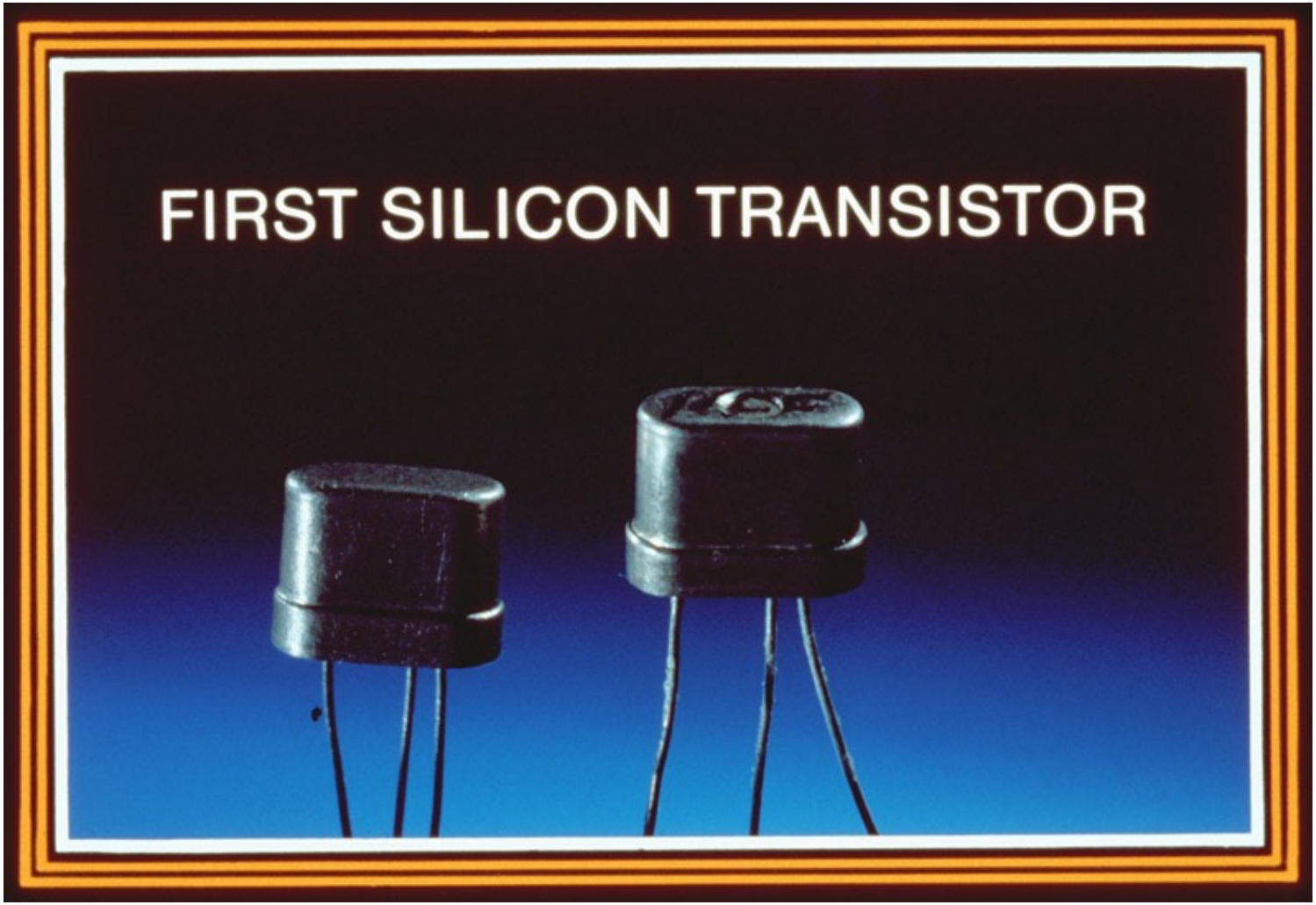
Introduction à l'électronique digitale
Microcontroleurs

