FUNDAMENTALS OF NANOELECTRONICS

Basic Concepts

1. The New Perspective
2. Energy Band Model
3. **What & Where is the "Voltage"?**
4. Heat & Electricity: Second Law & Information

3.1. Introduction

3.2. A New Boundary Condition

3.3. Quasi-Fermi Levels (QFL's)

3.4. Current from QFL's

3.5. Landauer Formulas

3.6. What a Probe Measures

3.7. Electrostatic Potential

3.8. Boltzmann Equation

3.9. Spin voltages

3.10. Summing up ..

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Spring 2015

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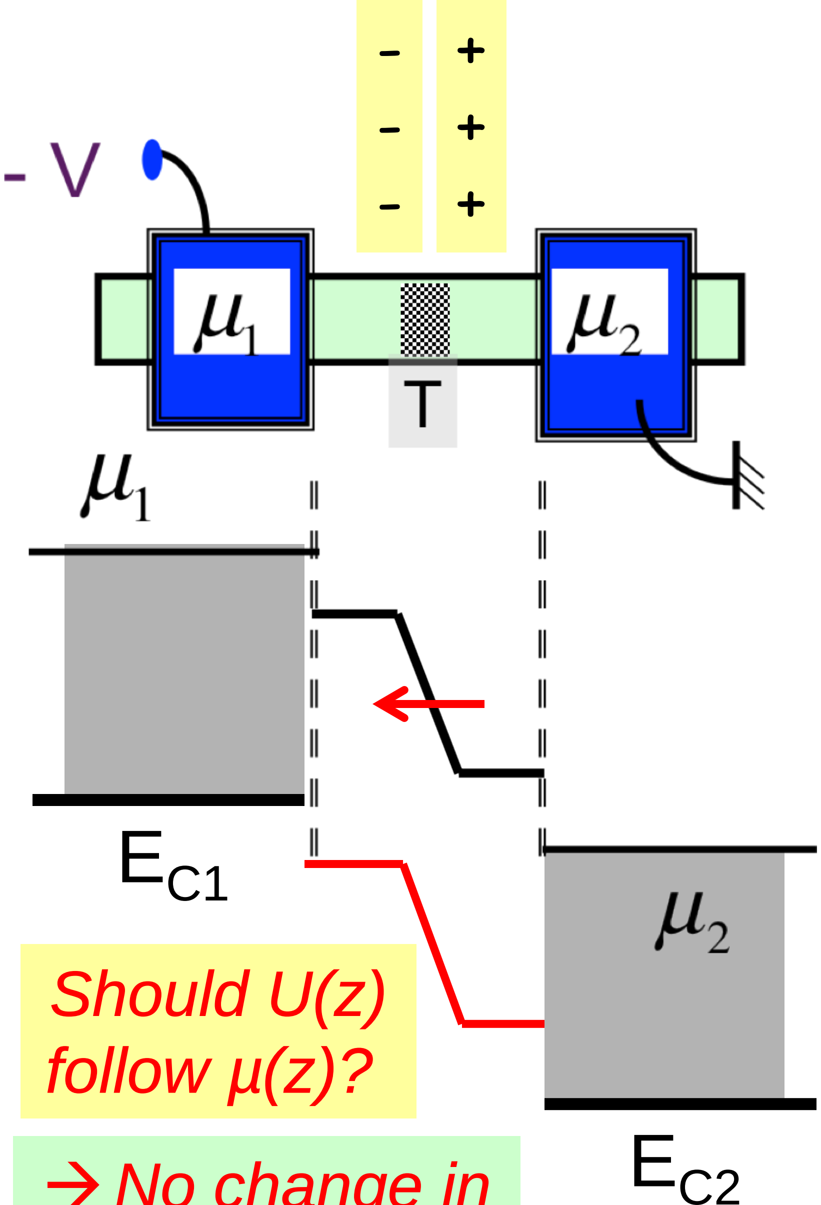
3.7a Electrostatic Potential



Should U(z) follow μ(z)?

