Physics of Semiconductors (8)

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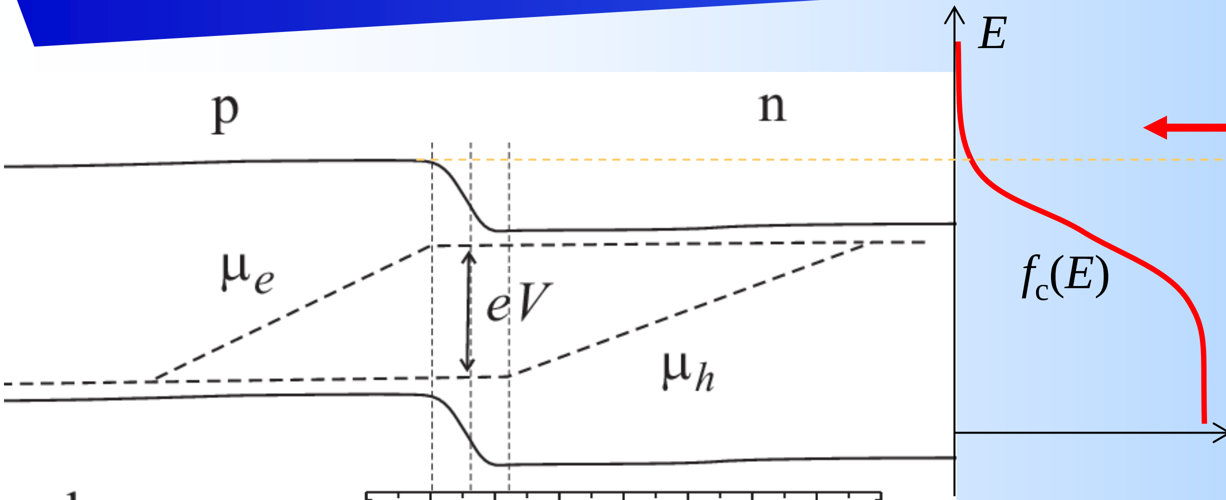
LED paradox (?)

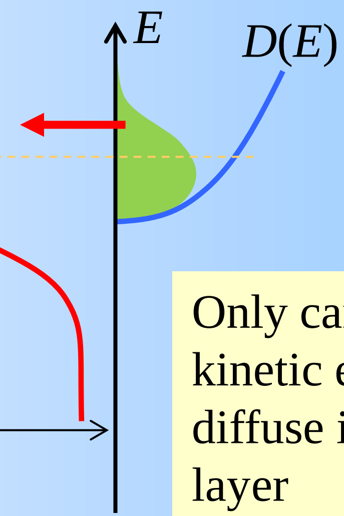
$$\frac{h}{\lambda} = eV \quad \lambda(\mu\mathrm{m})E(\mathrm{eV}) = 1.24$$

2.4 V: 0.517 μm   Green!

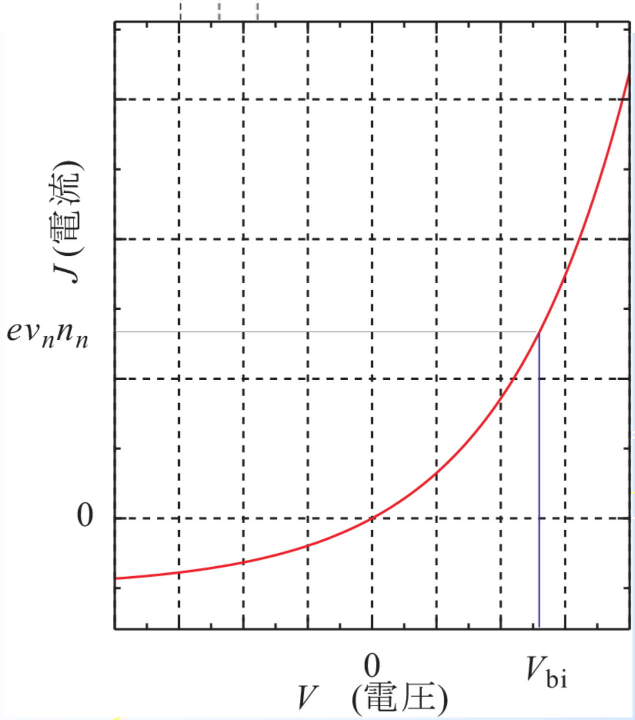
Blue: 0.45 μm -> 2.76eV

LED paradox (?)





Only carriers with high kinetic energies can diffuse into the other layer

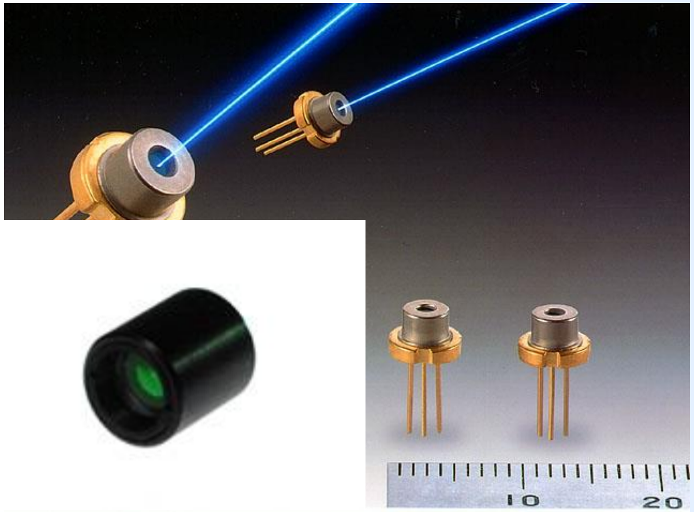


I-V characteristics: observation of distribution function

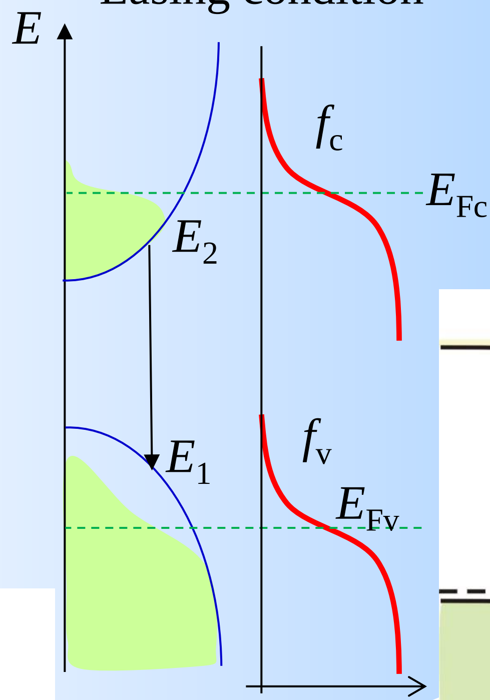
Can be used as a thermometer.

