Physics of Semiconductors (9)

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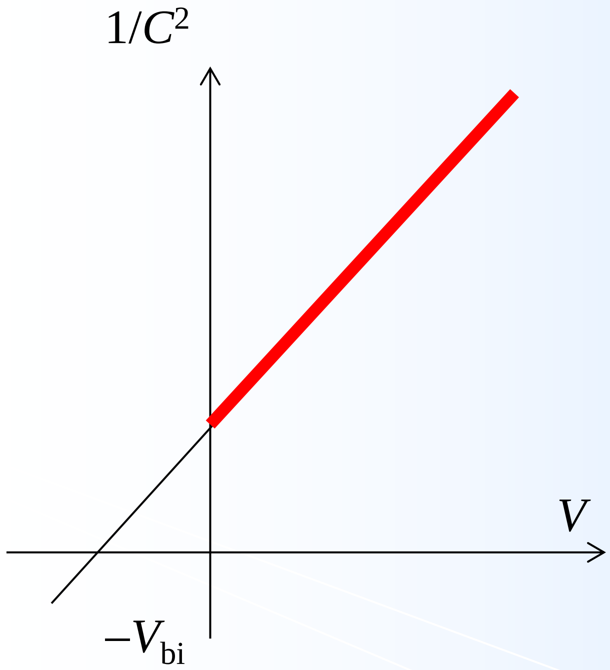
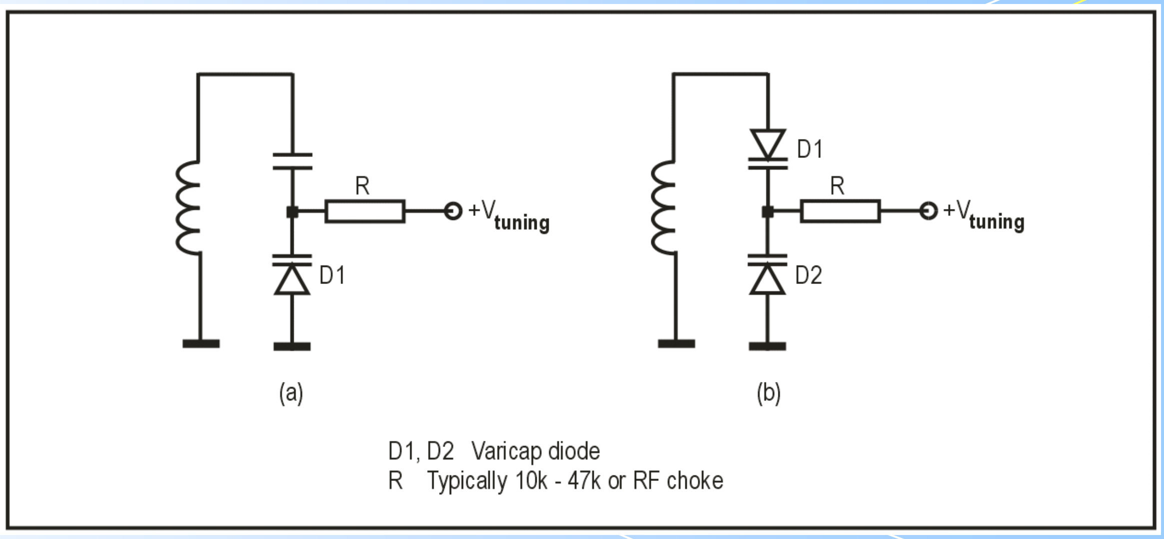
Reverse bias characteristics