Cours n. 5 Photodiode, LED

EPFL
Section de Physique

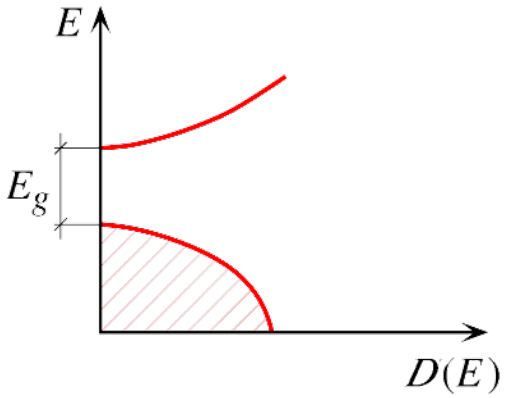
D. Mari, C. Meinen

Semi-conducteurs



Matériaux semi-conducteurs

Isolants a T=0



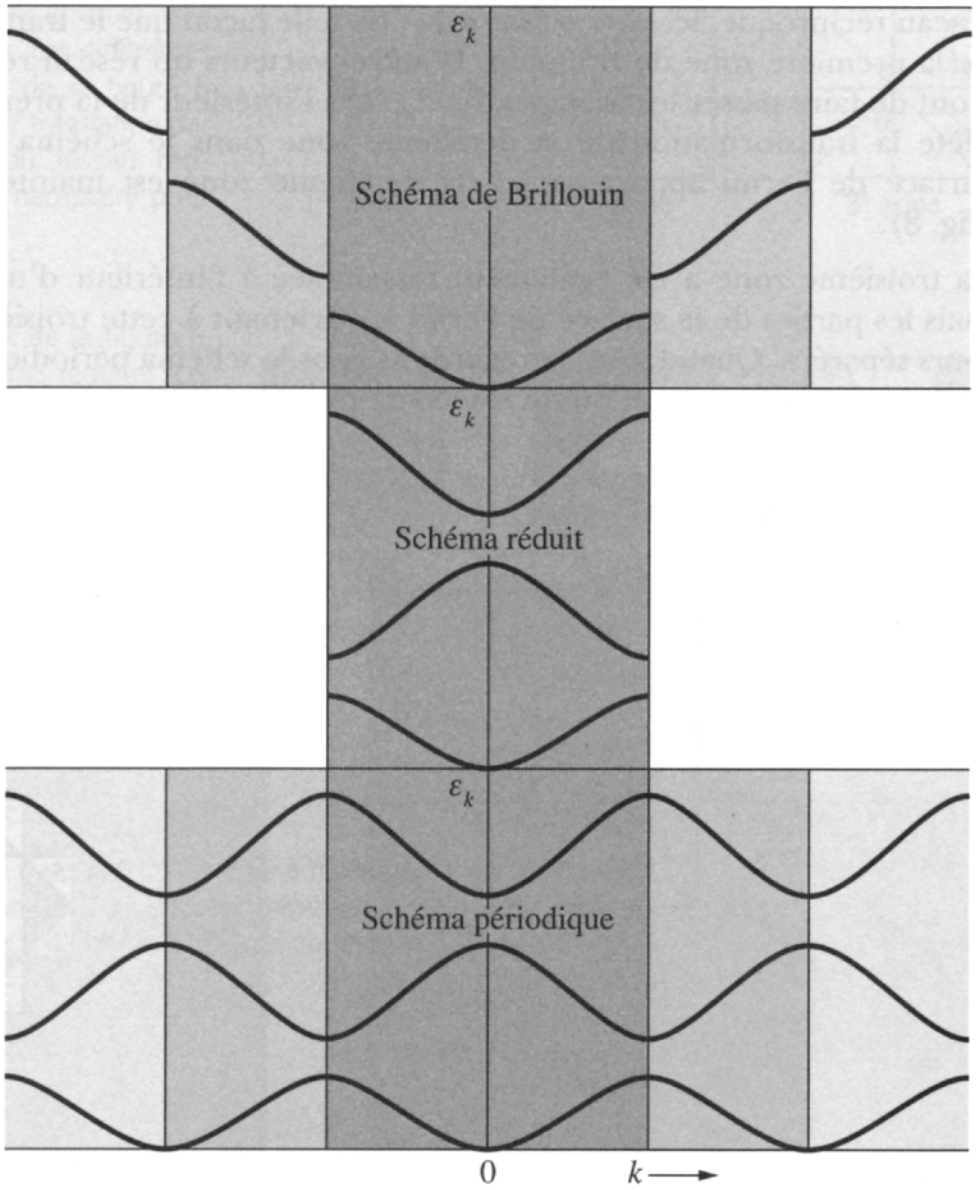
$$\rho(T) = (10^{-2} - 10^{9})\Omega \cdot \mathrm{cm}$$

dépend de la température

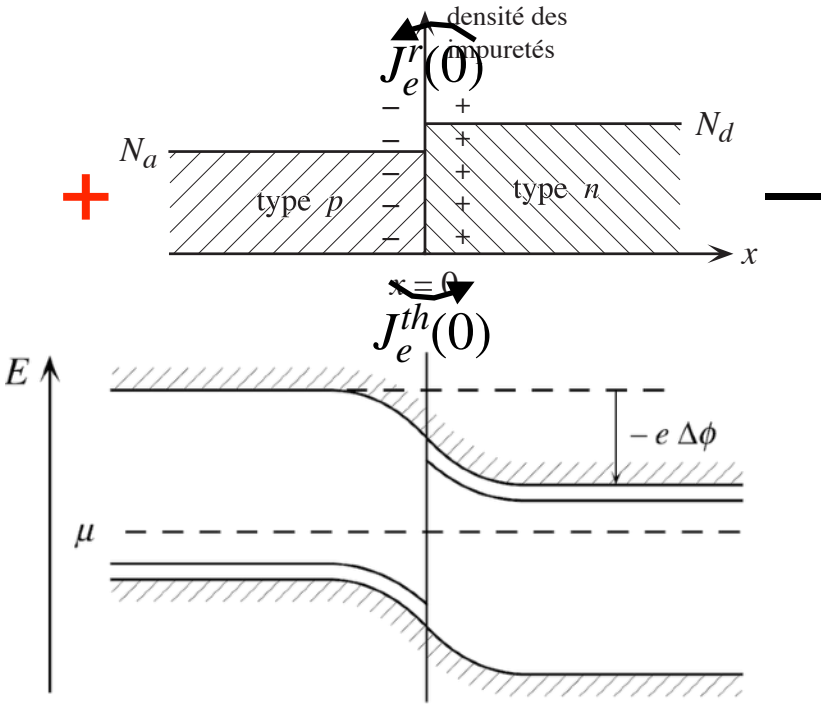
Semi-conducteur intrinsèques

		IIIA	IVA	VA	VIA	VIIA	VIIIA
							2 He 4.003
		5 B 10.811	6 C 12.011	7 N 14.007	8 O 15.999	9 F 18.998	10 Ne 20.183
IB	IIB	13 Al 26.982	14 Si 28.086	15 P 30.974	16 S 32.064	17 Cl 35.453	18 Ar 39.948
29 Cu 63.54	30 Zn 65.37	31 Ga 69.72	32 Ge 72.59	33 As 74.922	34 Se 78.96	35 Br 79.909	36 Kr 83.80
47 Ag 107.870	48 Cd 112.40	49 In 114.82	50 Sn 118.69	51 Sb 121.75	52 Te 127.60	53 I 126.904	54 Xe 131.30
79 Au 196.967	80 Hg 200.59	81 Tl 204.37	82 Pb 207.19	83 Bi 208.980	84 Po (210)	85 At (210)	86 Rn (222)