Laser diodes (LDs)

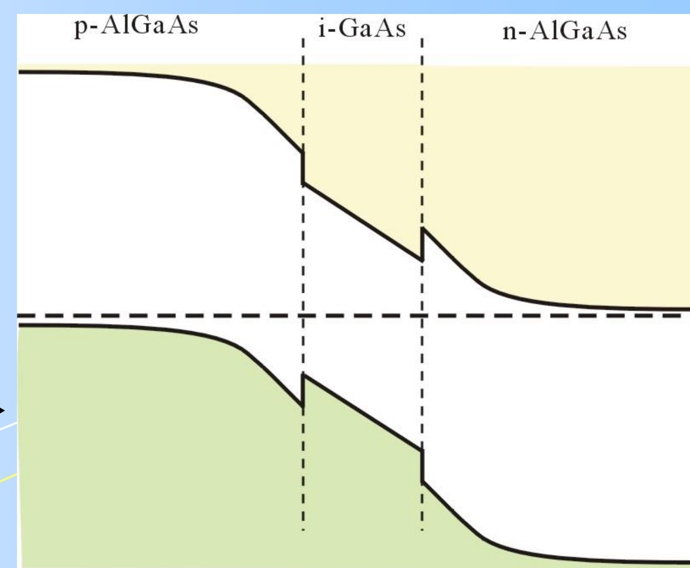
Lasing condition $E_{Fc} - E_{Fv} > E_2 - E_1$

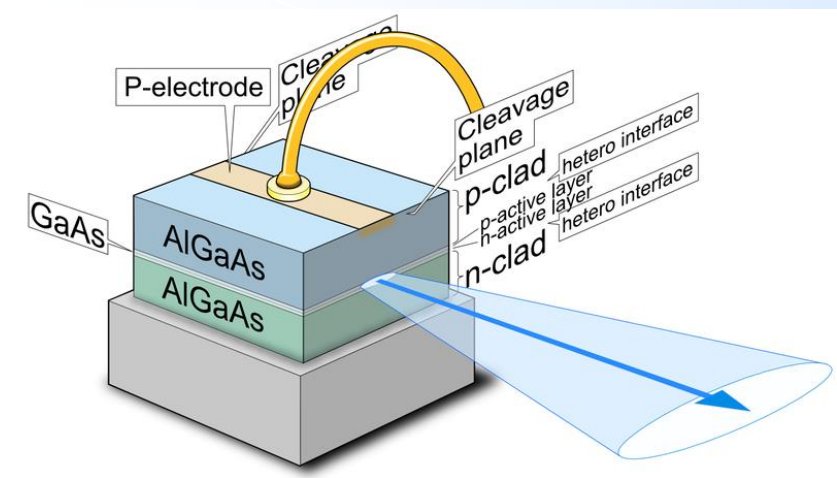


blue LD ((In,Ga)N well material)



double hetero-structure





$$I(z) = I_0 \exp(-\alpha' z)$$

$\alpha' < 0$

Waveguide in LDs

Fabry-Pérot resonator

$$m_j \frac{\lambda}{\bar{n}_2} = 2L$$

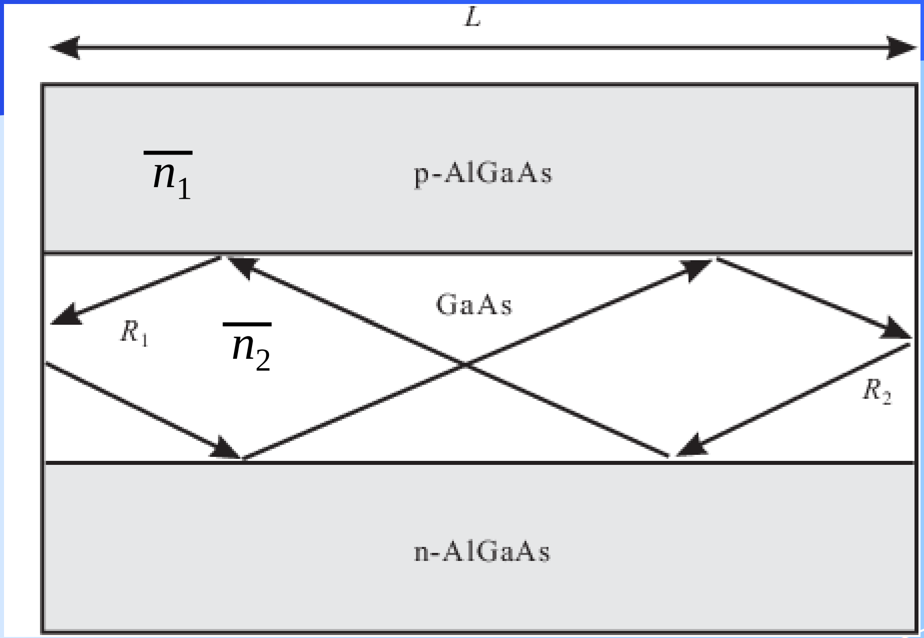
$$\Delta\lambda = \frac{\lambda^2}{2L\bar{n}}, \qquad \Delta\nu = \frac{c}{2L\bar{n}}$$

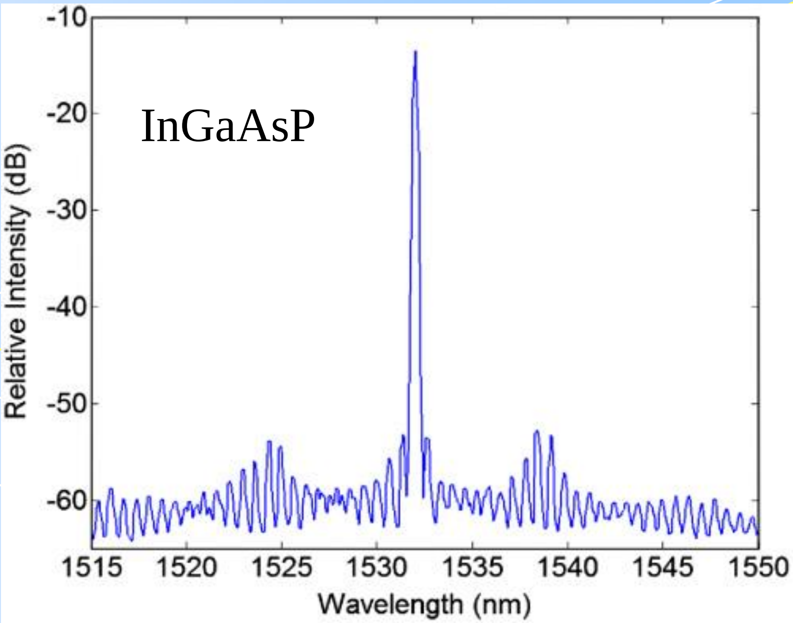
$$I(z) = I_0 \exp(-\alpha' z) = I_0 \exp((g-\alpha)z)$$