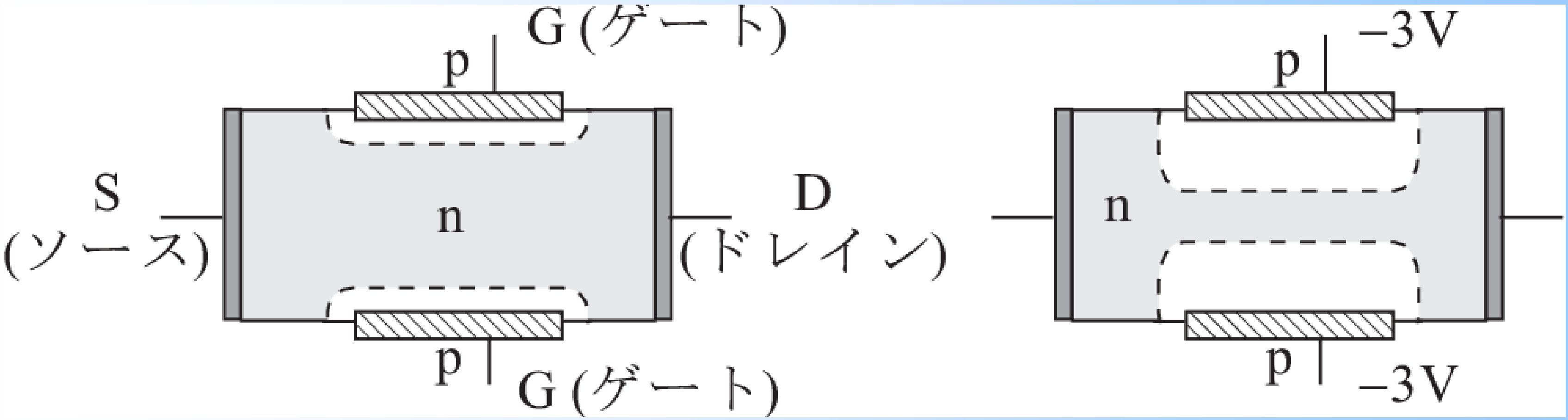


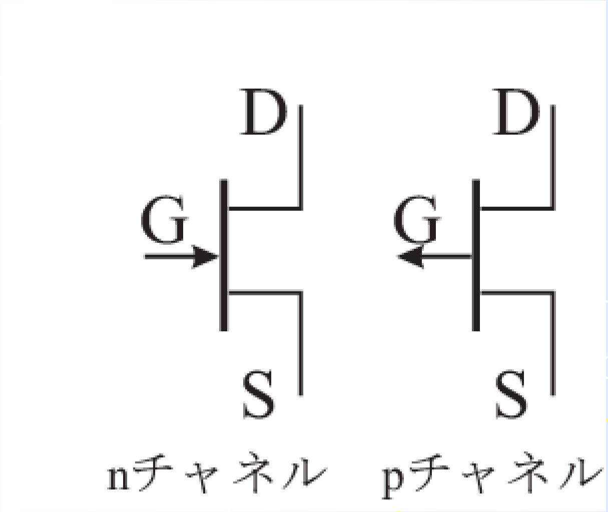
$$w_d \approx \left[\frac{2\epsilon\epsilon_0(V+V_{\rm bi})}{eN_D}\right]^{1/2} \approx w_n.$$

$$\frac{dQ}{dV} = eN_D\sqrt{\frac{2\epsilon\epsilon_0}{eN_D}}\frac{1}{2\sqrt{V+V_{\rm bi}}} = \sqrt{\frac{\epsilon\epsilon_0 eN_D}{2}}(V+V_{\rm bi})^{-1/2}$$

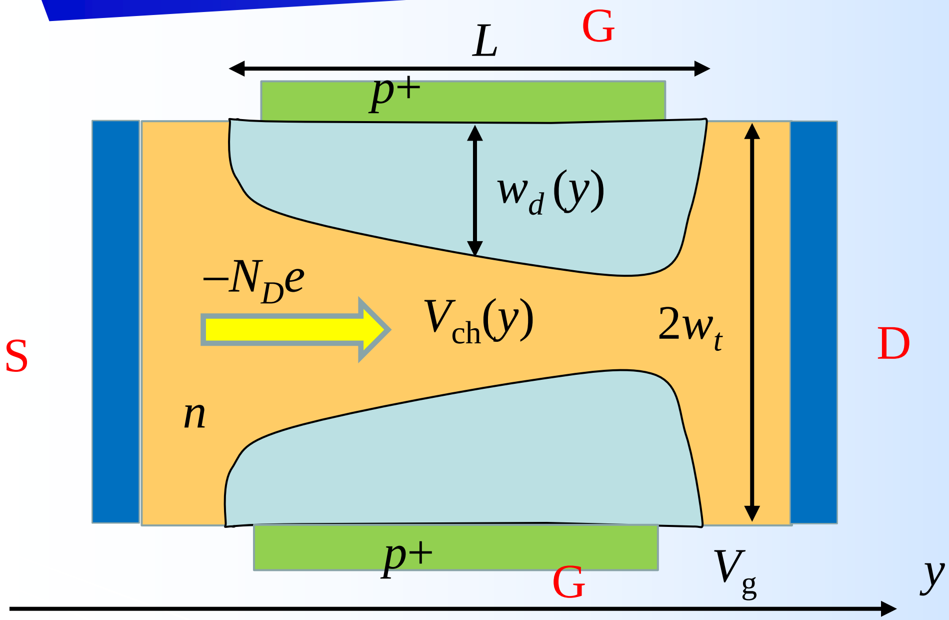


pn junction field effect transistor (JFET)





