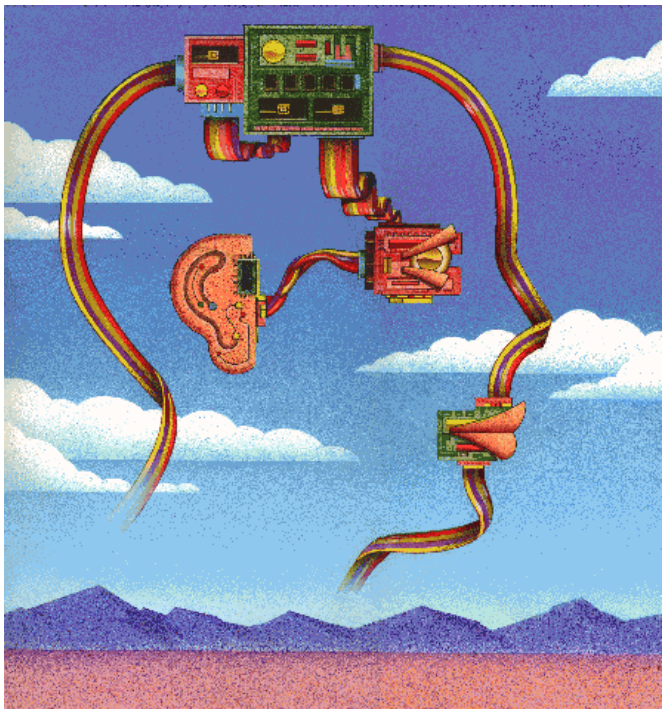

Silicon Photoreceptors

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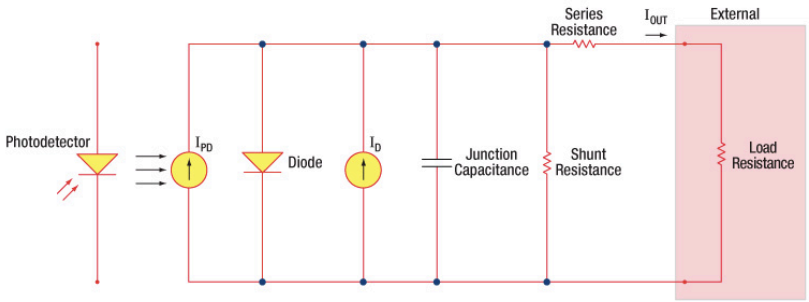
Silicon Photoreceptors – Levels of Abstraction-

Model Equations

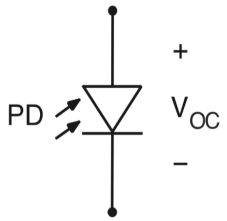
$$I_D = I_{SAT}\left(e^{\frac{qV_A}{k_B T}} - 1\right)$$

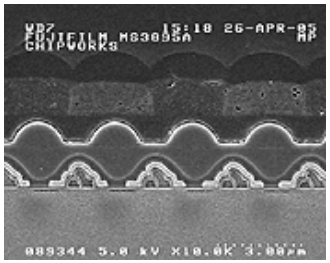
$$V_{oc} = N * V_t \ln\left(\frac{I_{photo}}{I_{dark}} + 1\right)$$