→ No change in electron density

small large

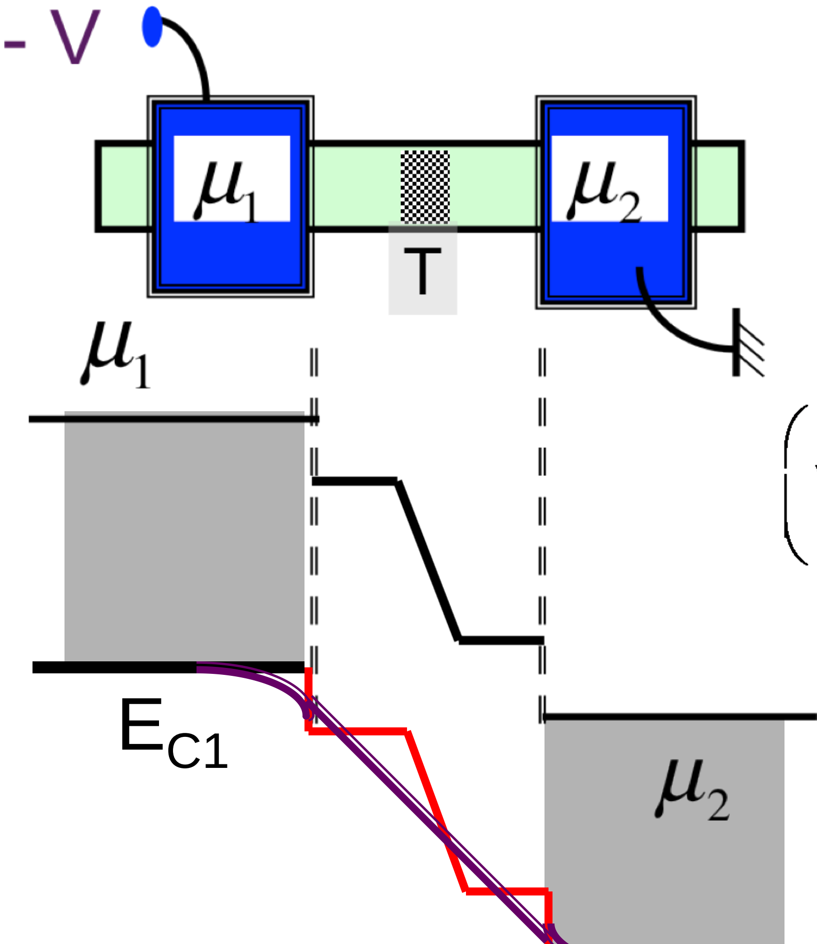
$$\delta n = \delta(\mu - U) \times D_0$$

$$\delta N \approx \delta(\mu - U) \times \int_{-\infty}^{+\infty} dE \left(-\frac{\partial f_0}{\partial E}\right) D(E)$$

$$= \int_{-\infty}^{+\infty} dE\, D(E)\, f(E - \mu + U)$$

$$N = \int_{-\infty}^{+\infty} dE\, D(E - U)\, f(E - \mu)$$

3.7b Electrostatic Potential



$$\delta U \approx \delta\mu \otimes S(z)$$

$$\delta n = \delta(\mu - U) \times D_0$$

$$\nabla^2(\delta U) = -\frac{q^2(\delta n)}{\varepsilon} = -\frac{q^2 D_0}{\varepsilon}(\delta\mu - \delta U)$$