$$R_1 R_2 \exp[(g-\alpha)2L] > 1$$

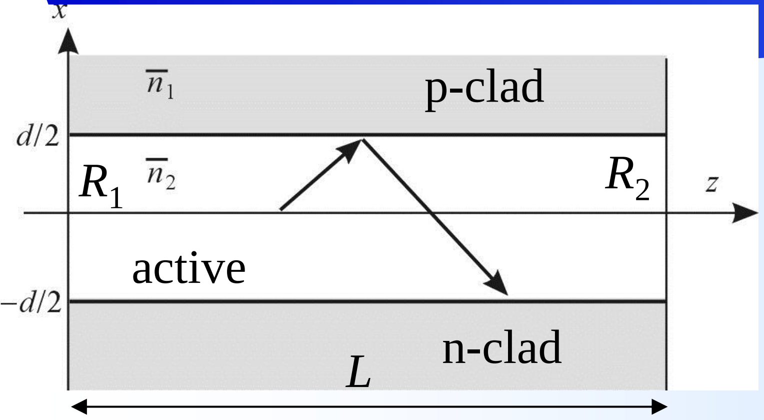
$$g_{\text{th}} = \alpha + \frac{1}{L}\ln\left(\frac{1}{R_1 R_2}\right)$$

critical angle $\theta_c = \arcsin\left[\frac{\bar{n}_1}{\bar{n}_2}\right] \quad \therefore \bar{n}_2 > \bar{n}_1$





Waveguide in LDs



TE mode

$$\left[\frac{\partial^2}{\partial x^2}+\frac{\partial^2}{\partial z^2}-\mu_0\epsilon_0\epsilon\frac{\partial^2}{\partial t^2}\right]\mathcal{E}_y=0.$$

$$\mathcal{E}_y(x,z,t)=A\cos\left(\frac{\kappa d}{2}\right)\exp\left[-\gamma\left(|x|-\frac{d}{2}\right)\right]\exp[i(\omega t-\beta z)]\quad\left(|x|>\frac{d}{2}\right)$$

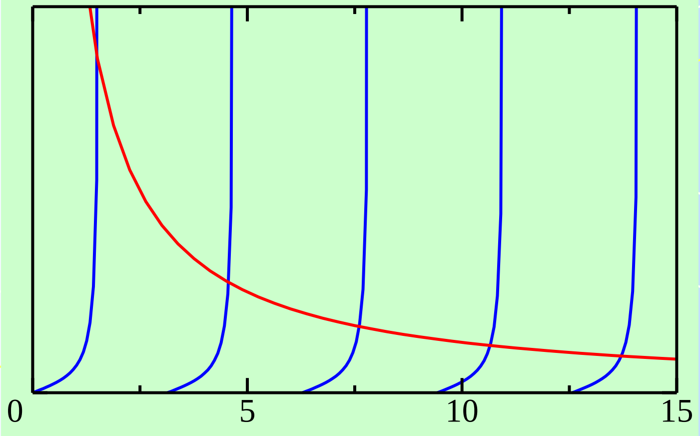
$$\mathcal{E}_y(x,z,t)=A\cos(\kappa x)\exp[i(\omega t-\beta z)]\quad\left(|x|\le\frac{d}{2}\right)$$

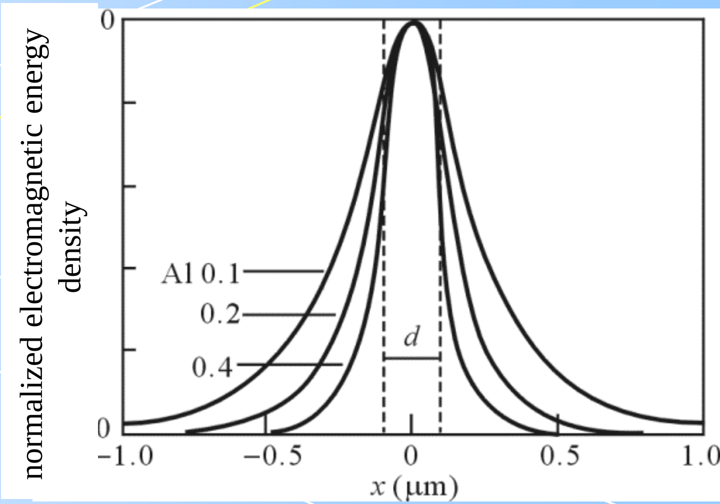
$$\kappa^2=\mu_0\epsilon\epsilon_0\omega^2-\beta^2=\bar{n}_2^2k_0^2-\beta^2,\quad k_0=\frac{\omega}{c^*\bar{n}_2}$$

$$\gamma^2=\beta^2-\bar{n}_1^2k_0^2$$

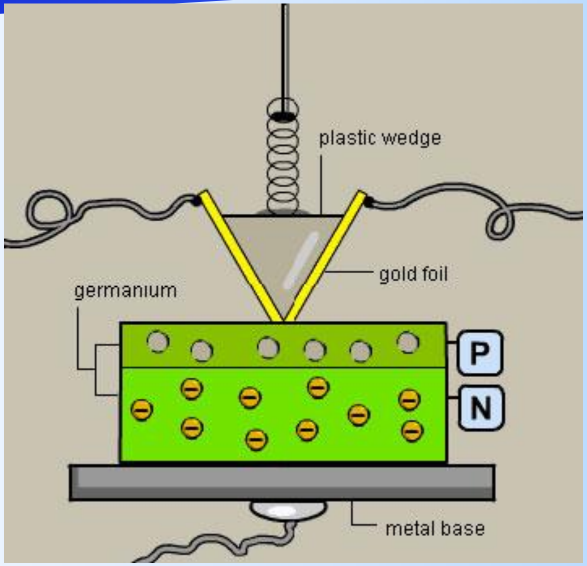
$$\tan\left(\frac{\kappa d}{2}\right)=\frac{\gamma}{\kappa}$$

