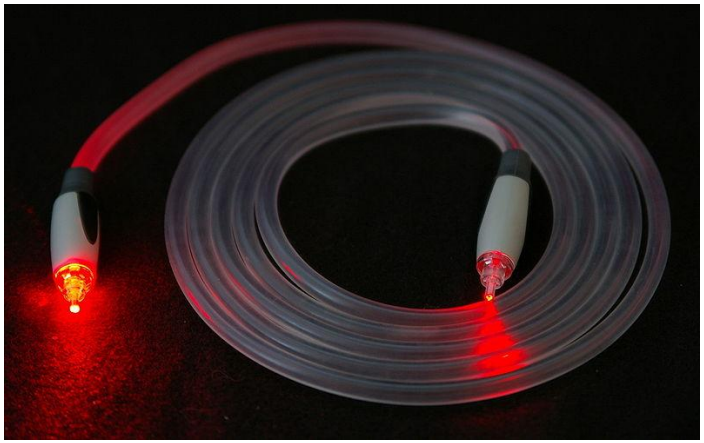
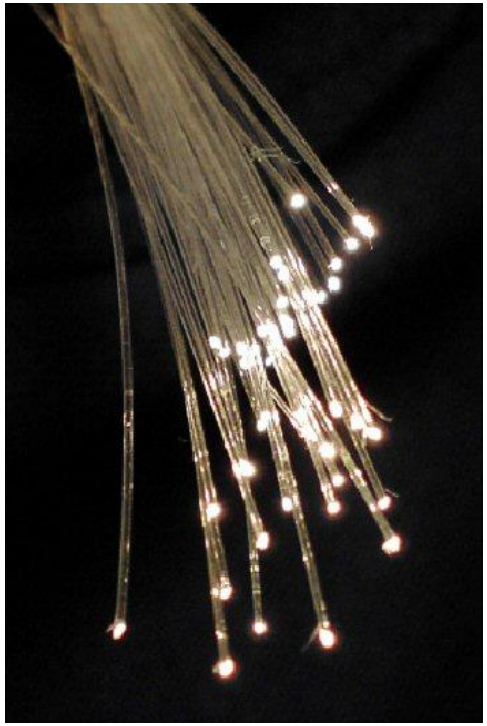
Sensores Ópticos

Medição de luz

Geração de luz



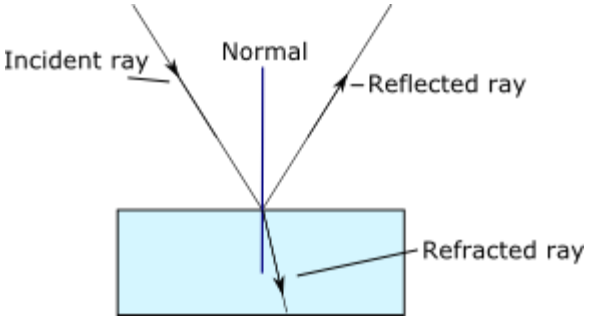


O que é luz???

