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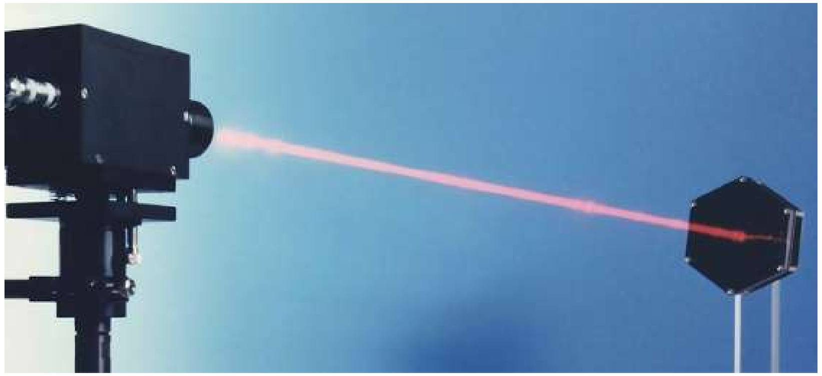
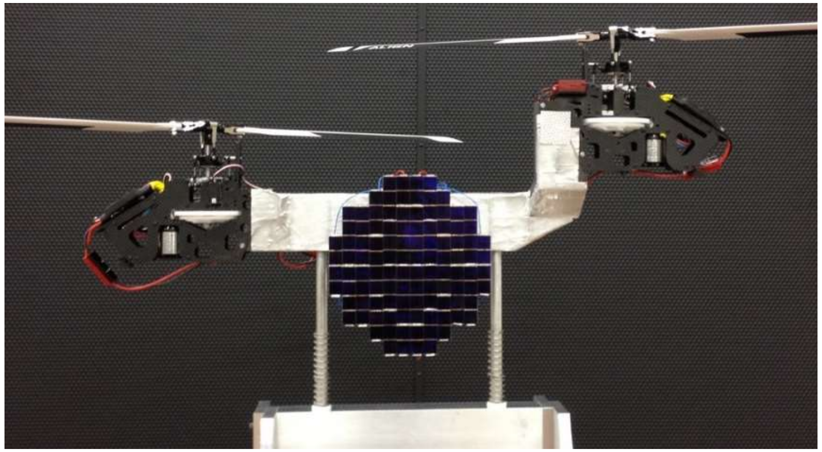
Exercice 8.3: Laser Power Converter (LPC)

Un laser est utilisé pour alimenter en énergie une batterie.
Discutez le design des cellules photovoltaiques (Laser Power Converter).





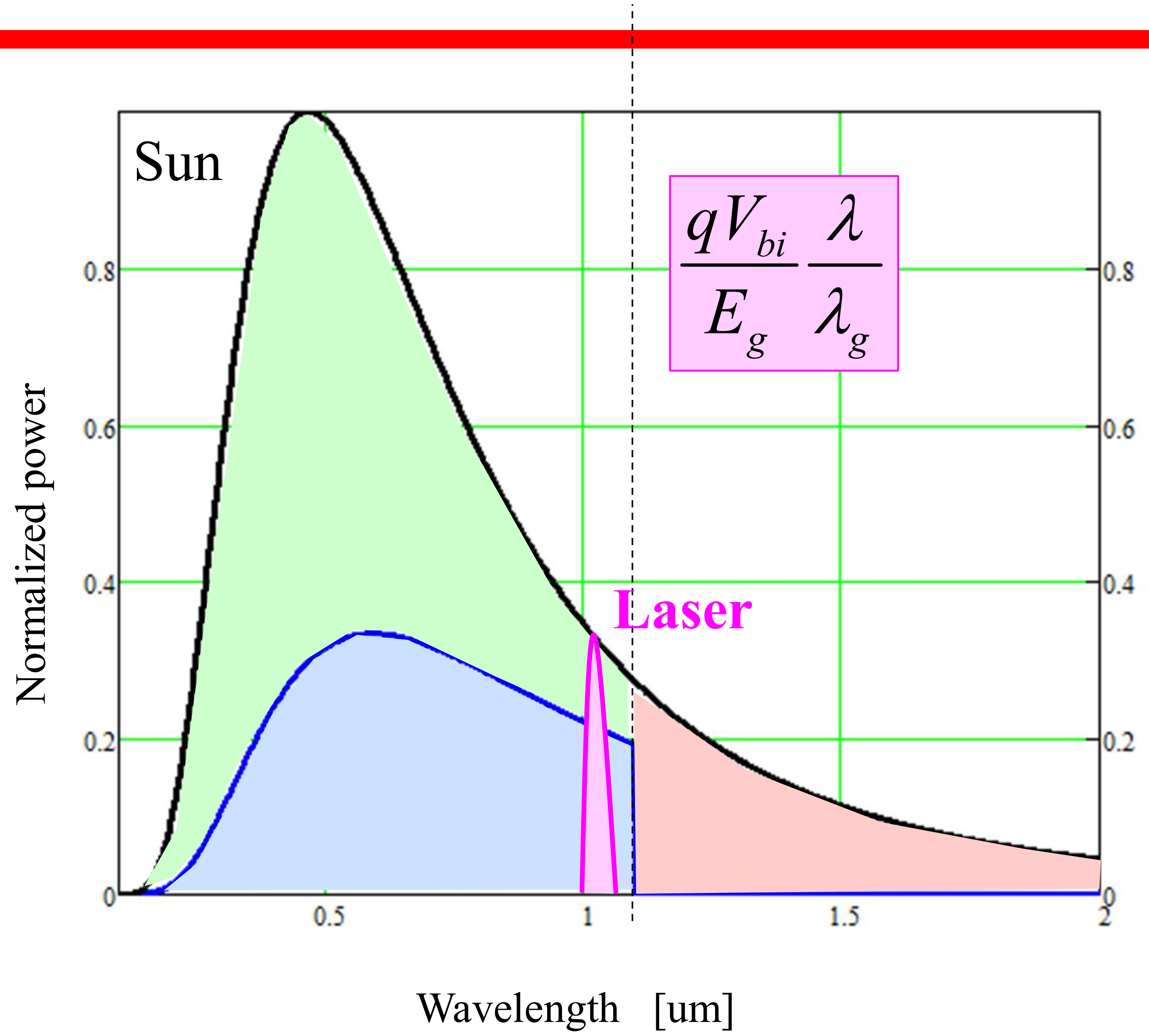
Le laser émet:

- **une lumière monochromatique**
- de puissance constante

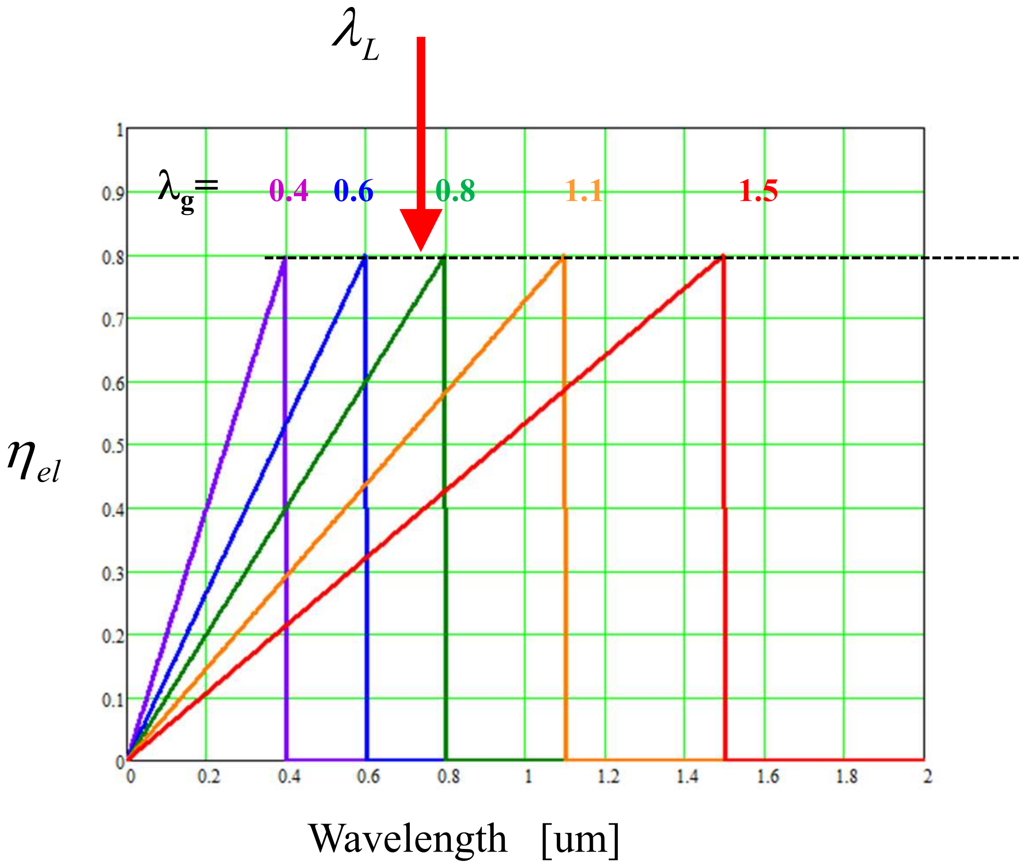
1) Enoncez des lignes directrices pour le design de la cellule PV

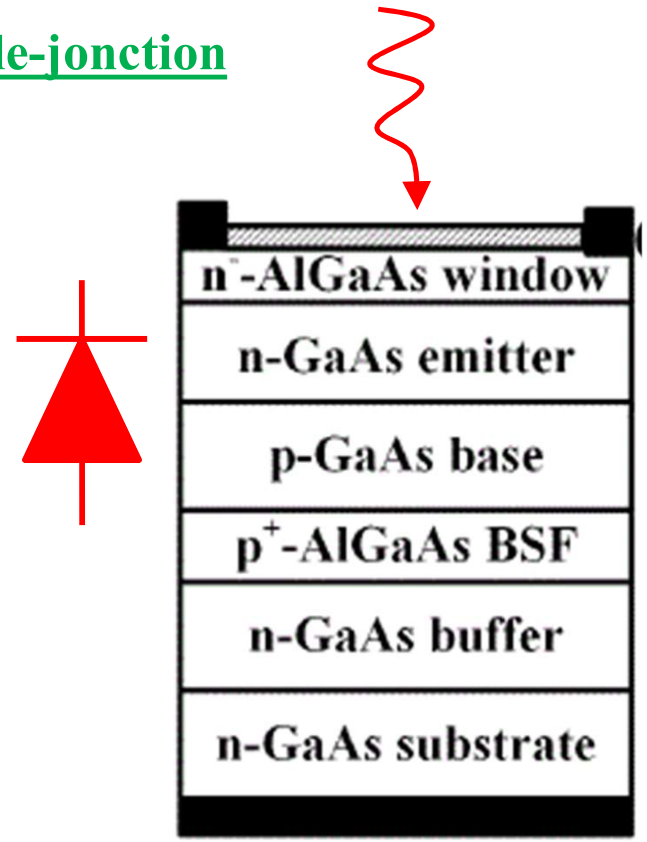
2) Quels seraient les avantages d'une cellule photovoltaïque (PV) multi-jonction pour cette application ?

Efficience électrique «monochromatique»



Exercice: Laser Power Converter (LPC)





$$\eta_{el} \cong \frac{q \cdot V_{bi}}{E_g} \cdot \eta_{opt} \cdot \frac{\lambda}{\lambda_g}$$

- **Jonction unique**
- **Choisir le matériel avec λ_g juste supérieur à λ_L**
- Évitez les recombinaisons dans le matériel
- Interfaces réflectifs aux contacts

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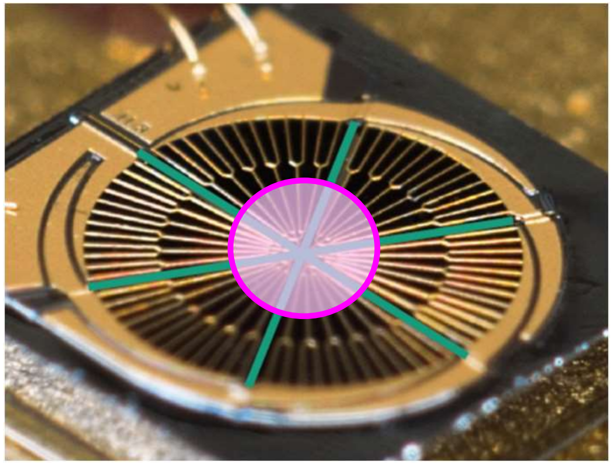
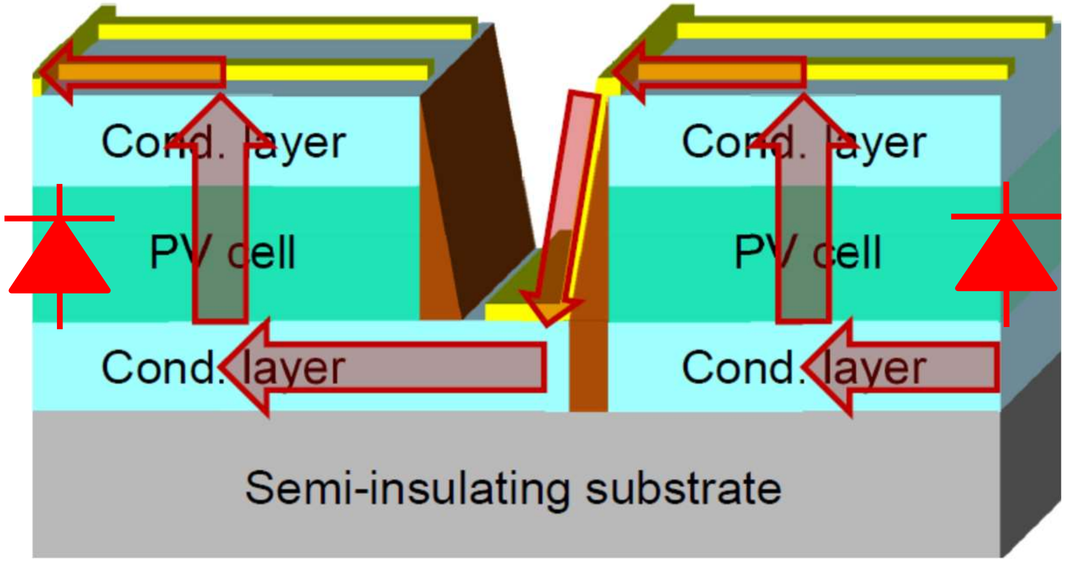
Multi-jonction pour augmenter la tension

