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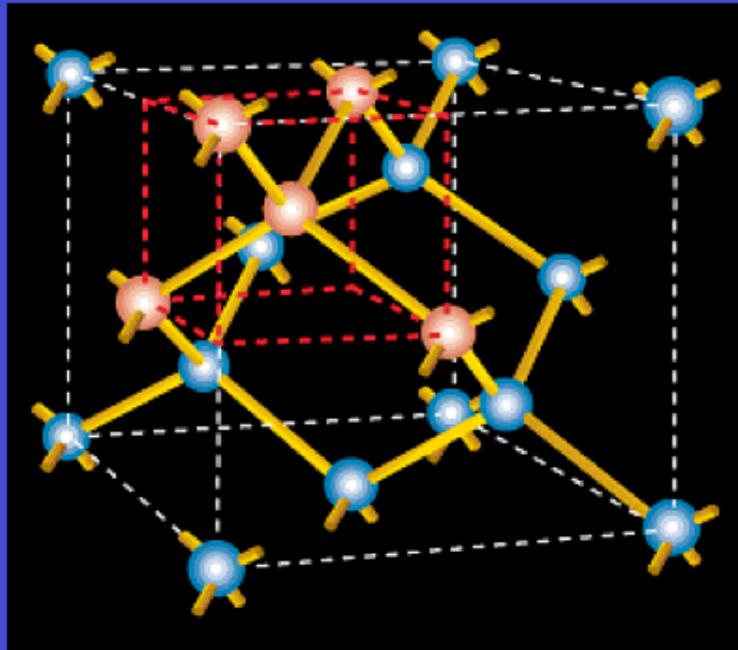
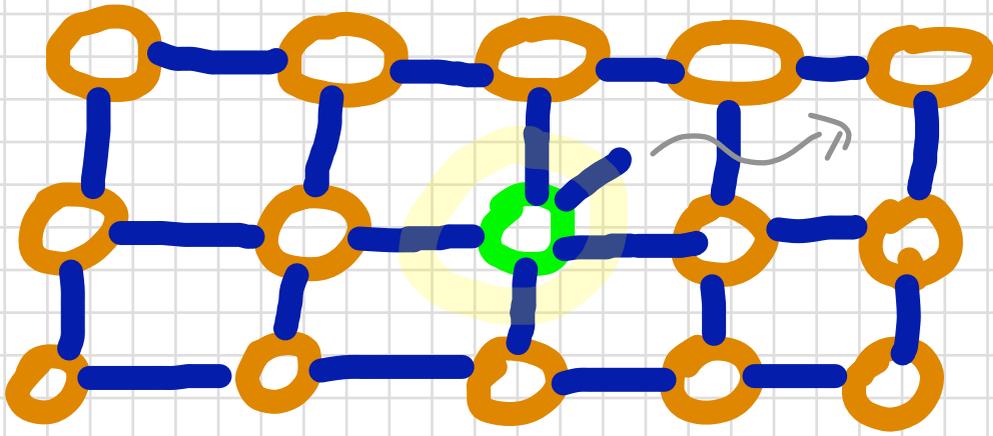
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