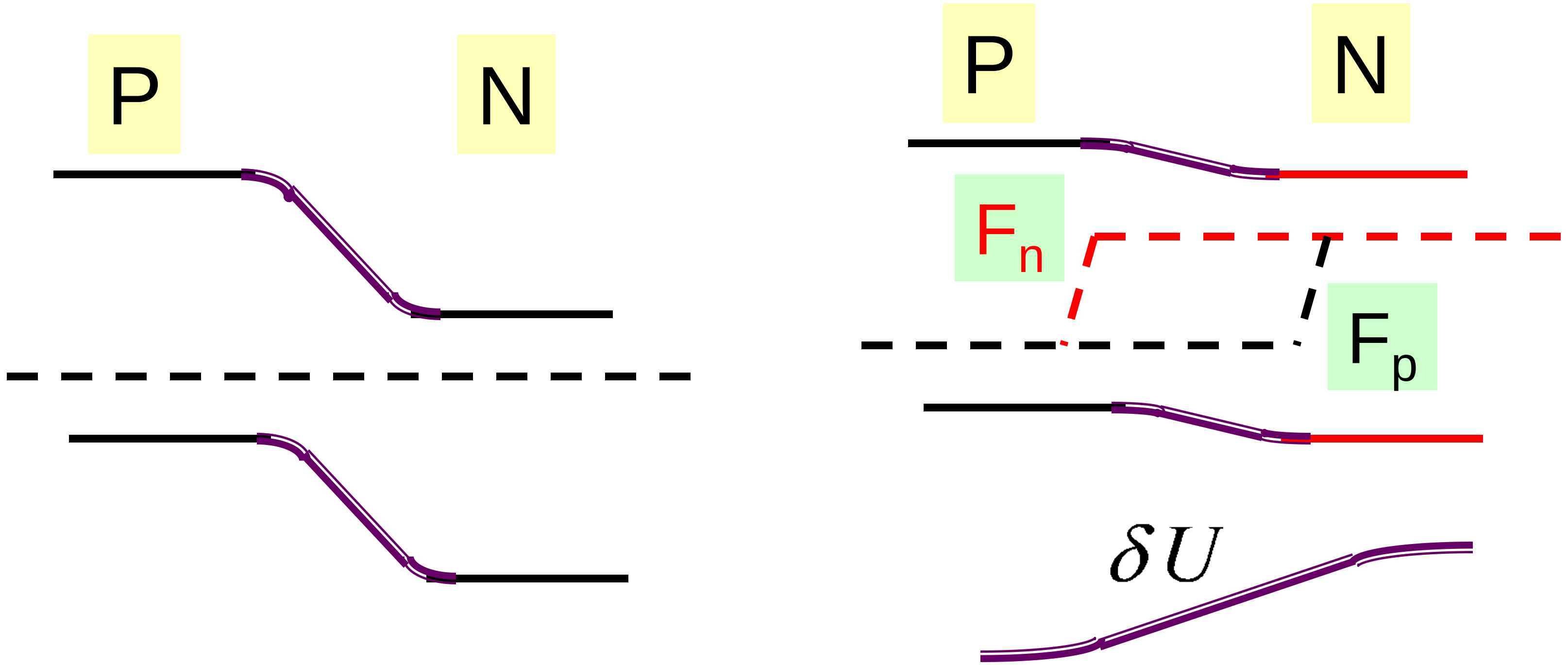
$$\left(\nabla^2 - \frac{1}{\lambda_S^2}\right) S = \delta(\vec{r})$$

Screening Length

$$\left(\nabla^2 - \frac{1}{\lambda_S^2}\right) \delta U = -\frac{\delta\mu}{\lambda_s^2}$$

$$\lambda_S \equiv \sqrt{\frac{\varepsilon}{q^2 D_0}} \rightarrow 0: \quad \delta U \approx \delta\mu$$