$$\bar{n}_2>\bar{n}_1$$



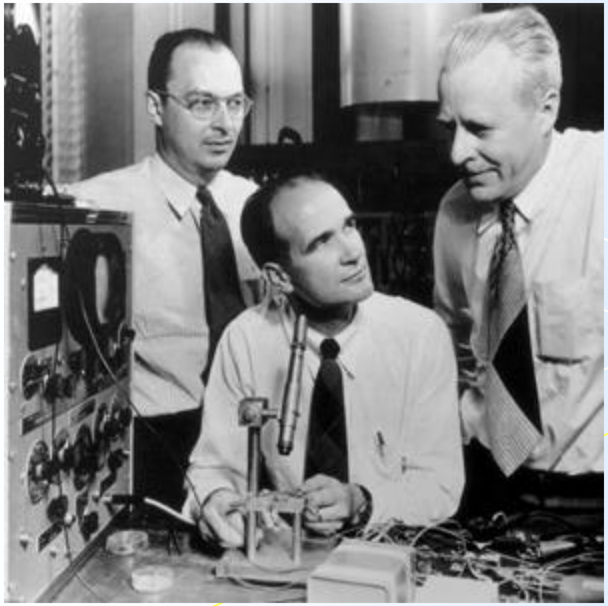


Invention of Transistor



The first point contact transistor

(Dec. 1947,
published Jun. 1948)

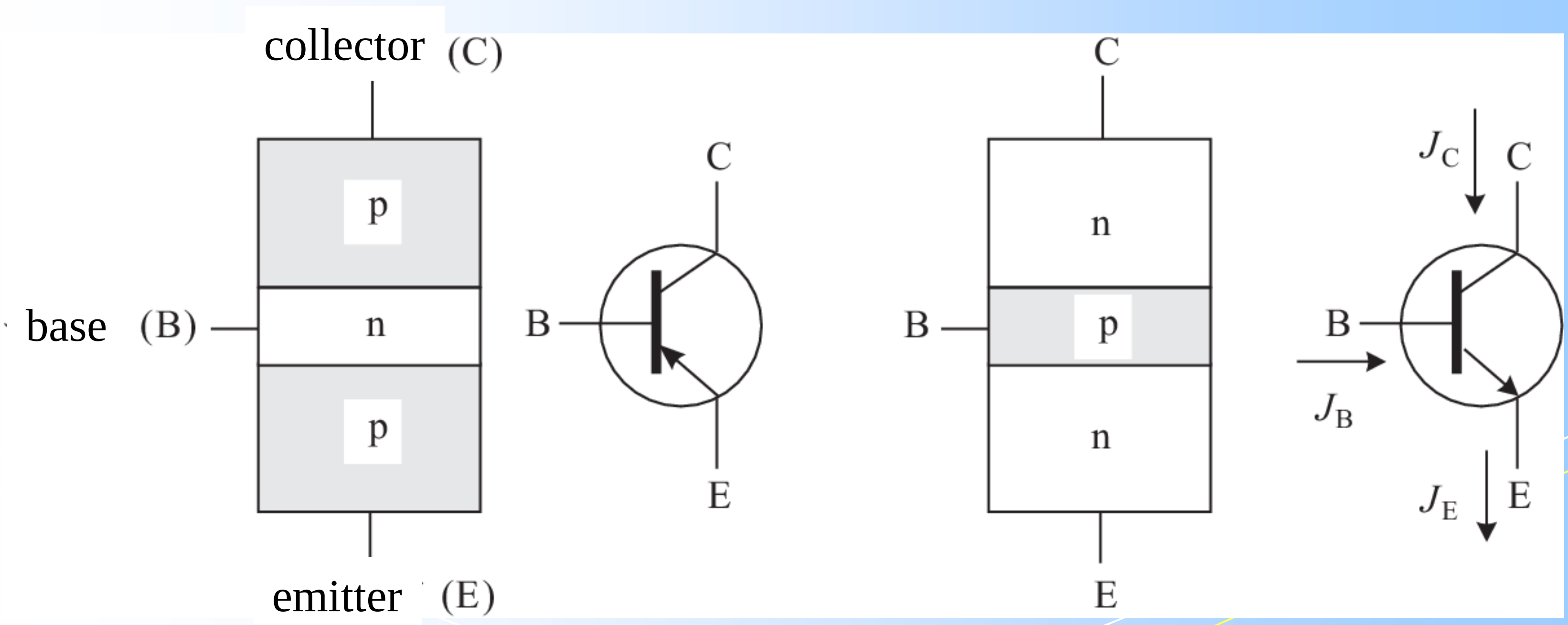


John Bardeen

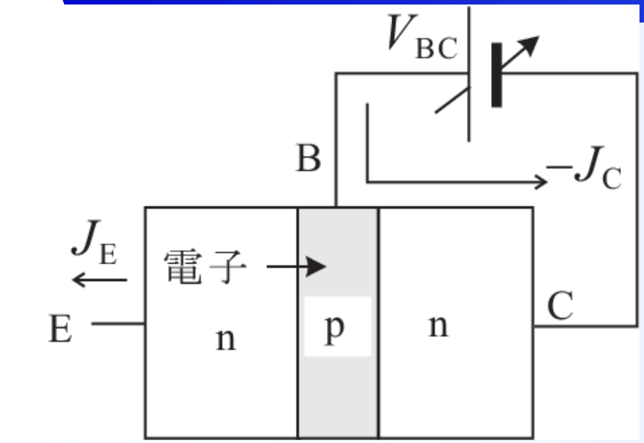
William Shockley

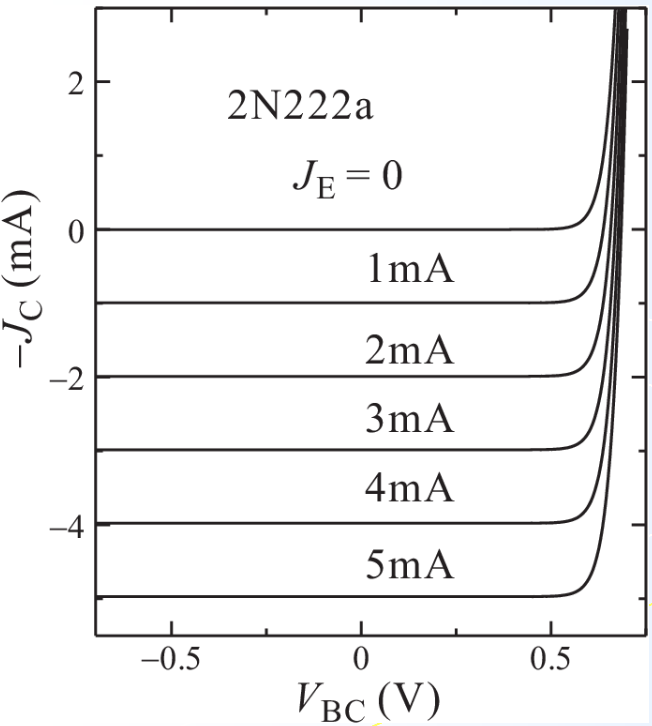
Walter Brattain

Bipolar Junction Transistors (BJT)