Raio
Onda
Partícula

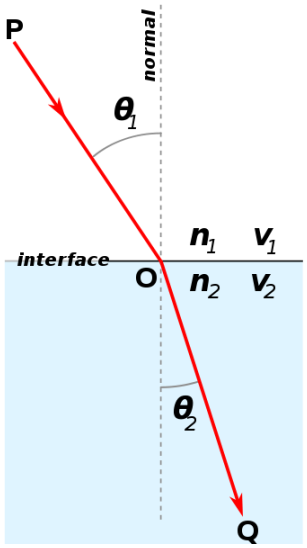
Raios

Propagação retilínea

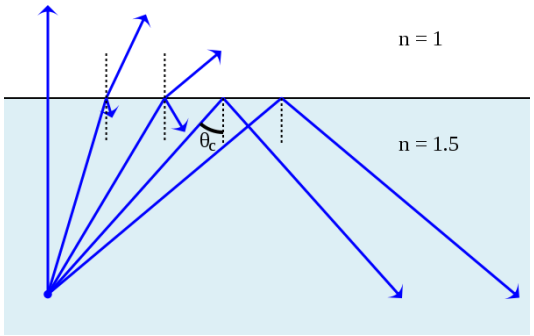


Lei de Snell

$$\frac{\sin\theta_1}{\sin\theta_2} = \frac{v_1}{v_2} = \frac{n_2}{n_1}$$

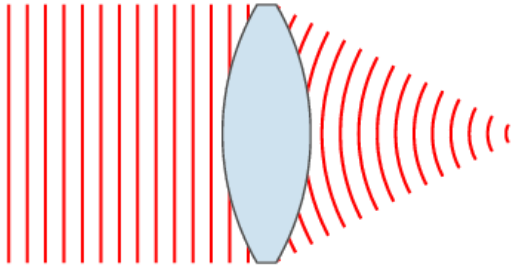


Reflexão total

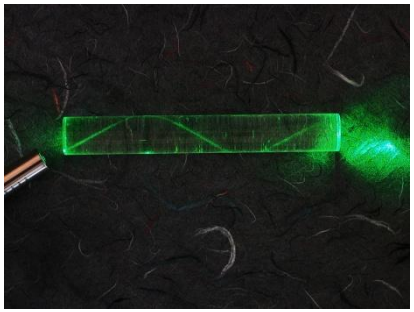


Raios

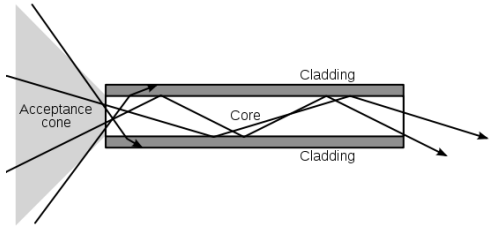
Focalização e colimação



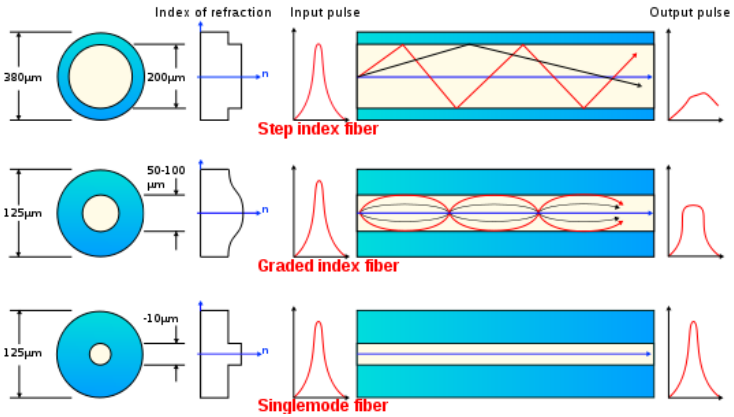
Confinamento de luz

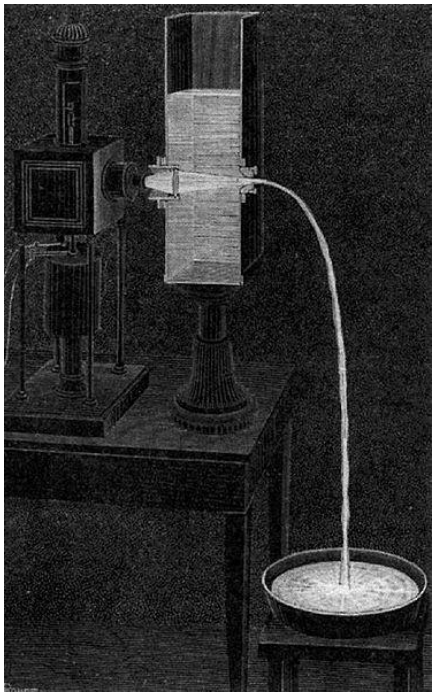


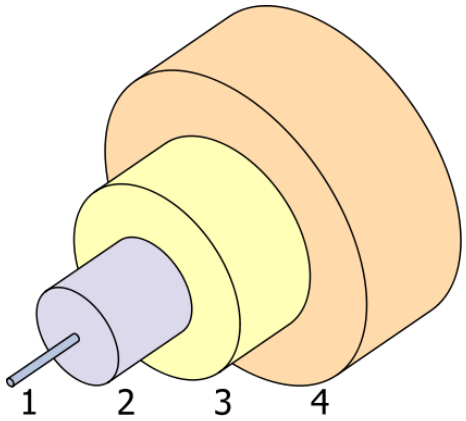
Fibra óptica



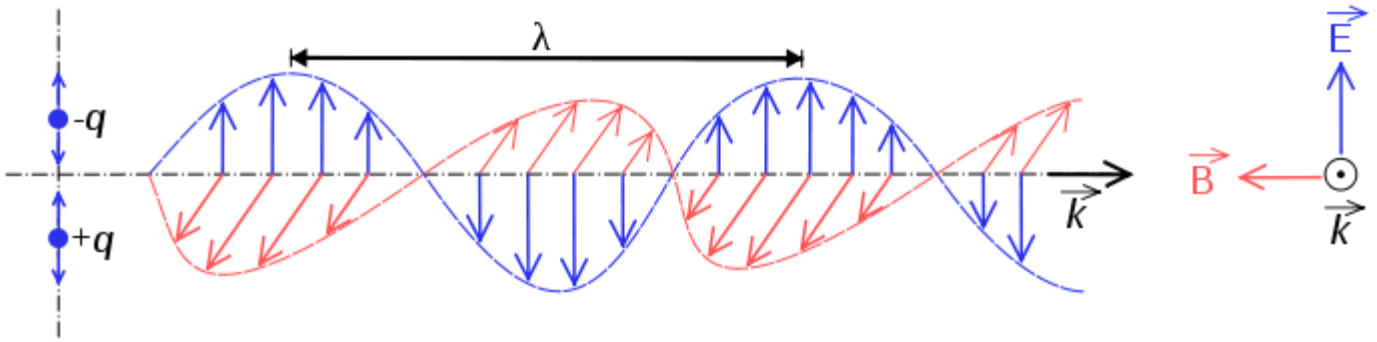
Fibra óptica

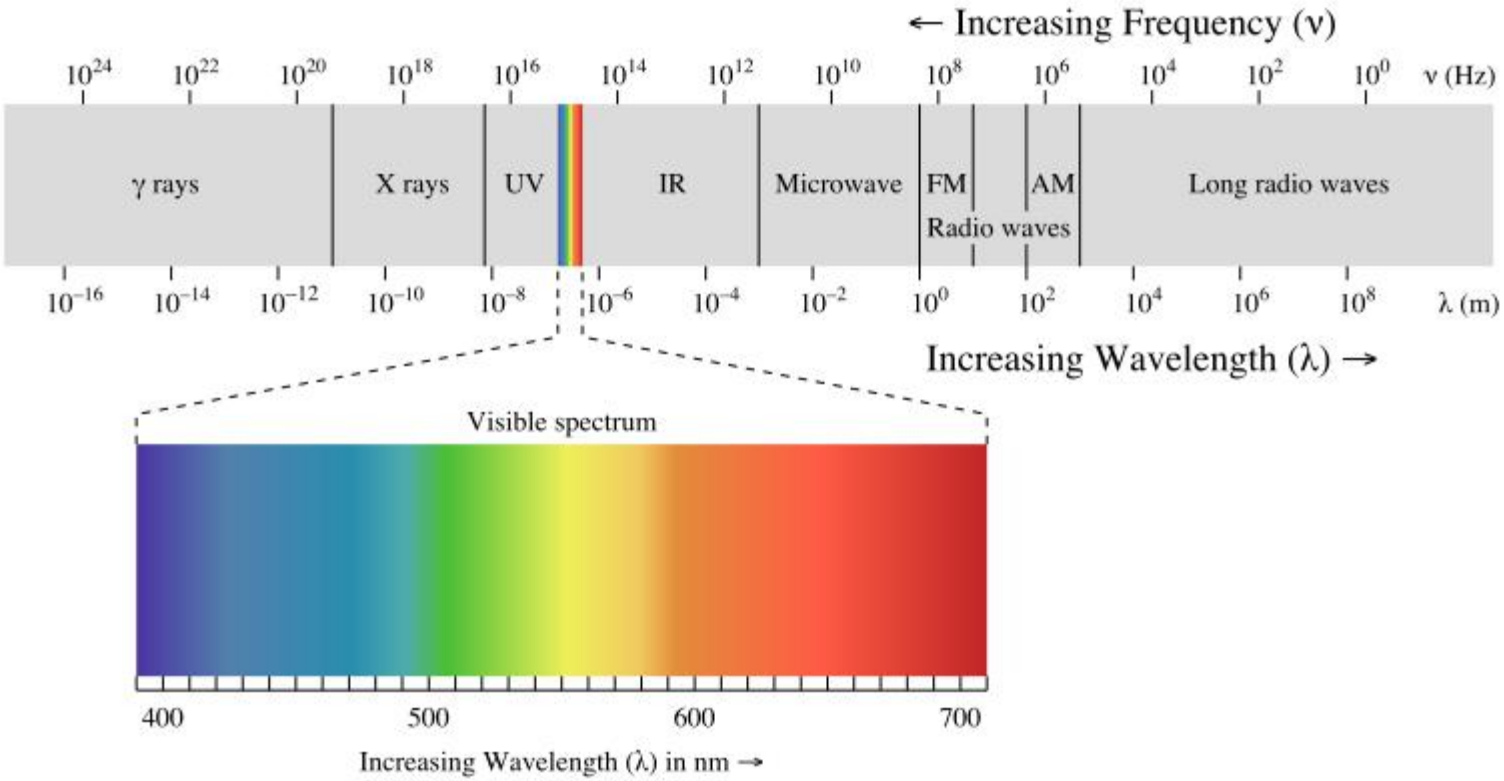






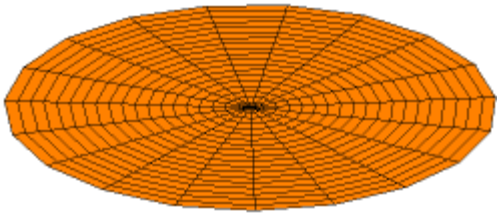
Onda

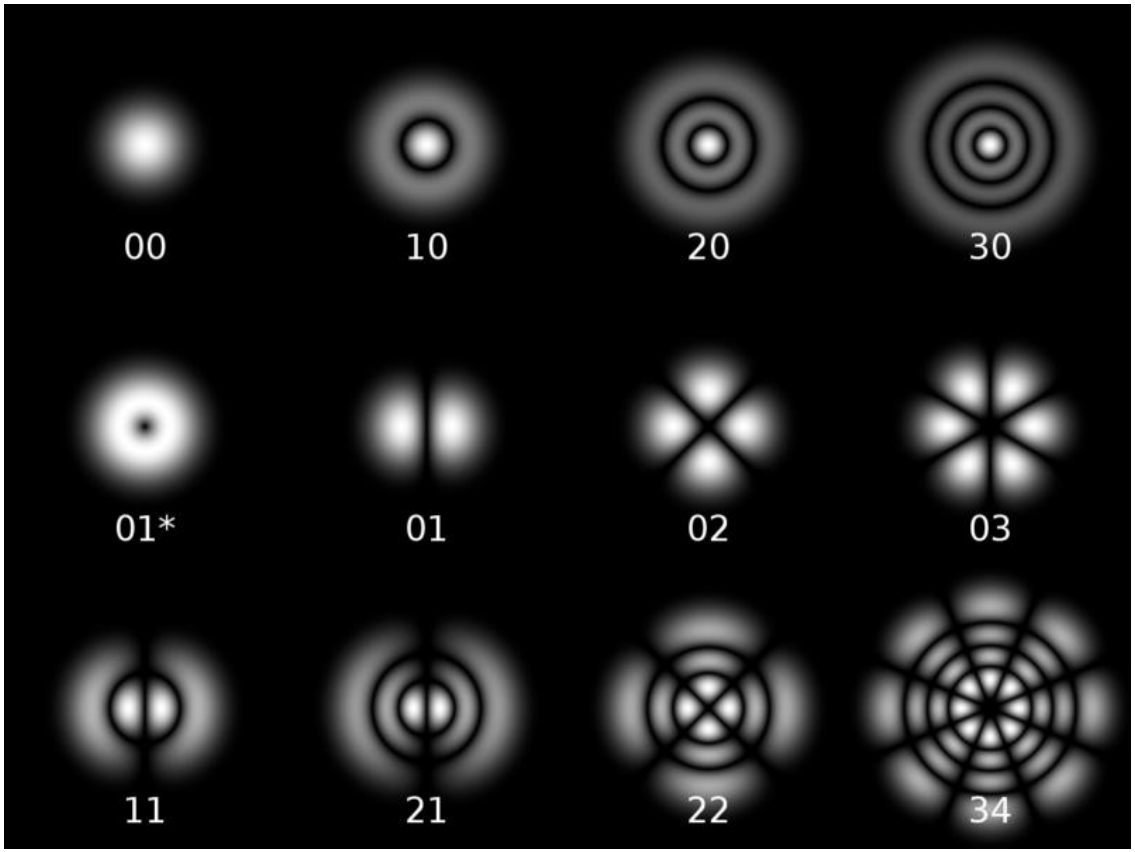

λ
-q
+q
k
E
B
k


← Increasing Frequency (ν)
10^24 10^22 10^20 10^18 10^16 10^14 10^12 10^10 10^8 10^6 10^4 10^2 10^0 ν (Hz)
γ rays
X rays
UV
IR
Microwave
FM
AM
Radio waves
Long radio waves
10^-16 10^-14 10^-12 10^-10 10^-8 10^-6 10^-4 10^-2 10^0 10^2 10^4 10^6 10^8 λ (m)
Increasing Wavelength (λ) →
Visible spectrum
400
500
600
700
Increasing Wavelength (λ) in nm →

