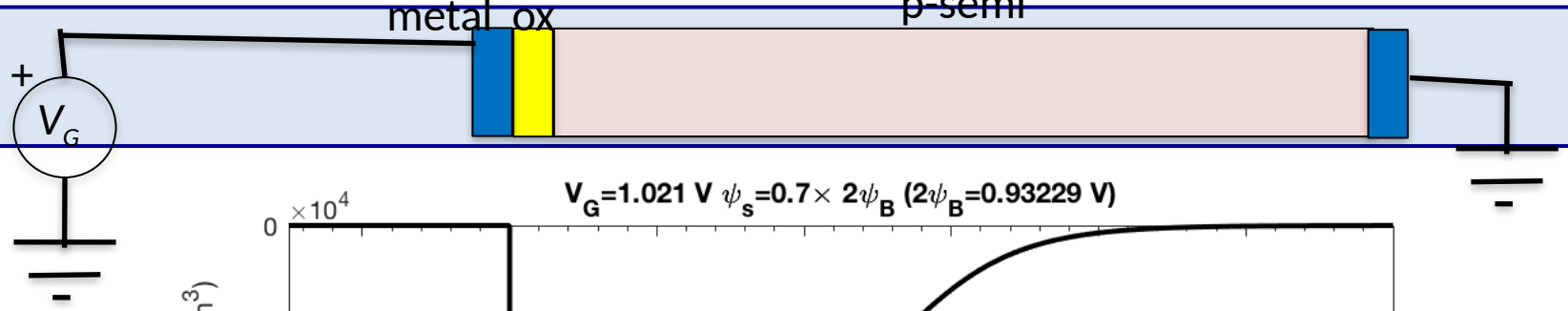

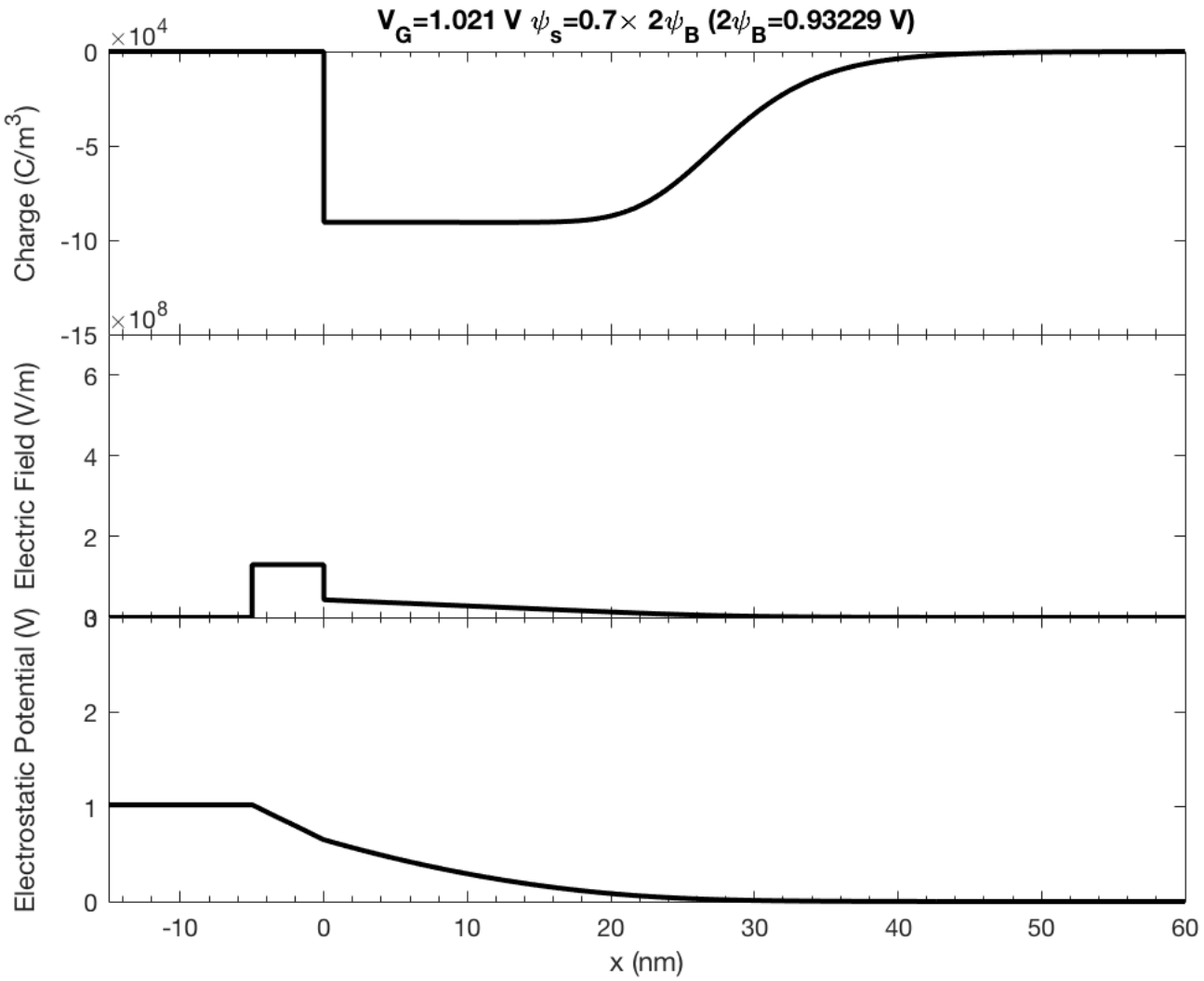

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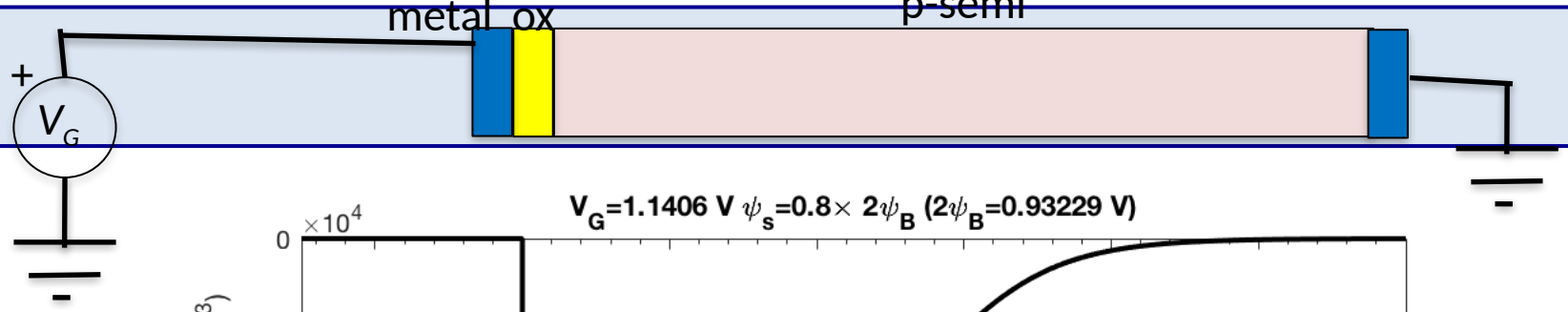

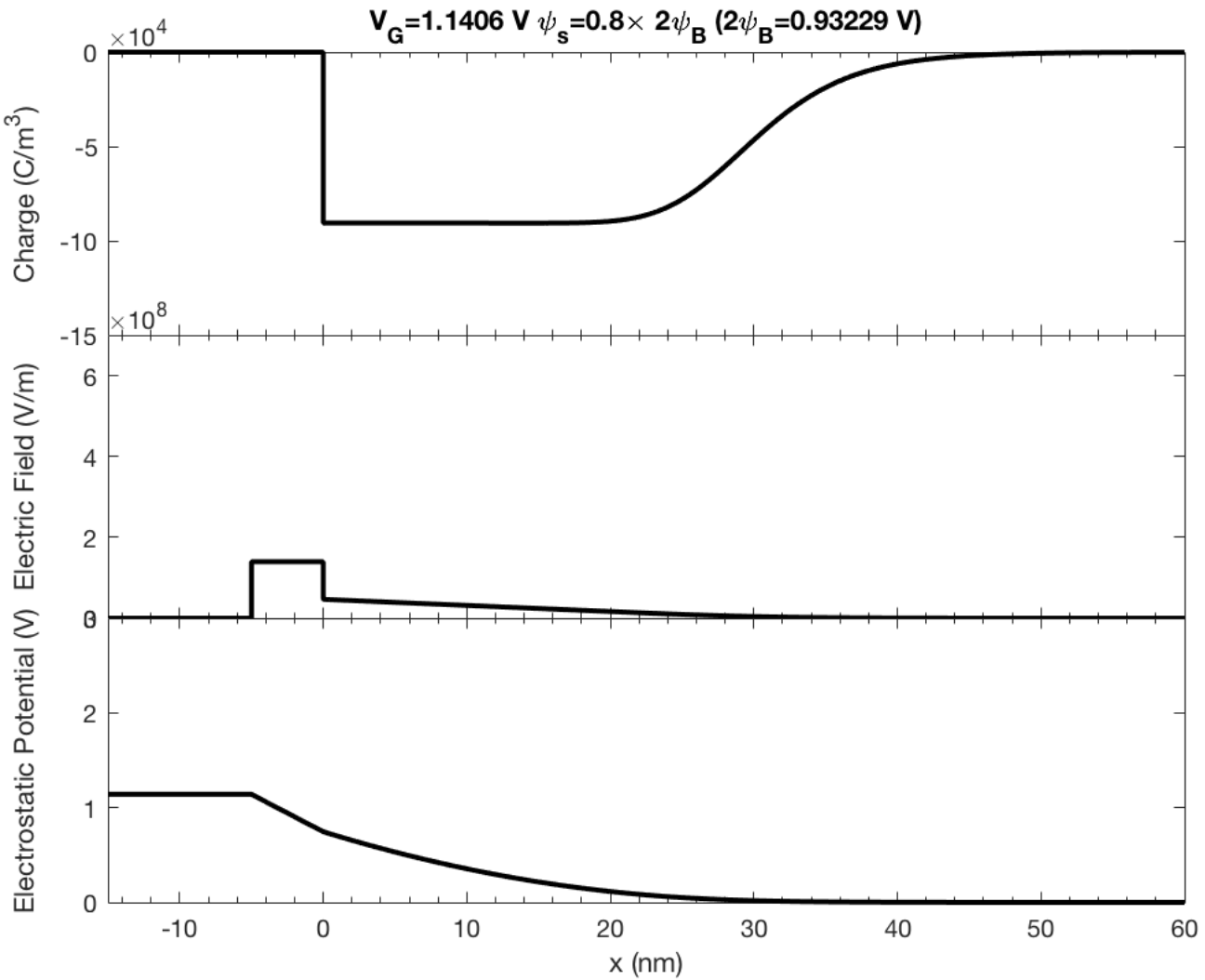

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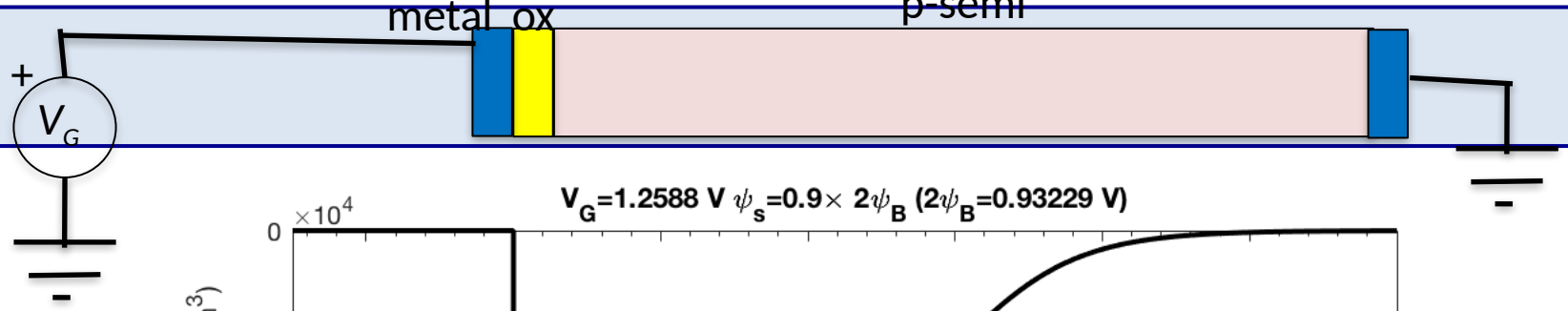