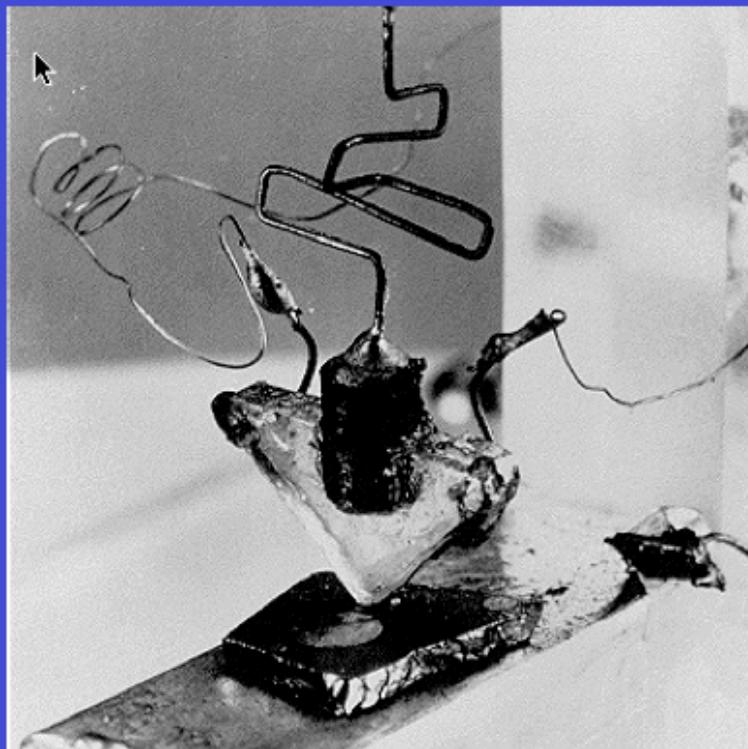
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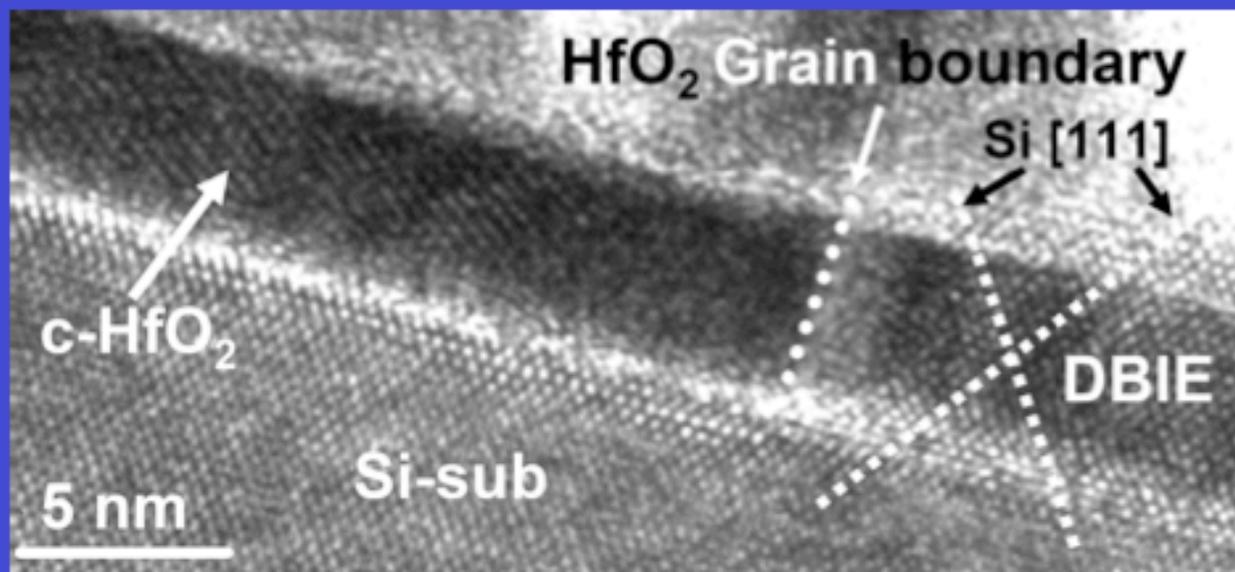
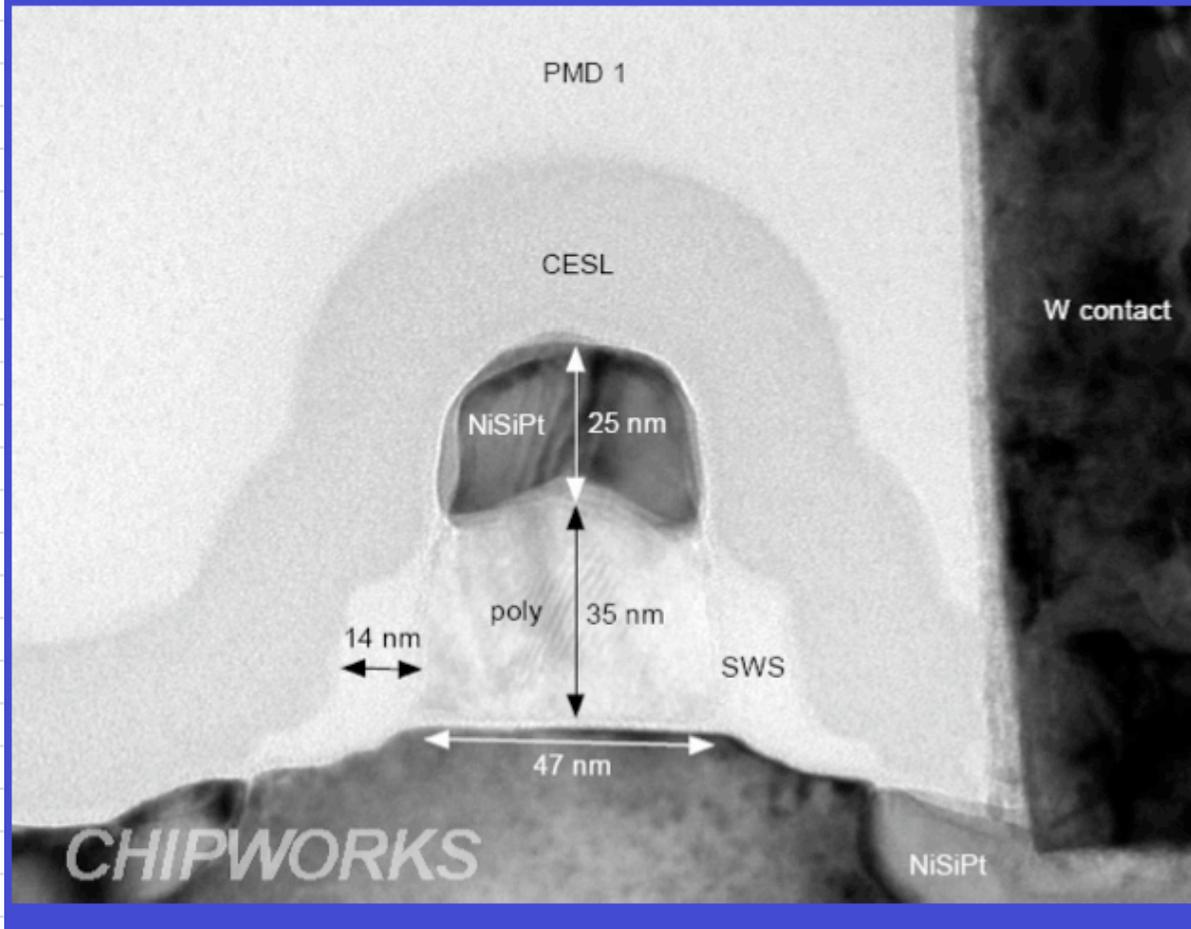
○ As