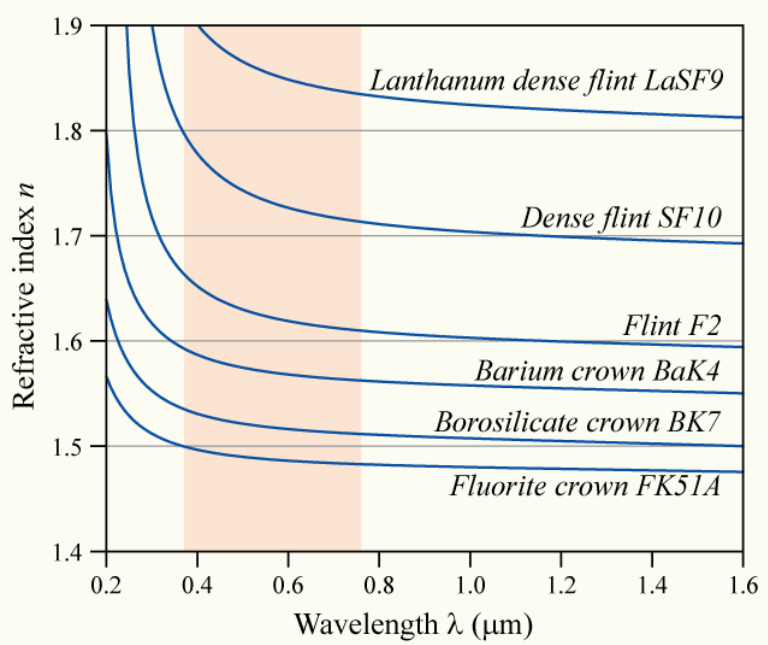
Onda

Modos transversais





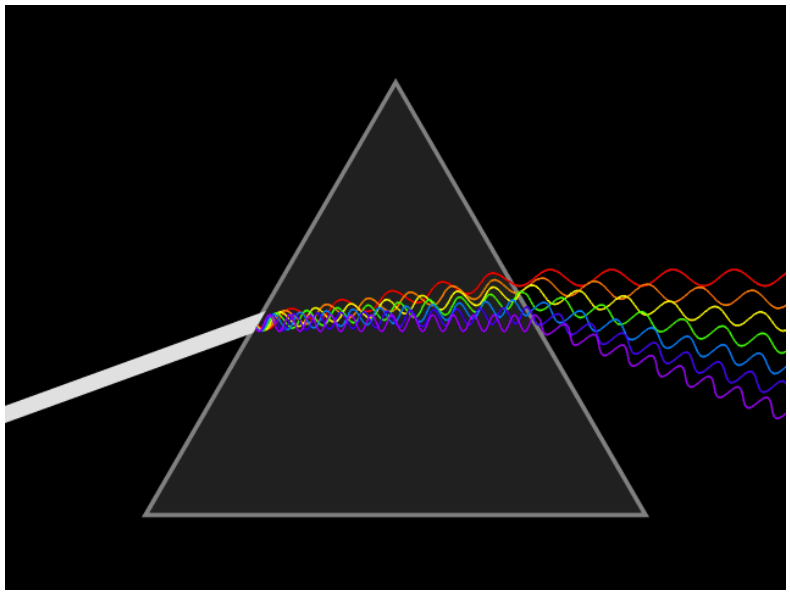
Lei de Snell



Equação de Sellmeier

$$n^2(\lambda) = A + \frac{B_1\lambda^2}{\lambda^2 - C_1} + \frac{B_2\lambda^2}{\lambda^2 - C_2}.$$