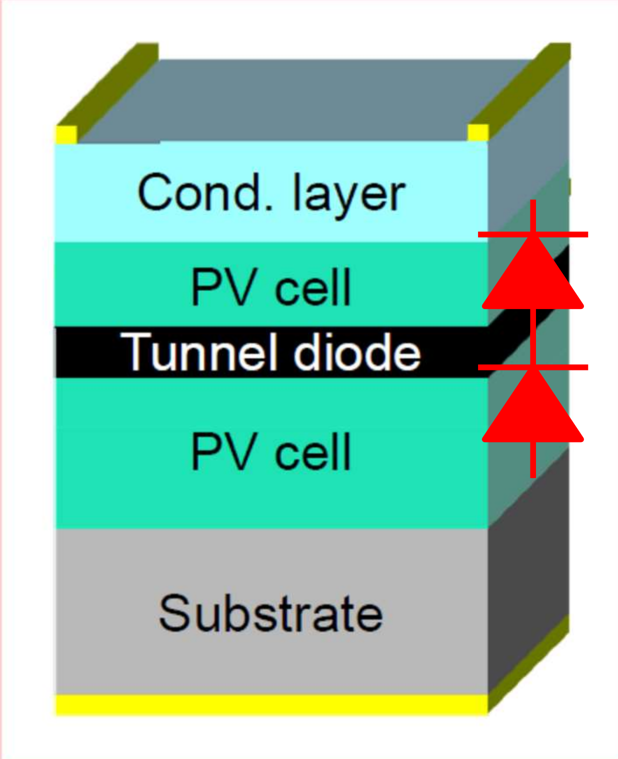
Pie-shaped



Current matching



Vertically-stacked



H Helmers,K. Reichmuth, Photovoltaic cells for optical power and data transmission, 2014

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LPC: 6-layer design

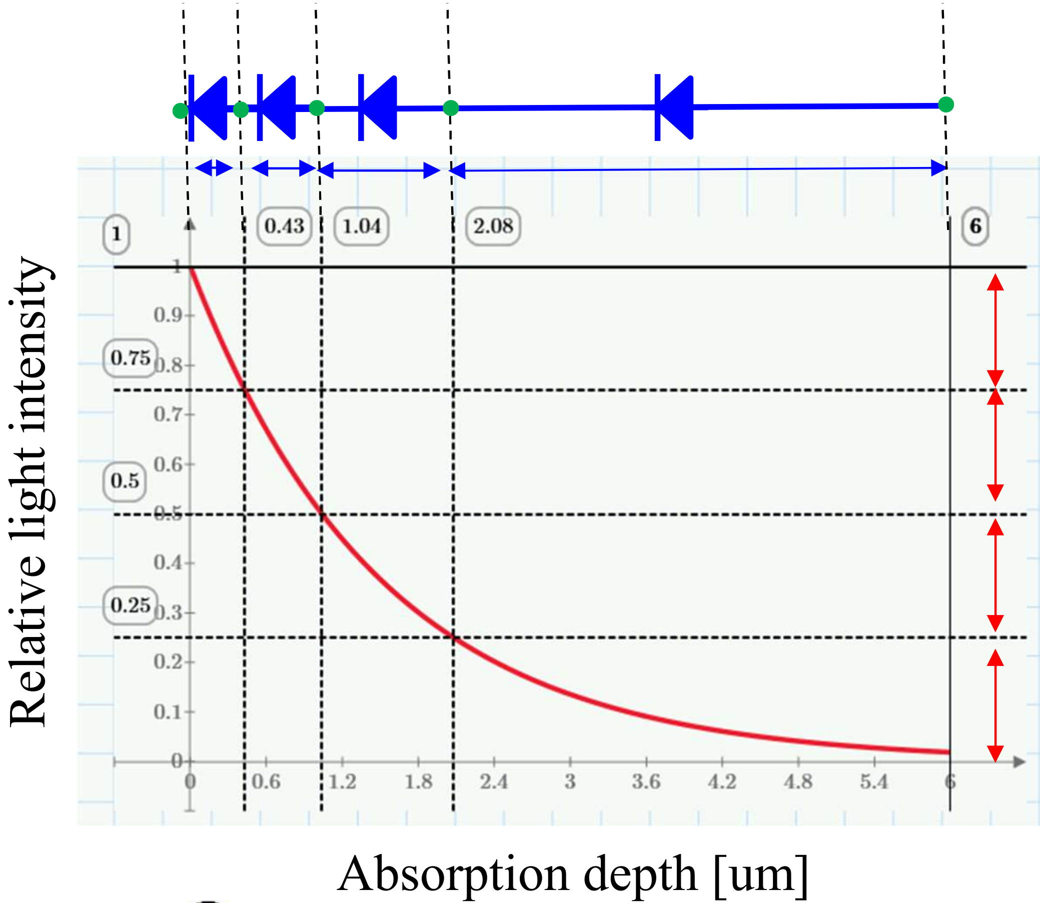
Y. Zhao et al., «Design and fabrication of sixvolt vertically-stacked GaAs photovoltaic power converter» Scientific Reports | 6:38044 | DOI: 10.1038/srep38044

