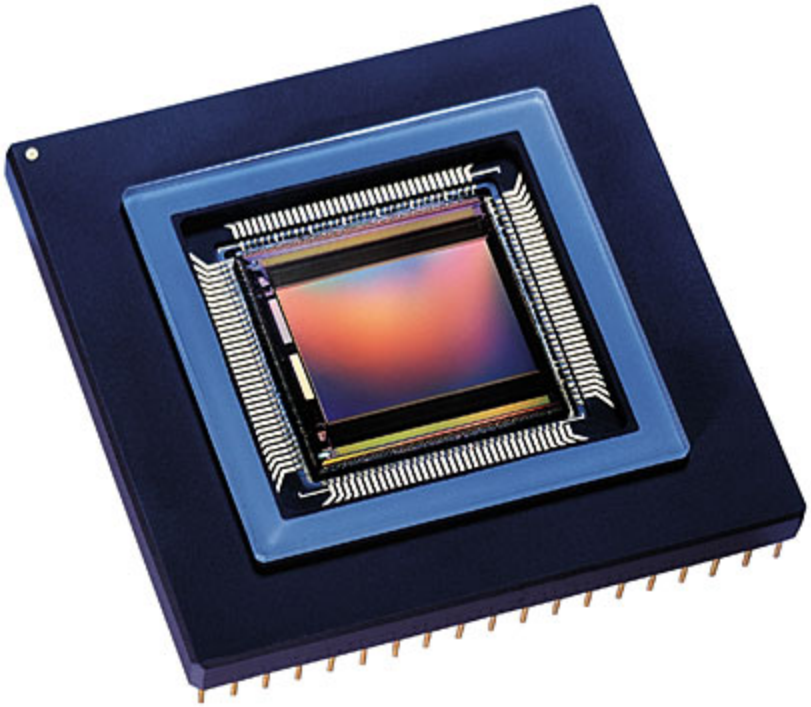
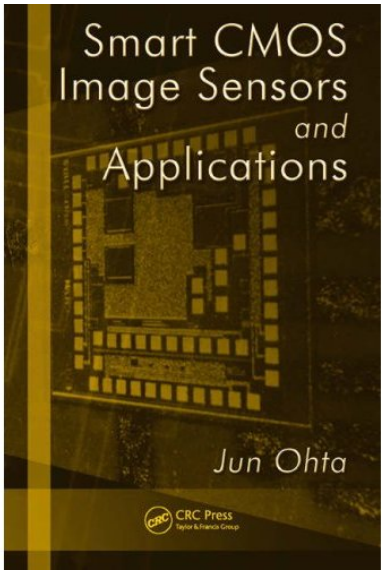
Image Sensors

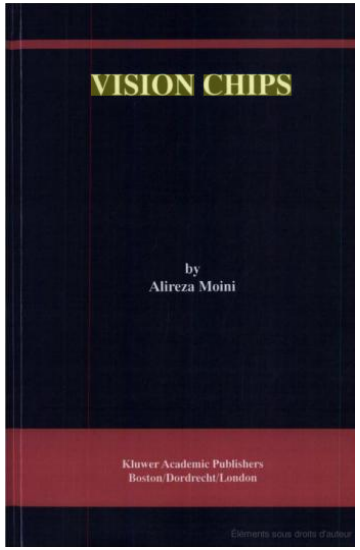
CCD – CMOS image sensors

Master

CMOS Image Sensors







Historical background

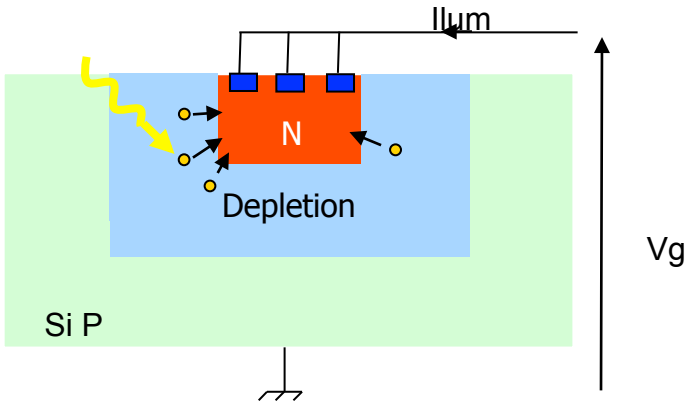
- 1960 :
  - First CMOS image sensor : Passive Pixel Sensor
- 1973:
  - First CCDs : Characteristics are better than CMOS image sensors
- 2000 :
  - The development of CMOS stems from the comercial crisis of the microelectronics industry at the end of the 20th century. Microlectronic industry has work on the developpement of new image sensors using CMOS process