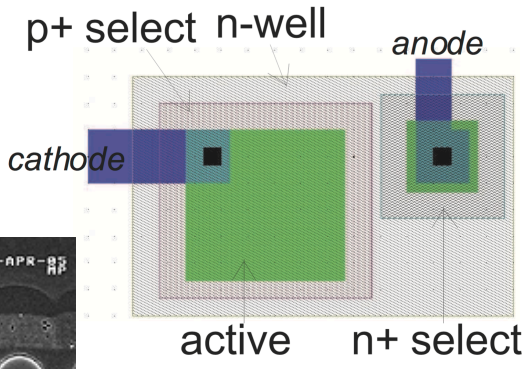
MATHEMATICAL

Symbol

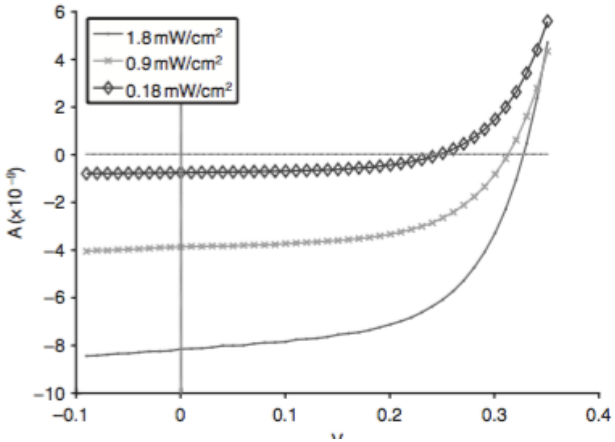




SEM picture



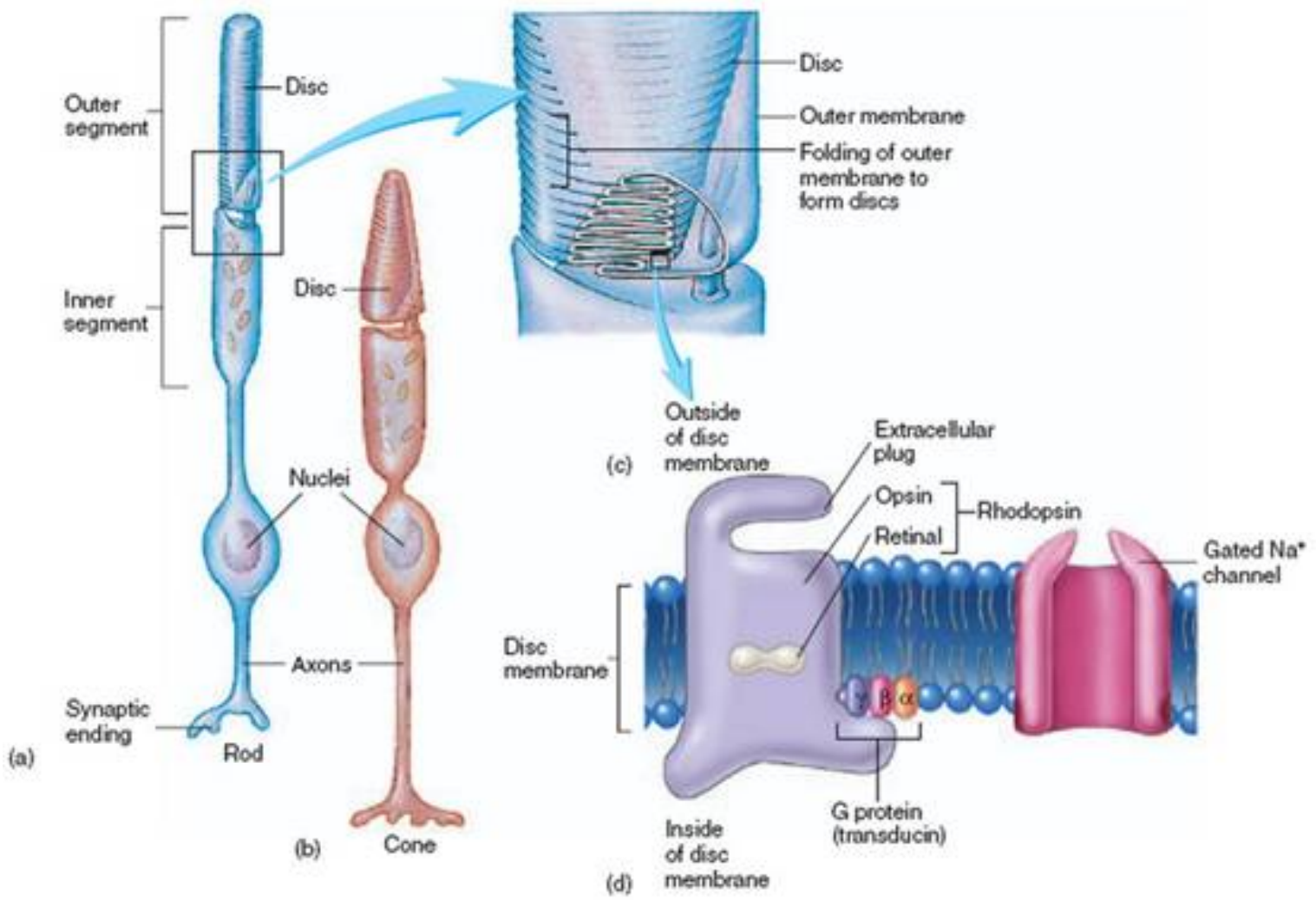
Layout



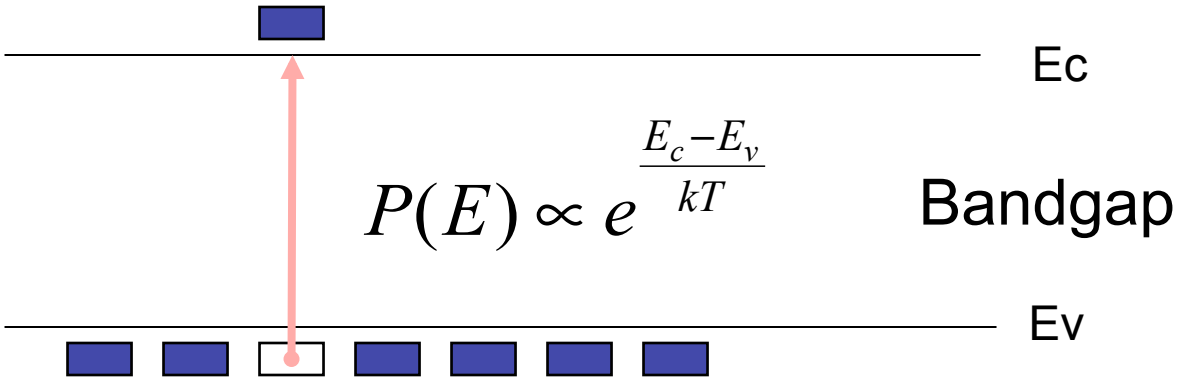
Current – Voltage Characteristics

PHYSICAL

How do we see?