pn junction FET



$$V(y) = V_g + V_{bi} - V_{ch}(y)$$

$$w_d(y) = \sqrt{\frac{2\epsilon\epsilon_0 V(y)}{eN_D}}$$

$$J_{ch} = eN_D\mu_n \frac{dV_{ch}}{dy} \cdot 2[w_t - w_d(y)]W$$

conductivity

electric field

channel width

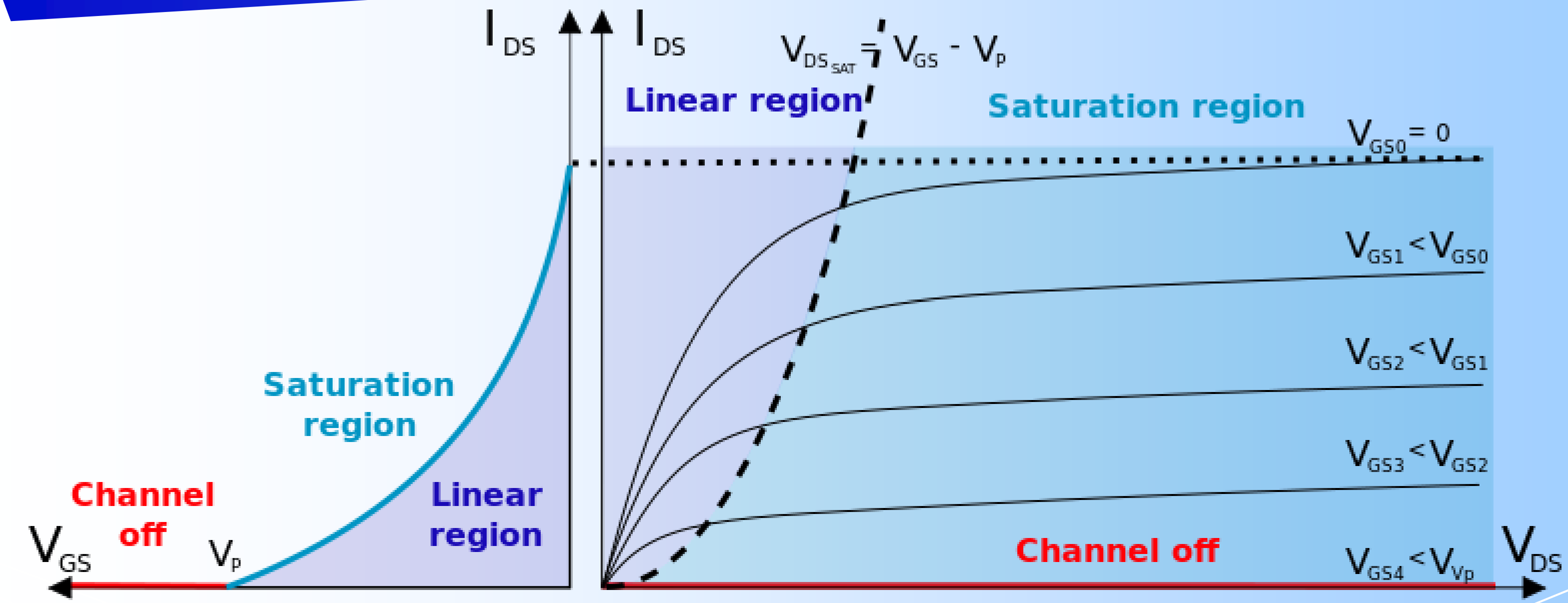
$$J_{ch}L = \int_0^L J_{ch}dy = 2eN_D\mu_n W \int_0^L (w_t - w_d)\frac{dV_{ch}}{dy}dy = 2w_t eN_D\mu_n W \int_{V_0}^{V_L} \left(1 - \frac{w_d}{w_t}\right) dV_{ch}$$

pinch off (internal) voltage $\quad w_d(V_c) = w_t \quad V_c = \dfrac{eN_D w_t^2}{2\epsilon\epsilon_0}$

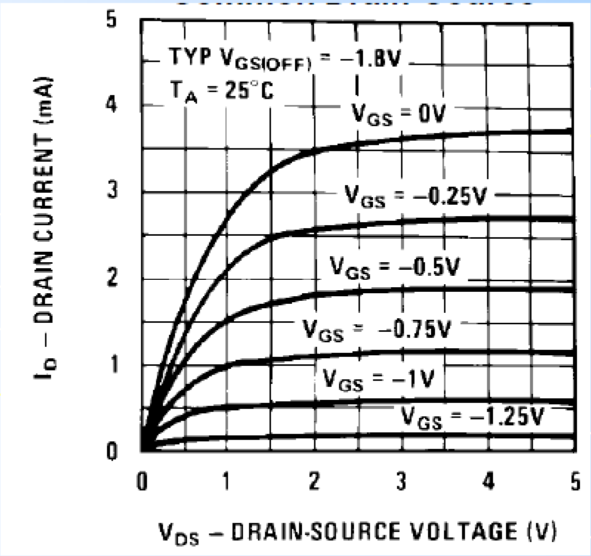
$$J_{ch} = \frac{2N_D e\mu_n W w_t}{L}\left[V_L - V_0 + \frac{2}{3\sqrt{V_c}}\left(V(V_0)^{3/2} - V(V_L)^{3/2}\right)\right]$$

Only valid for $w_d < w_t/2$.