## Primo Transistor (1947)

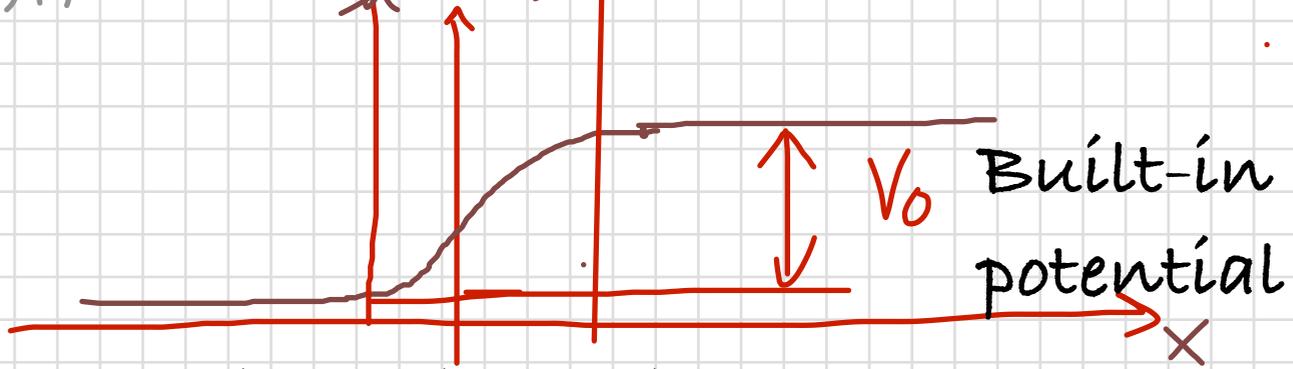
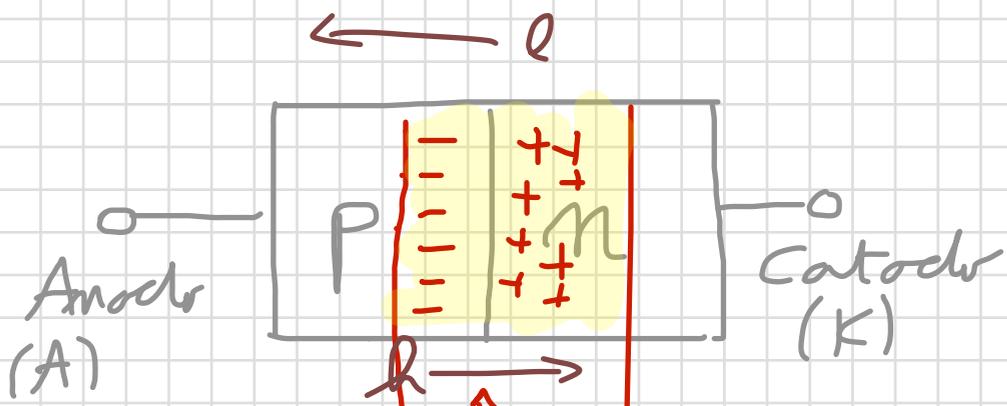