Transistors and Solar Cells

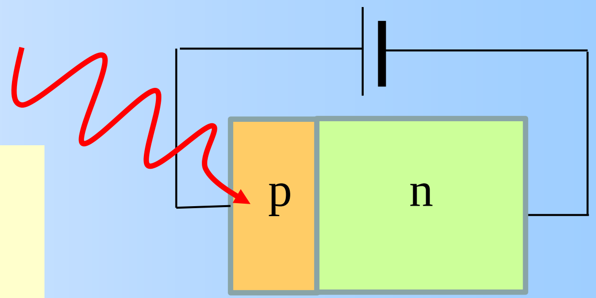




Transistors

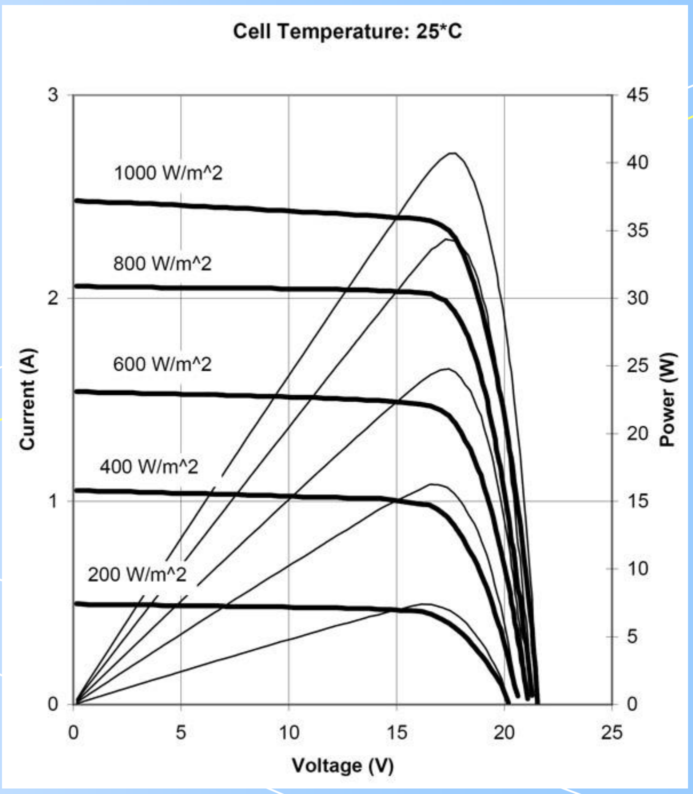
minority carrier injection by another pn junction