Structure de bandes



Jonction p-n polarisée

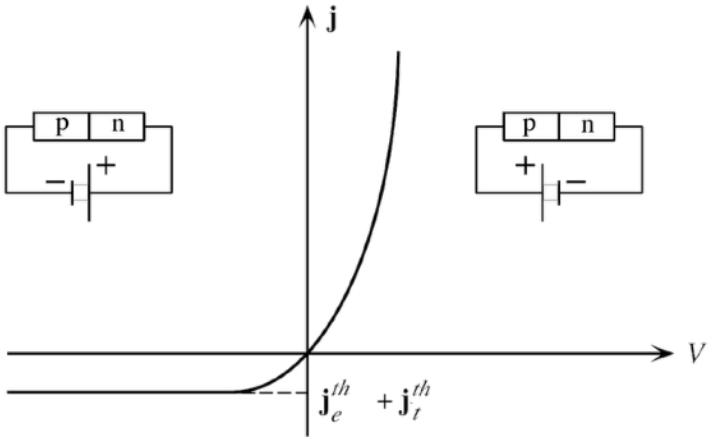


V=0

$$J_e^{th}(0) + J_e^r(0) = 0$$

Polarisation inverse

Polarisation directe



$$J = -\left(J_e^{th}(0) + J_t^{th}(0)\right)\exp\left[\left(eV/k_BT\right) - 1\right]$$

$$J = J_s \exp\left[\left(eV/k_BT\right) - 1\right]$$

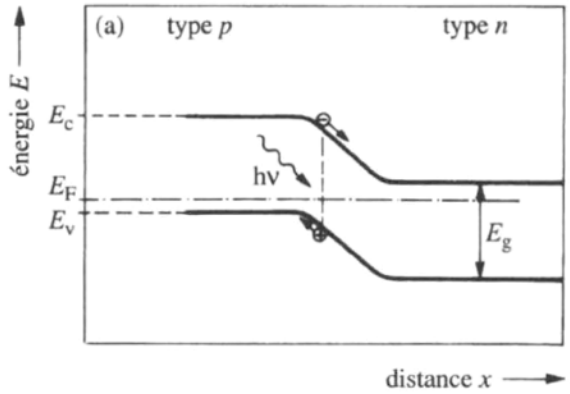
diode

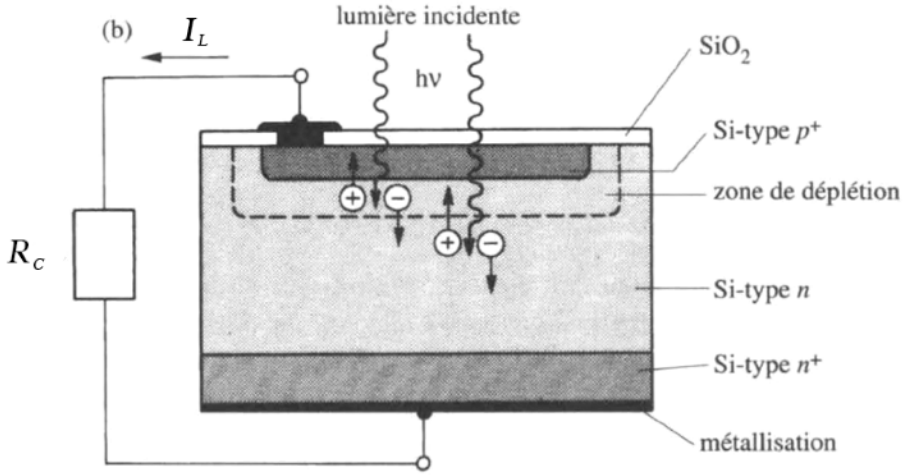
Cellules solaires

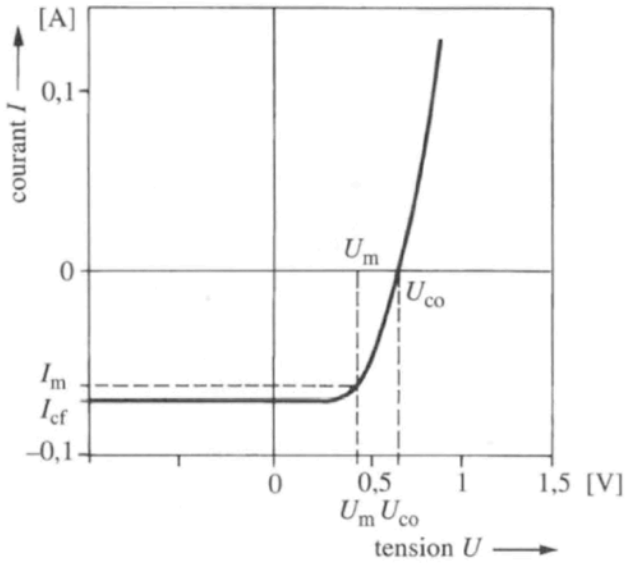
$$I = I_s \left[\exp\left(\frac{eU}{k_B T}\right) - 1 \right] - I_L$$

photo-courant $I_L = \xi_{eA\Phi}$

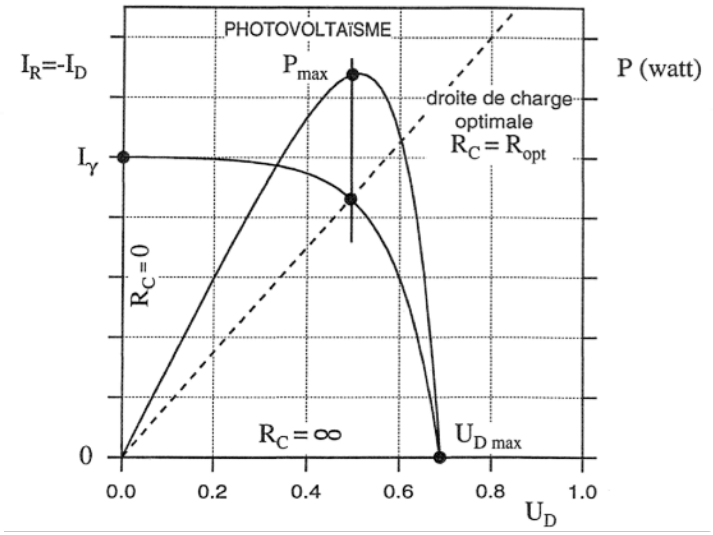
$$U_{CO} = \frac{k_B T}{e} \ln\left(\frac{I_L}{I_s} + 1\right)$$