Realistic I-V characteristics of JFET



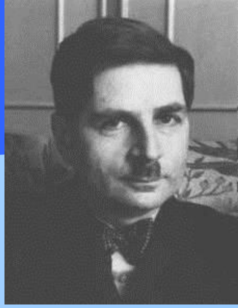
From Wikipedia

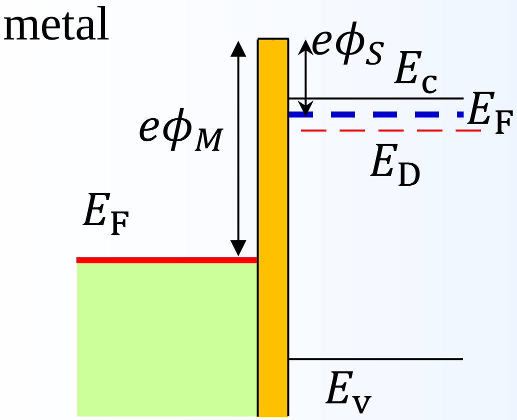


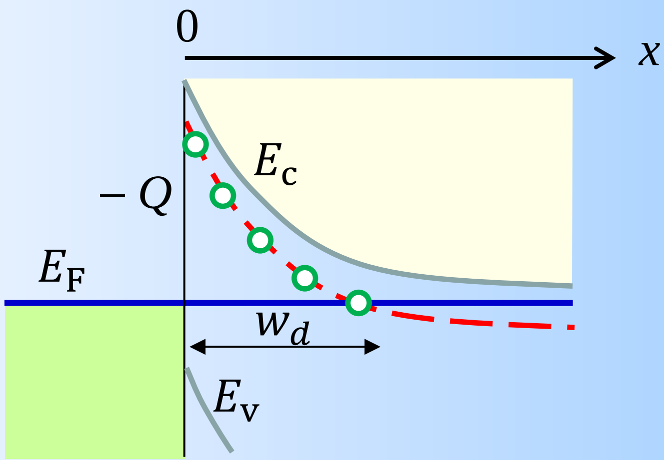
2N5459

$R(V_g)$ is non-linear

Schottky barrier







$$\phi(x_d) = \int_0^{x_d} (eN_D x - Q)/\epsilon\epsilon_0 dx = \frac{1}{\epsilon\epsilon_0}\left(\frac{eN_D}{2}x_d^2 - Qx_d\right)$$

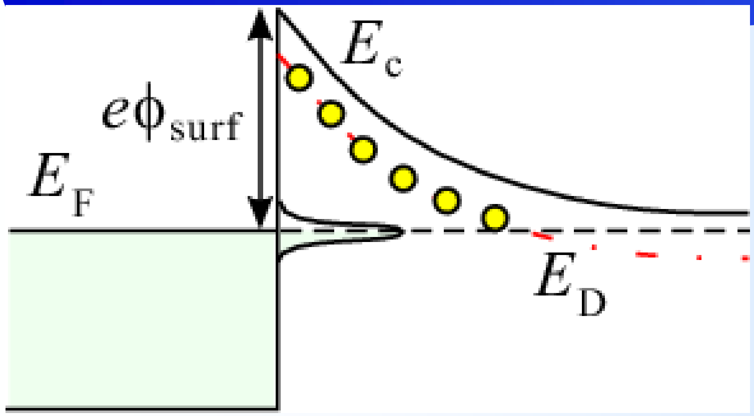
Charge balance: $w_d = Q/eN_D$

$$Q = \sqrt{2\epsilon\epsilon_0 N_D e(\phi_M - \phi_S)}, \quad \therefore w_d = \sqrt{\frac{2\epsilon\epsilon_0(\phi_M - \phi_S)}{eN_D}} \equiv \sqrt{\frac{2\epsilon\epsilon_0 V_s}{eN_D}}$$

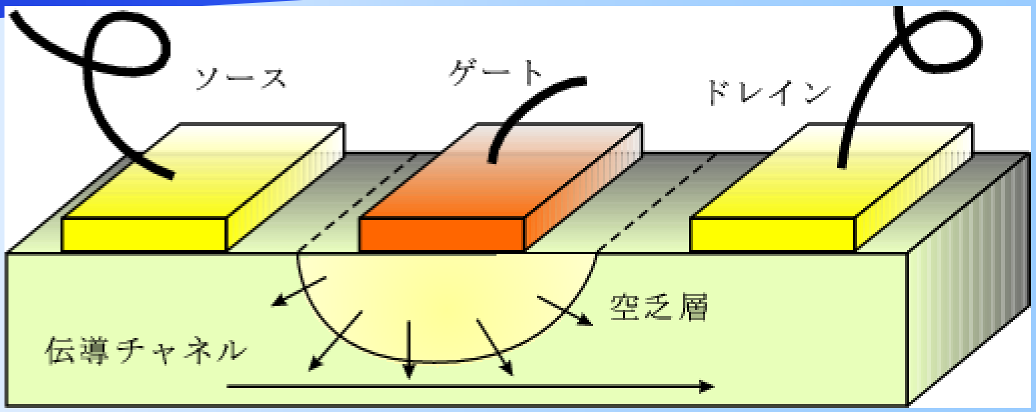
Voltage V --> barrier height $e(V_s - V)$

$$J = AT^2\left[\exp\left(\frac{e(V - V_s)}{k_B T}\right) - \exp\left(\frac{-eV_s}{k_B T}\right)\right] = eAT^2 \exp\left(\frac{-eV_s}{k_B T}\right)\left[\exp\left(\frac{eV}{k_B T}\right) - 1\right]$$