-> large reverse current

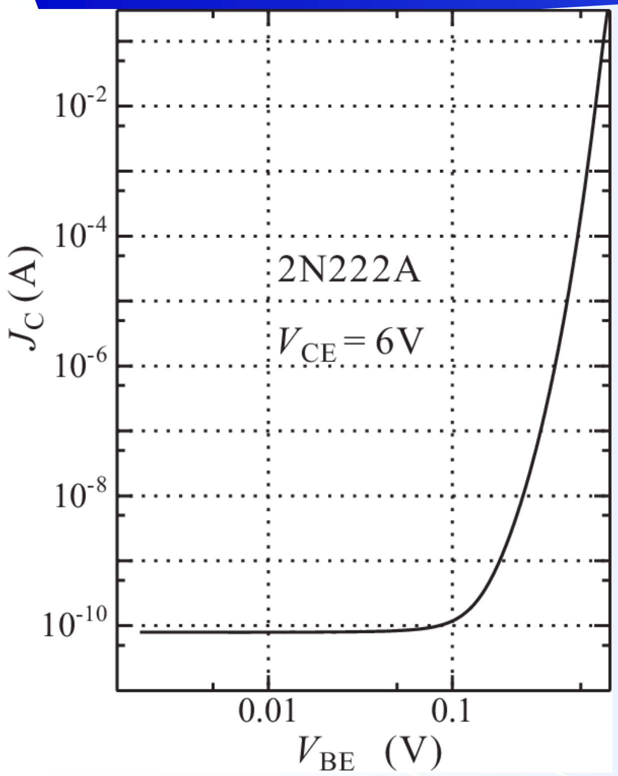


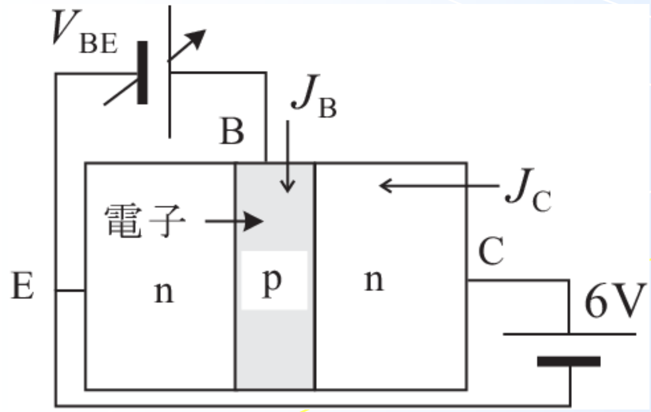
Solar cells

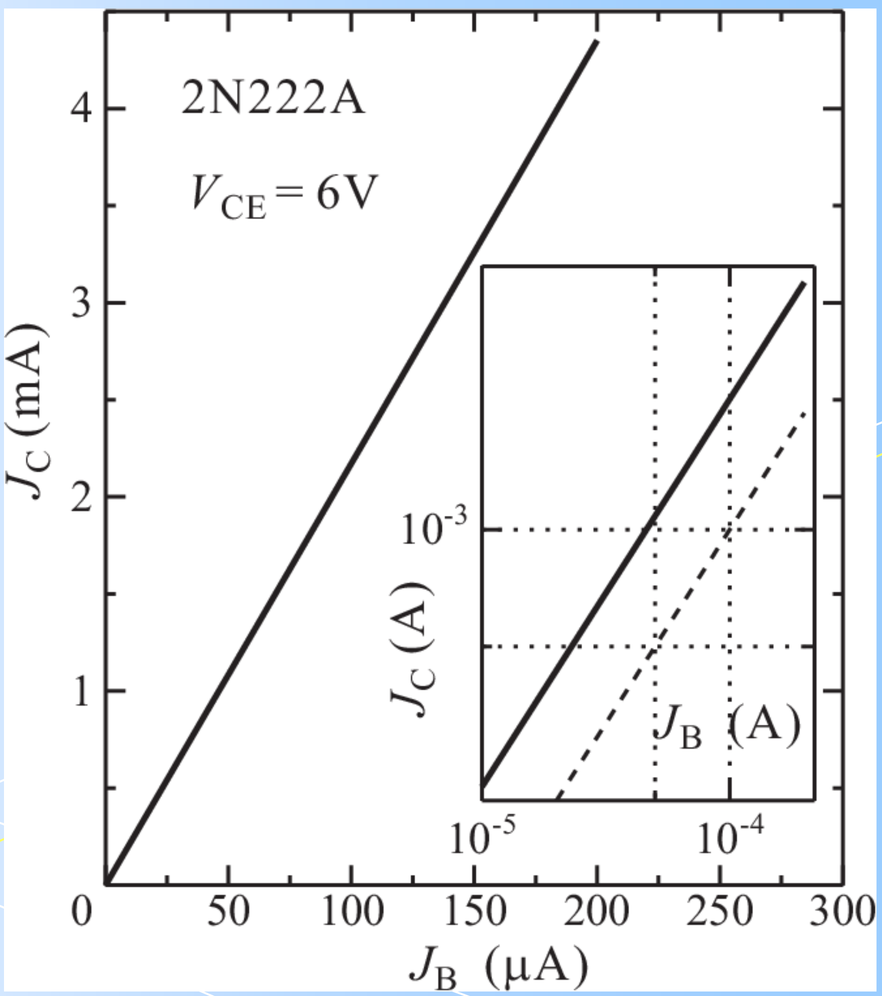
optical injection of minority carriers



"Current amplification" by BJT



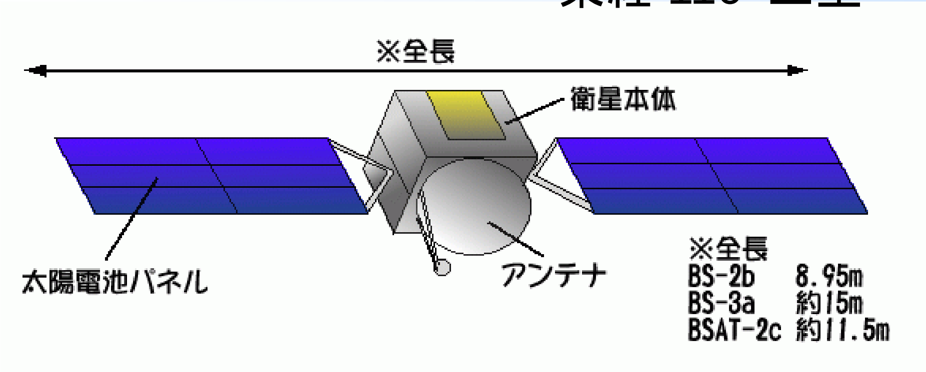