Type	Voltage (V)	Incident energy	Illumination wavelength (nm)	Efficiency(%)
GaAs	1	5 W/cm²	808	52.2[1]
GaAs	1	36.5 W/cm²	810	54.9[15]
GaAs	1		809	~60[33]
GaAs	1	43 W/cm²	810	53.4[34]
GaAs	1	0.522 W	835	56[17]
Vertically-stacked	2	100 W/cm²	810	41[34]
Pie-shaped	2	15 W/cm²	810	~47.5[14]
Pie-shaped	4	0.8 W	830	~47[35]
Pie-shaped	4	8.5 W/cm²	810	55.1[14]
Pie-shaped	4	0.17 W	808	45.4[36]
Pie-shaped	5	2 W/cm²	793	50.4[5]
Vertically-stacked	5	11 W/cm²	835	60[3]
Pie-shaped	6	17 W/cm²	810	43[34]
Pie-shaped	6	22 W/cm²	810	42.7[14]
Pie-shaped	6	~0.25 W	808	~43.5[36]
Vertically-stacked	6	2.6 W/cm²	808	50.2[*]

Record: 12 diodes GaAs, η_{el}=61%, V_{mp}=13.5V

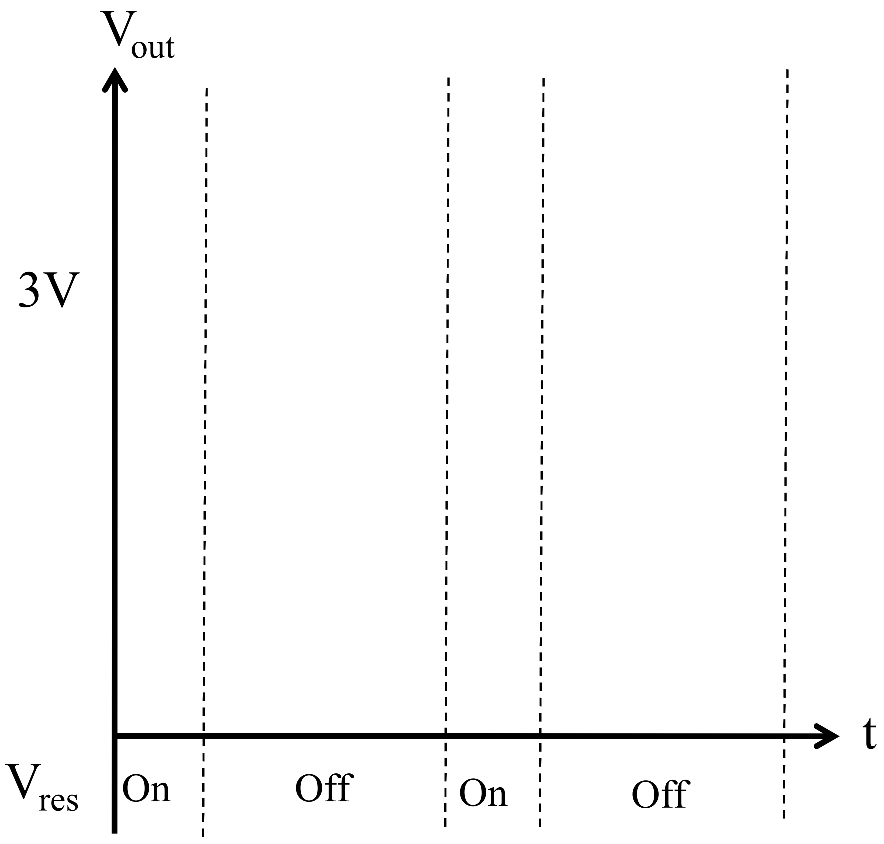
Photonics **2023**, 10, 940. https://doi.org/10.3390/photonics10080940

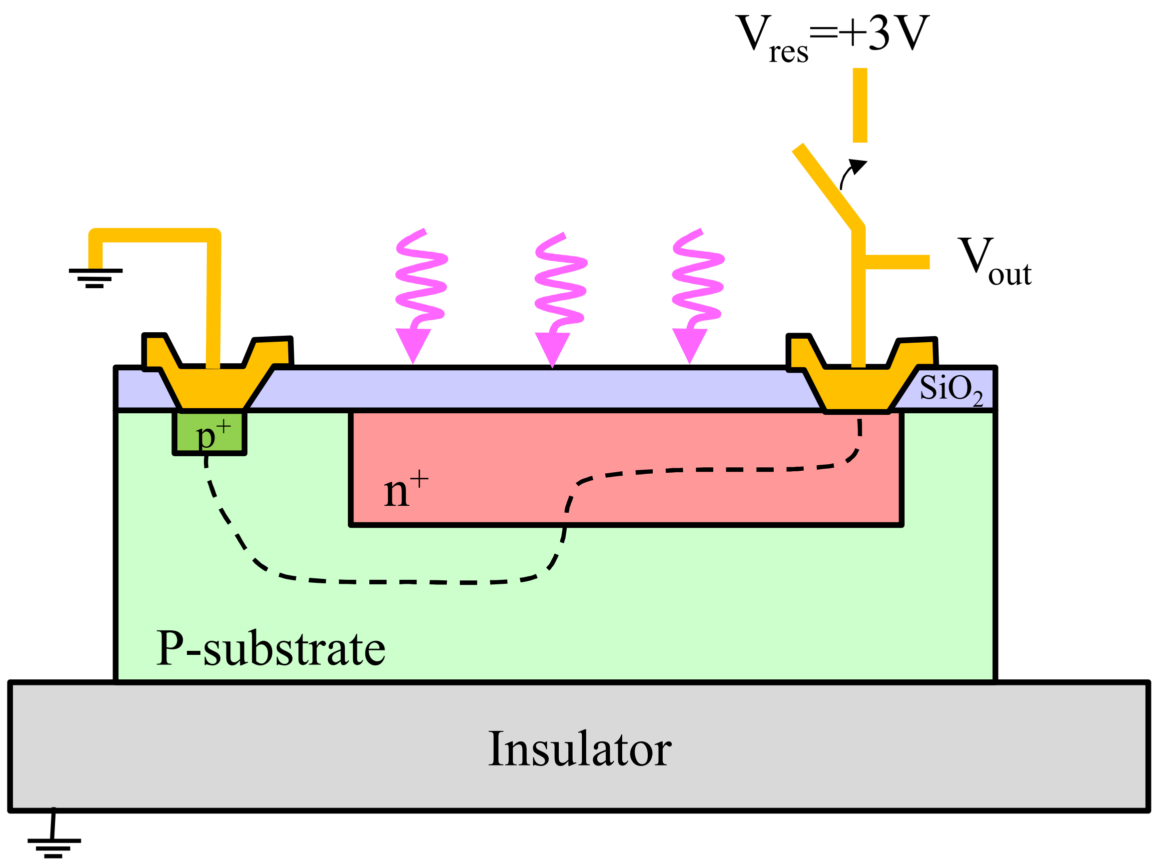
TJ= tunnel junction between cells



Current matching

Exercise 8.4: CMOS Camera (Pixel)