# Into the small

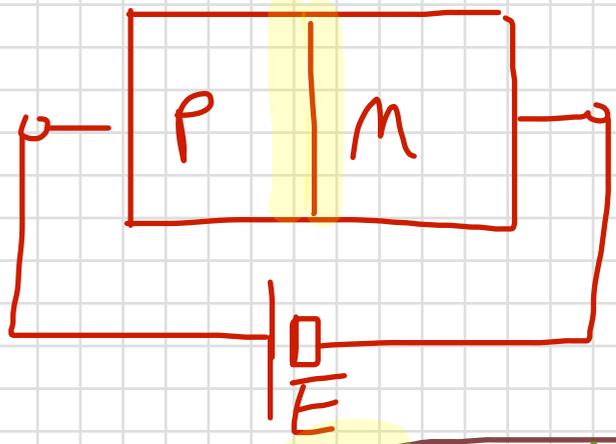


Legge di Moore

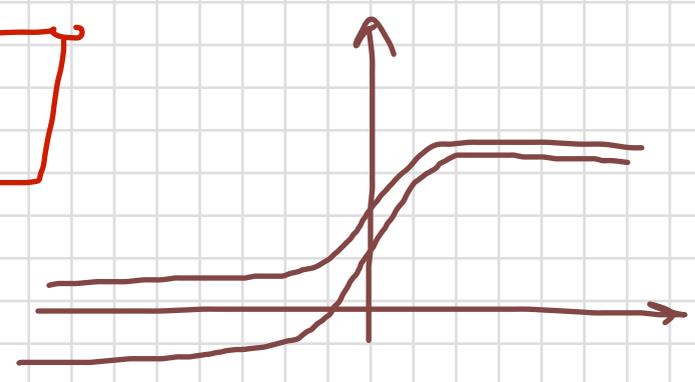
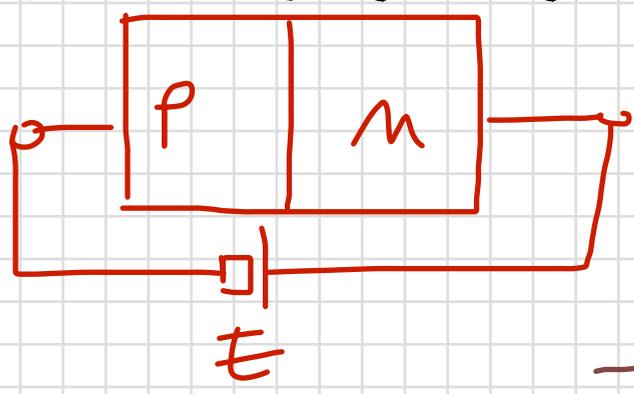
# GIUNZIONE PN