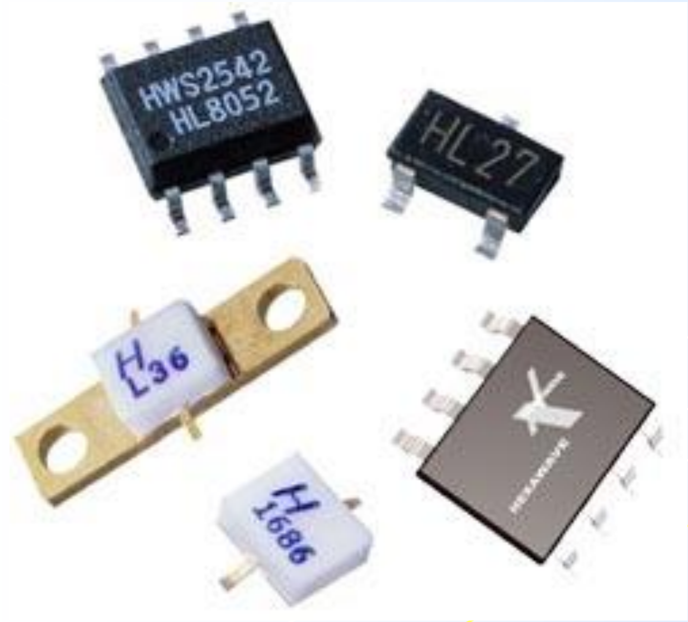
MES-FET



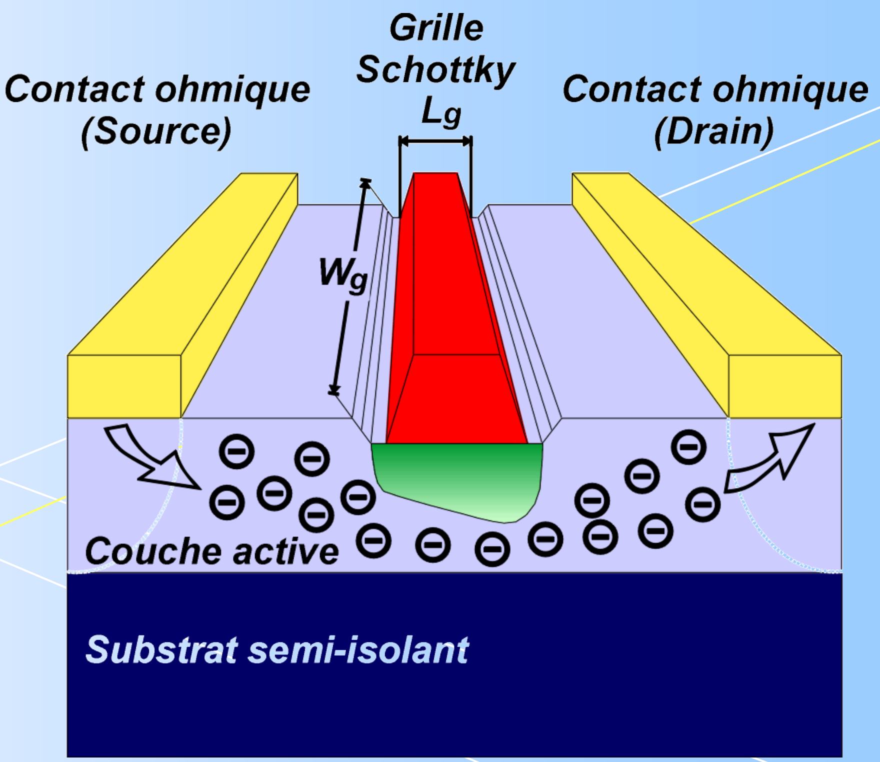
E_c
$e\phi_{surf}$
E_F
E_D



ソース
ゲート
ドレイン
空乏層
伝導チャネル

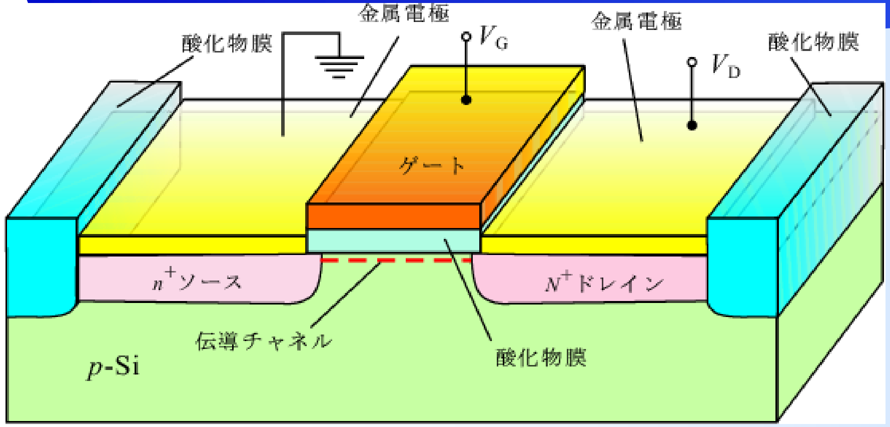