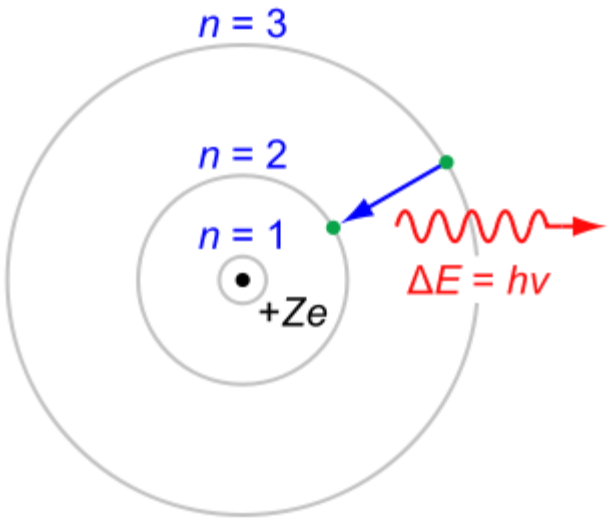
Dispersão



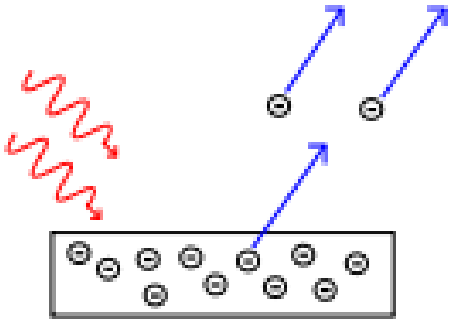
Aberração cromática

TESTE

Partícula

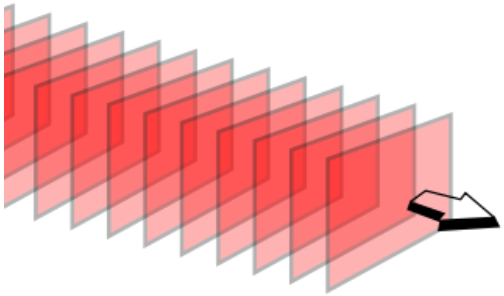


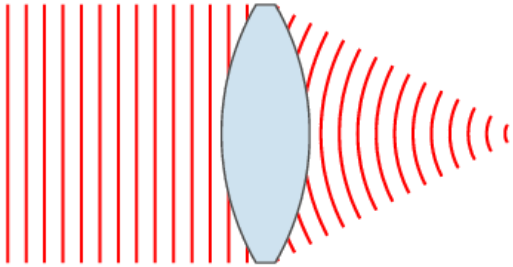
$$E = hf = \frac{hc}{\lambda}$$

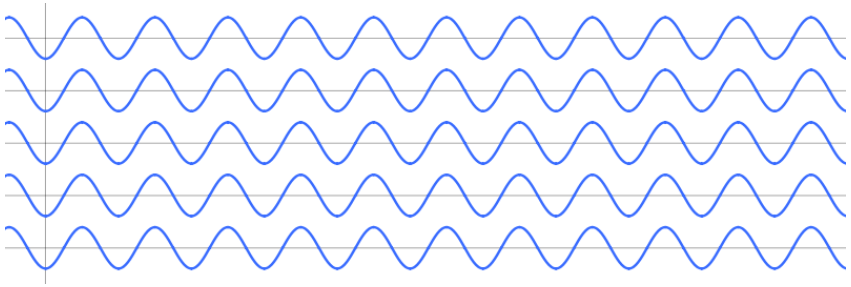


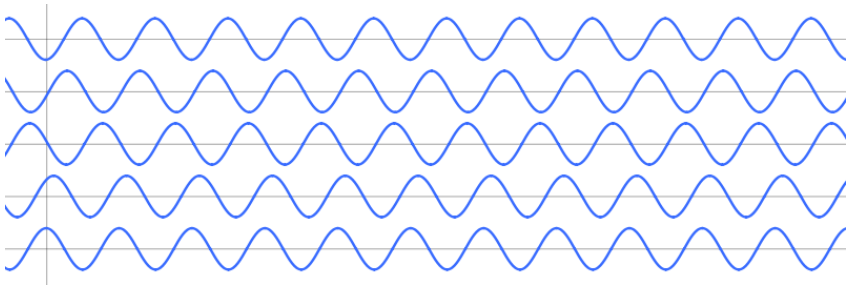
Onda

Frente de onda



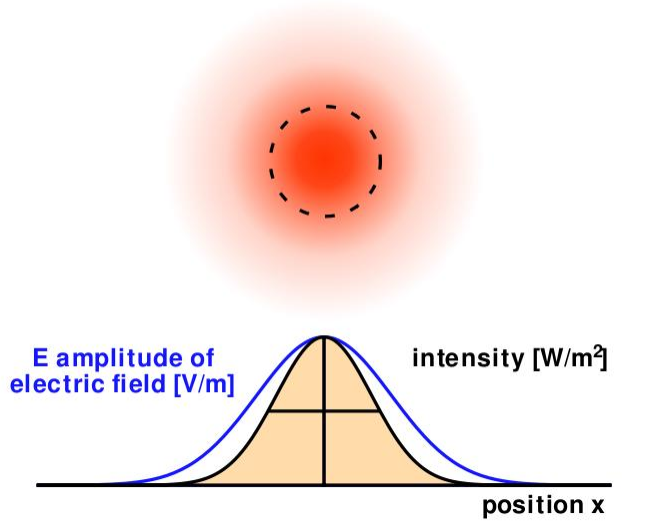


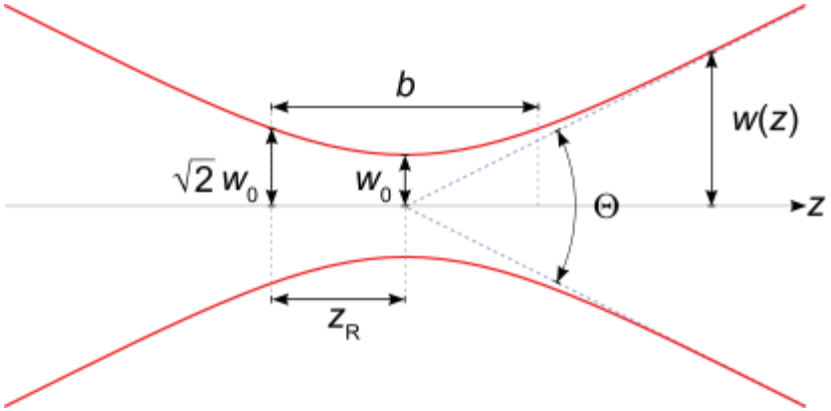




Onda

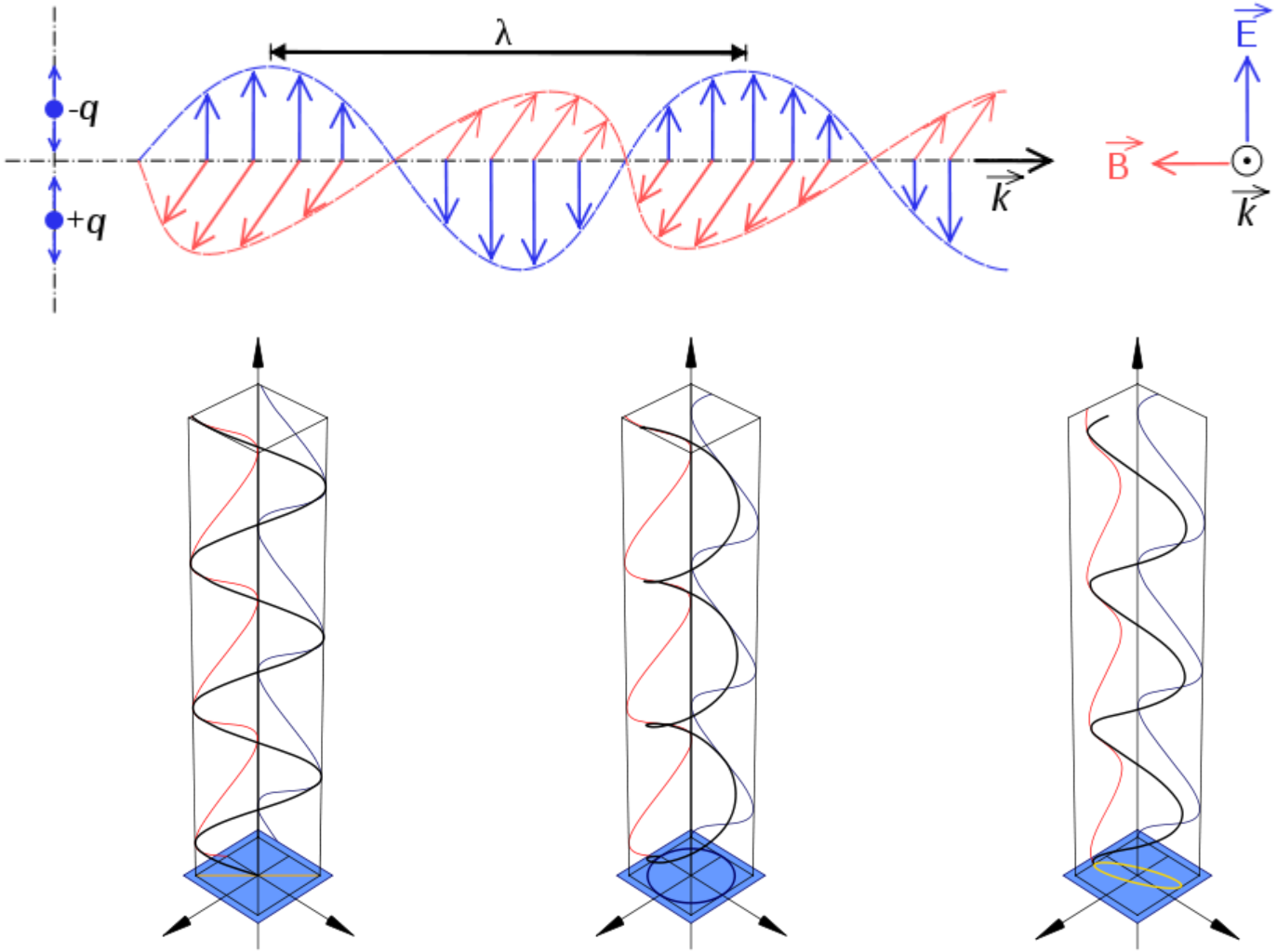
Feixe Gaussiano



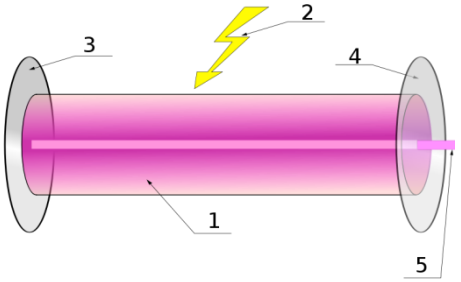


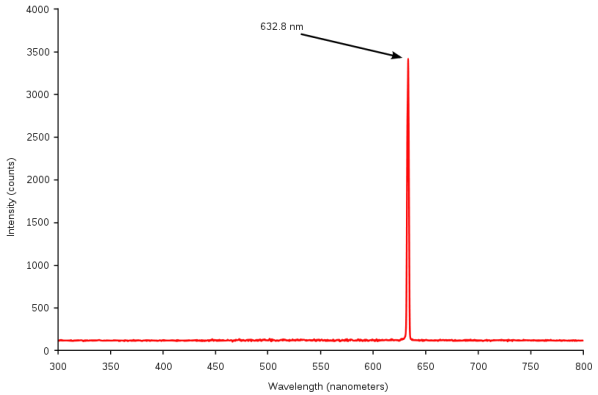
$$I(r,z) = \frac{|E(r,z)|^2}{2\eta} = I_0 \left(\frac{w_0}{w(z)}\right)^2 \exp\left(\frac{-2r^2}{w^2(z)}\right) ,$$