polarizzazione diretta



polarizzazione inversa



# Equazione di Shockley

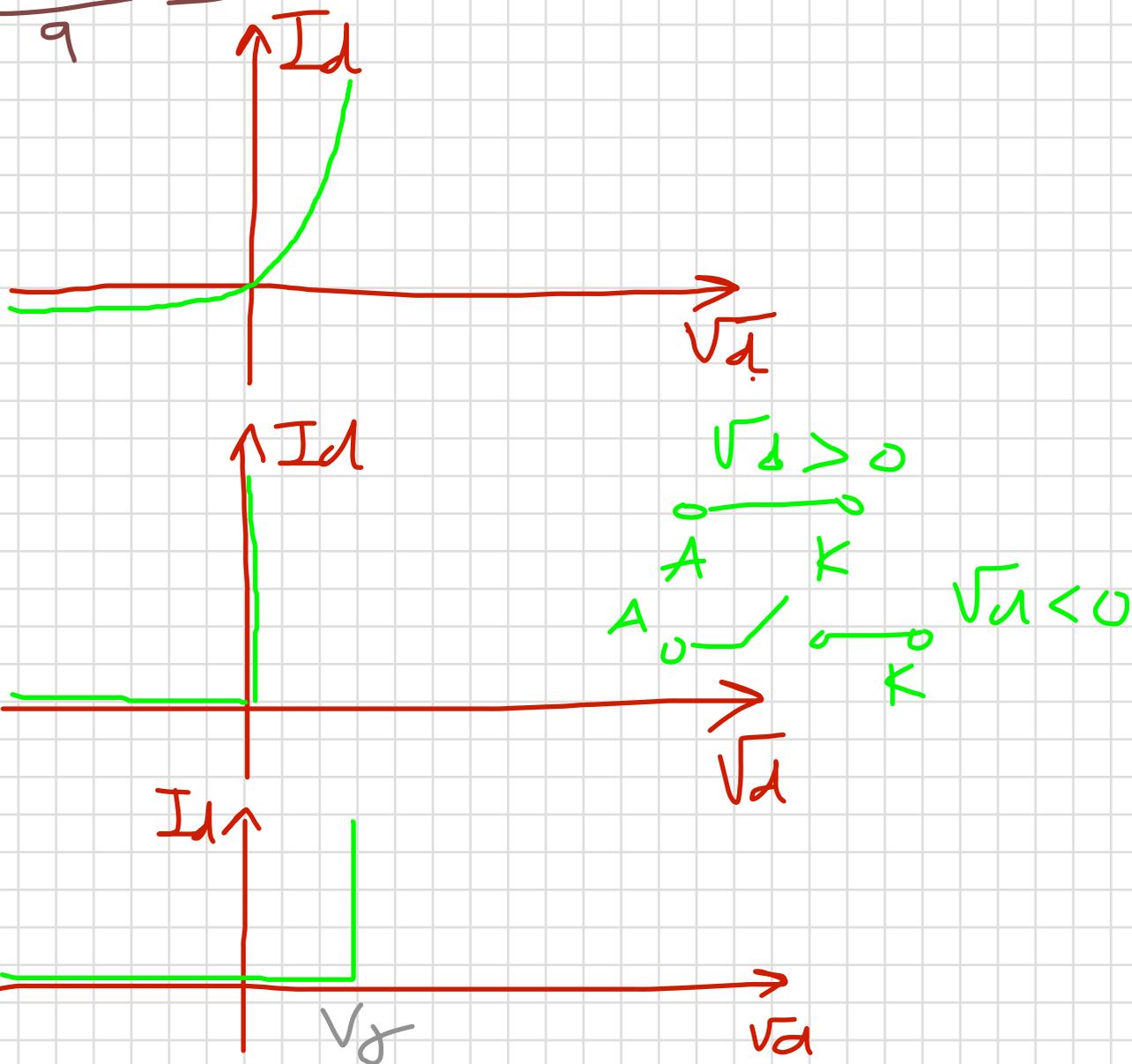
$$i_D = I_S \left( e^{\frac{V_D}{\eta V_T}} - 1 \right)$$