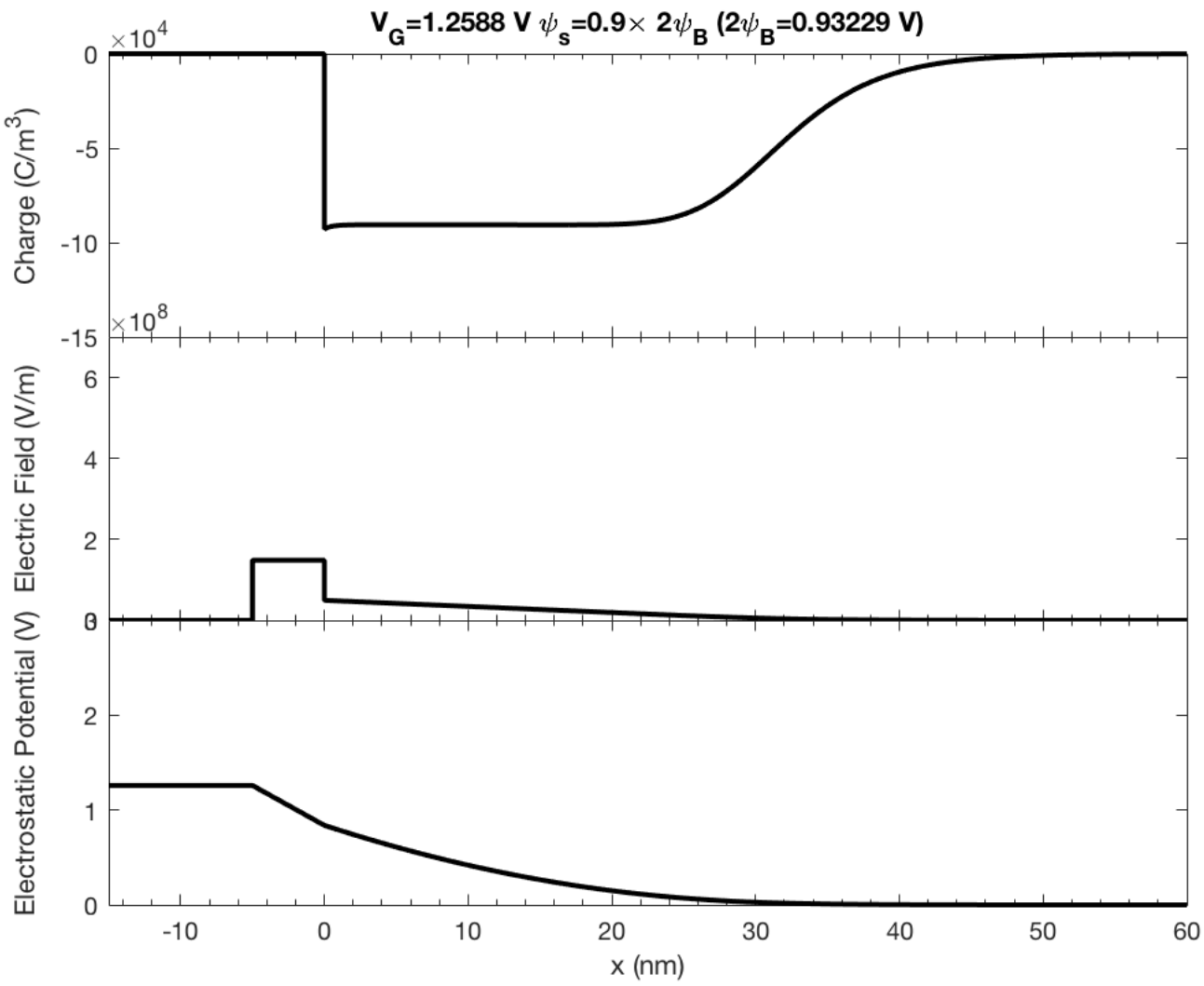

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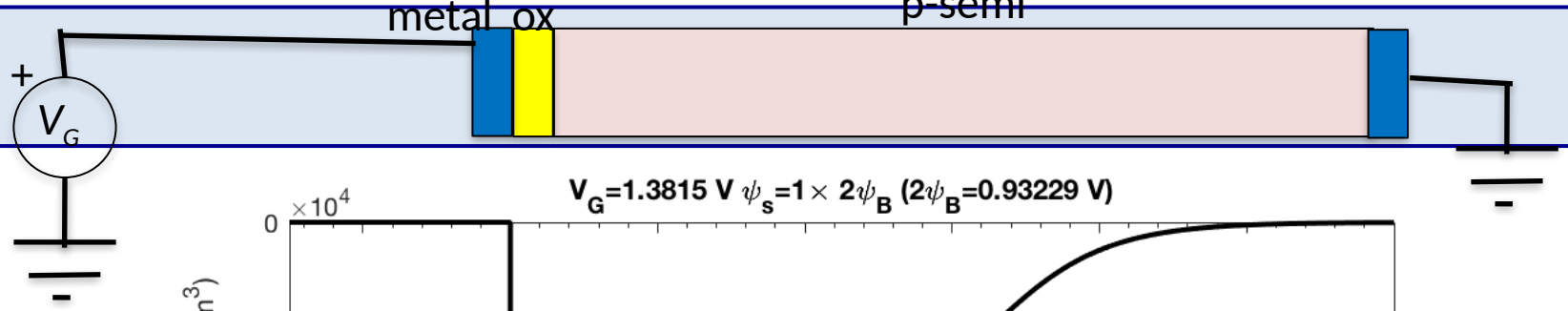

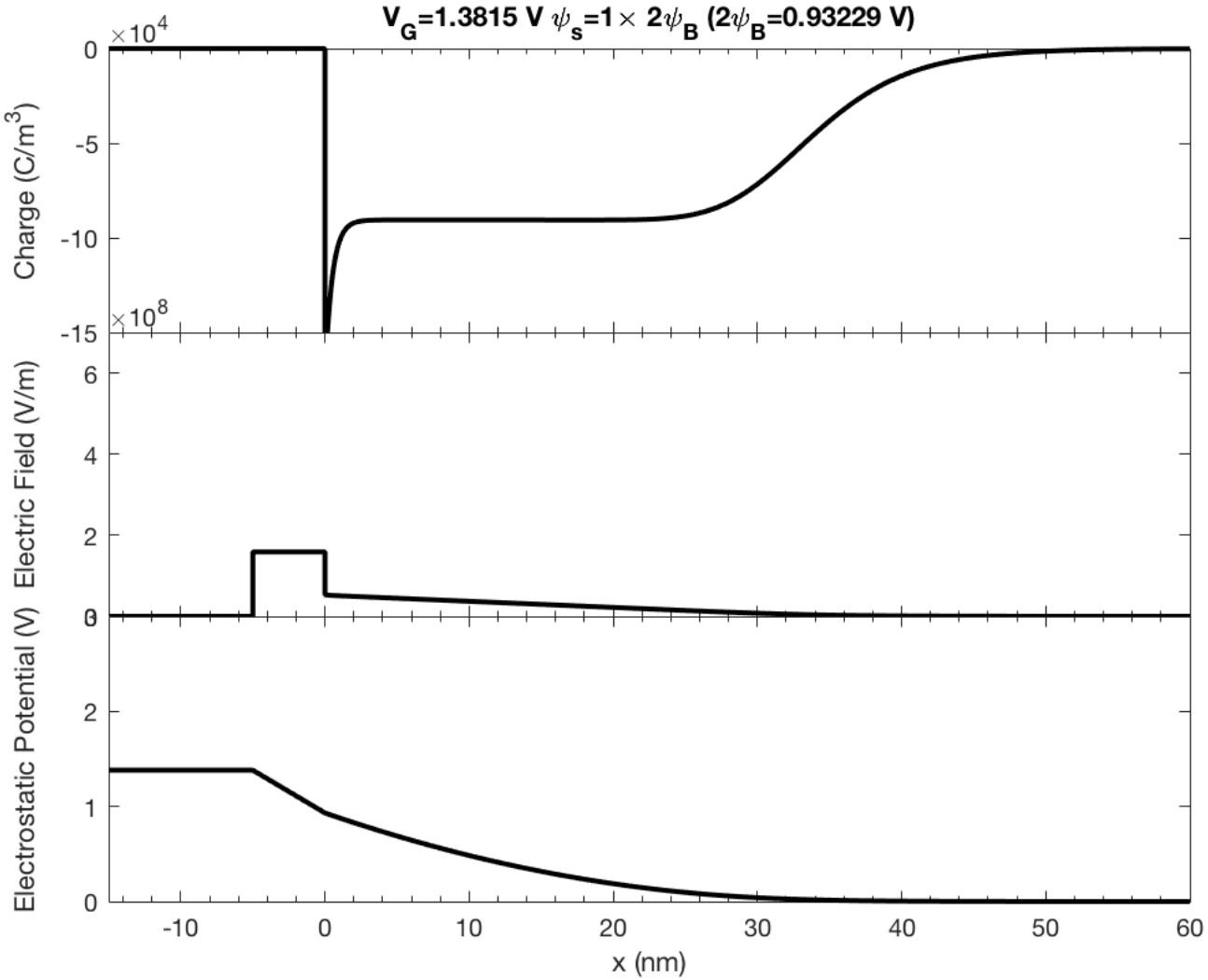

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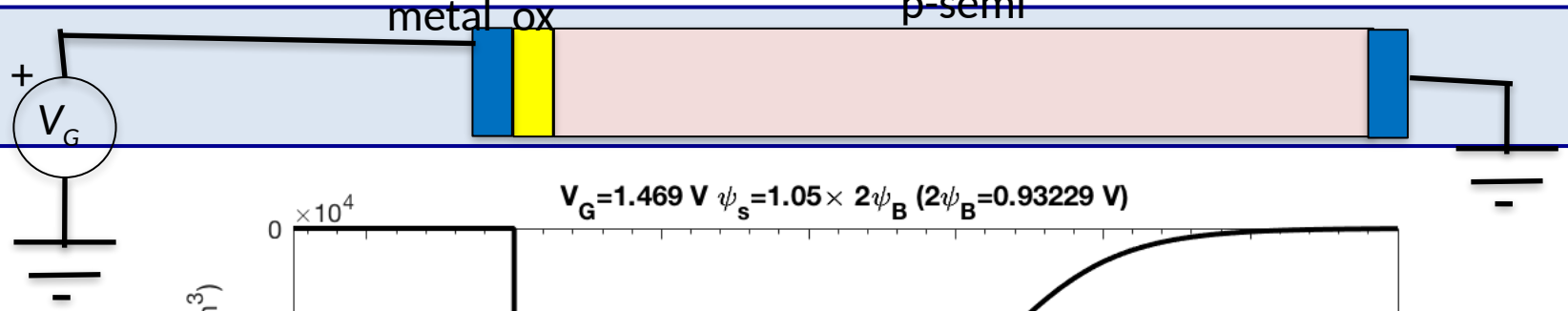