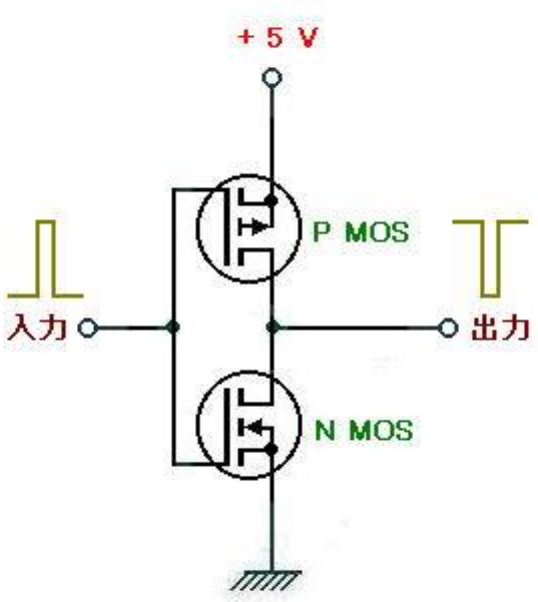
HWS2542
HL8052
HL27
H L36
H 1686



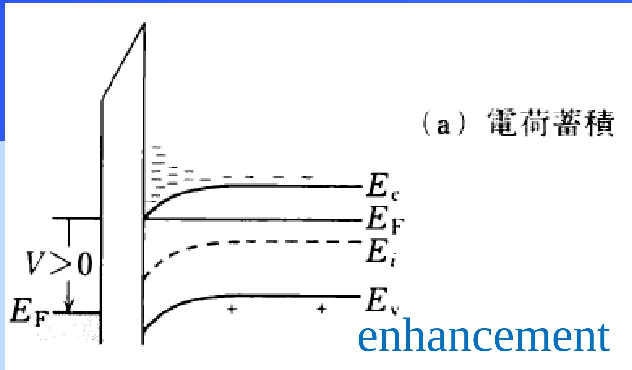
Grille Schottky
L_g
Contact ohmique (Source)
Contact ohmique (Drain)
W_g
Couche active
Substrat semi-isolant