Polarização

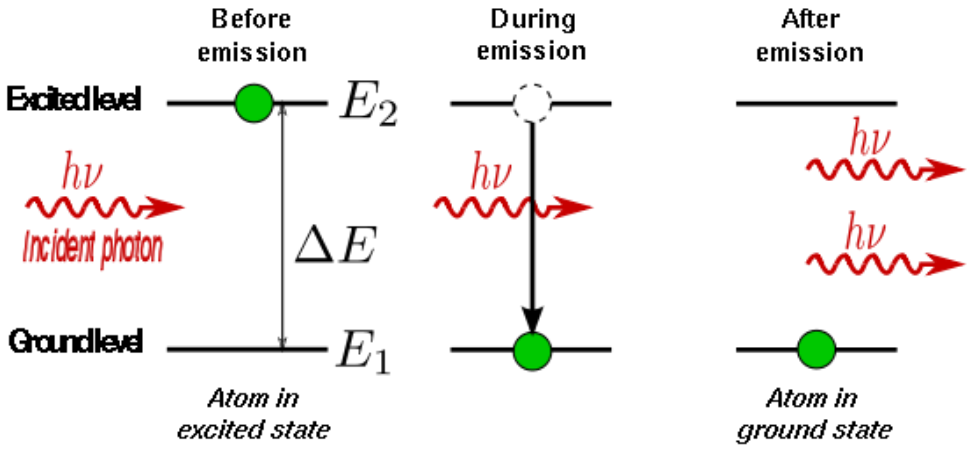


Laser





Emissão espontânea X Emissão estimulada



$$E_2 - E_1 = \Delta E = h\nu$$

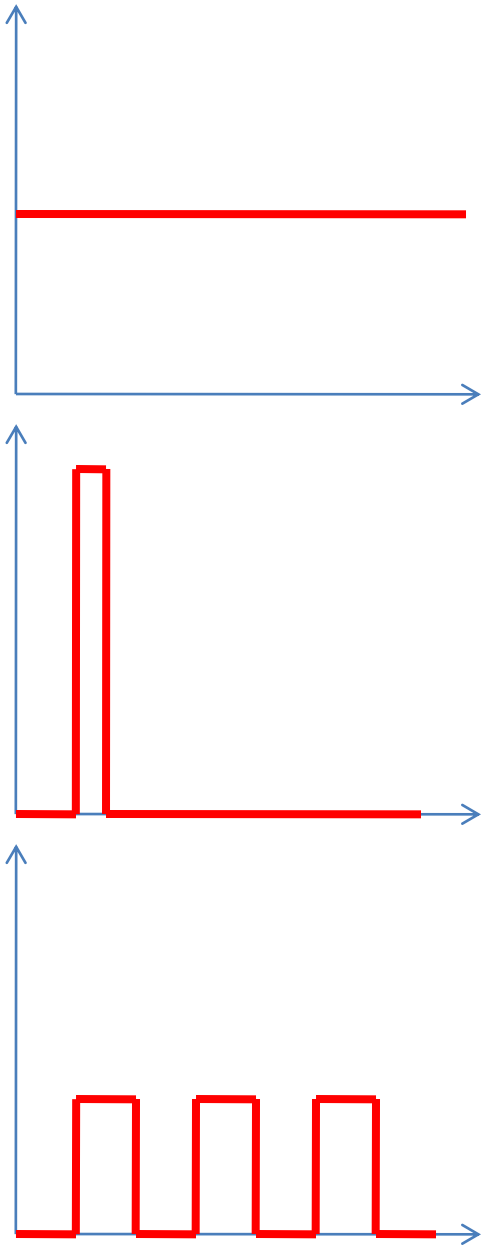
Laser

Modos de operação

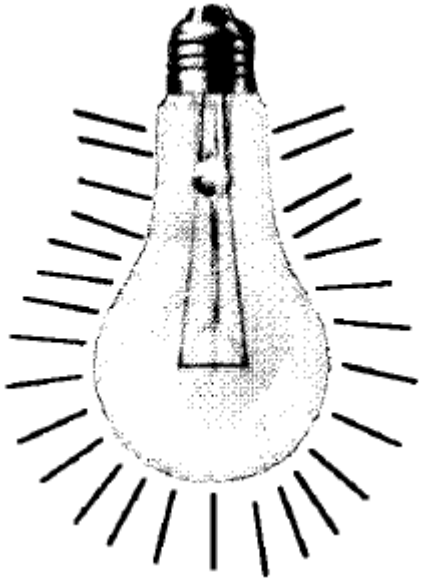
CW

Pulsado – Acúmulo de energia

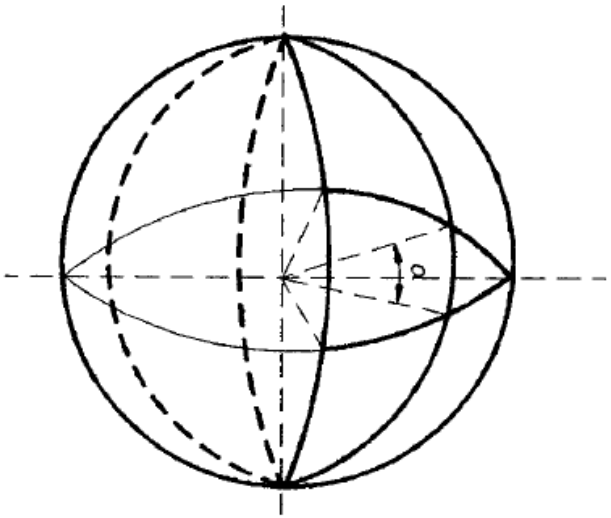
Chaveado – AM



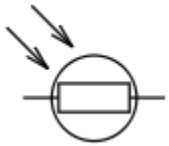
Sensores Ópticos



Iluminância – fluxo luminoso/área de uma superfície (lux)
Fluxo luminoso – potência de radiação emitida por uma fonte luminosa (lúmen)
Eficiência luminosa – fluxo luminoso/potência consumida (lúmens/W)
Intensidade luminosa – fluxo luminoso/ângulo sólido (candela – cd)
Luminância – Intensidade luminosa/superfície iluminada (cd/m^2)
Reflectância
Emitância ($lúmens/m^2$)



LDR

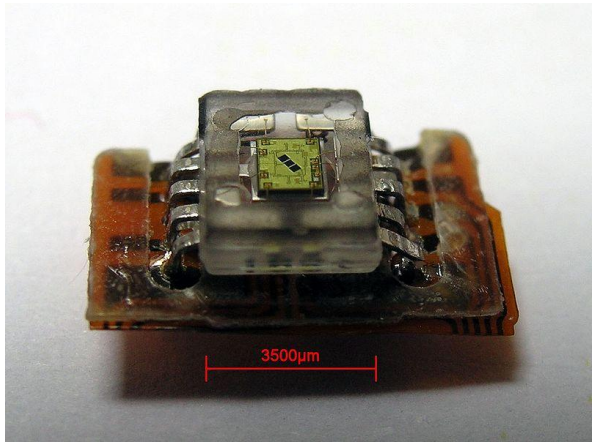


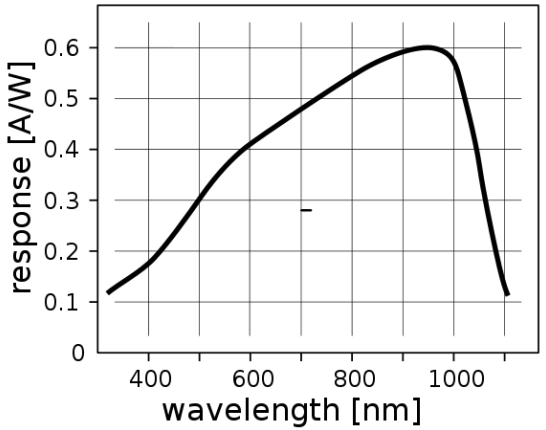
Material semicondutor

Variação de resistência com luz

Tempo de resposta de dezenas de ms (desvantagem???)