宇宙用太陽電池 – 応用研究の例

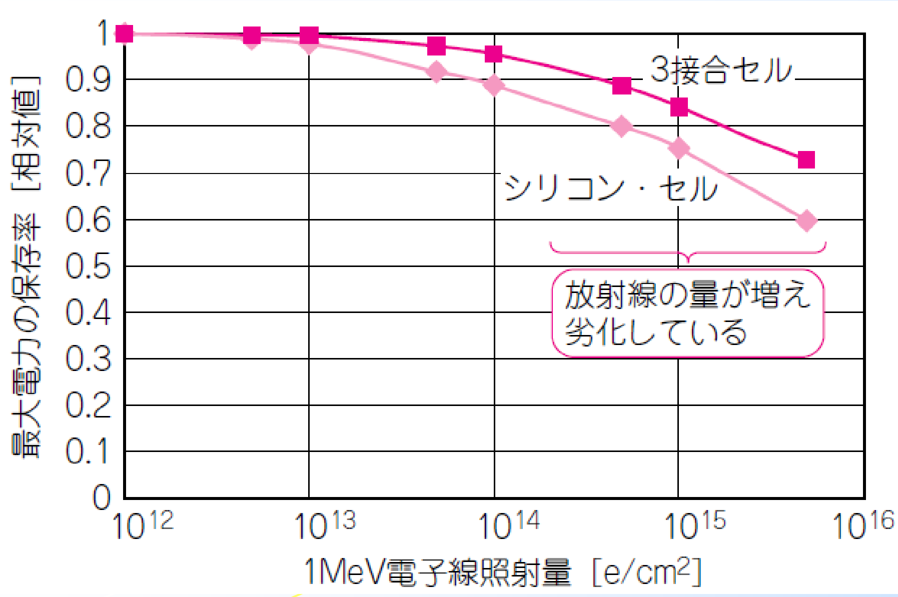
BS電源トラブルの例

東経 110°上空



放送衛星の基本形状と大きさ

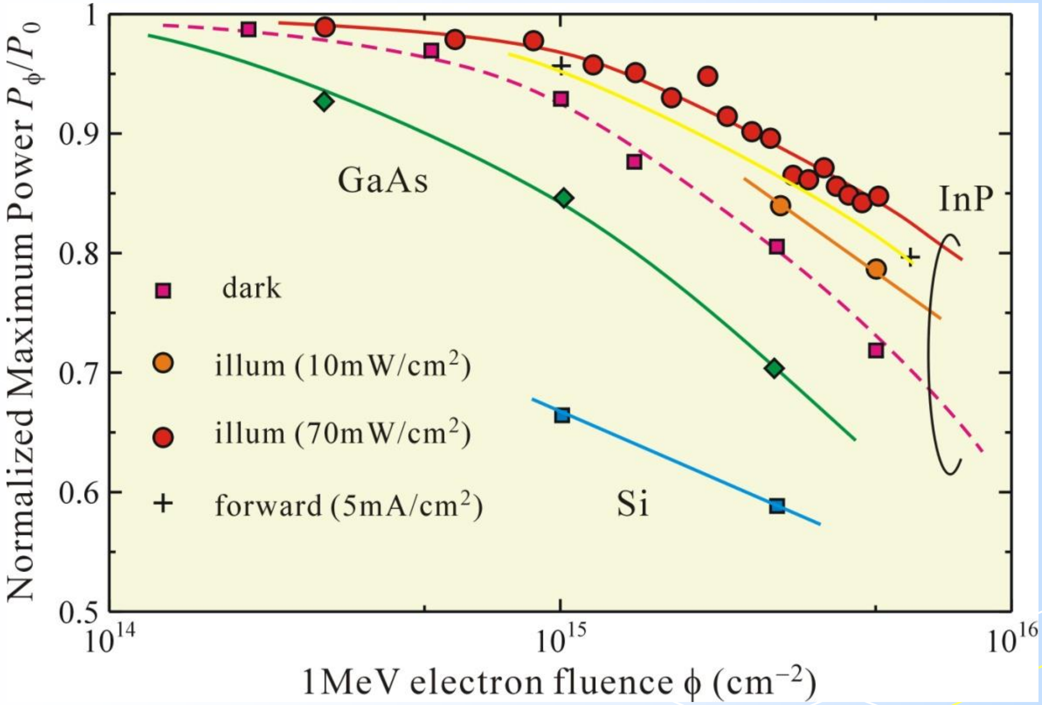
BS-3a では打ち上げ当初から、衛星の不良により所要の発生電力が得られないため、この衛星だけでは 2ch 同時放送しかできず、残り 1ch を古いBS-2b が肩代わり.
初期不良？初期劣化？
食の時期には太陽電池に光が当たらず、放送に必要な電力を賄えないため、放送中断