Cellules solaires



$$I = I_s \left[\exp\left(\frac{eU}{k_B T}\right) - 1 \right] - I_L$$

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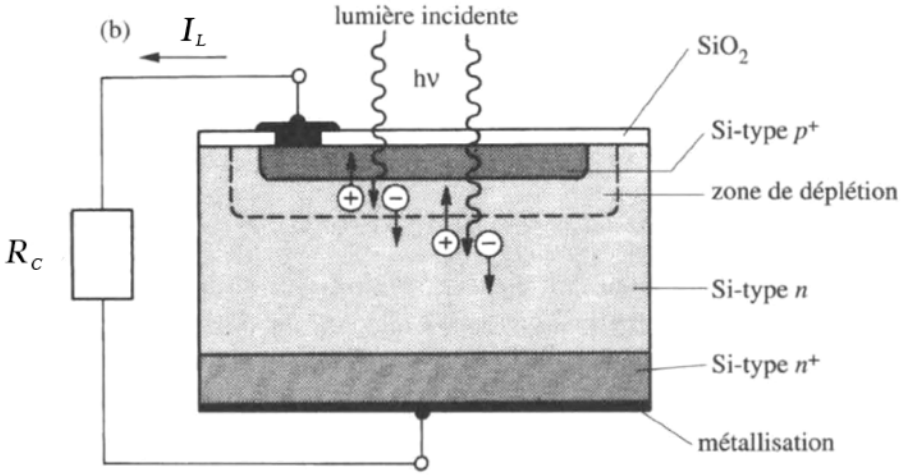
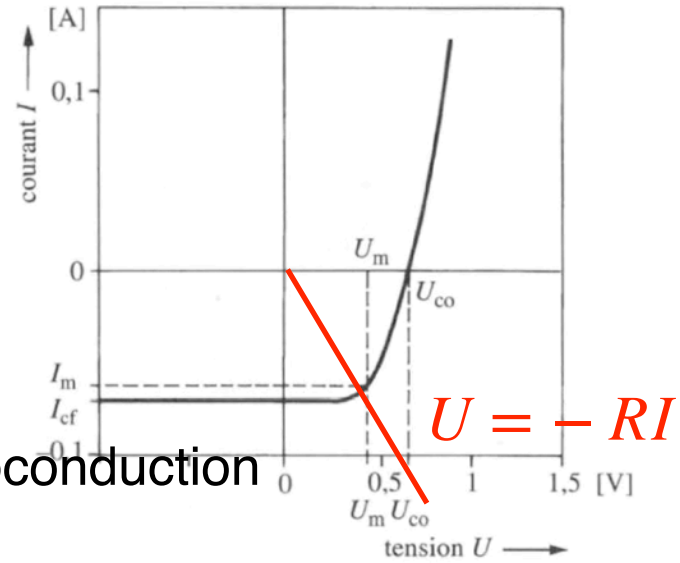