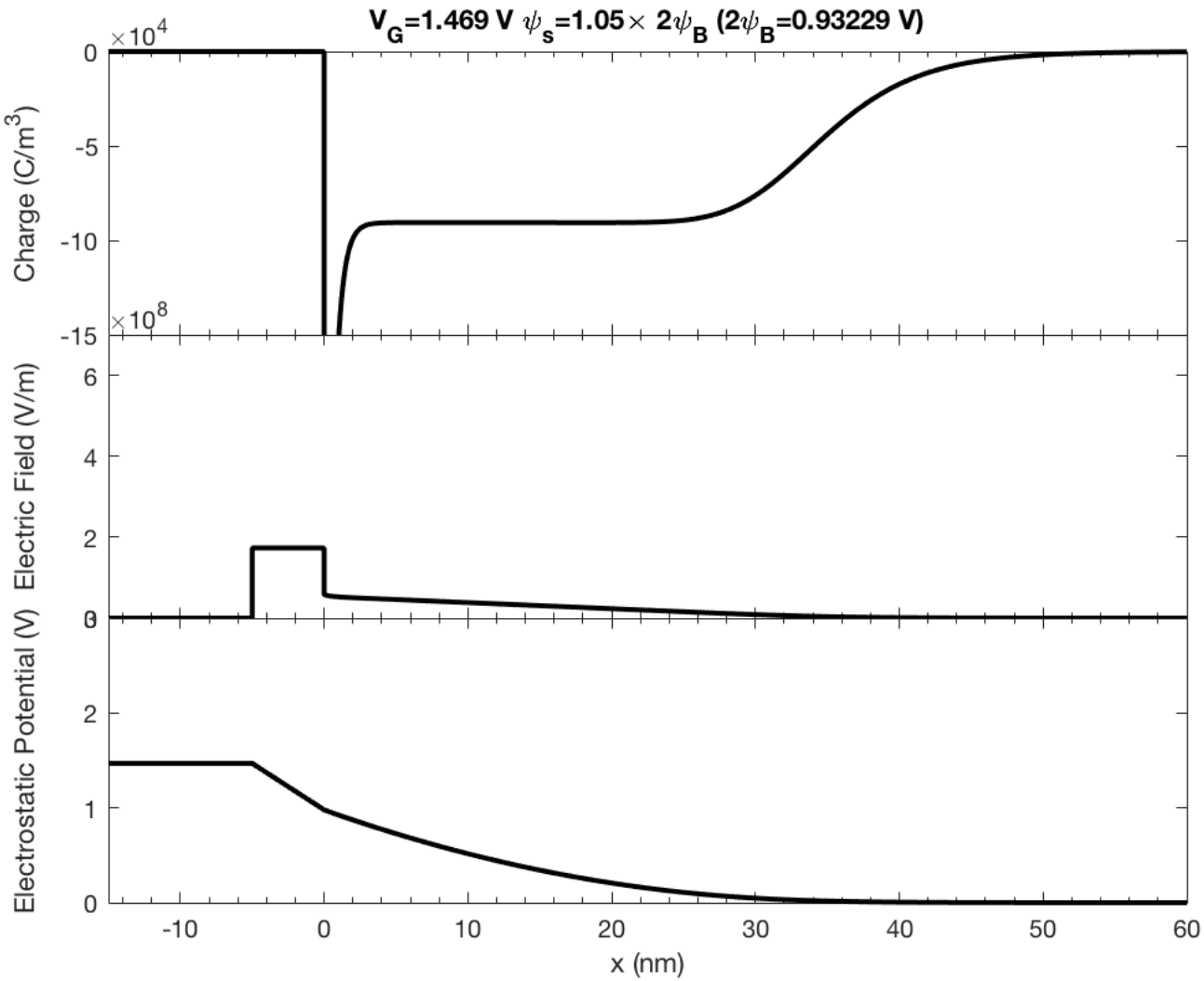

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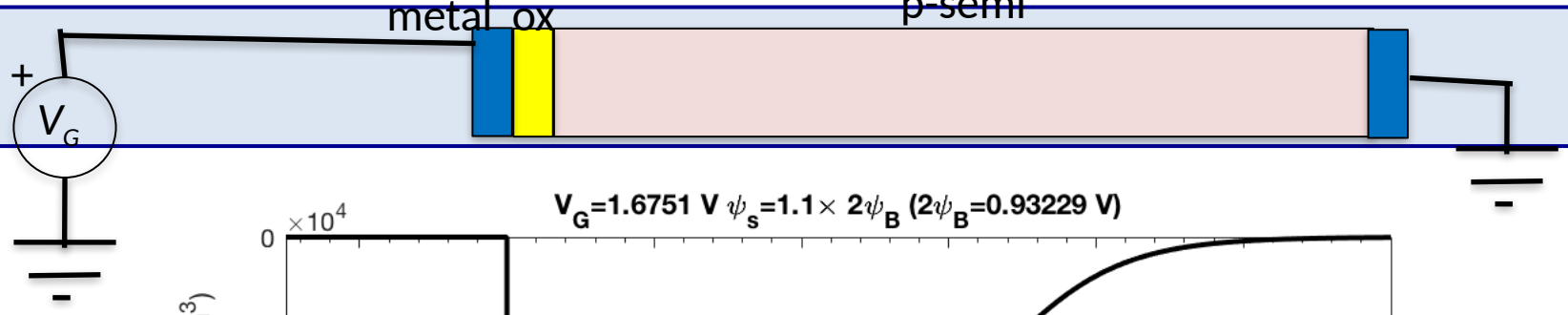

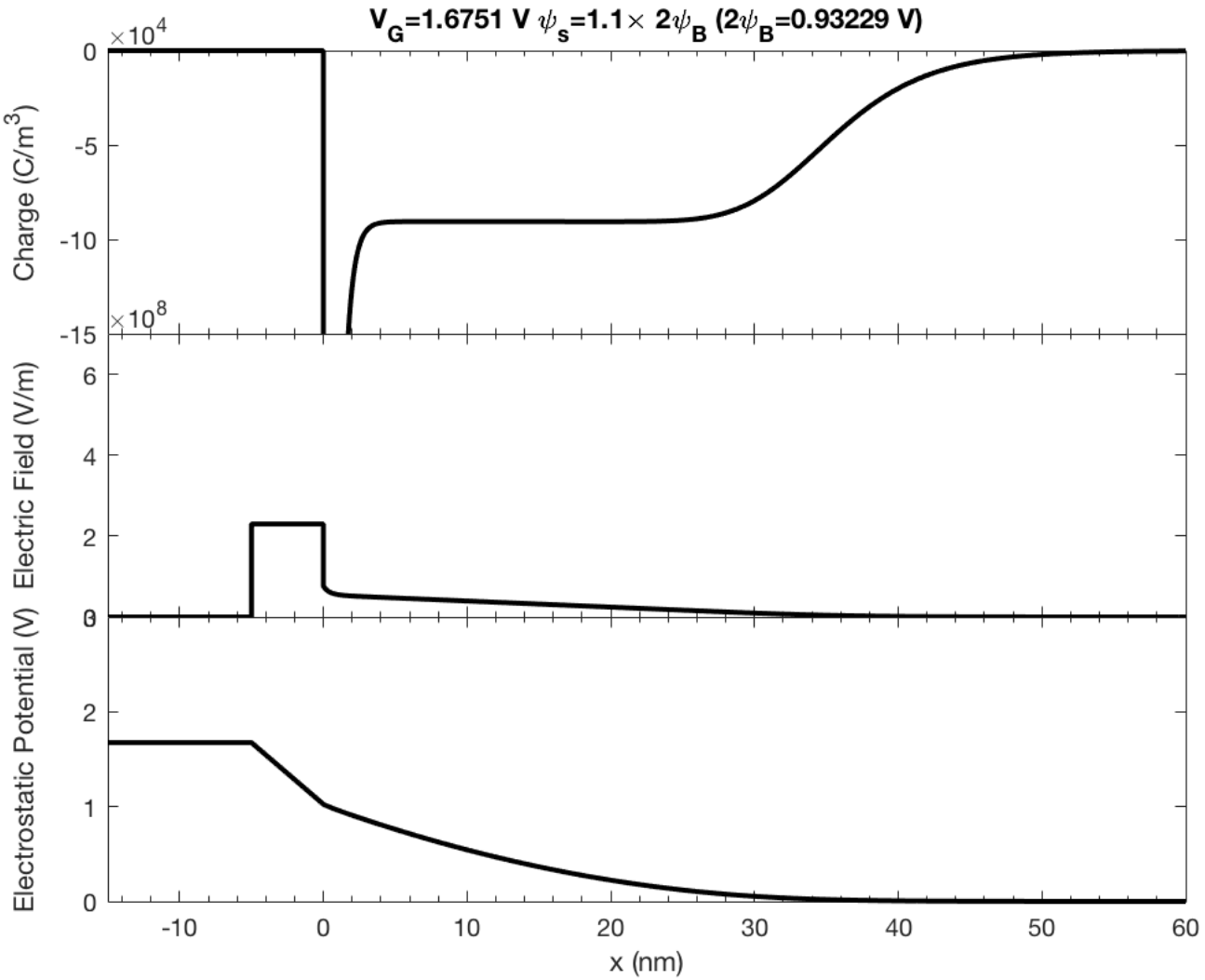

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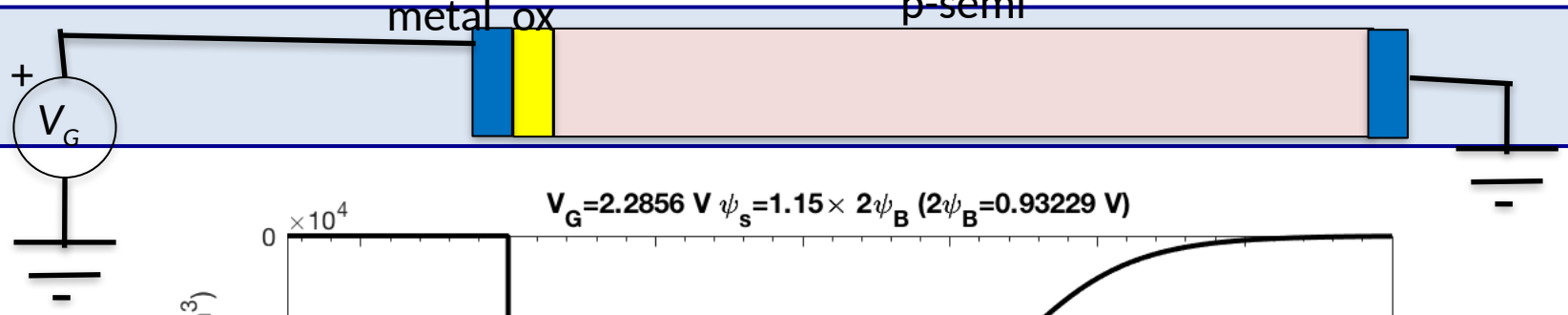

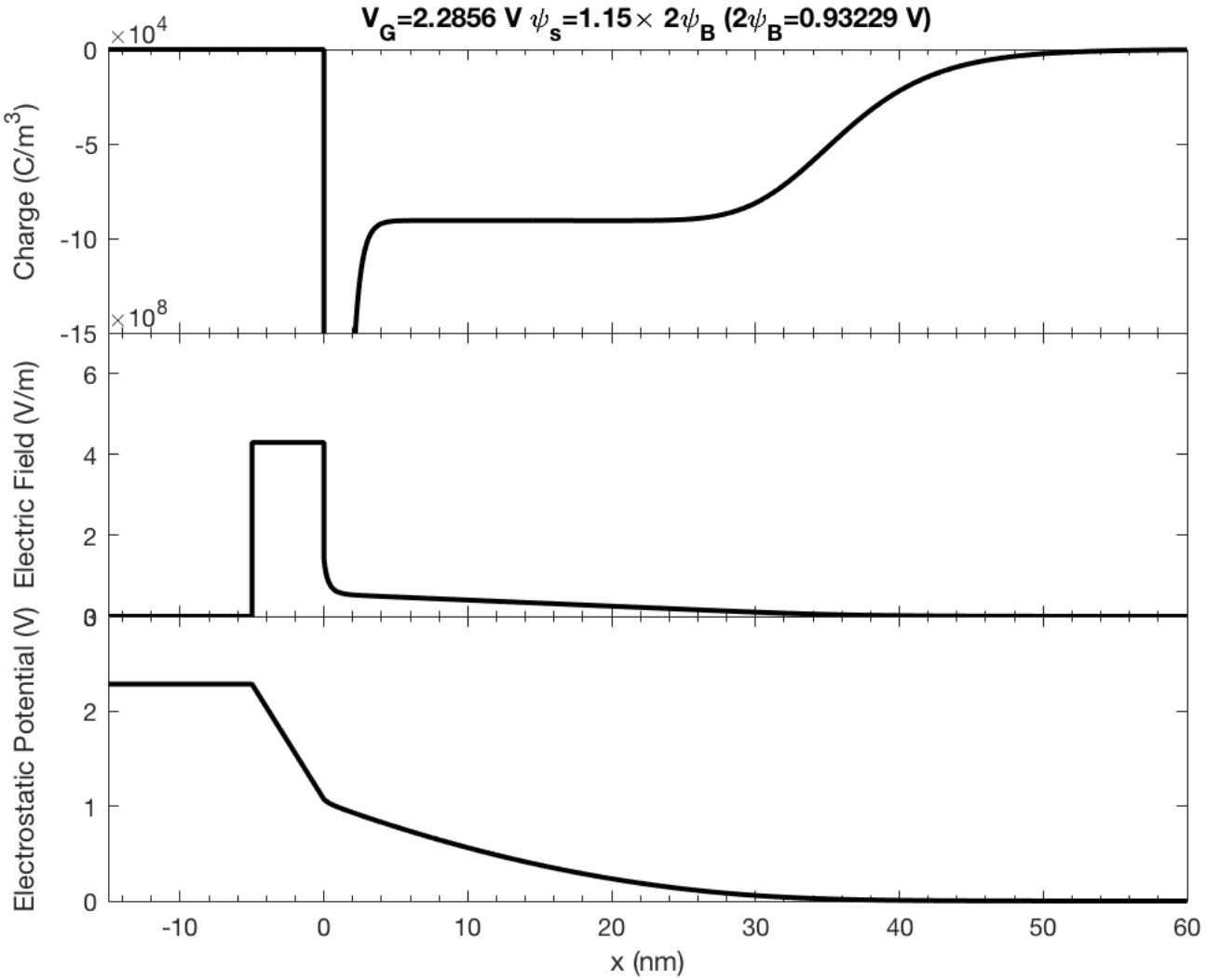

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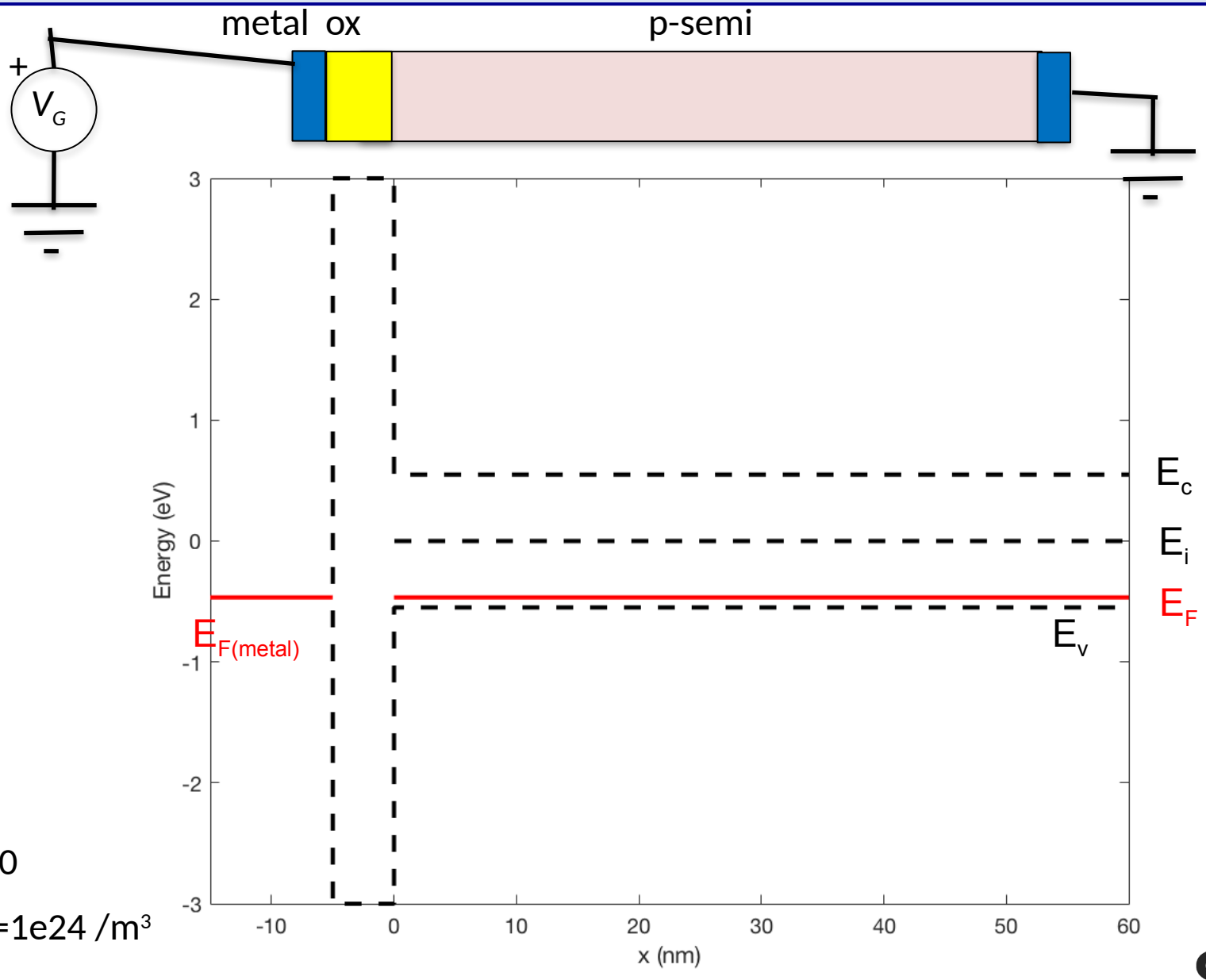
Band Diagram of MOS Capacitors