Fotodiodo





Modo fotovoltaico
Modo fotocondutivo

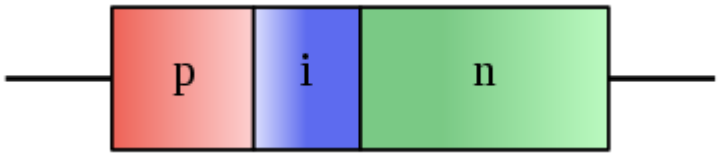
Fotodiodo

Características construtivas

Tipo PN – fotodiodo x fototransistor

Tipo PIN

Tipo avalanche (APD)



Sensibilidade (Responsivity) – A/W, A/lm

Corrente de escuro (Dark current)

Potência equivalente de ruído (Noise-equivalente power)

Resposta em frequência – capacitância da junção

Fotodiodo

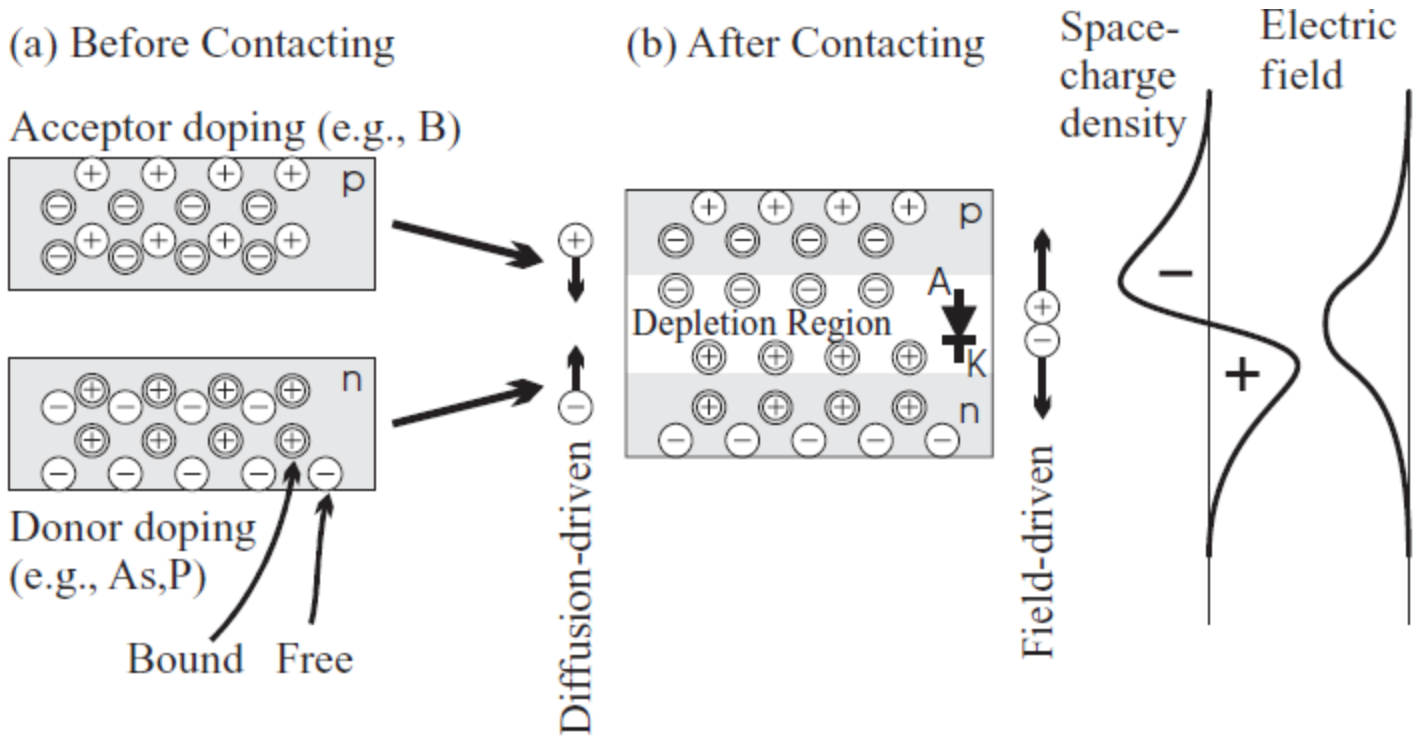


Figure 1.1 The pn-junction. The presence of predominately different polarities of free carriers in the two contacted materials leads to asymmetrical conductivity, a rectifying action. Bound charges are indicated by a double circle and free charges by a single circle.

Fotodiodo

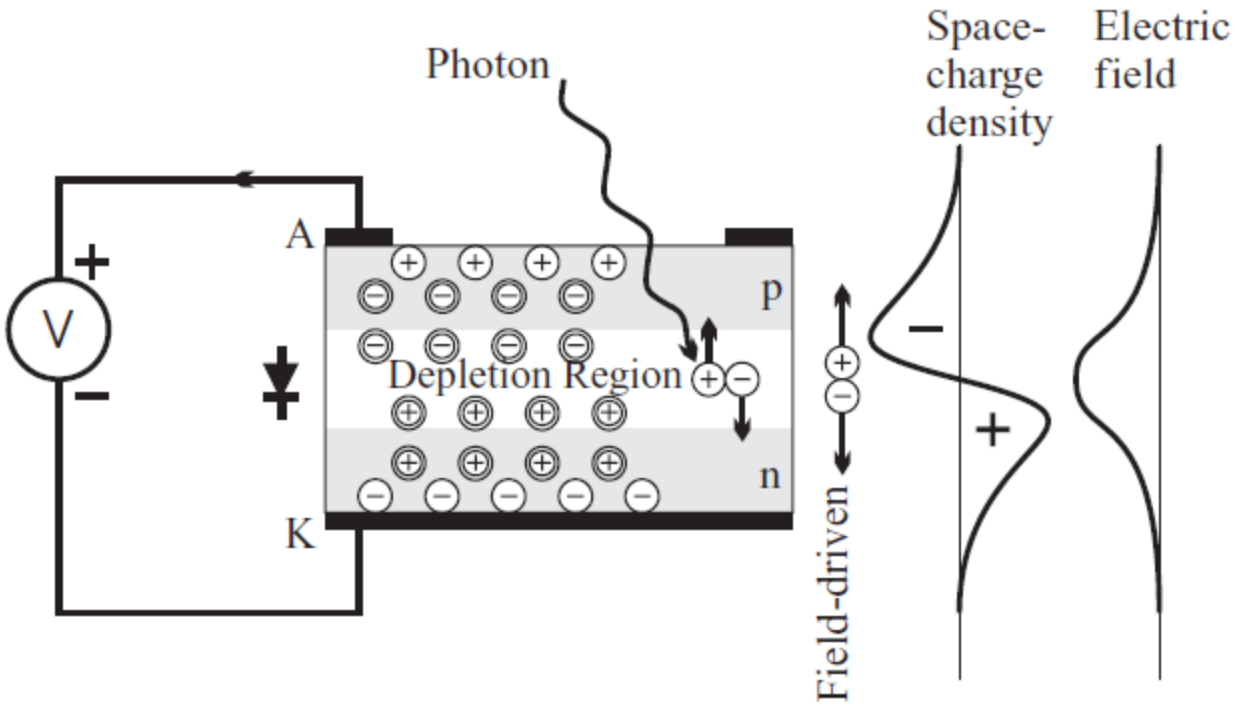


Figure 1.2 When a photon with energy greater than the material bandgap forms a hole-electron pair, a terminal voltage will be generated, positive at the p-type anode.