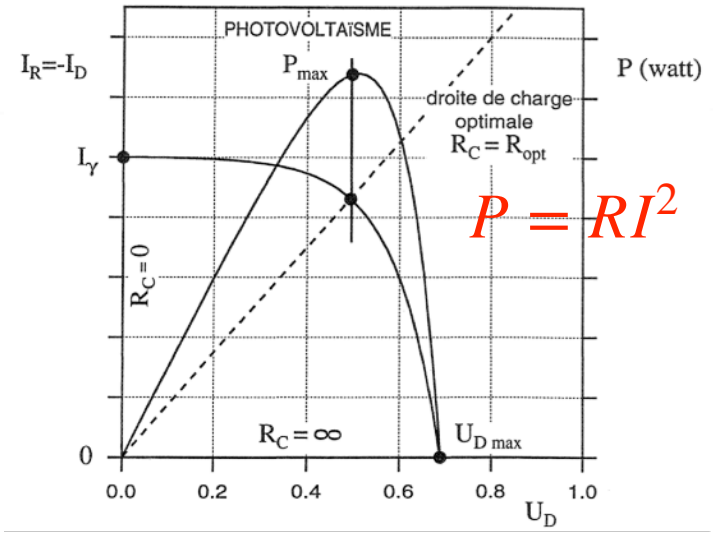
$$P_m = I_m U_m$$

$$\eta = P_m / P_{in}$$



Photoconduction $U = -RI$

Cellules solaires

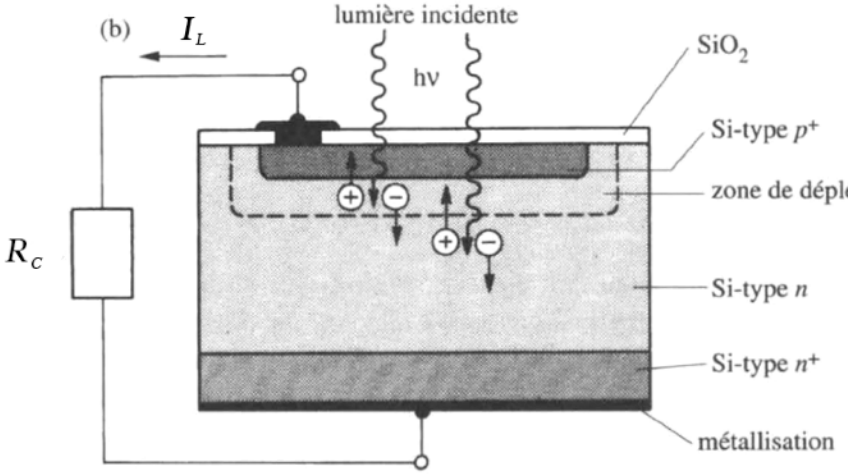


$$P = RI^2$$

$$I = I_s\left[\exp\left(\frac{eU}{k_BT}\right) - 1\right] - I_L$$

photo-courant $\quad I_L = \xi_{eA\Phi}$

$$U_{CO} = \frac{k_BT}{e}\ln\left(\frac{I_L}{I_s} + 1\right)$$



$$P_m = I_m U_m$$

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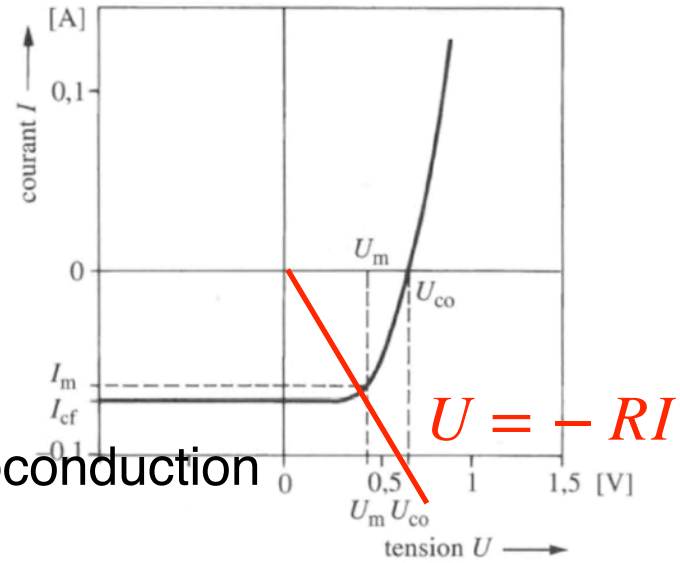
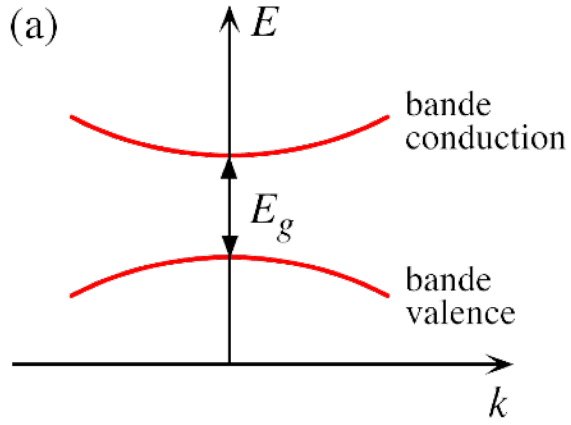