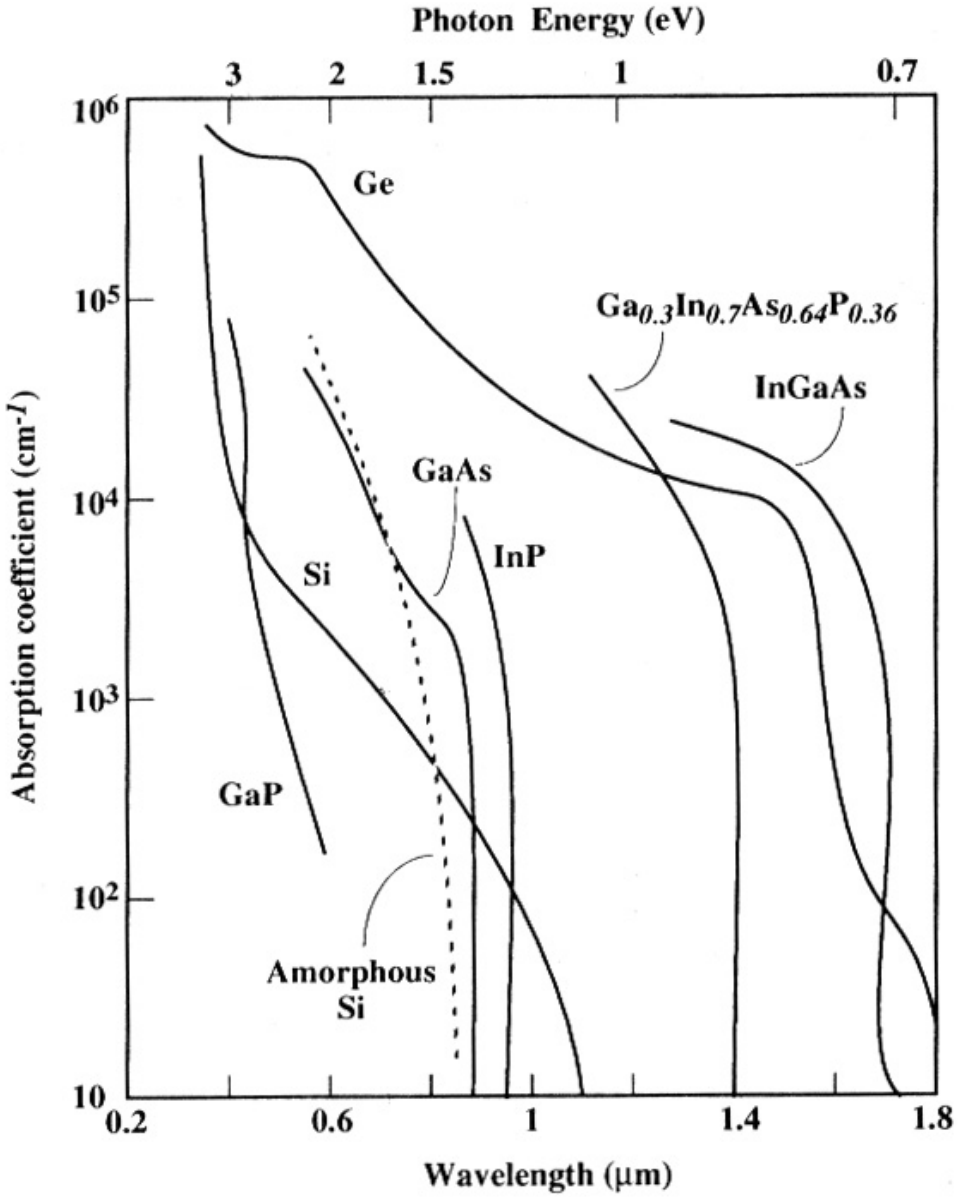

Outer segment
Inner segment
Disc
Nuclei
Axons
Synaptic ending
Rod
(a)
Disc
Cone
(b)
Disc
Outer membrane
Folding of outer membrane to form discs
Outside of disc membrane
(c)
Extracellular plug
Opsin
Retinal
Rhodopsin
Gated Na+ channel
Disc membrane
G protein (transducin)
Inside of disc membrane