V_G=0

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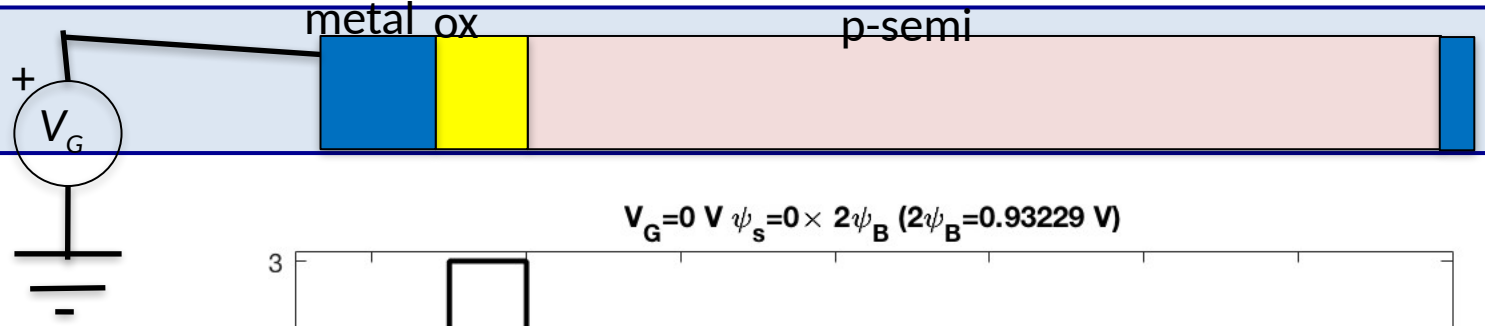

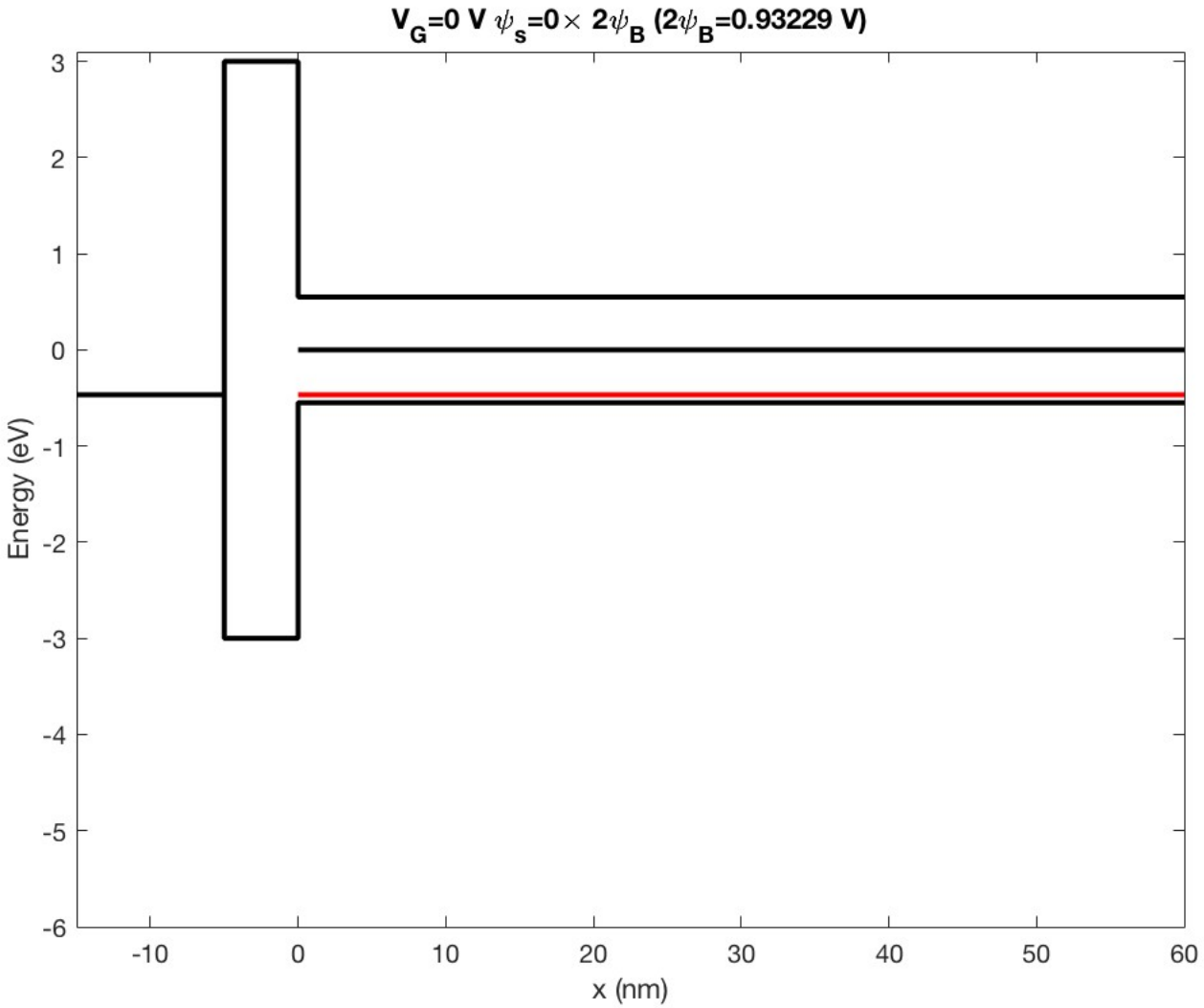

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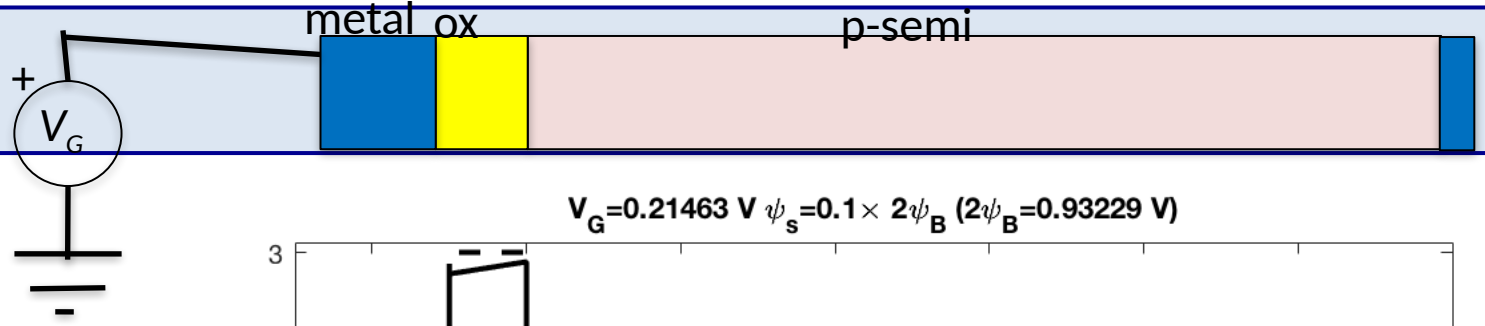

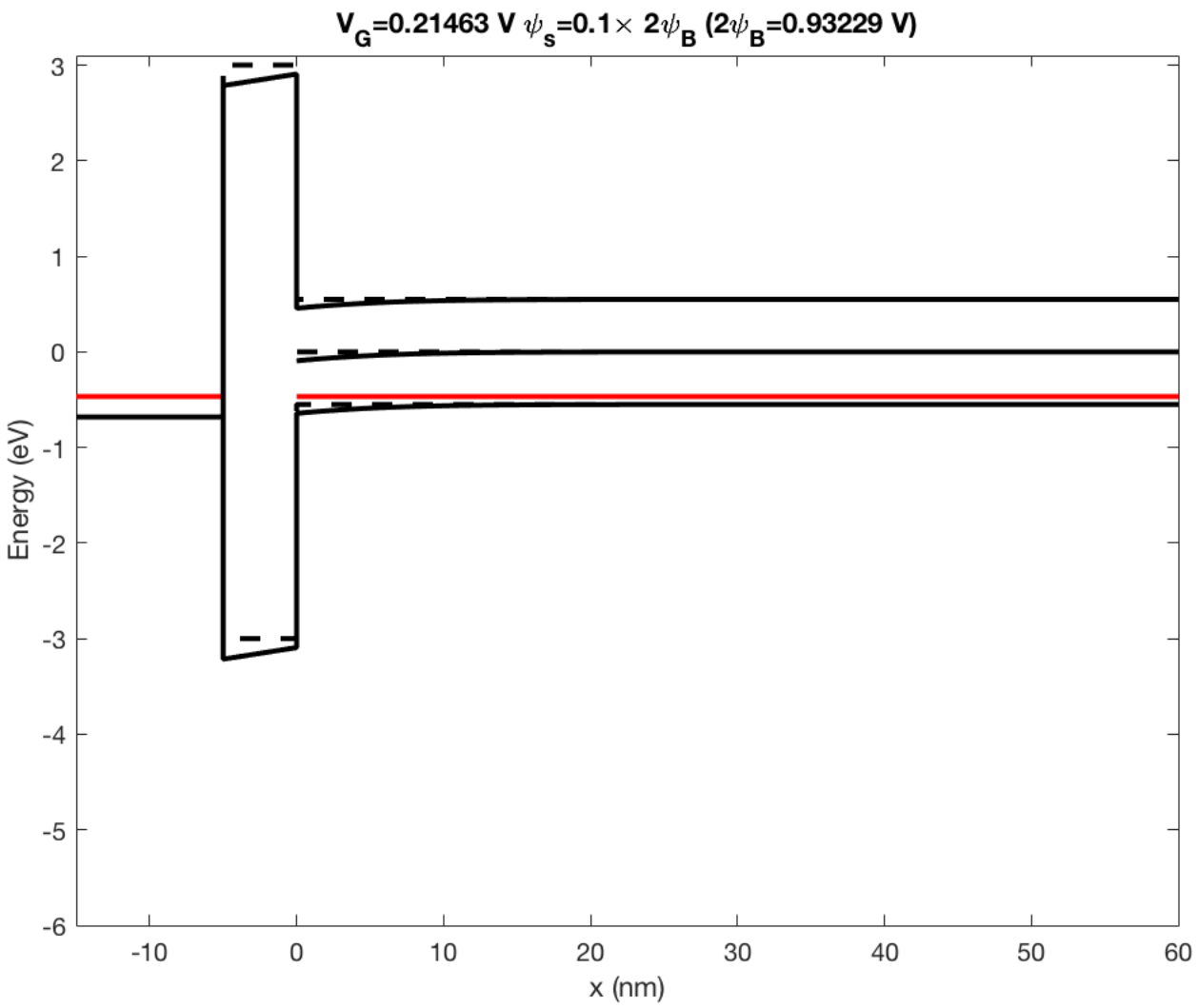

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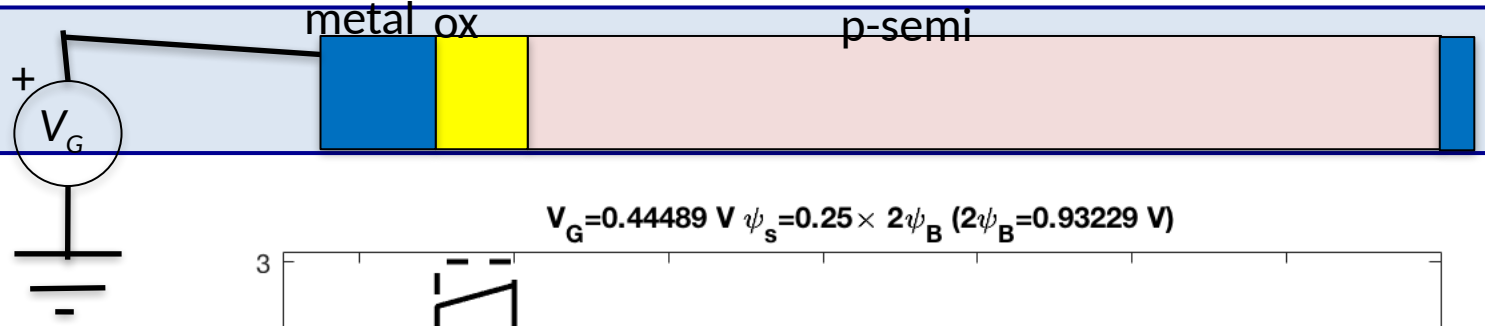