Photoconduction

$$U = -RI$$

Matériaux semi-conducteurs

Emission d'un photon

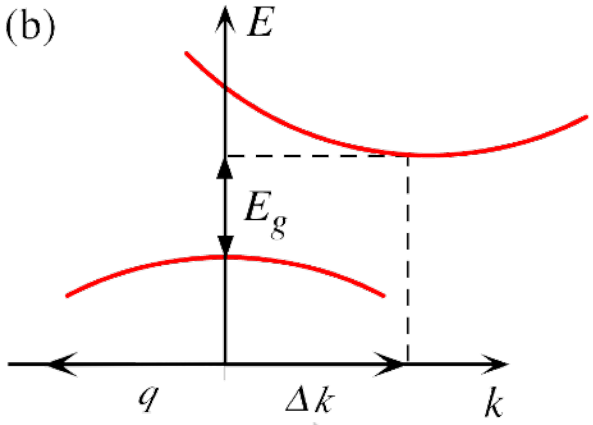


directe

GaAs, InAs, InP

LED

Absorption d'un photon



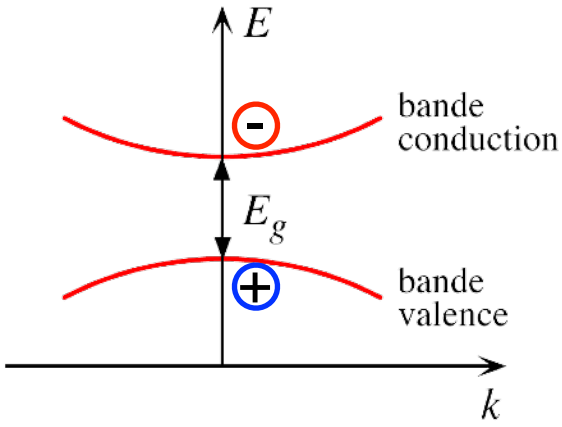
indirecte

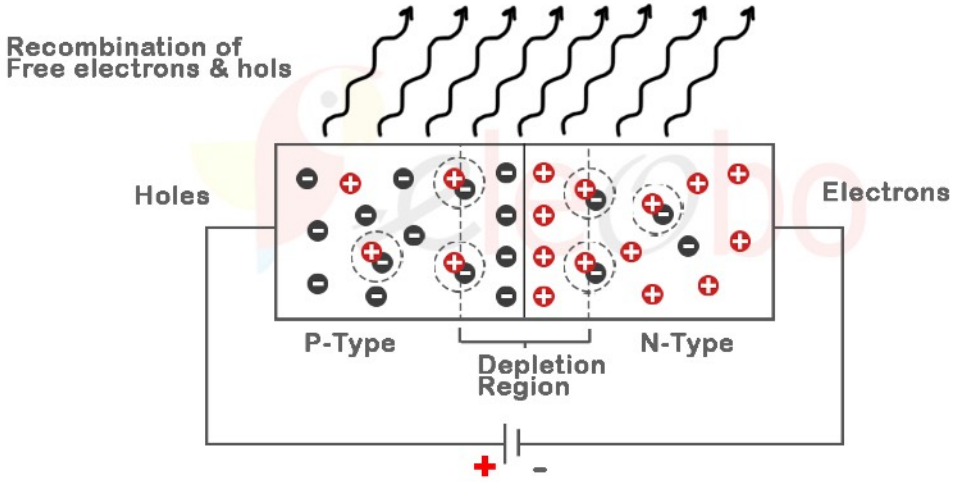
Si , Ge

Cellules solaires
Transistors

LED