3.7c Electrostatic Potential

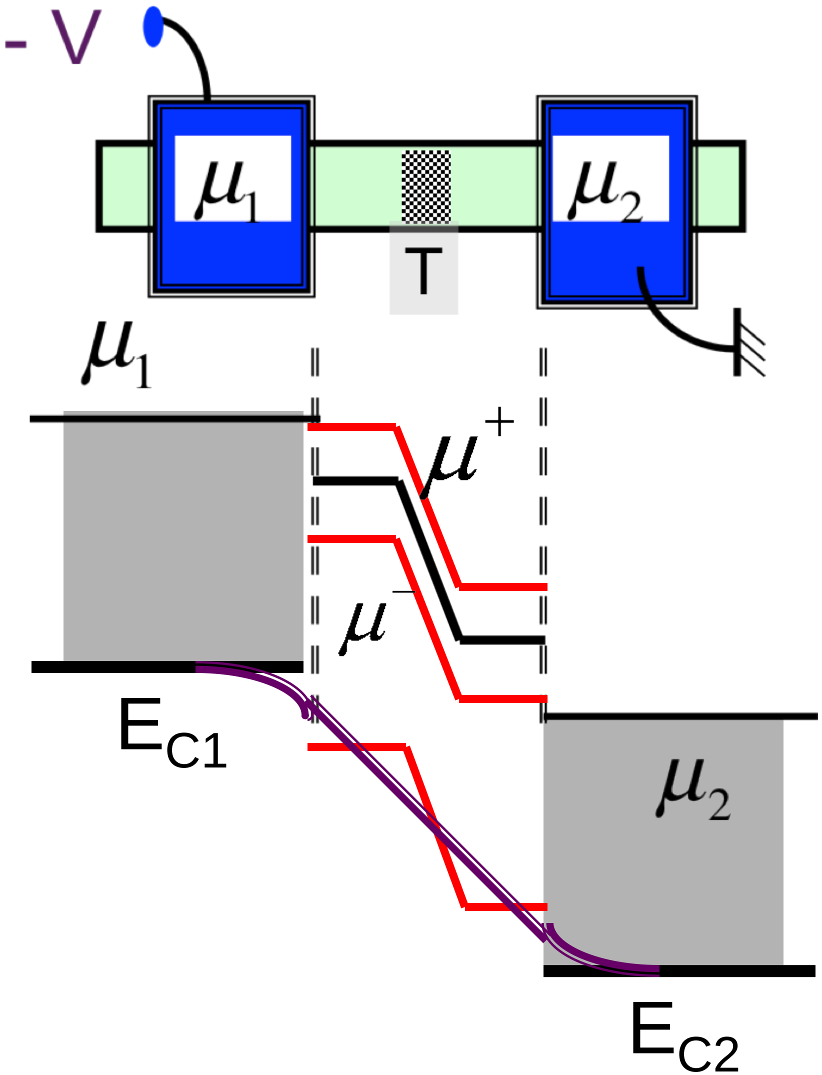


$$\delta U \approx \quad \delta\mu \otimes S(z)$$

Electrostatic Potential Is Smeared by the Screening Length

$$\lambda_S \equiv \sqrt{\frac{\varepsilon}{q^2 D_0}} \quad , \quad \left(\nabla^2 - \frac{1}{\lambda_S^2}\right)\delta U = \; -\frac{\delta\mu}{\lambda_s^2}$$

3.7d Electrostatic Potential



$$I = -\frac{\sigma_0 A}{q}\frac{d\mu}{dz}$$

$$\mu(z=0) = \mu_1 - \frac{q I R_B}{2}$$

$$\mu(z=L) = \mu_2 + \frac{q I R_B}{2}$$

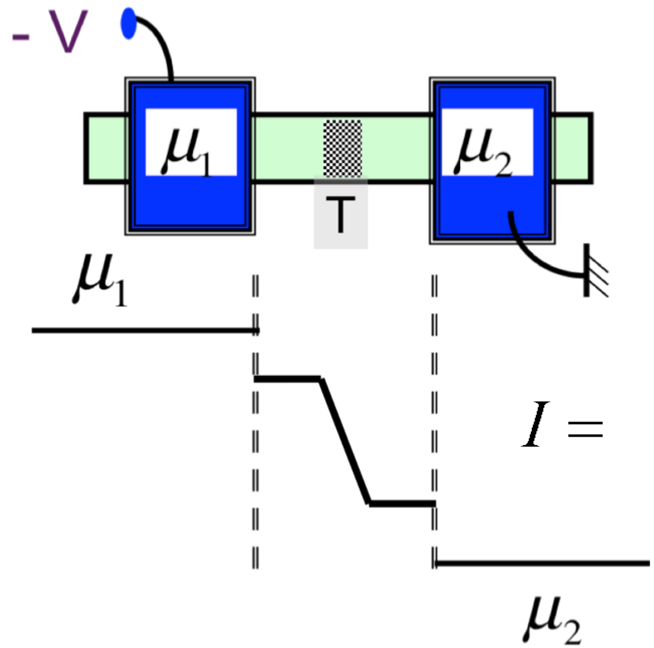
Quasi-Fermi Levels (QFL's)

$$\mu^+(z=0) = \mu_1$$

$$\mu^-(z=L) = \mu_2$$

Electrostatic Potential Is Smeared by the Screening Length

Coming up next ..



$$I = -\frac{\sigma_0 A}{q}\frac{d\mu}{dz}$$

$$\mu(z=0) = \mu_1 - \frac{q I R_B}{2}$$

$$\mu(z=L) = \mu_2 + \frac{q I R_B}{2}$$

$$\boxed{v_z \frac{\partial f}{\partial z} + F_z \frac{\partial f}{\partial p_z} = -\frac{f-\bar{f}}{\tau}}$$

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