(d)

Silicon material: a solid-state physics primer



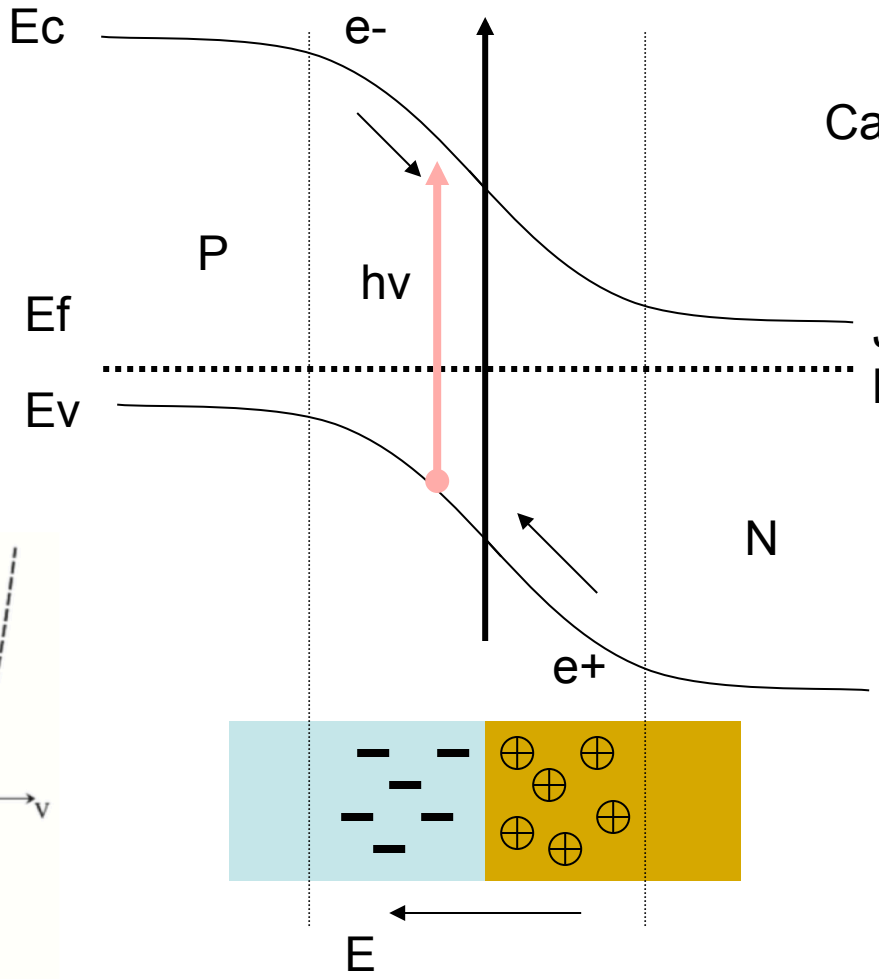
Energy: hv = hc / l = 1.24 / l(m) in eV hv= Eg = 1.1eV for Si

From photons to electrons: the physics of phototransduction



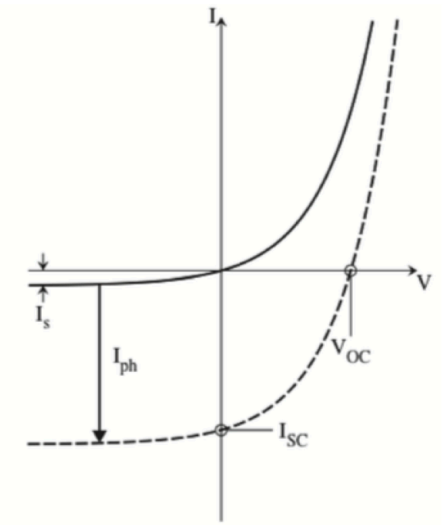
Green: 550 nm ~ 2.5 eV
Red: 700-800 nm ~ 1.7 eV
GaAs LEDs: 860nm ~ 1.3eV