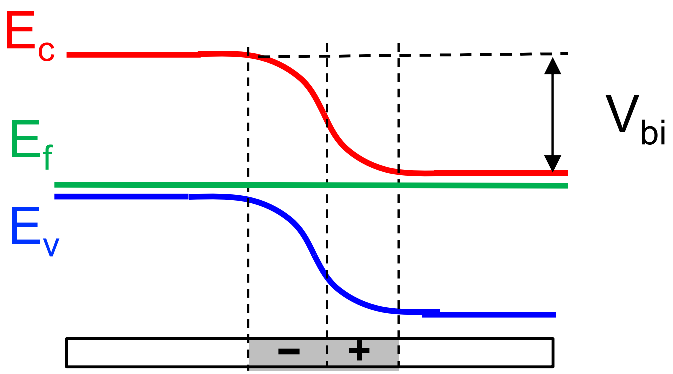




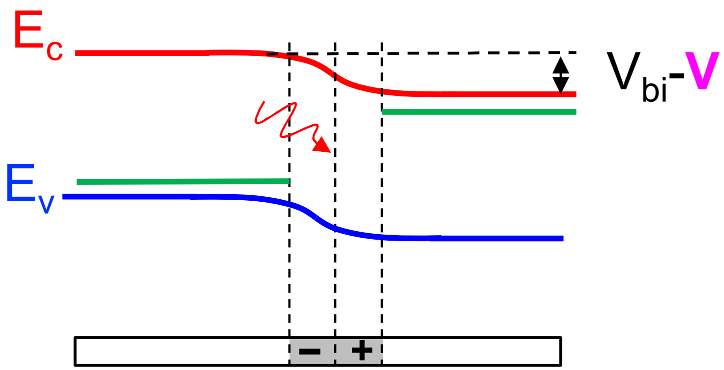
- Draw the band diagram and the electrical charges along the dotted line and and analyze their temporal behavior when the pixel is illuminated.
- Plot the output voltage with and without light.