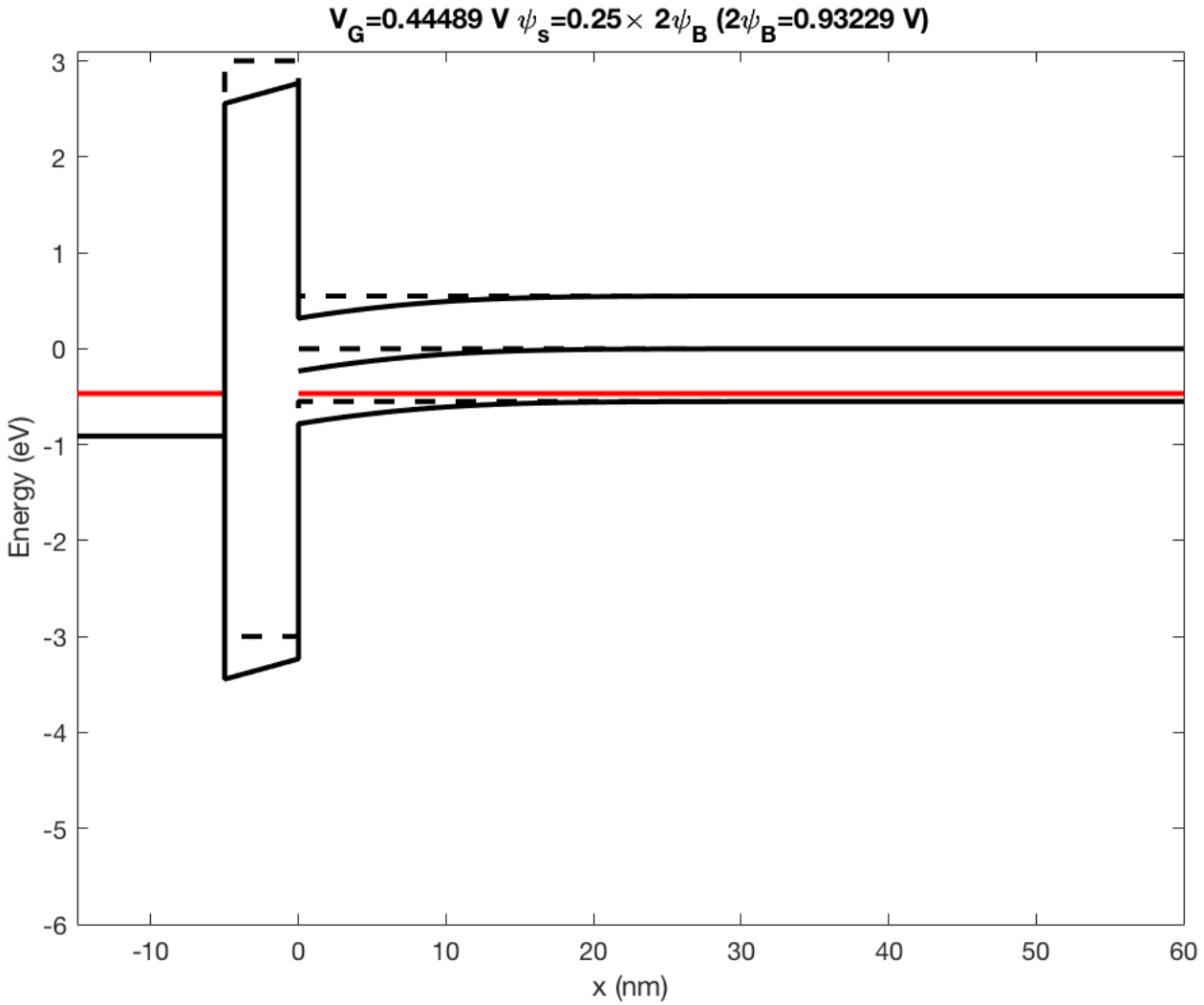

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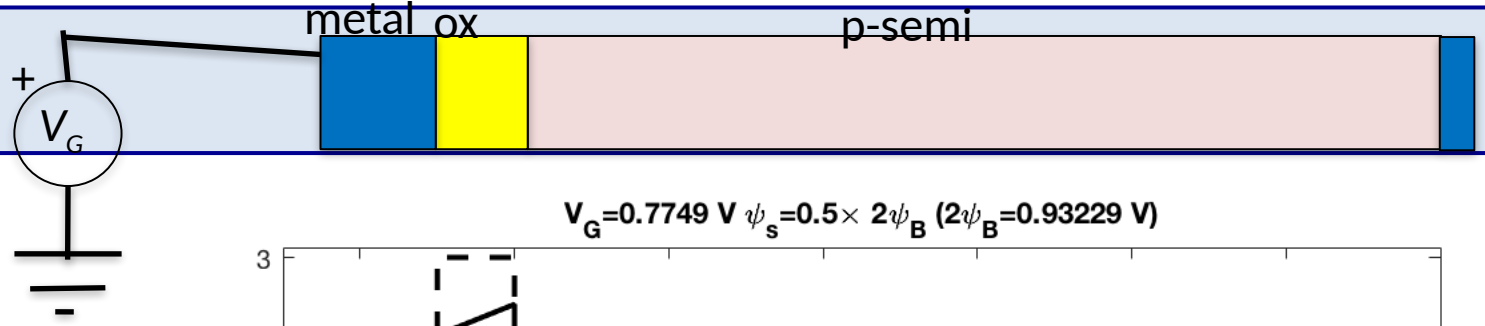

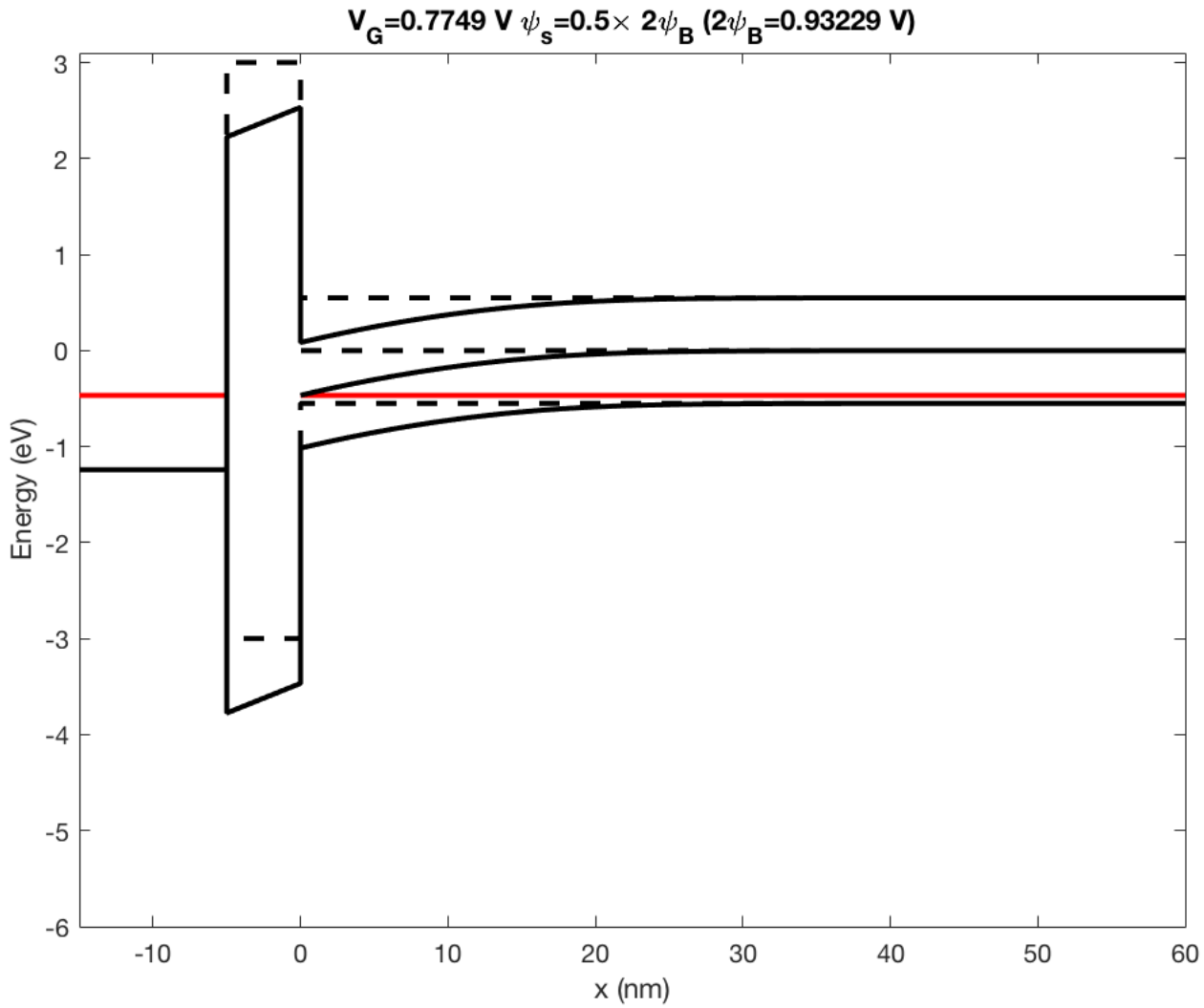

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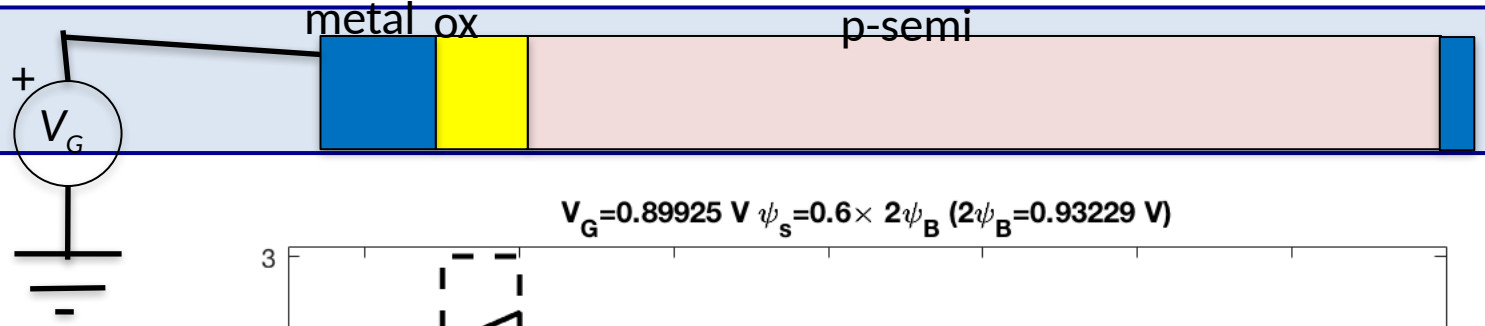