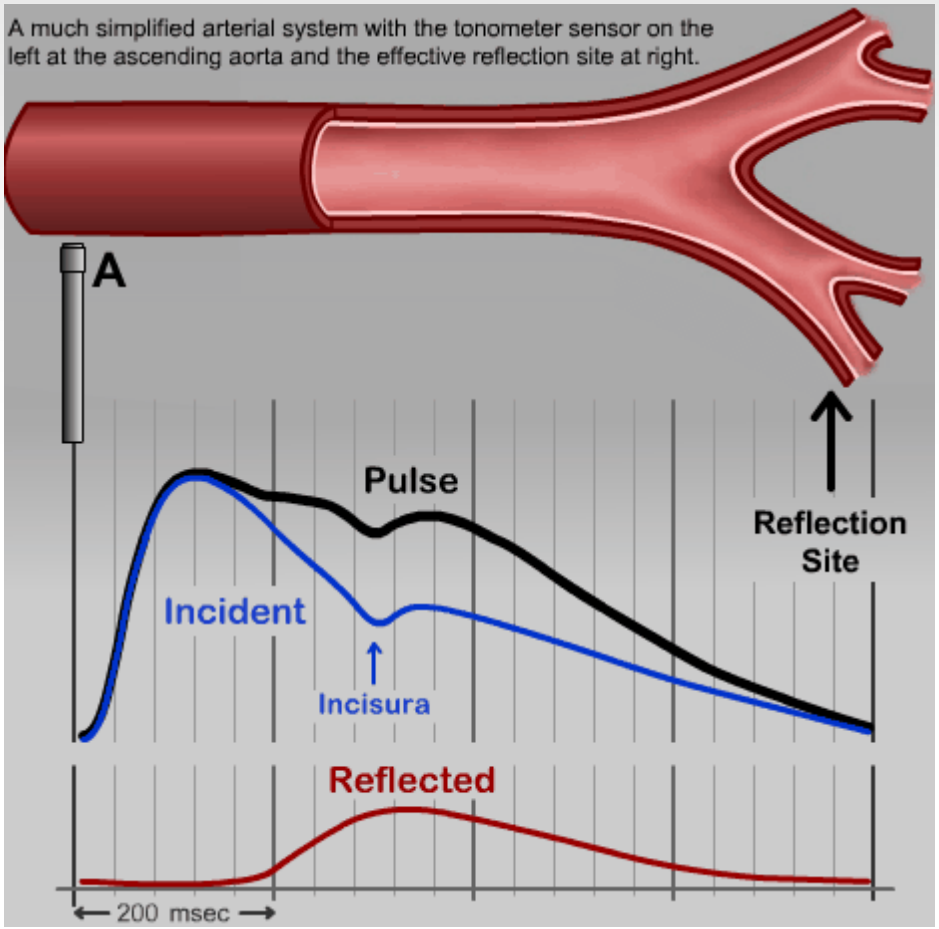
Emission d'un photon





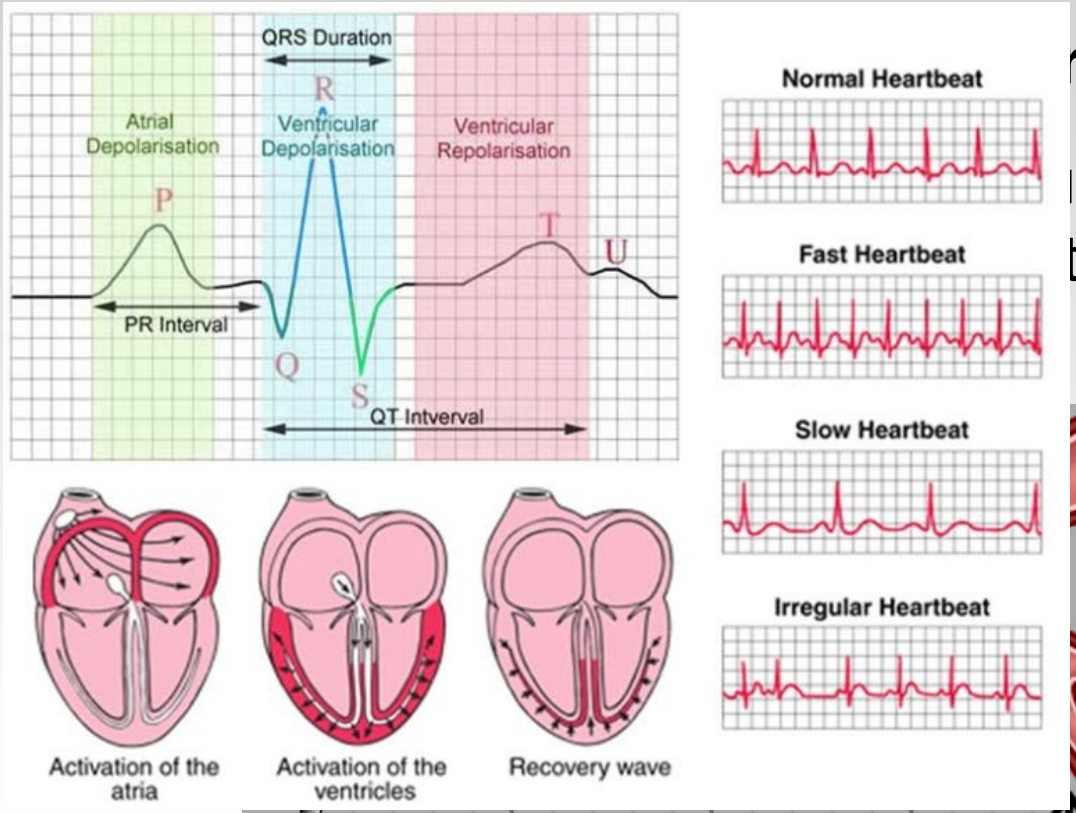
Mesure de la pression artérielle

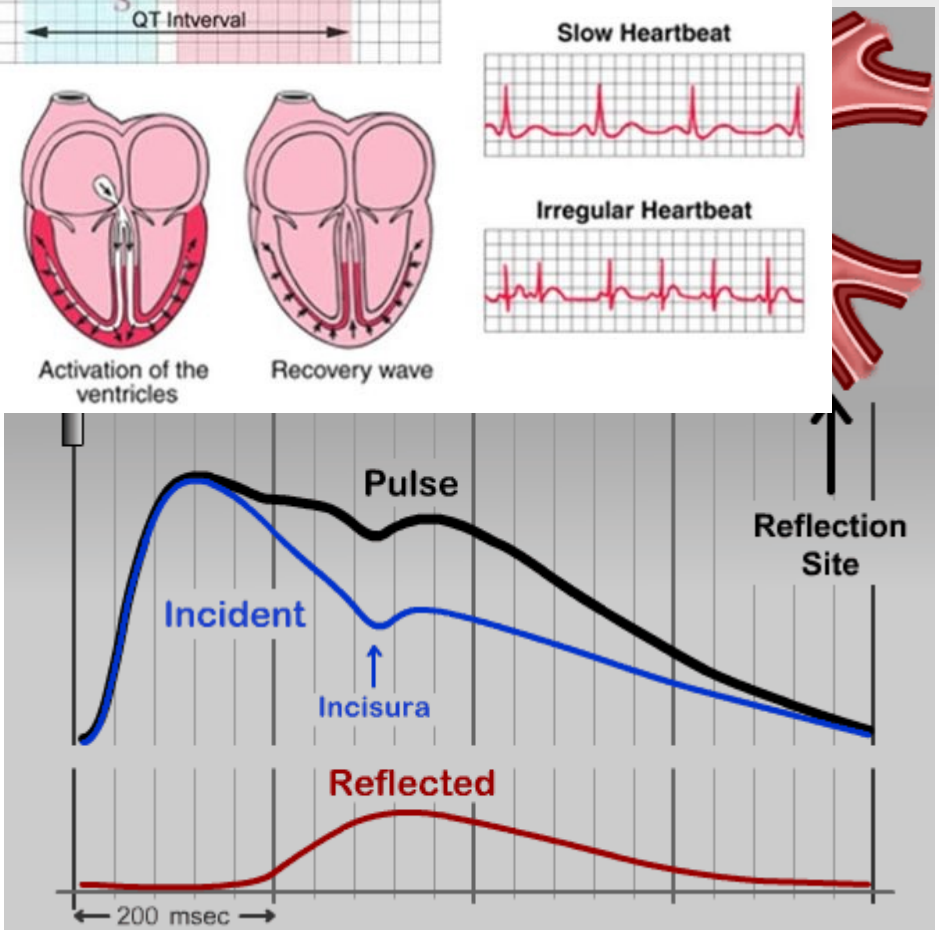
On utilise la photoconduction pour mesurer la lumière absorbée par le sang : on détecte la variation de diamètre des artères ou des capillaires