Solar cell – CMOS pixel

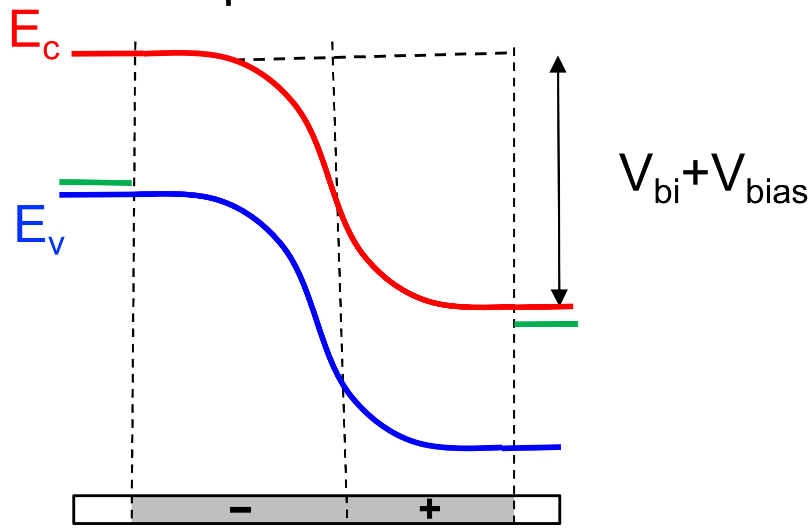
Solar cell: no illumination



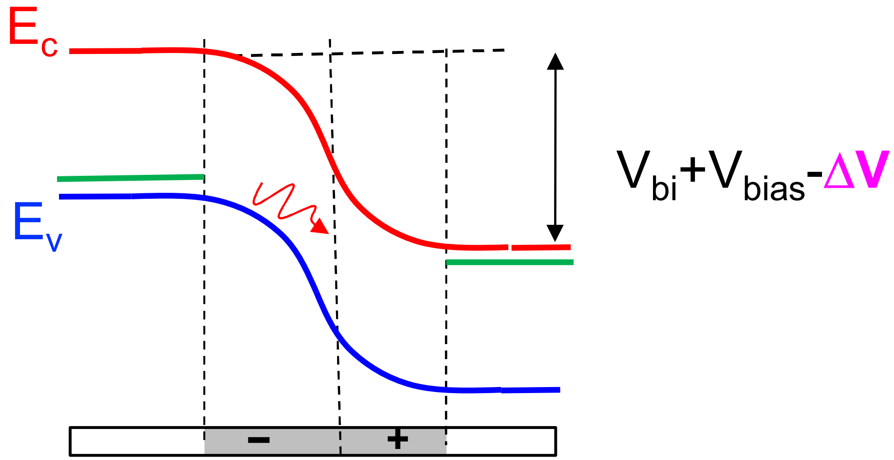
Solar cell: with illumination



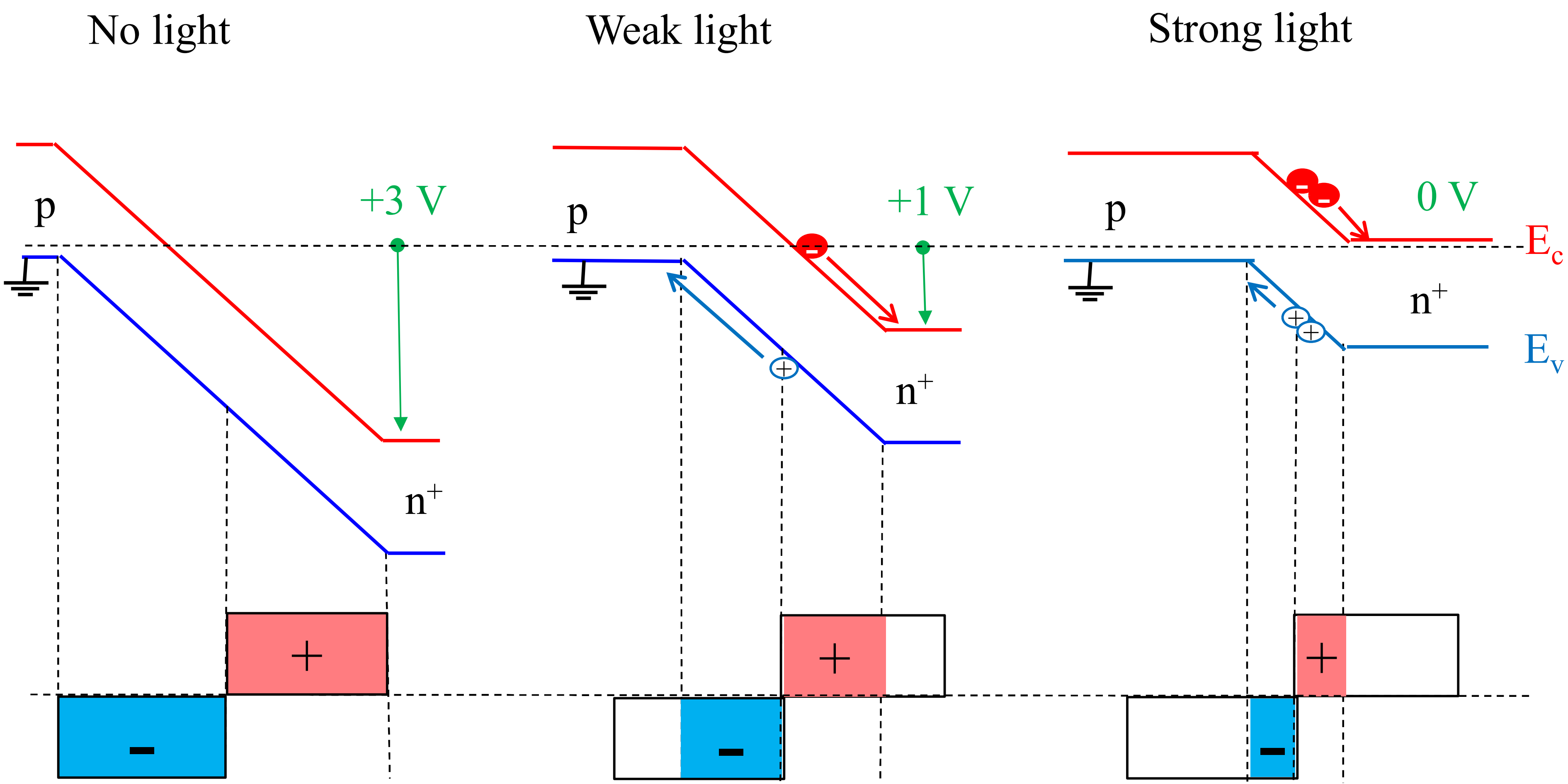
CMOS pixel before illumination



CMOS pixel under illumination



A CMOS Camera: Pixel (1)

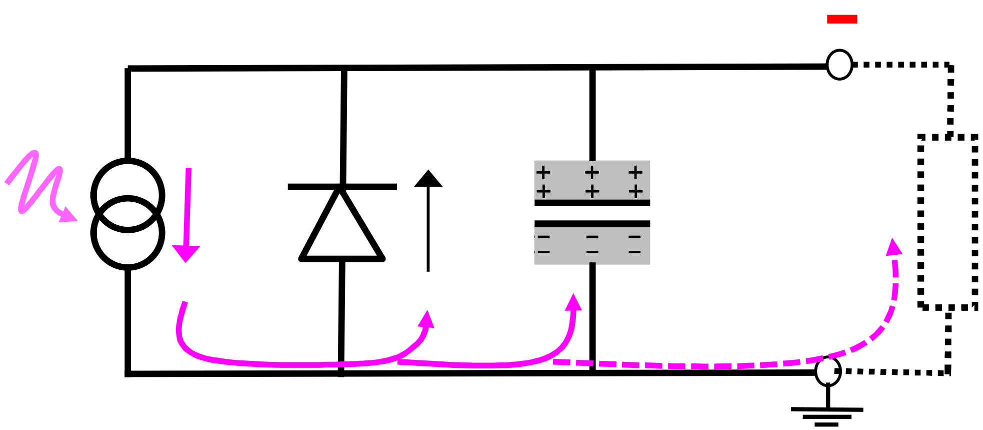


- With no light, the depletion capacity contains the maximum of charges
- The carriers that are produced by the illumnation reduce the charges in the depletion region

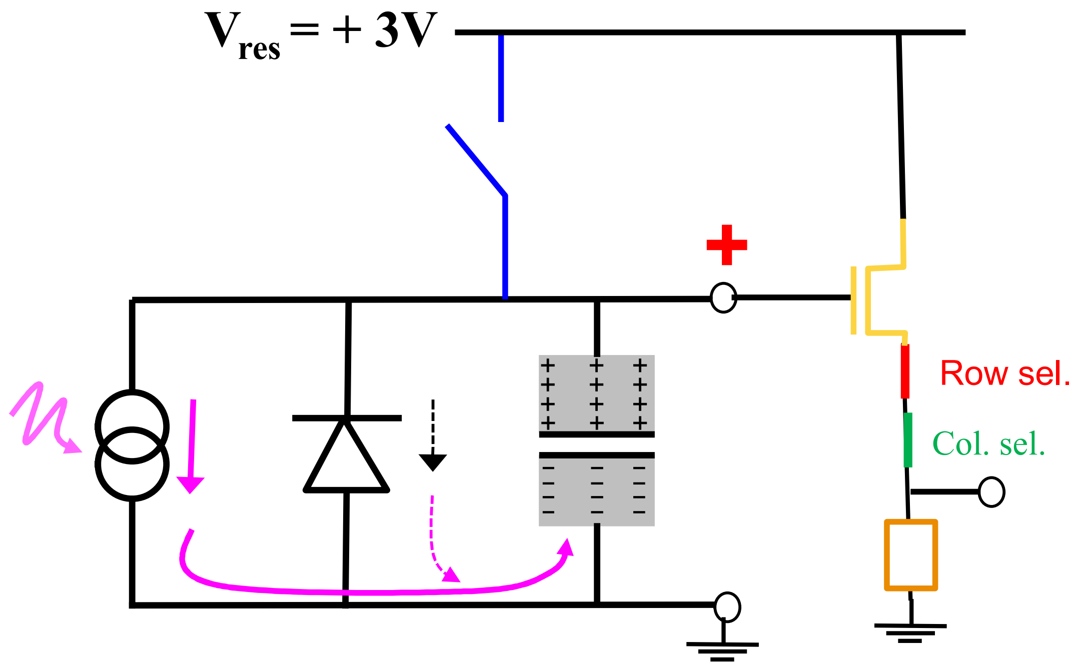
→ The depletion capacity integrates the generated charges.