PN junction under Illumination

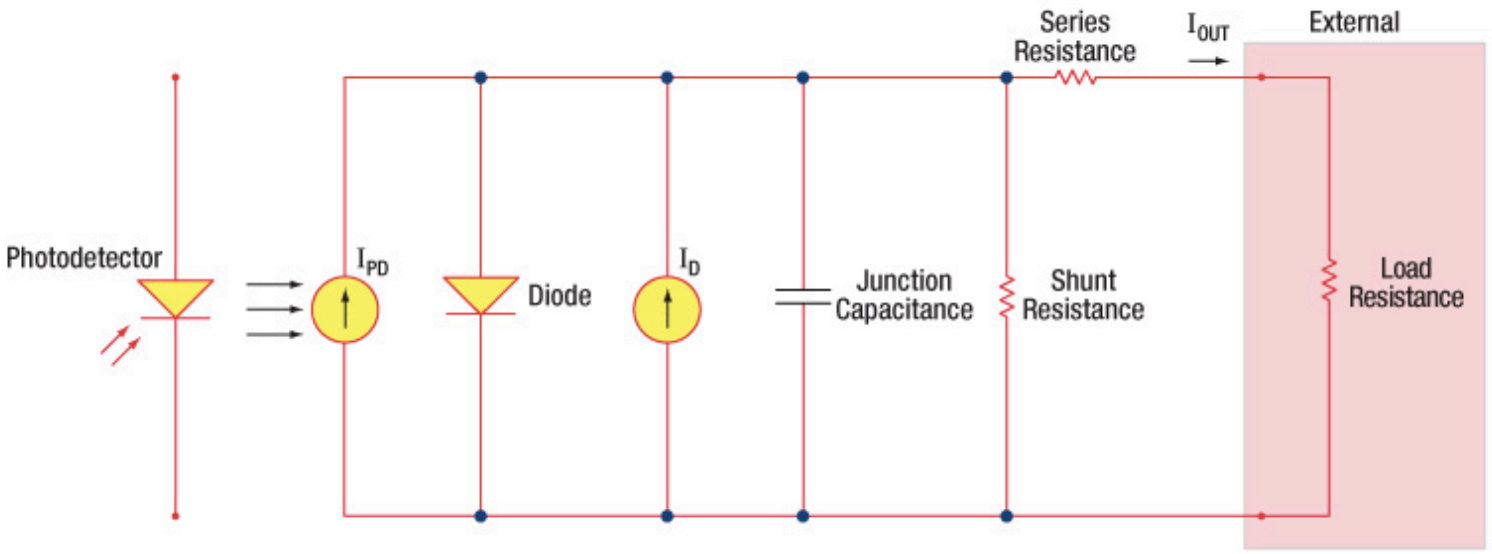


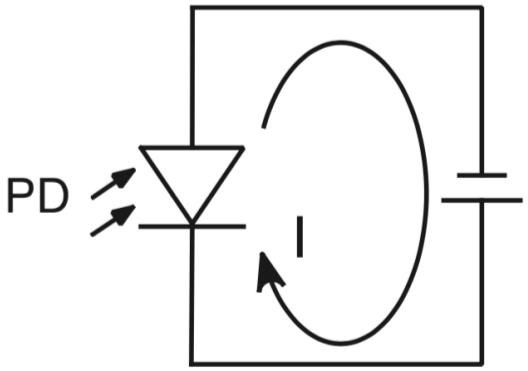
Carriers “Go home”