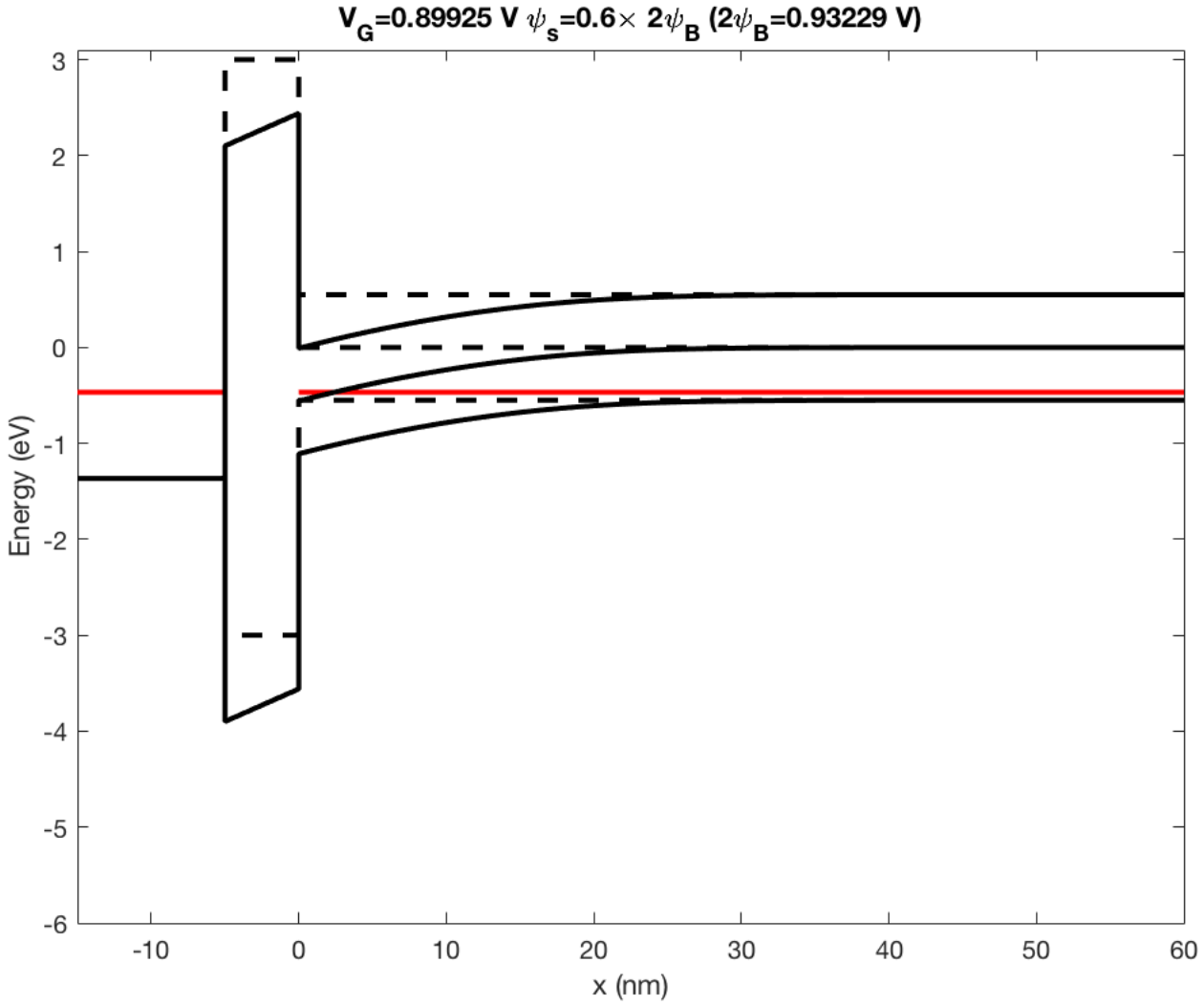

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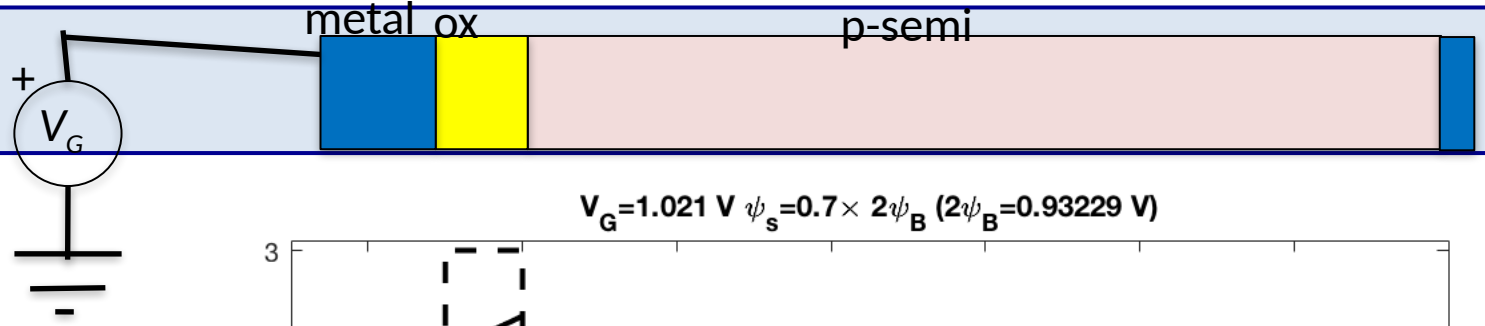

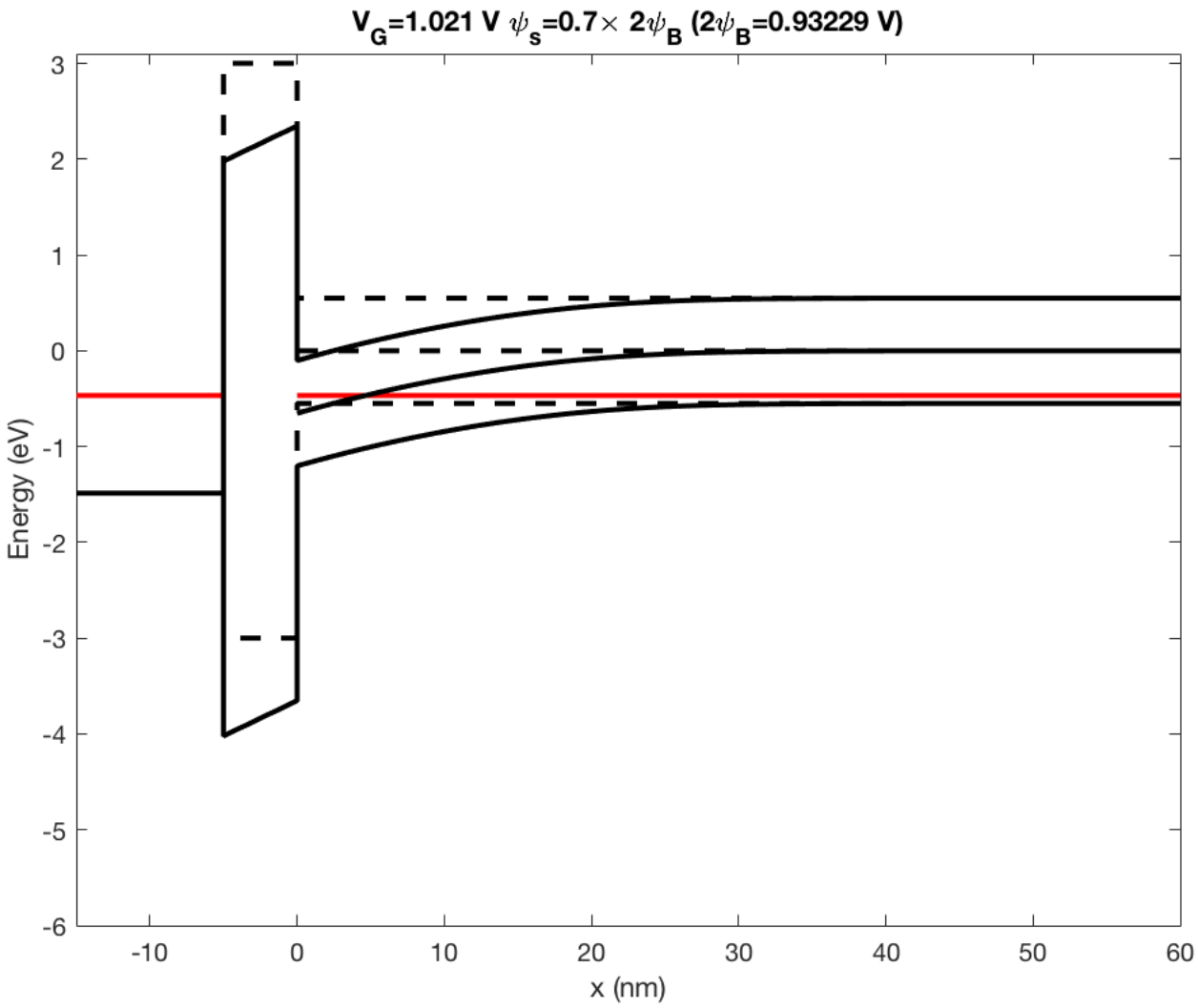

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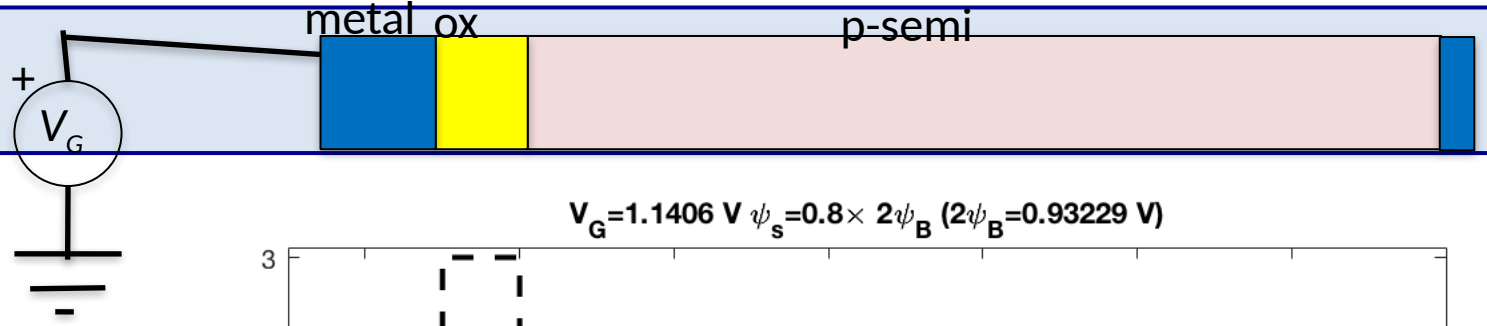

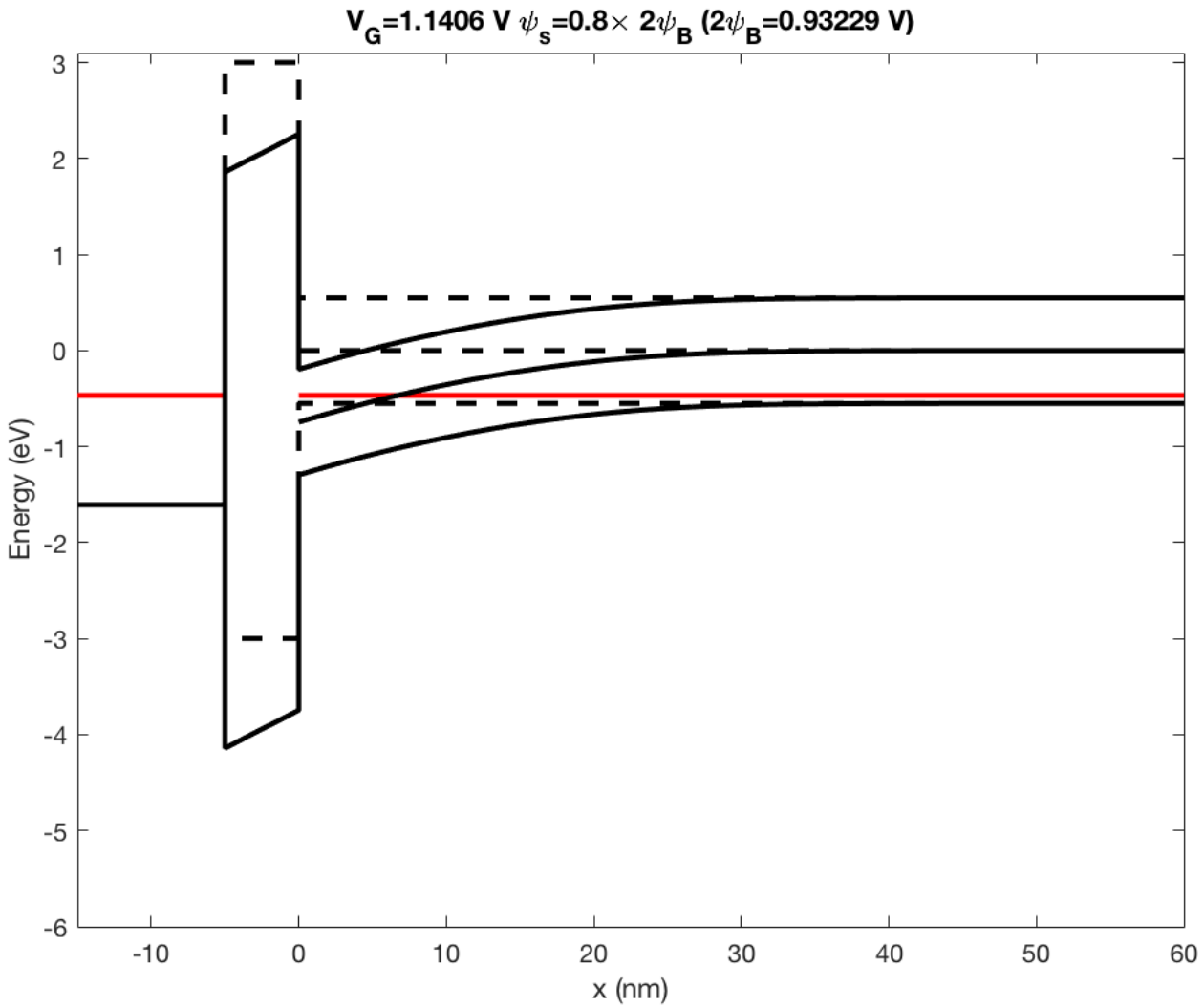

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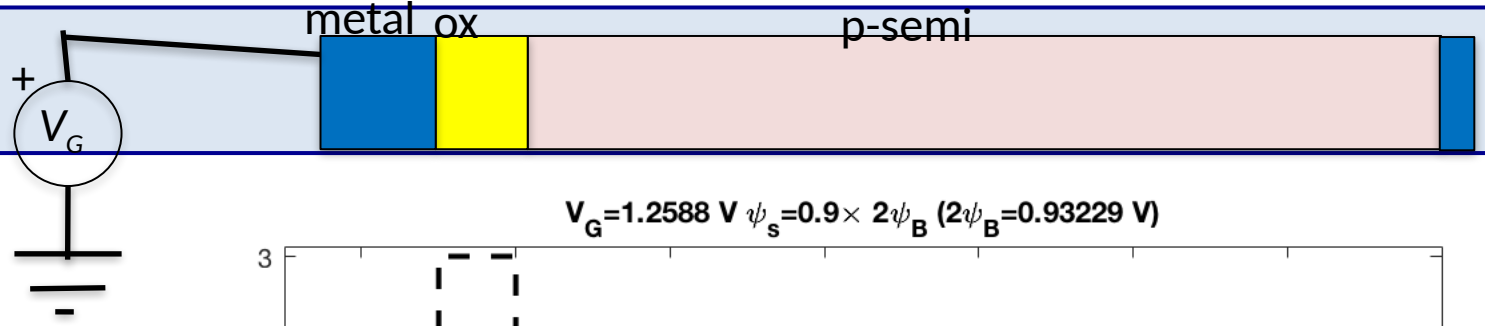