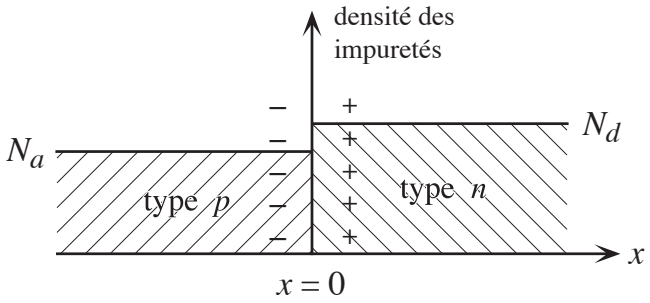
rielle

r mesurer la
tecte la variation
capillaires



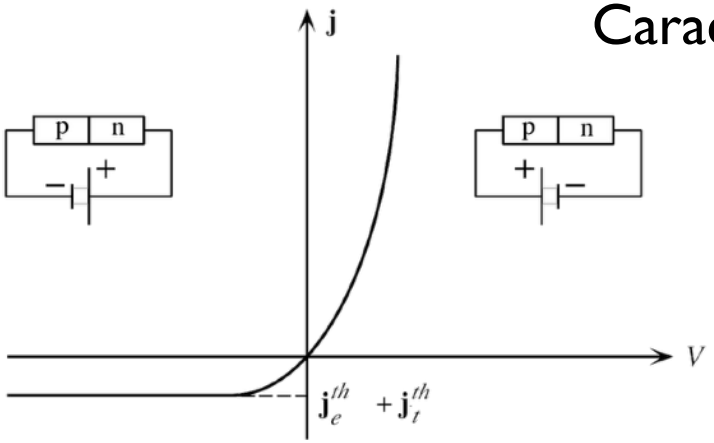


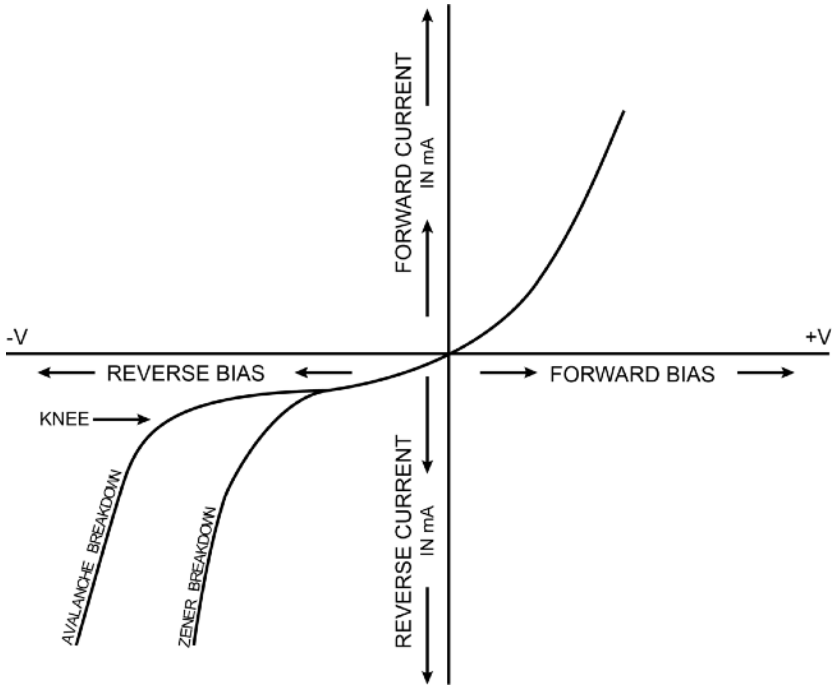
Jonction p-n polarisée reverse-bias



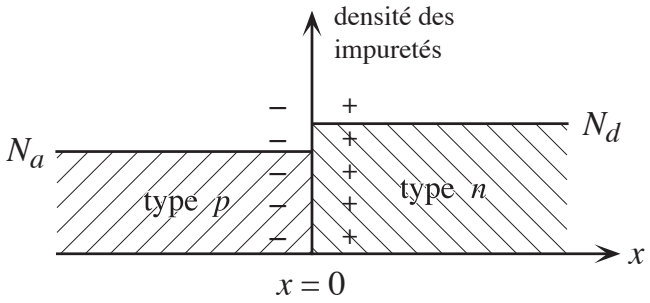
Polarisation inverse

Caractéristique diode

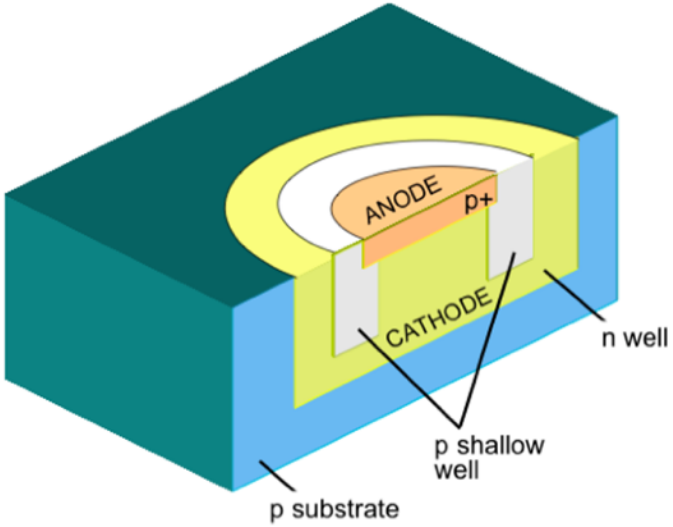


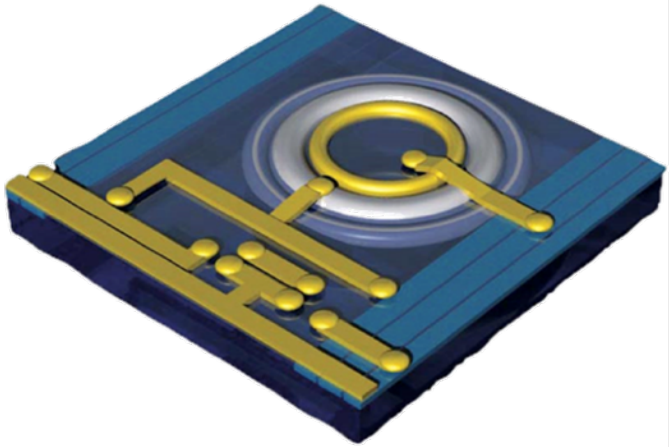


SPAD Single Photon Avalanche Diode

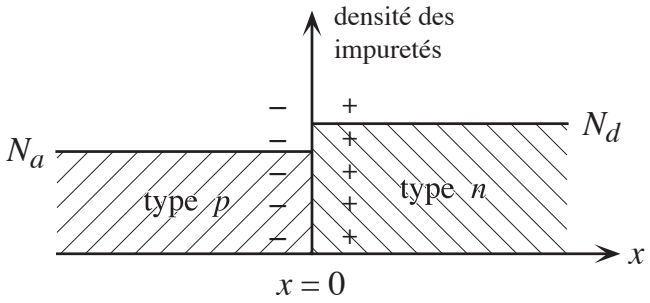


Polarisation inverse





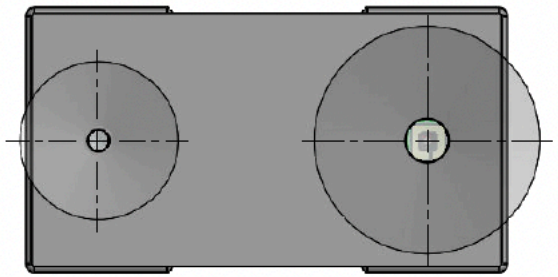
SPAD Single Photon Avalanche Diod



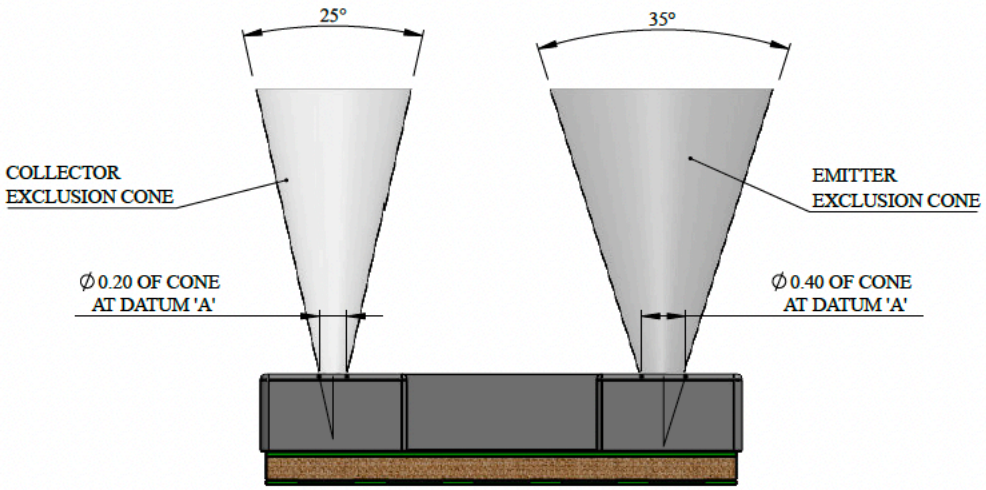
Polarisation inverse

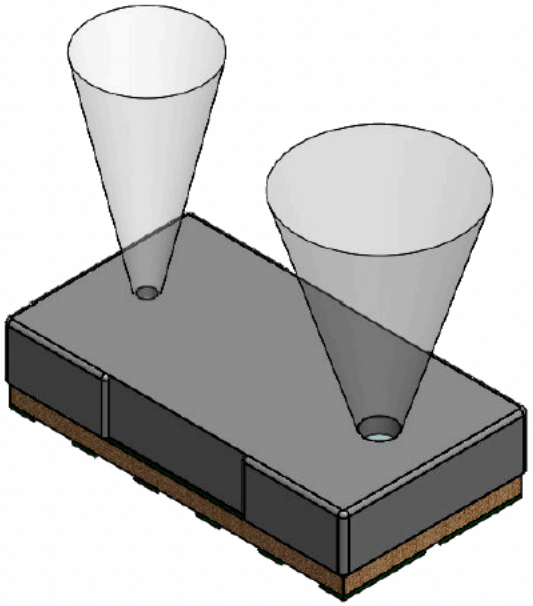
$$t_D = 2 \cdot \frac{D}{c} = 2 \cdot \frac{2.5 \text{ m}}{300000000 \frac{\text{m}}{\text{s}}} = 0.000000001666 \text{ s} = 16.66 \text{ ns}$$

SPAD VL53L0X



Laser IR 940 nm





Application: LIDAR (Light Detection and