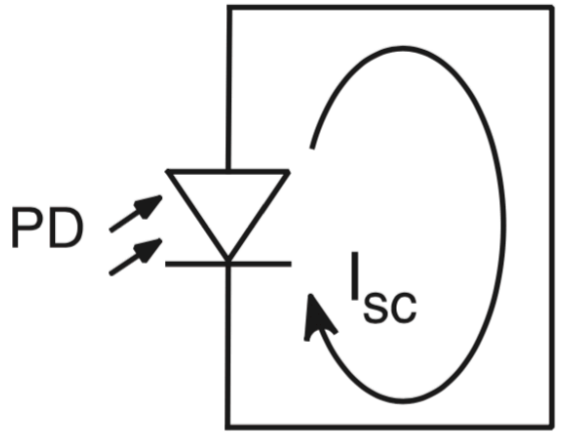
Junction is forward biased by the light



Photodiode Models



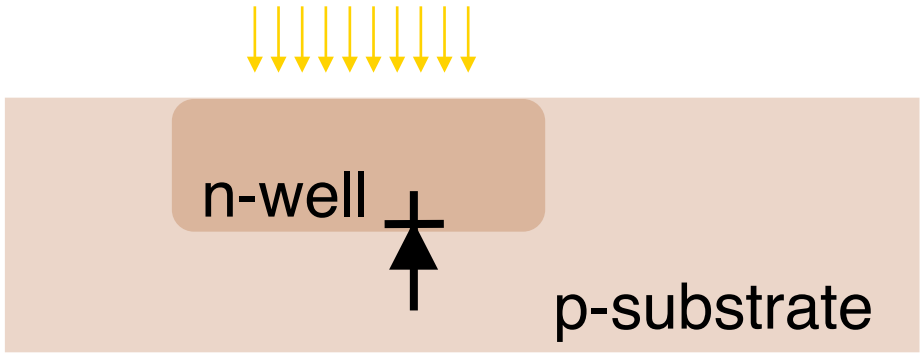




PN Junction in CMOS: your ideas?

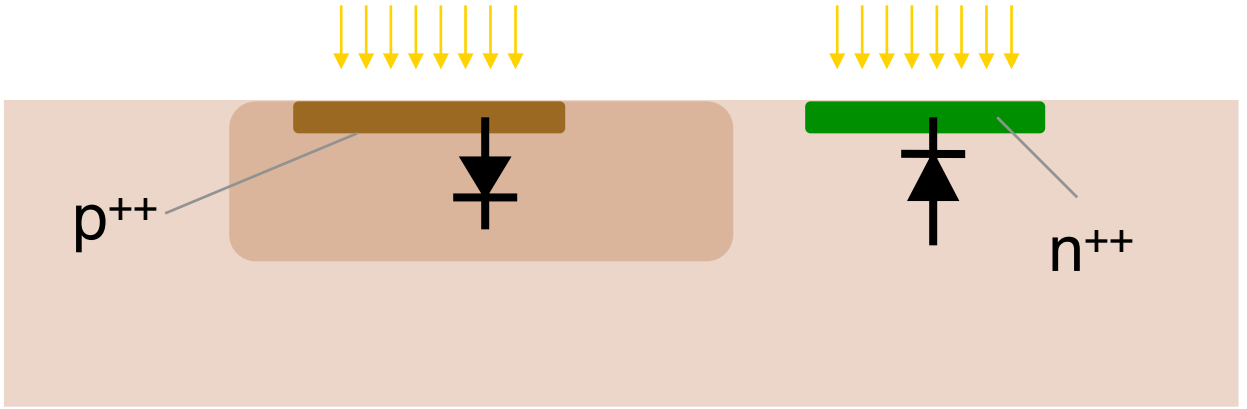
PN junctions in CMOS (I)