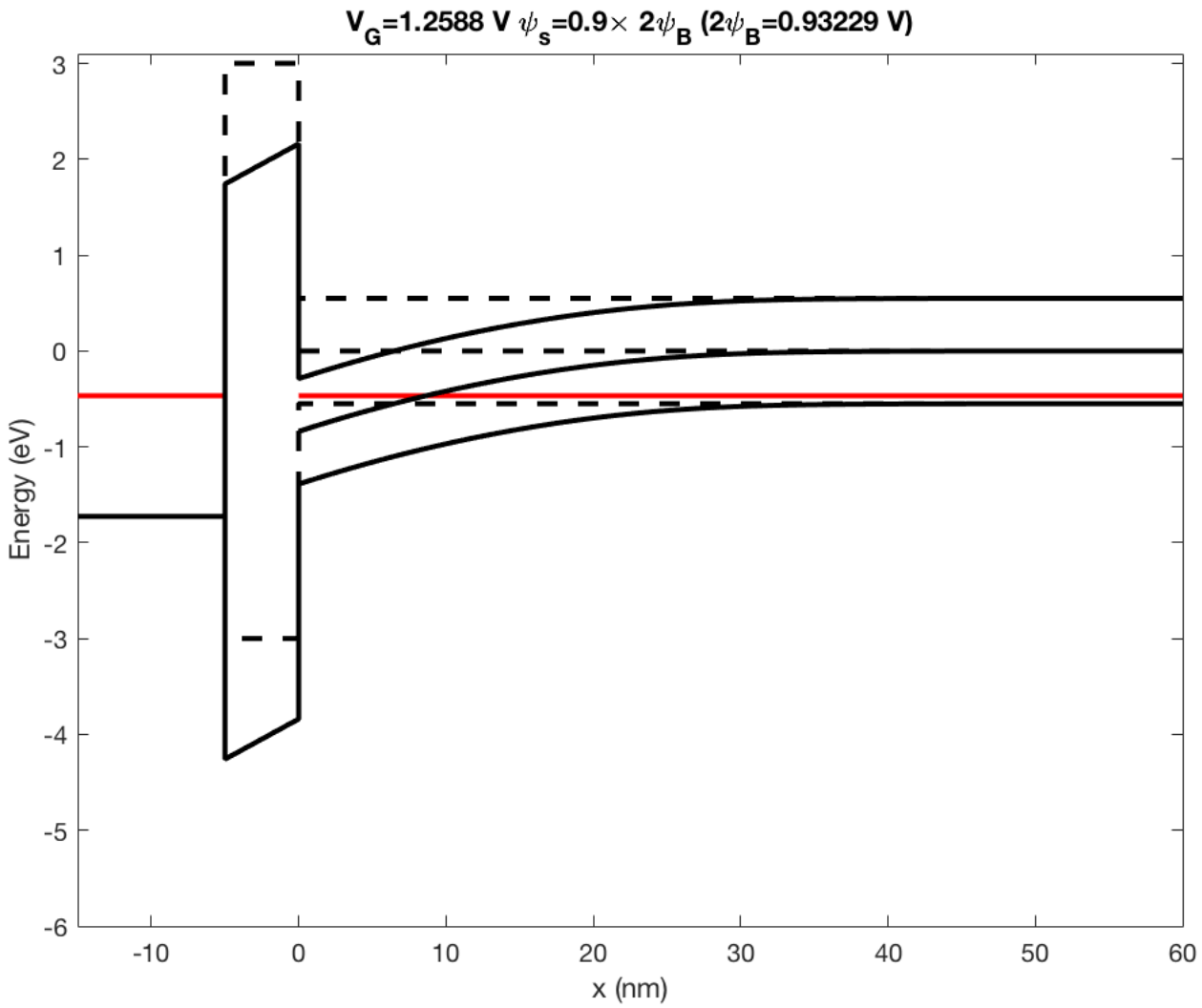

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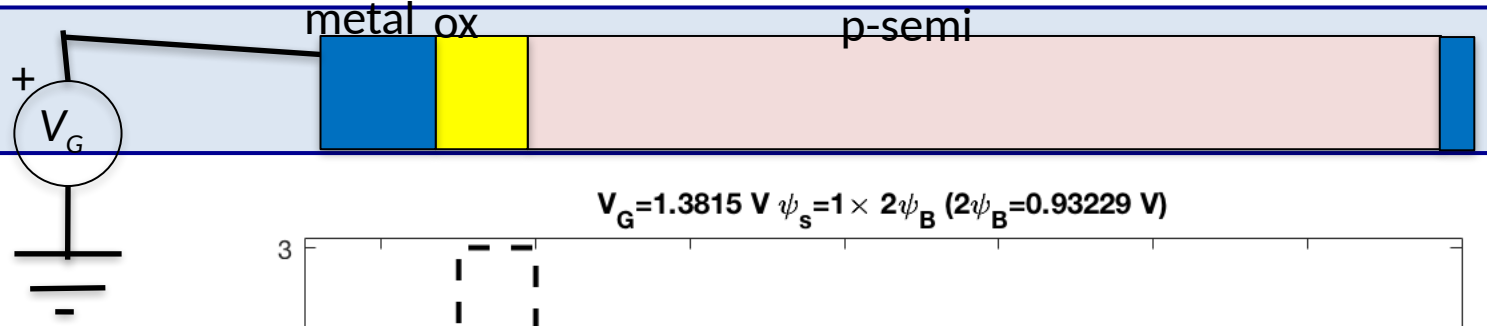

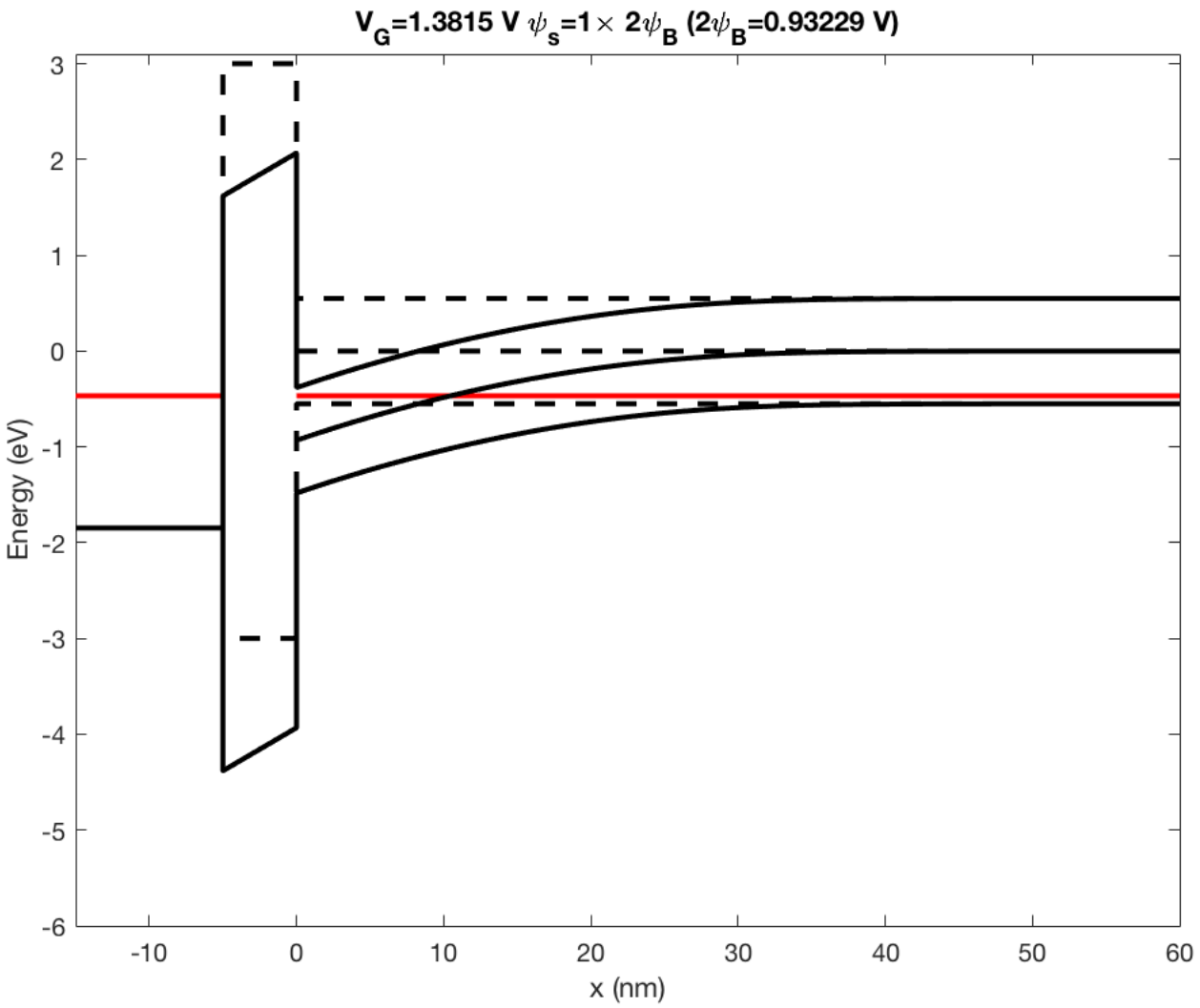

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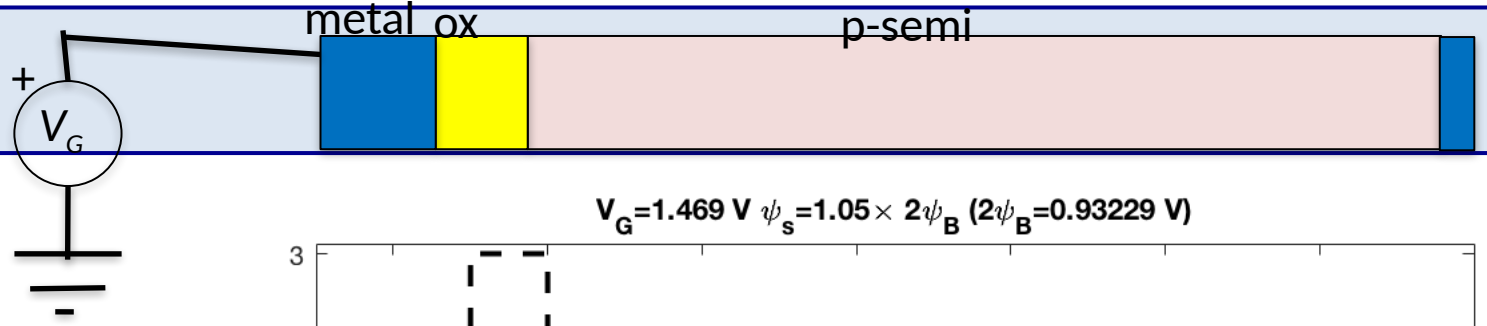