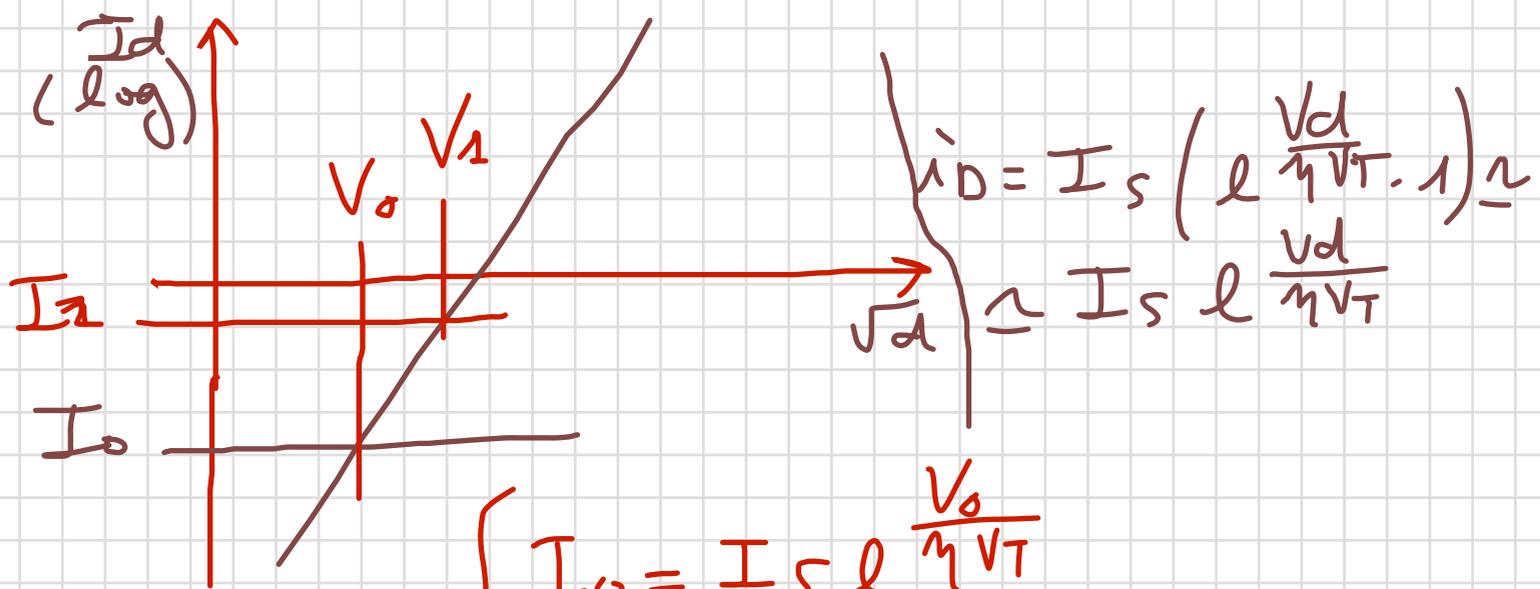
$i_D$  e  $V_D$  : corrente e tensione nel diodo

$\eta$  : fattore di idealità (1-2)

$I_S$  : corrente inversa di saturazione

$$V_T = \frac{kT}{q} = 26 \text{ mV}$$





$$\begin{cases} I_0 = I_S \exp\left(\frac{V_0}{\eta V_T}\right) \\ I_1 = I_S \exp\left(\frac{V_1}{\eta V_T}\right) \end{cases}$$

$$\frac{I_0}{I_1} = \frac{I_S \exp\left(\frac{V_0}{\eta V_T}\right)}{I_S \exp\left(\frac{V_1}{\eta V_T}\right)} = \exp\left(\frac{V_0 - V_1}{\eta V_T}\right)$$

$$\ln\left(\frac{I_0}{I_1}\right) = \ln\left[\exp\left(\frac{V_0 - V_1}{\eta V_T}\right)\right] = \frac{V_0 - V_1}{\eta V_T} = \frac{\Delta V}{\eta V_T}$$

$$\eta = \frac{\Delta V}{\ln\left(\frac{I_0}{I_1}\right) V_T}$$

$$I_S = I_0 \exp\left(-\frac{V_0}{\eta V_T}\right)$$

$$\frac{dI_S(T)}{dT} \approx I_S(T) \cdot \frac{0,072}{K}$$

$$I_S(T) = I_S(T_0) \exp^{+0,072(T - T_0)}$$

$$I_S(T_1) = 2I_S(T_0) = I_S(T_0) \exp^{0,072(T_1 - T_0)}$$

$$2 = \exp^{0,072(T_1 - T_0)} \Rightarrow T_1 = T_0 + \underline{\underline{9,627K}}$$

$$I_D = I_S \left( e^{\frac{V_d}{\eta V_T}} - 1 \right) @ I_0$$

$$\underline{I_0 = I_S \left( e^{\frac{V_d}{\eta V_T}} - 1 \right)} \quad V_T = \frac{k_B T}{q}$$

$$T = 300 \text{ K}; \quad q = 1,602 \cdot 10^{-19} \text{ C}$$

$$k_B = 1,38 \cdot 10^{-23} \frac{\text{J}}{\text{K}} \quad \frac{k_B T}{q} = V_T \approx 26 \text{ mV}$$

$$V_d = \eta V_T \ln \left( \frac{I_0 + I_S}{I_S} \right)$$

$$\frac{\partial V_d}{\partial T} = \frac{V_d}{T} + \eta V_T \frac{I_S}{I_S + I_0} \left( -\frac{I_0}{I_S^2} \right) I_S \cdot 0.072$$

$$I_S \ll I_0$$

$$\frac{\partial V_d}{\partial T} = \frac{V_d}{T} - 0,072 \eta V_T$$