n-well / p-sub diode



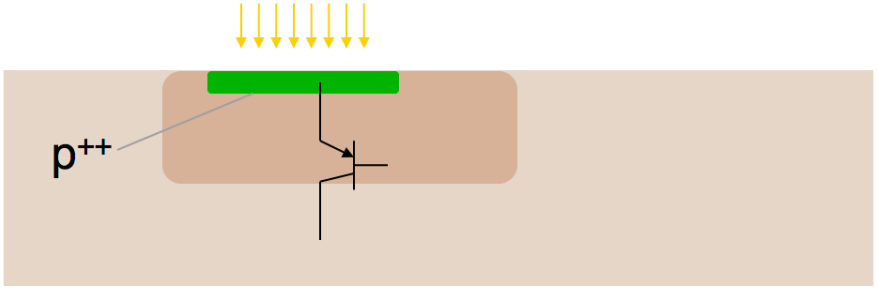
n-well / p-diff diode

n-diff / p-sub diode

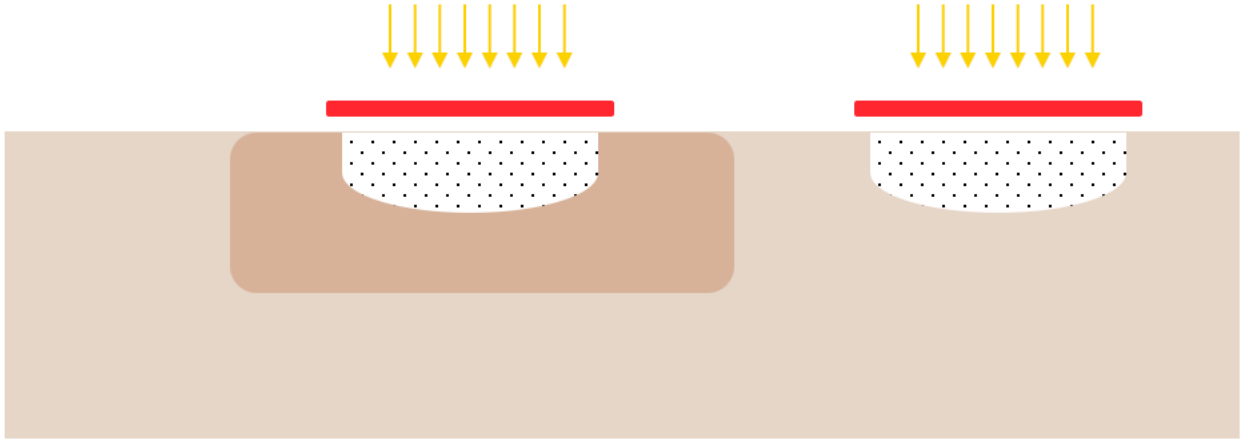


PN junctions in CMOS (II)

