Fundamentals of Nanoelectronics

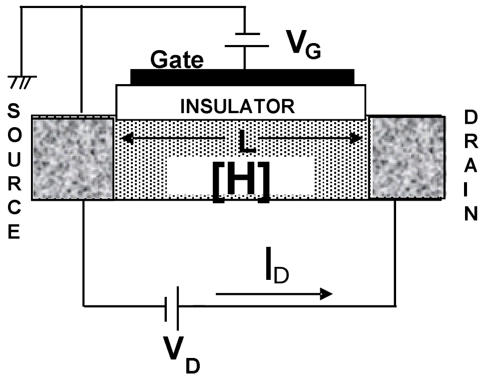
ECE495 - Session 42, Dec 11, 2009

Thermoelectricity II

Professor Supriyo Datta

Class notes taken by: Mehdi Salmani

$$I = 2\frac{q}{h}\int dE\ \underbrace{\bar{T}(E)}_{M(E)\frac{\lambda}{L+\lambda}}\ \underbrace{(f_1 - f_2)}_{\left(-\frac{\partial f}{\partial E}\right)\left(qV+\frac{(E-\mu)}{T}\Delta T\right)} = G_{11}V + G_{12}\Delta T$$



100 µm

10 µm

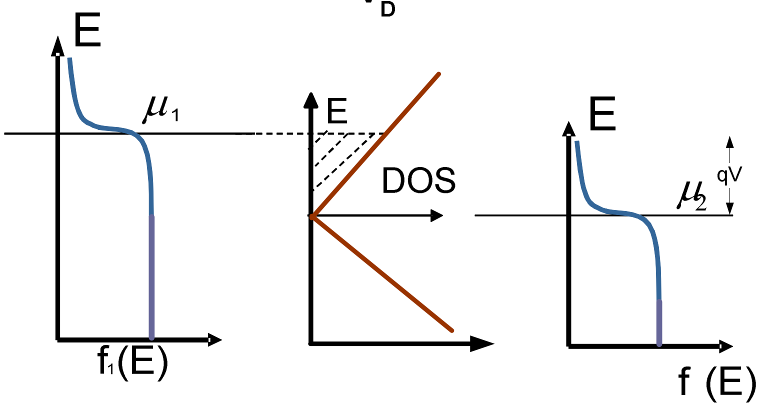
1 µm

0.1 µm

←

10 nm

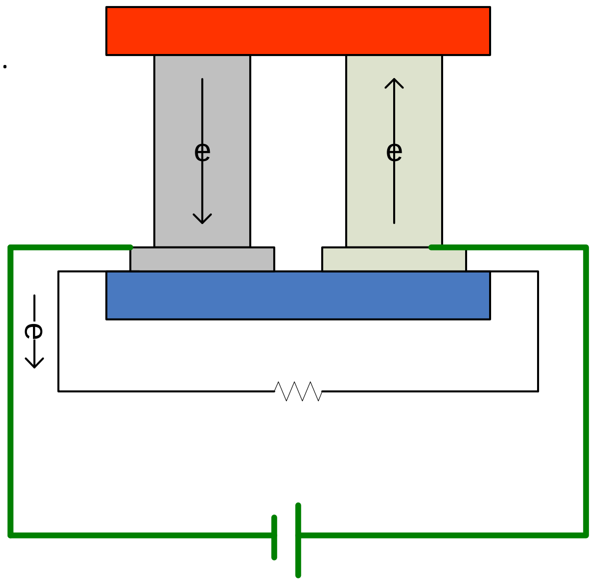
1 nm



Heat current:

$$I_{Q_1} = \frac{2}{h}\int dE\ \bar{T}(E)(E-\mu_1)(f_1 - f_2) = G_{21}V + G_{22}\Delta T$$

It carries $(E-\mu)$ energy before it was carry q charge.

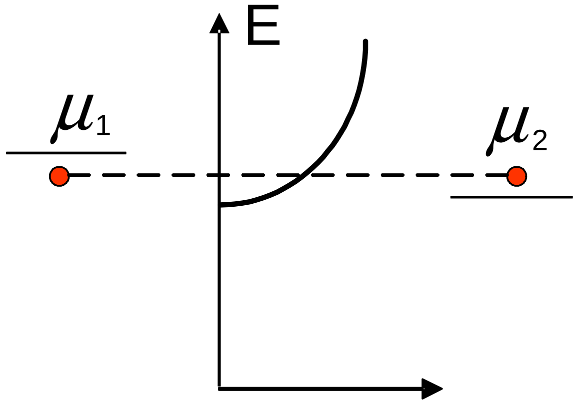


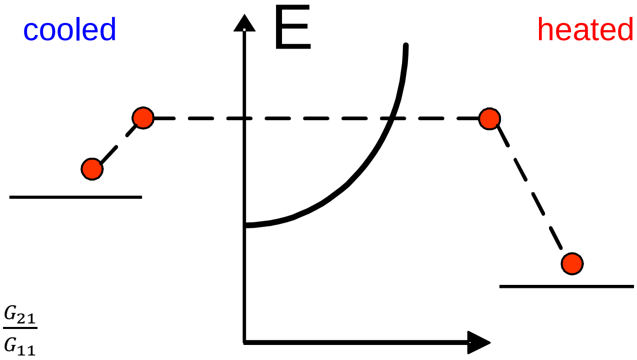
Fundamentals of Nanoelectronics, Session 42
Dec 11, 2009

$G_{11} = \frac{2q^2}{h} \int dE \left(-\frac{\partial f}{\partial E}\right) \bar{T}(E)$

$G_{12} = \frac{2q}{h} \int dE \ \bar{T}(E) \ \frac{(E-\mu)}{T} \left(-\frac{\partial f}{\partial E}\right)$

$G_{21} = \frac{2q}{h} \int dE \ \bar{T}(E) \ (E-\mu) \left(-\frac{\partial f}{\partial E}\right)$





$\Rightarrow TG_{12} = G_{21}$

$\begin{cases} I = G_{11}V + G_{12}\Delta T \\ I_Q = G_{21}V + G_{22}\Delta T \end{cases}$

I = 0 then Seebeck coefficient: $S = \frac{V}{\Delta T} = \frac{G_{12}}{G_{11}}$

f_1=$f_2$and ΔT=0 then Peltier Coefficient: $\Pi = \frac{I_Q}{I} = \frac{G_{21}}{G_{11}}$

$\Rightarrow \Pi = TS \ \ Kelvin\ relation$

$I = 2\frac{q}{h} \int dE \, \bar{T}(E) \ (f_1 - f_2)$

$\bar{T}(E) = \ M(E)\frac{\lambda}{L+\lambda}$ Semi-classical view

$\bar{T}(E) = Trace[\Gamma_1 G \Gamma_2 G^+]$ Full quantum view