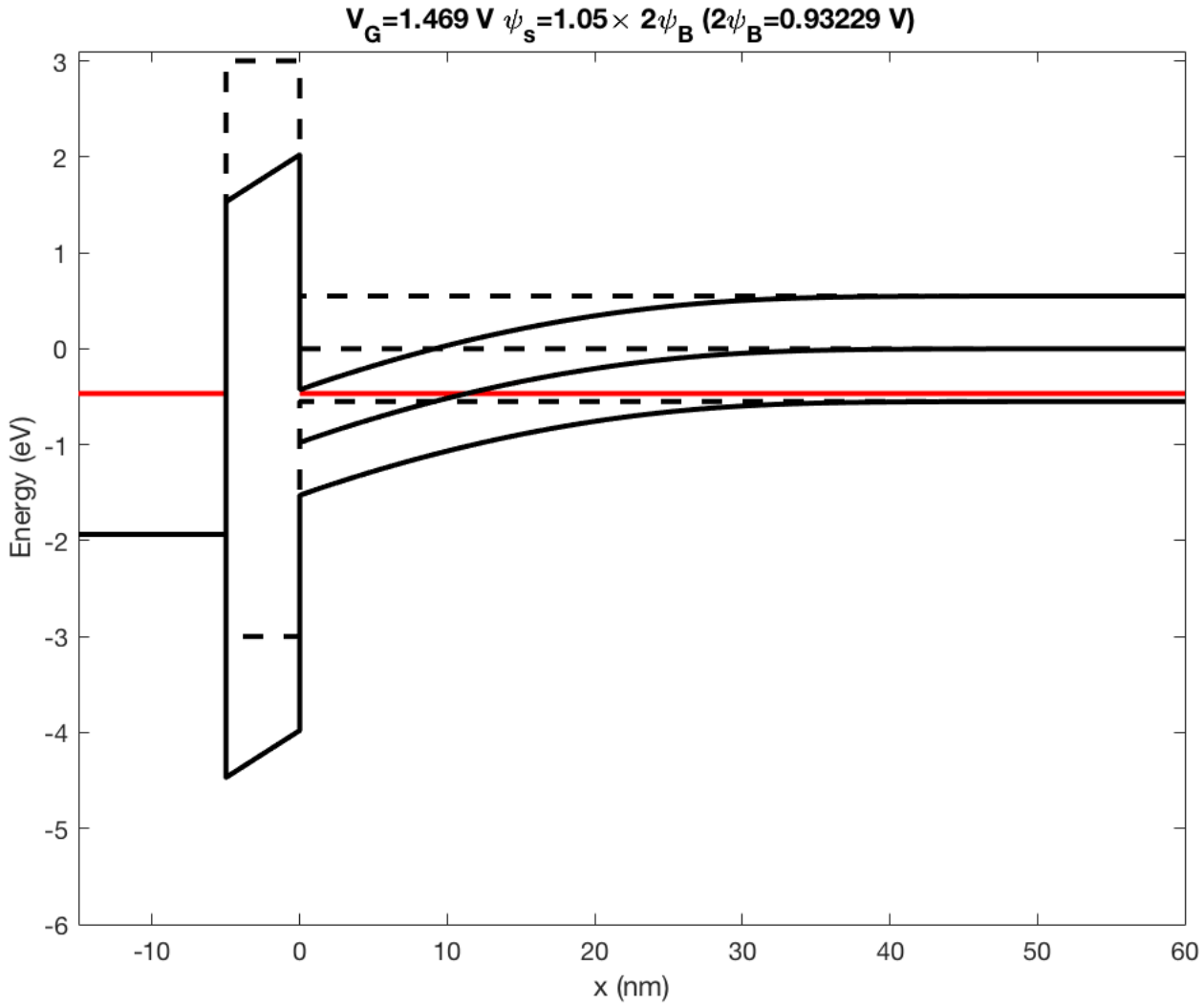

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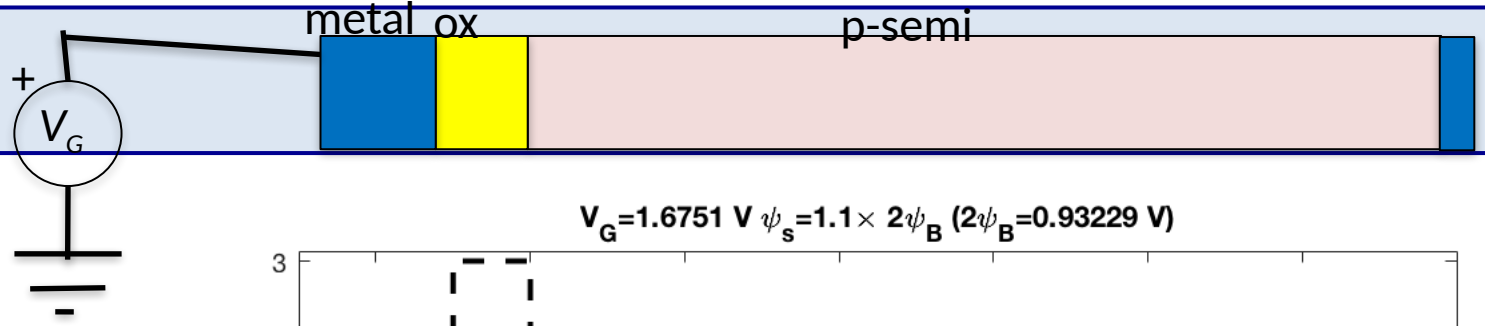

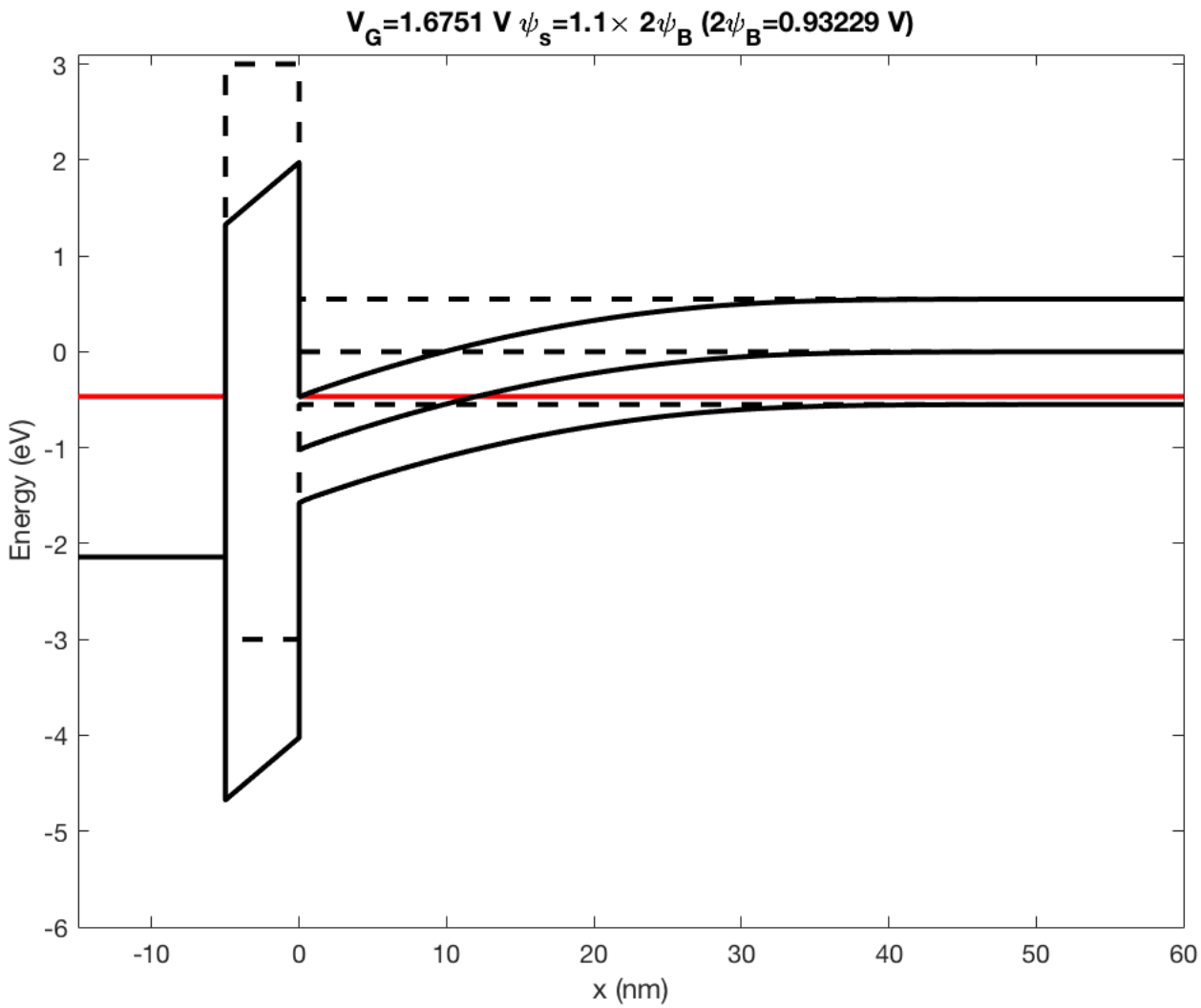

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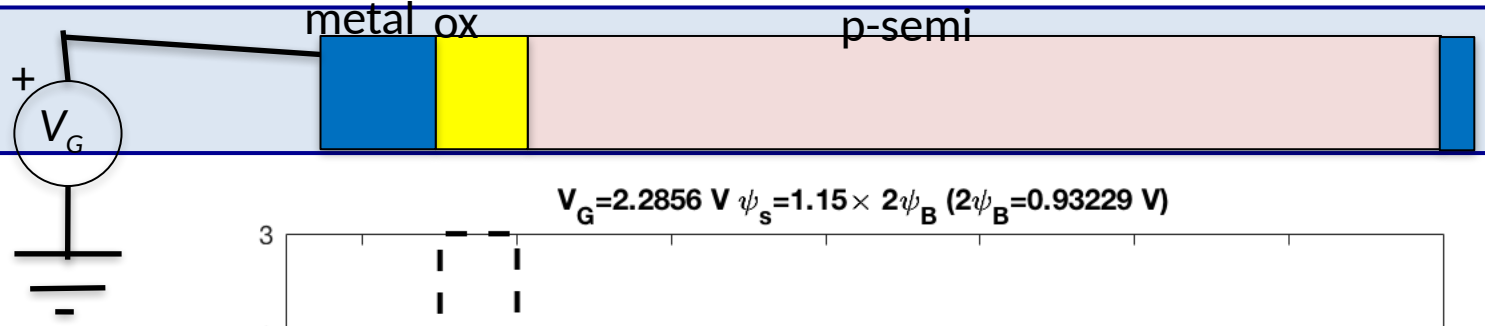

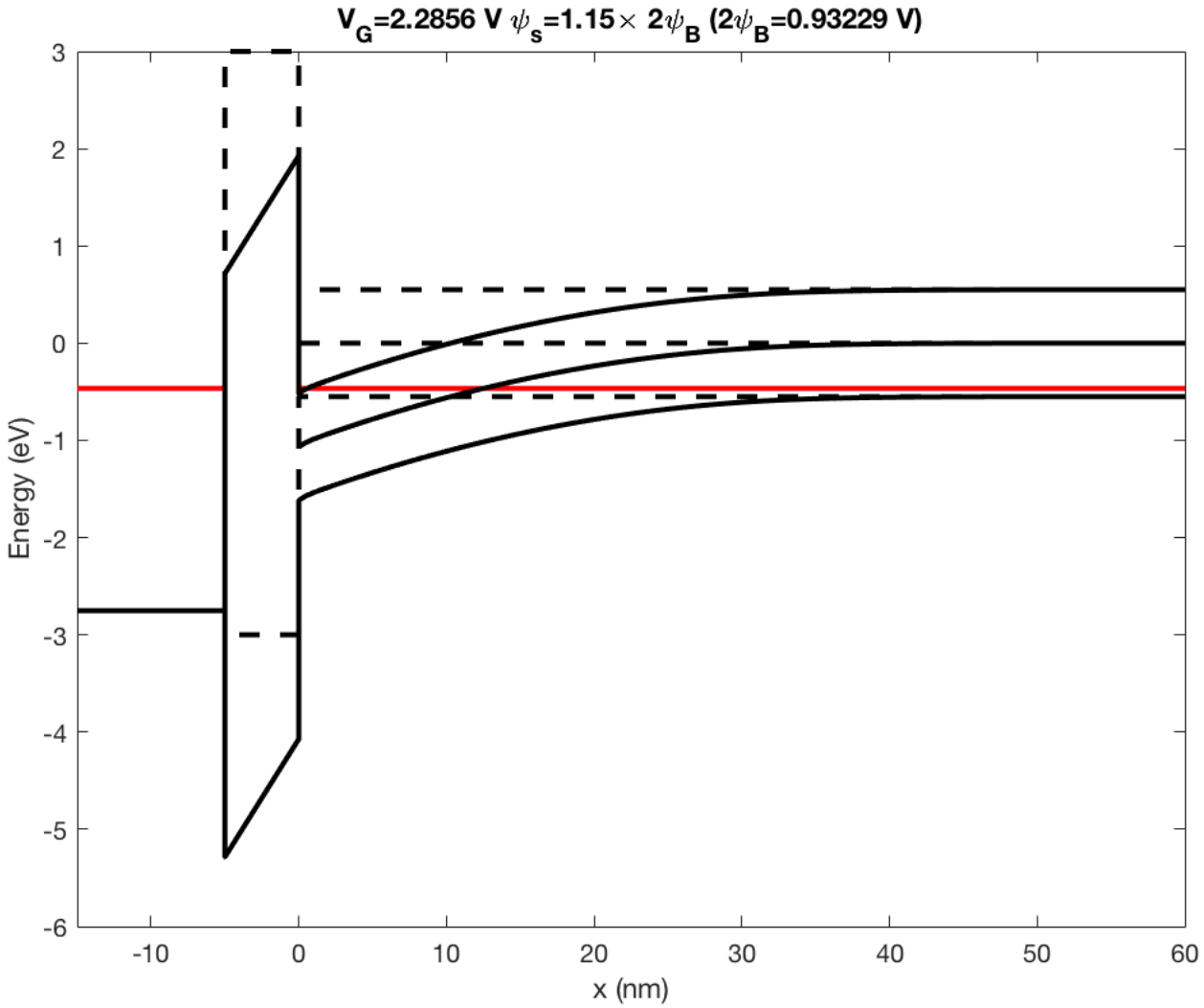

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