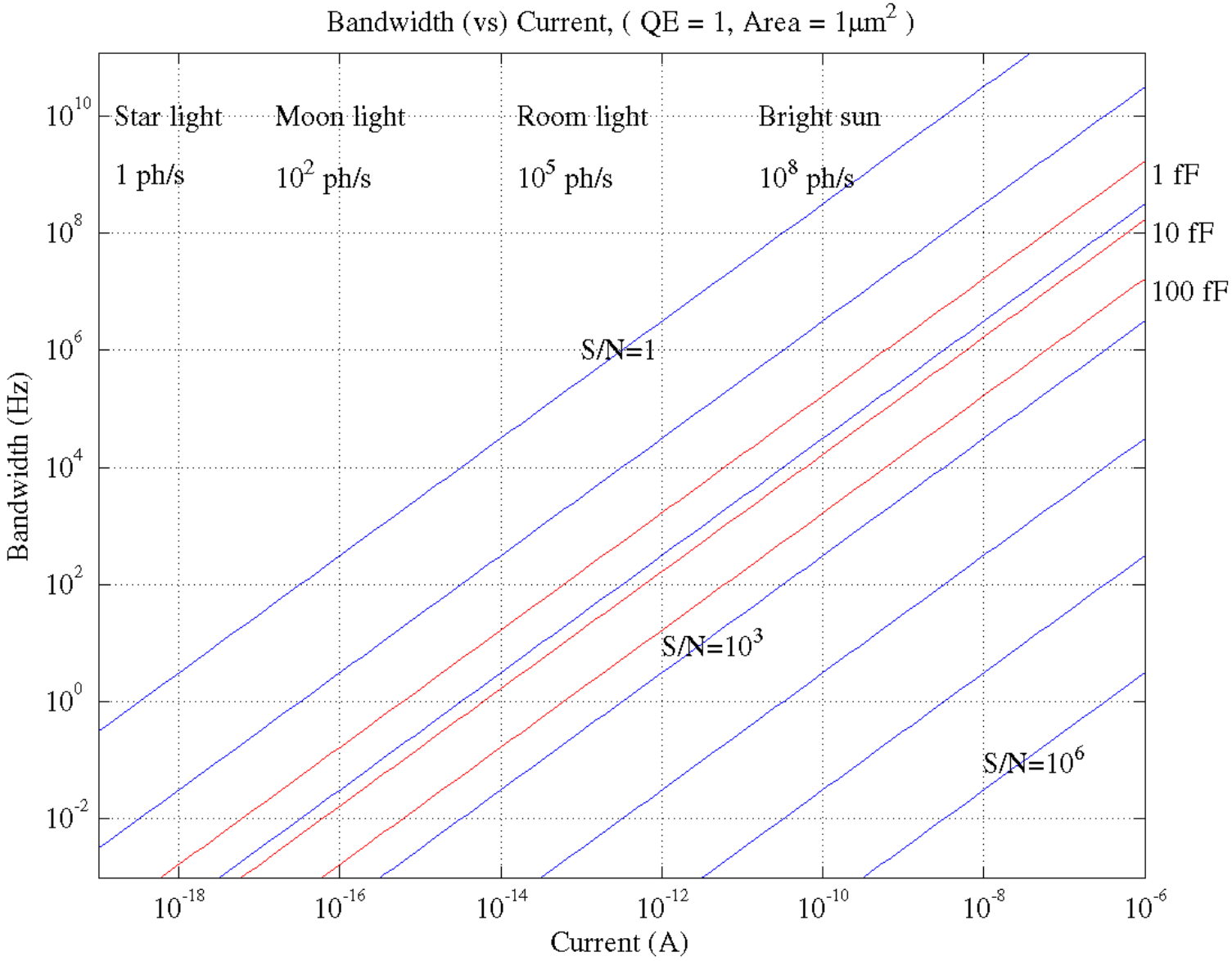
p-diff / n-well / p-sub bipolar



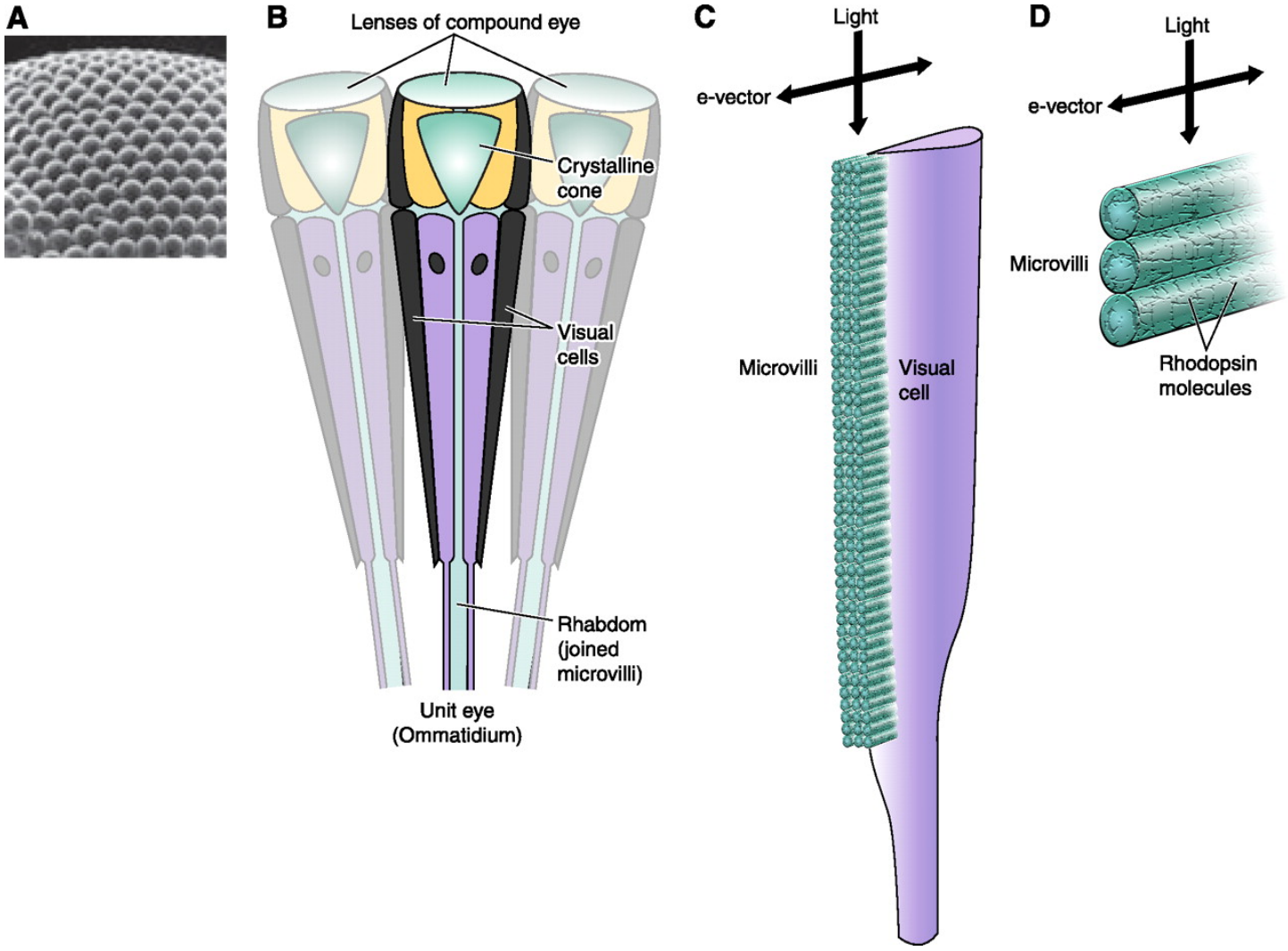
photogate



Photons, current, shot-noise ..



How about optics? Ommatidia in compound eyes



Physiol Rev 91: 413–460, 2011; doi:10.1152/physrev.00005.2010.

Optics structures on Silicon