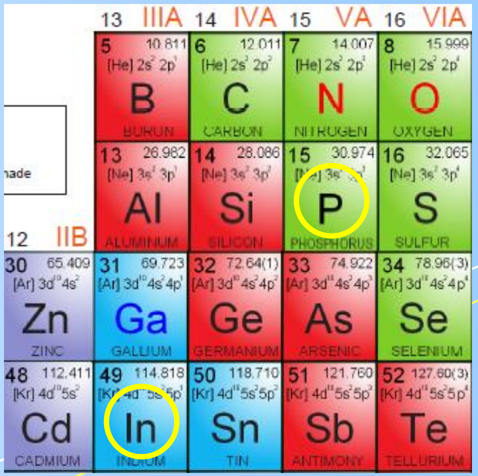


10 年間の被ばく量は1 MeV のエネルギの電子線に換算しておよそ1×10^{15} 個/cm^2 程度

面積単価より，高効率，低劣化，軽量が重要

Radiation resistive InP solar cells



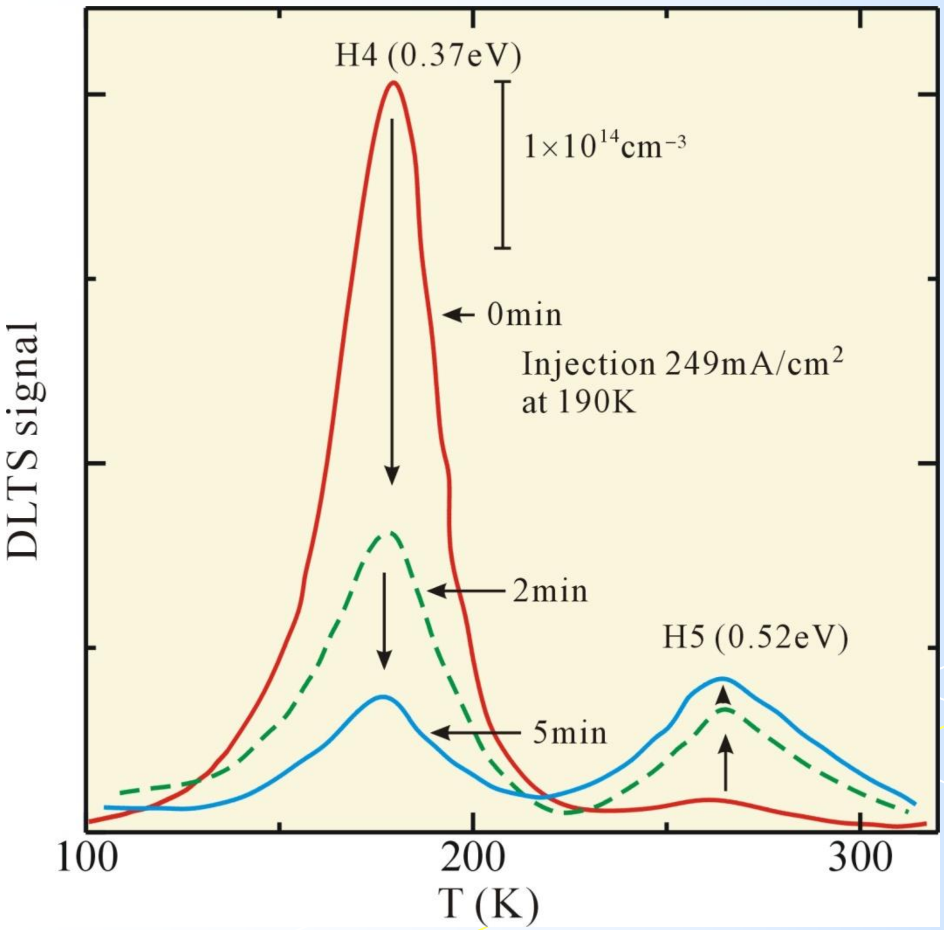


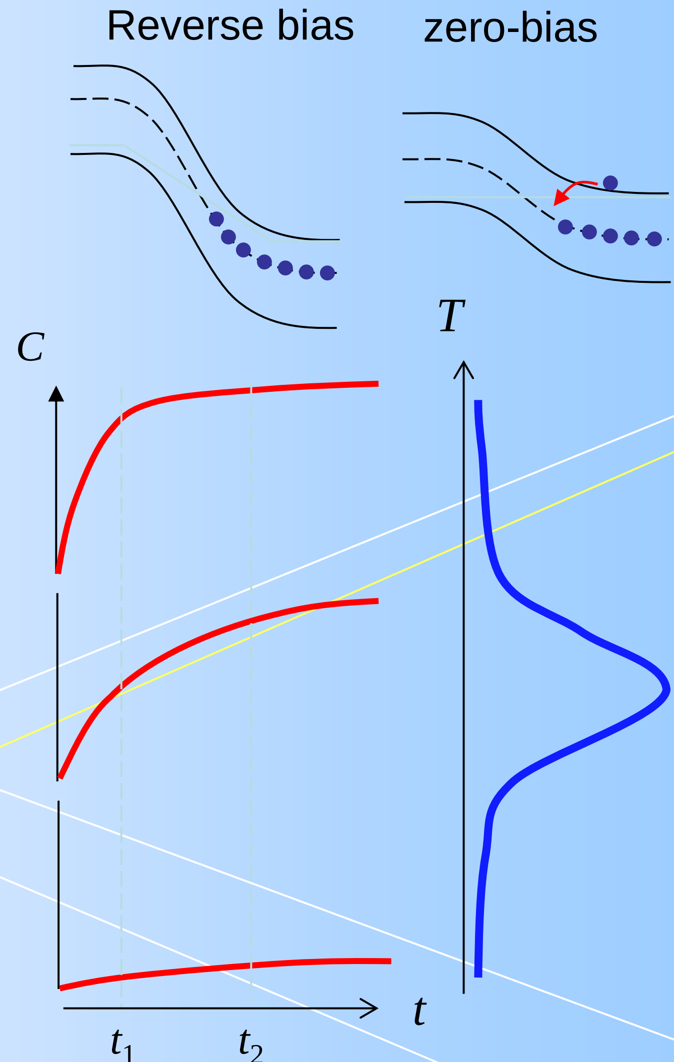
Radiation resistive InP solar cells

deep level transient spectroscopy, DLTS

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

depletion layer width





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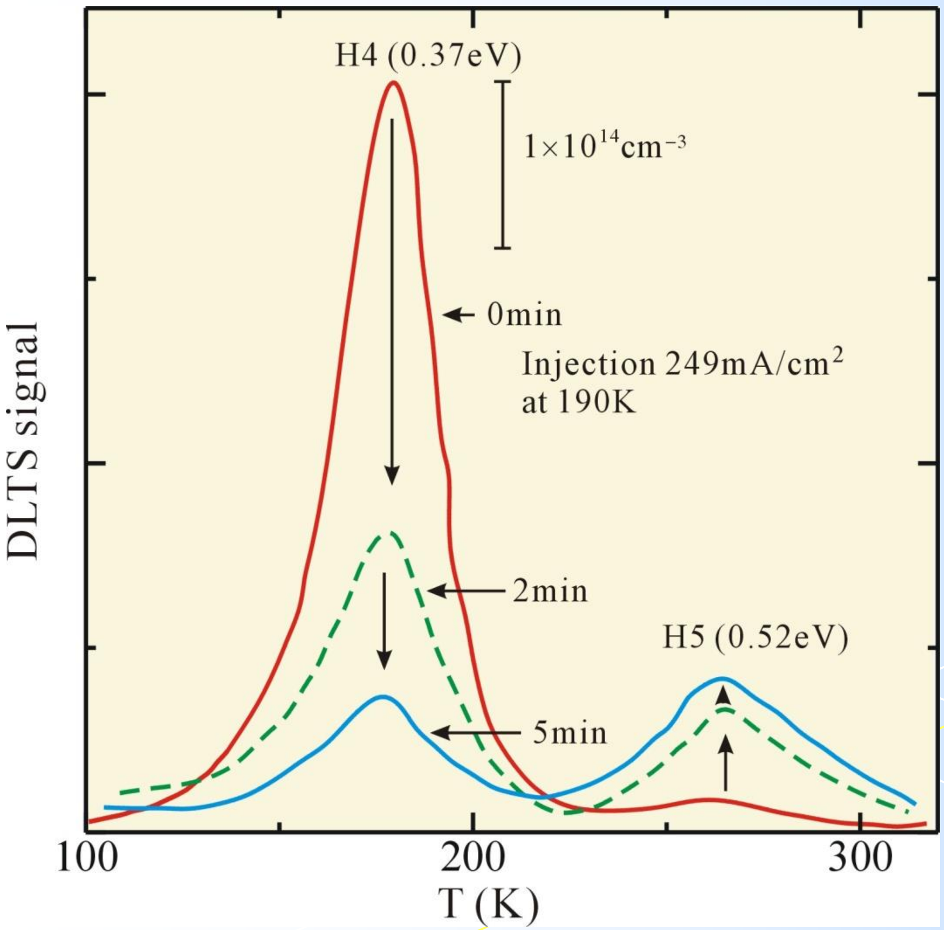

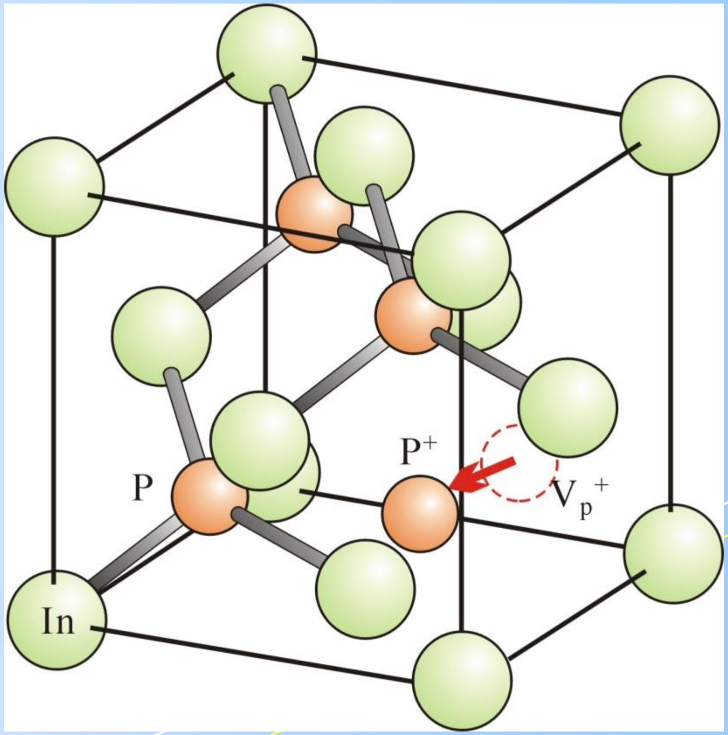

2004 Becquerel Prize
2008 Cherry Award

M. Yamaguchi

High-efficiency, light-weight cells

Materials with In: similar resistivity to radiation

InGaAs bottom cell
GaAs, InGaAlAs top cell

Film cells on Si