Solar cell – CMOS pixel

Solar cell



CMOS pixel: Photodiode



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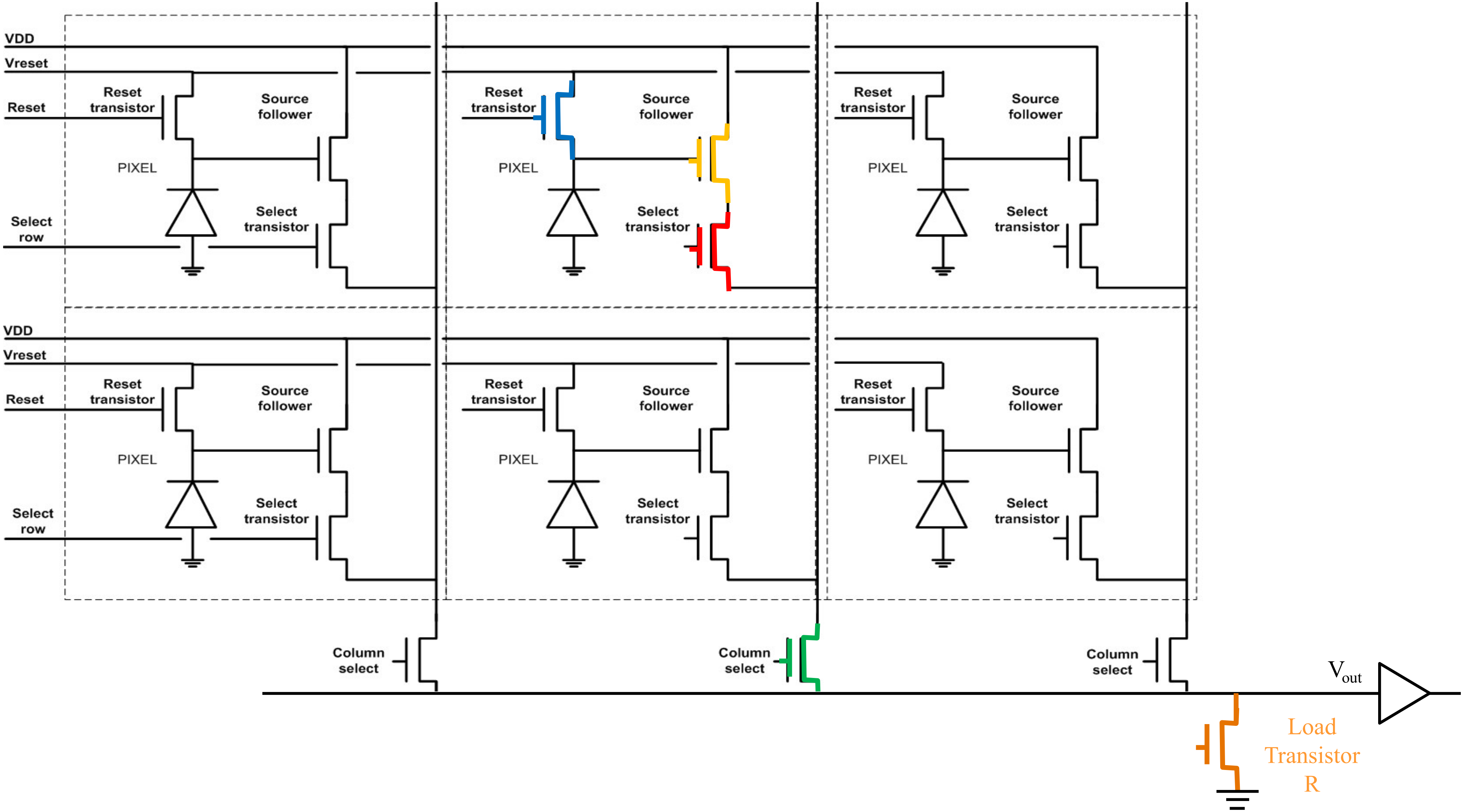
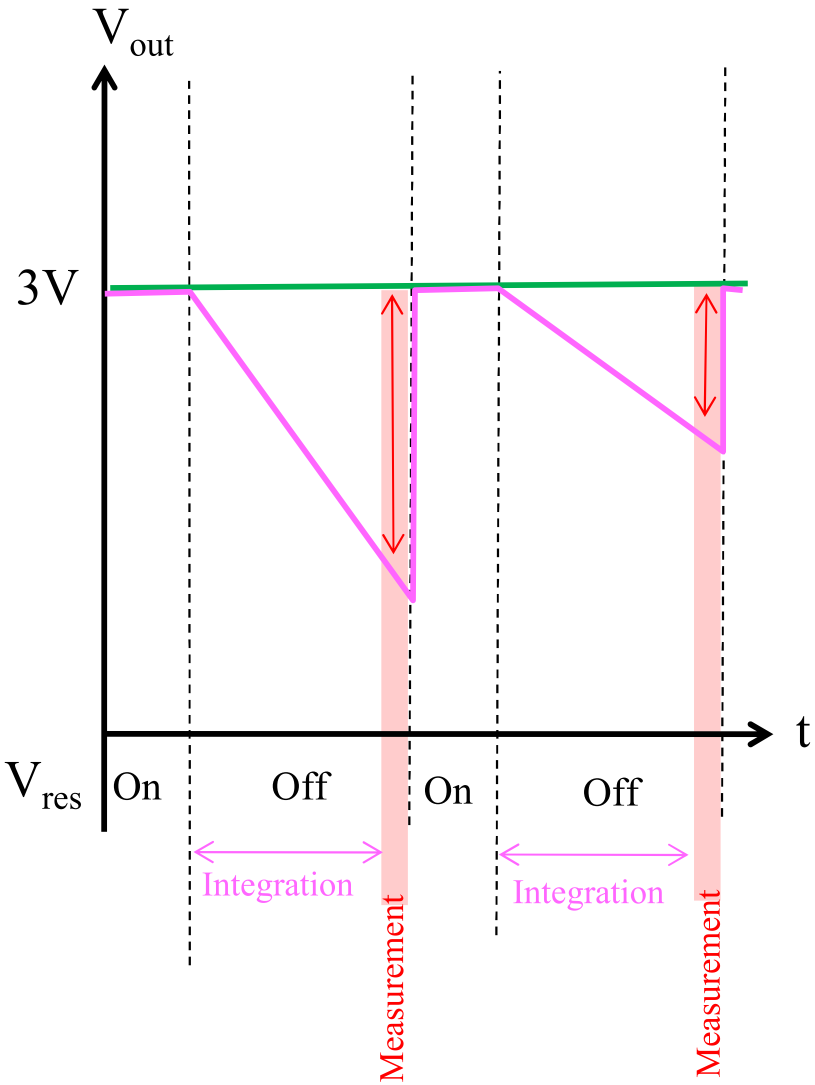
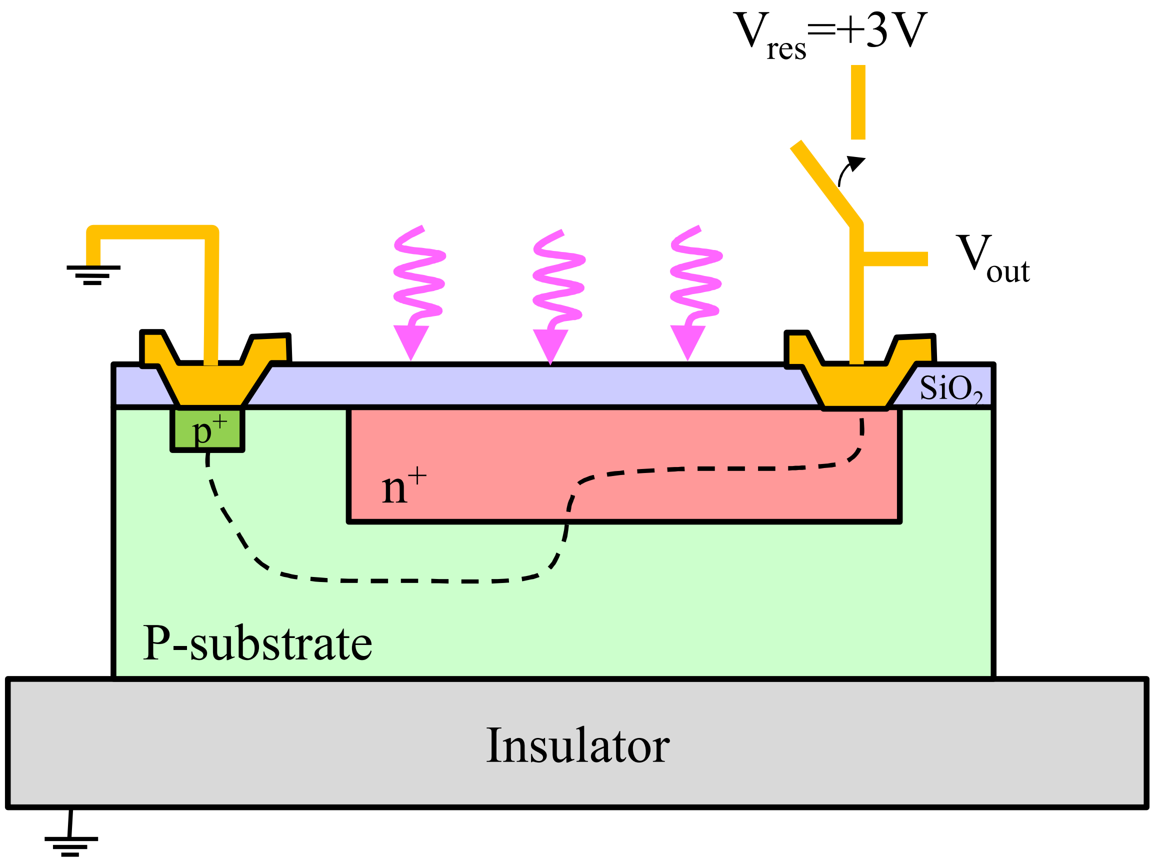
Caméra Standard 3T Pixel