Fotodiodo

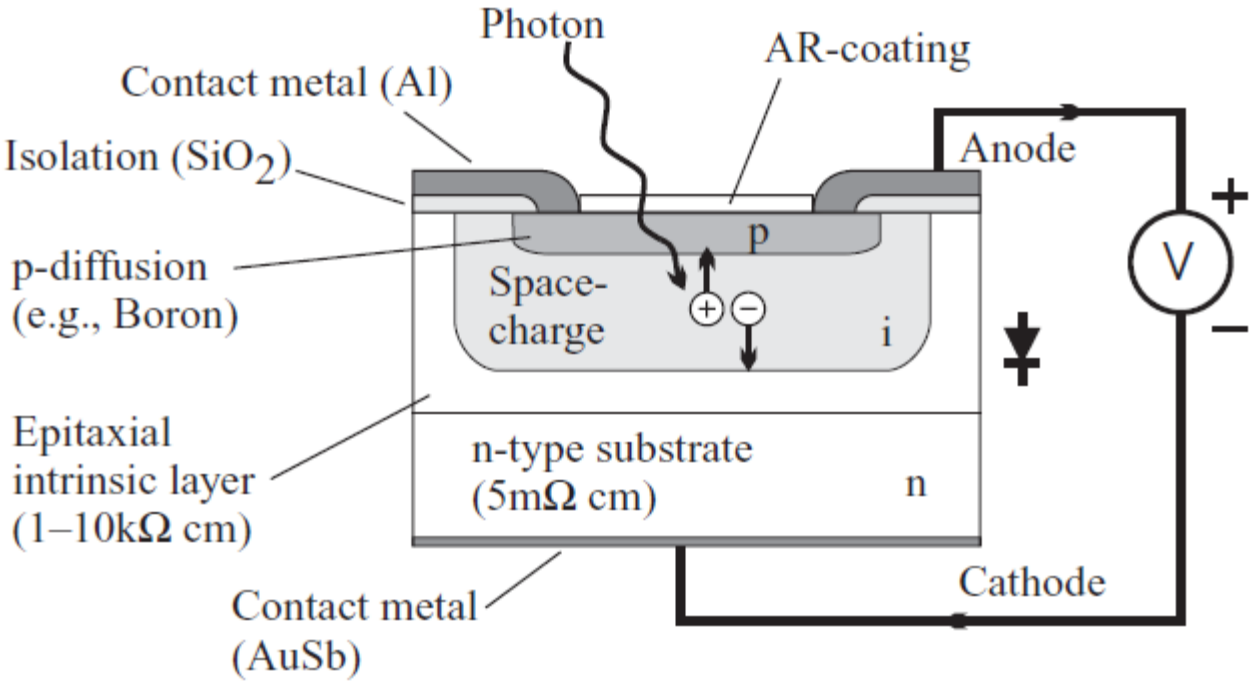


Figure 1.4 Most photodiodes are formed by diffusing dopants into epitaxially formed layers. The use of a low conductivity intrinsic layer leads to thickening of the space-charge region, lower capacitance, and improved sensitivity.

Fotodiodo

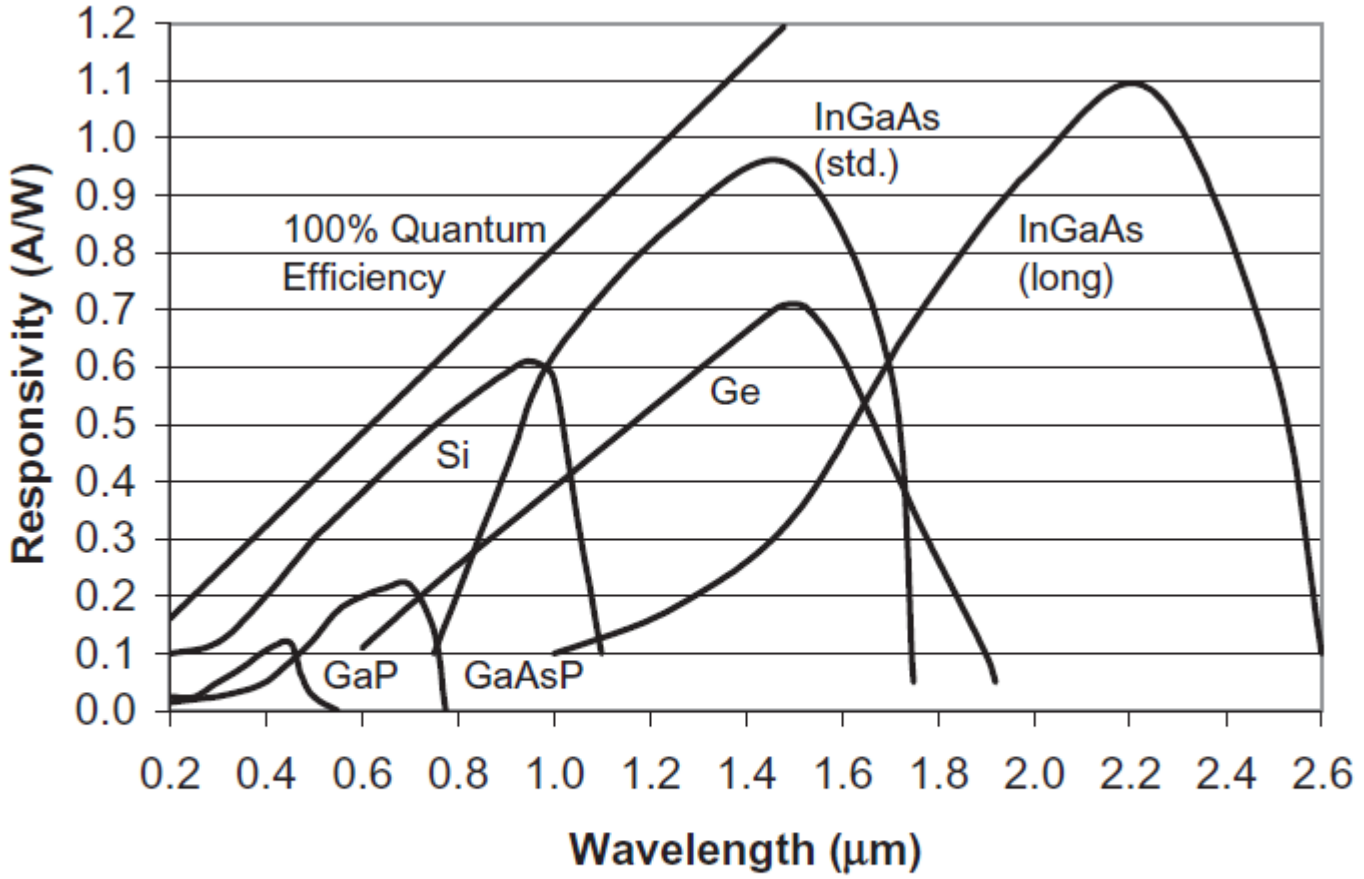


Figure 1.5 Photodiodes of different semiconductor materials show sensitivity in different wavelength regions, limited at long wavelength by their energy gap. 100 percent quantum efficiency means that one photon produces one hole-electron pair.

Fotodiodo

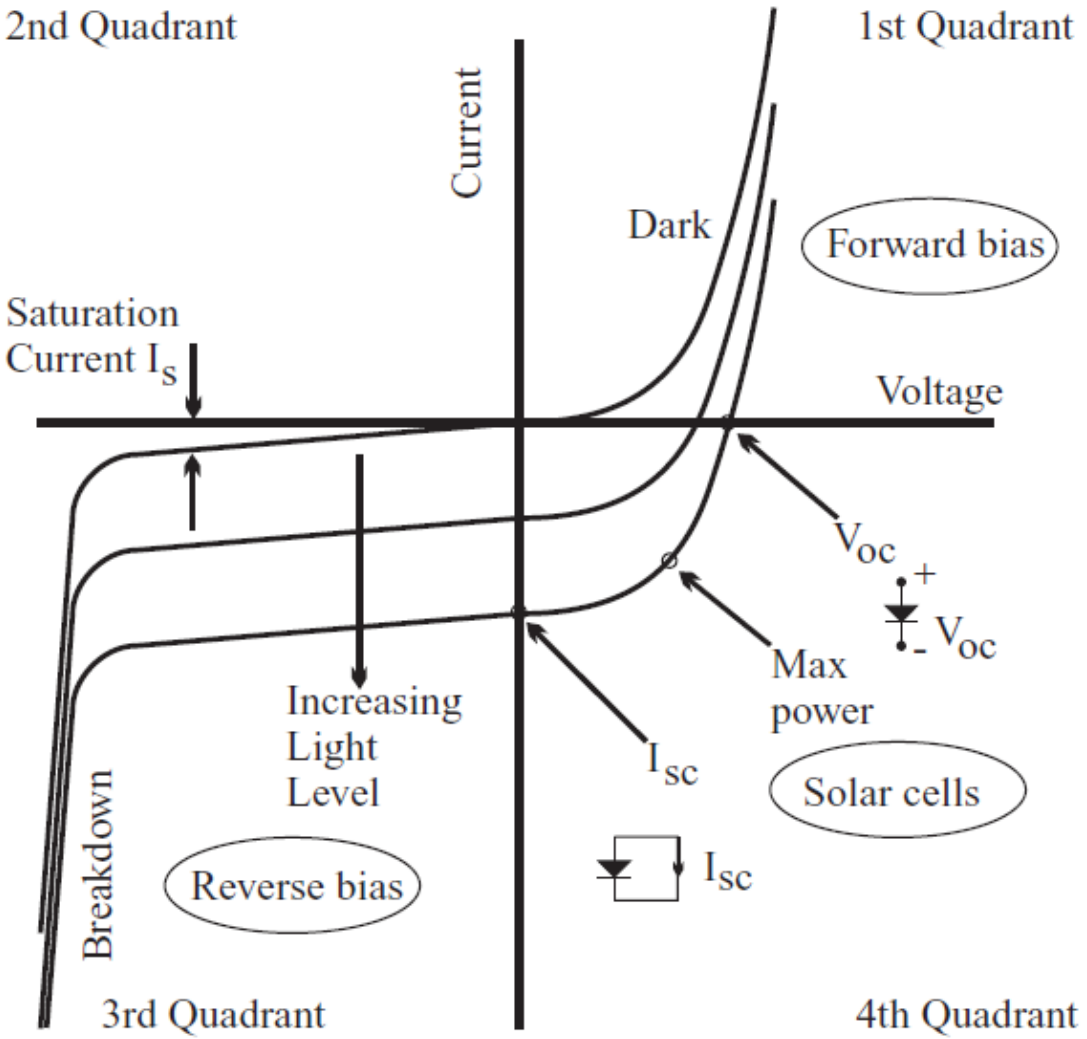
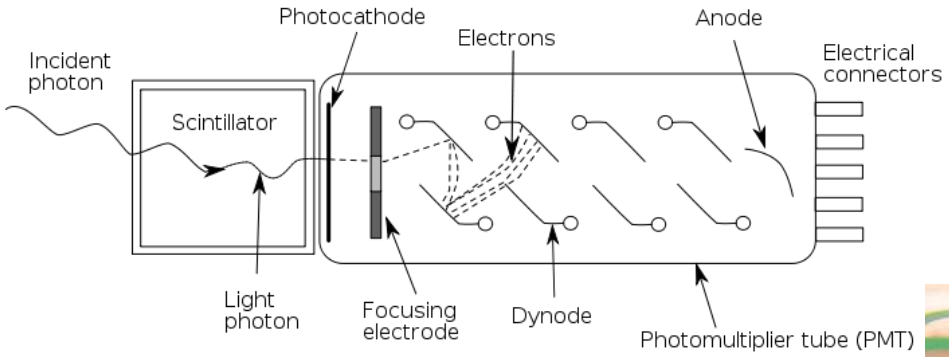