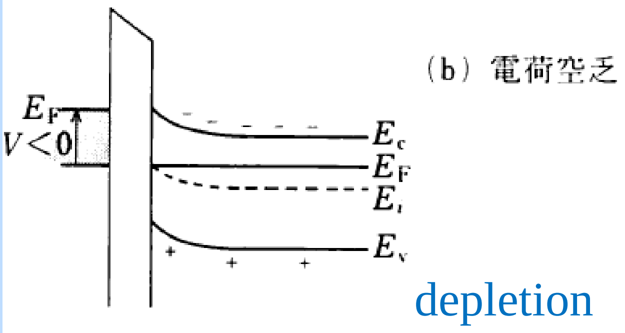
MOS-FET

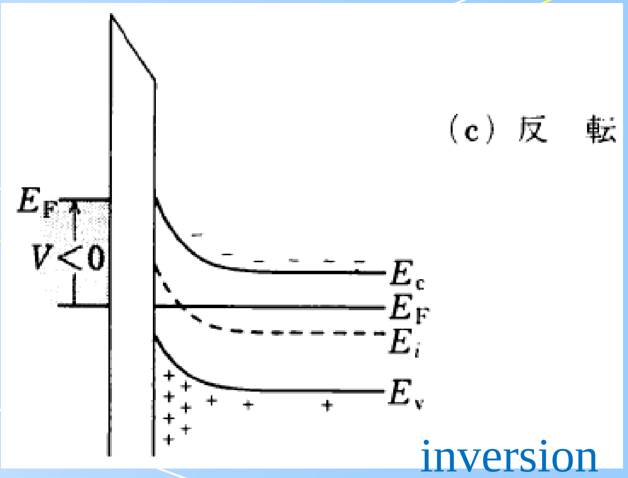




Simplified CMOS inverter circuit

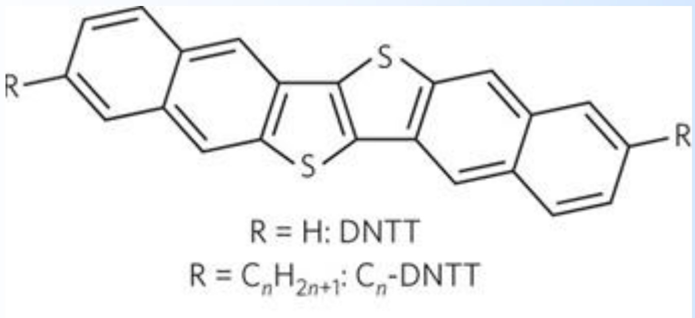


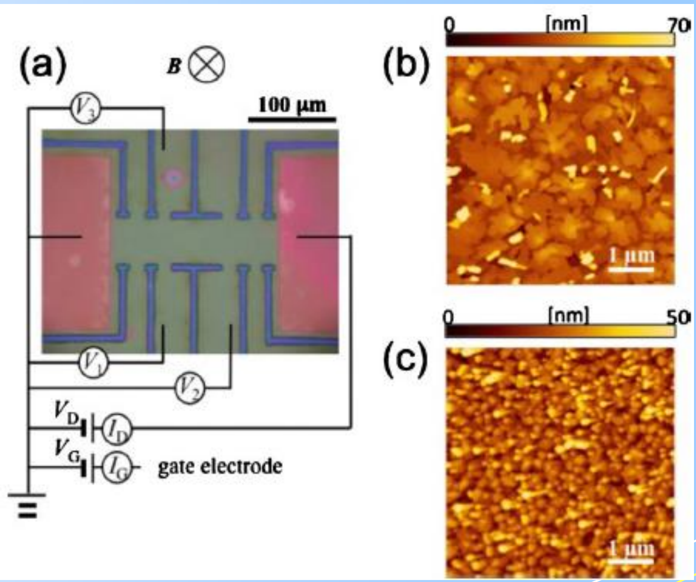


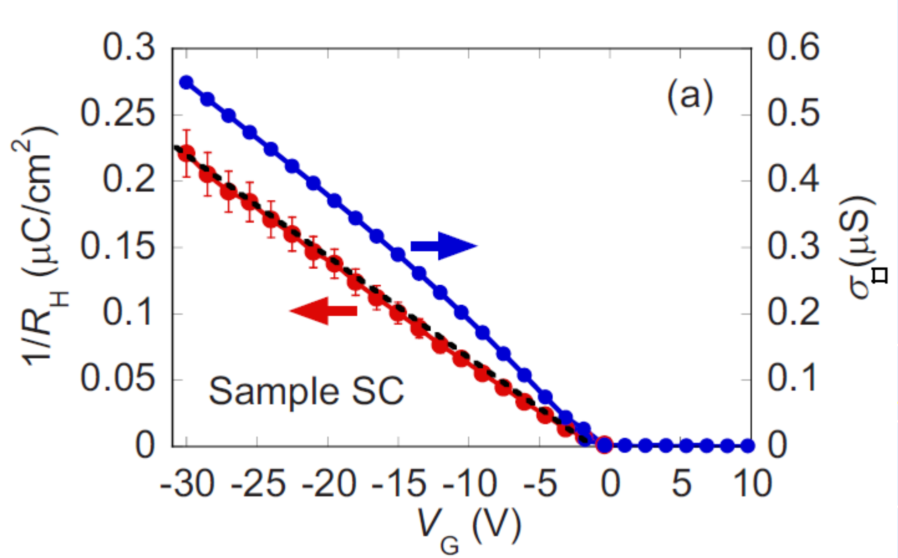


T. Ando, A. B. Fowler, and F. Stern, Rev. Mod. Phys. **54**, 437 (1982).

Organic semiconductor FET

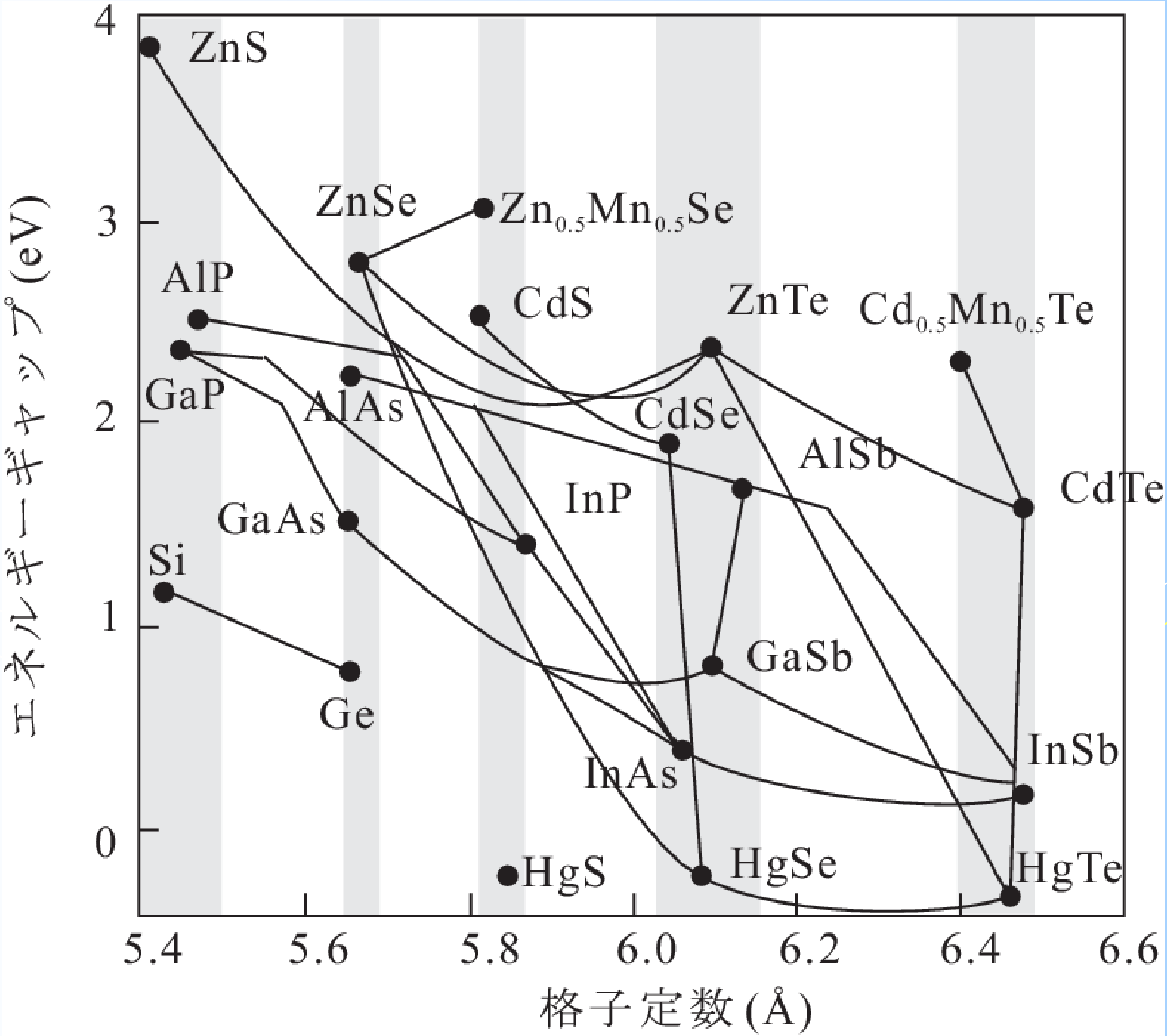






PRB **81**, 161306 (2010).

Chapter 4 Heterojunction and quantum structures



Nobel prize for semiconductor heterostructure

The Nobel Prize in Physics 2000

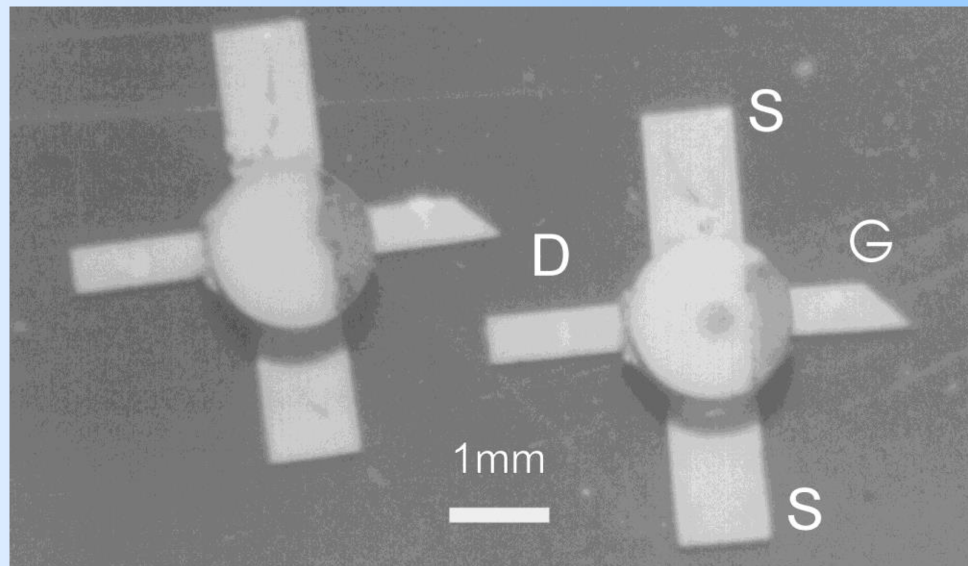
Zhores I. Alferov, Herbert Kroemer, Jack S. Kilby

Zhores I. Alferov | Herbert Kroemer | Jack S. Kilby

The Nobel Prize in Physics 2000 was awarded *"for basic work on information and communication technology"* with one half jointly to Zhores I. Alferov and Herbert Kroemer *"for developing semiconductor heterostructures used in high-speed- and opto-electronics"* and the other half to Jack S. Kilby *"for his part in the invention of the integrated circuit"*.

High electron mobility transistor (HEMT)

high electron mobility transistor (HEMT)



三村高志 (Takashi Mimura, 富士通)