CMOS Camera: Pixel (2)





- “Long” integration time: *1/(frame-rate)*
- “Very short” measurement time: *1/(frame-rate)*(Nb.pixels)*

→ Optimal for a camera

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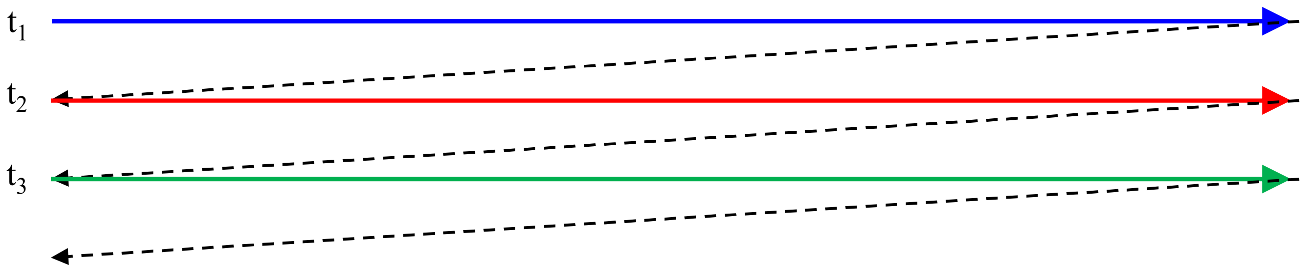
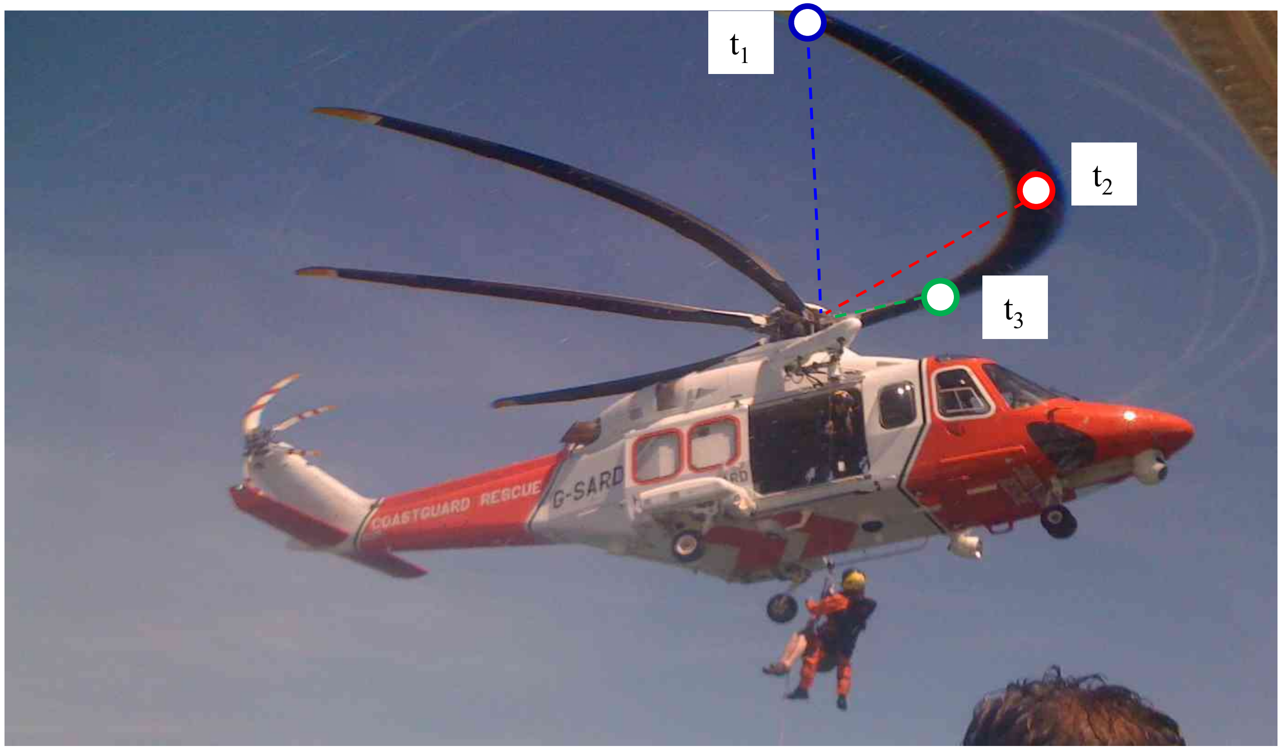
Pixels lus à des temps différents: rolling shutter





⇨ Introduction du global shutter …