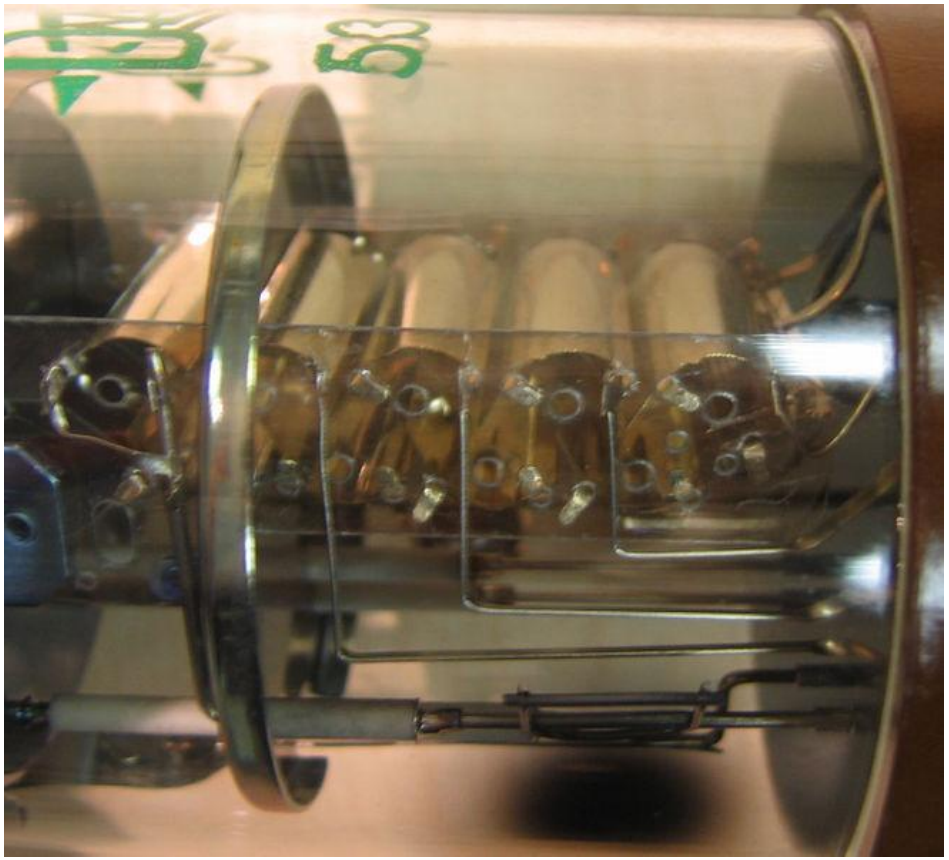
Figure 1.9 Four-quadrant current/voltage characteristic. Without illumination this is similar to a conventional diode. Increasing illumination shifts the characteristic in the negative current direction. Detection is possible in quadrants 1, 3, and 4.

Fotodiodo

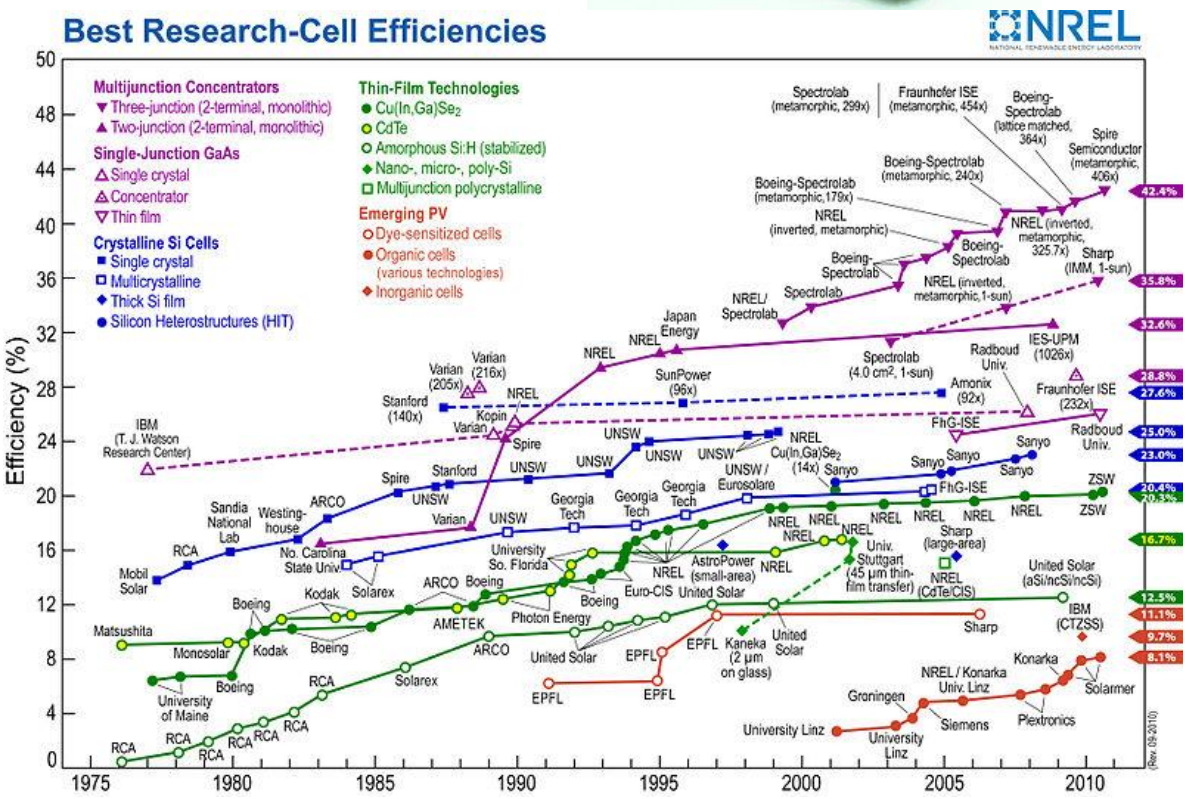
Fotomultiplicador



Ausência de ruído Johnson



Células fotovoltaicas



CCD x CMOS

Ruído, escalabilidade, estabilidade temporal