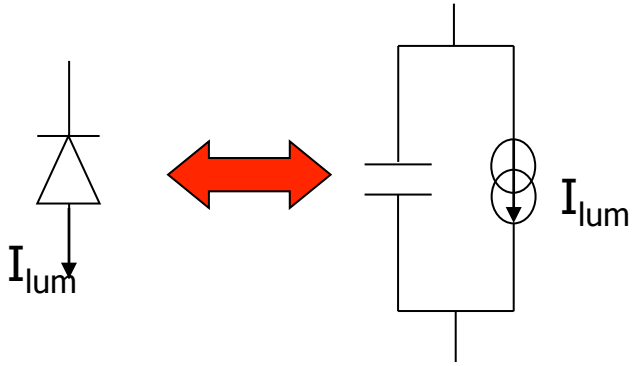
Architectures of CMOS pixels

- 3 Architectures of CMOS image sensor :
  - Passive Pixel Sensor (the oldest)
  - Active Pixel Sensor (the most used)
  - Digital Pixel Sensor (a promising technology)

Architectures of CMOS pixels

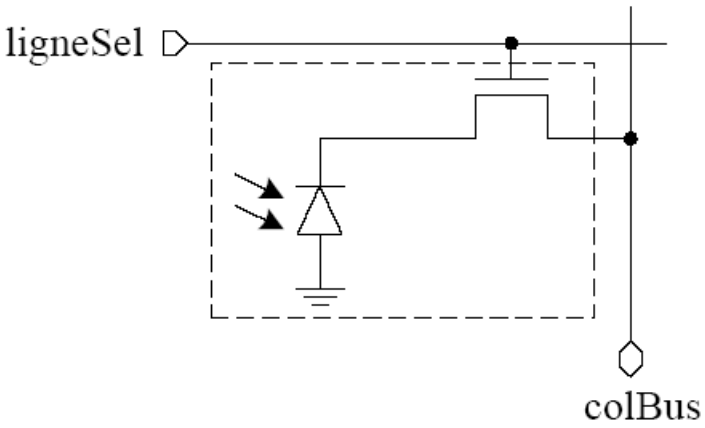
- Photo-element





Architectures of CMOS pixels

- Passive Pixel sensor

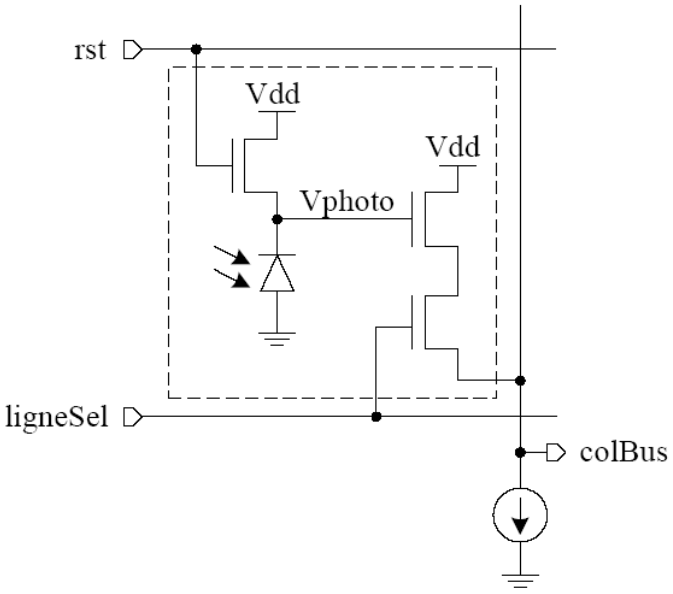


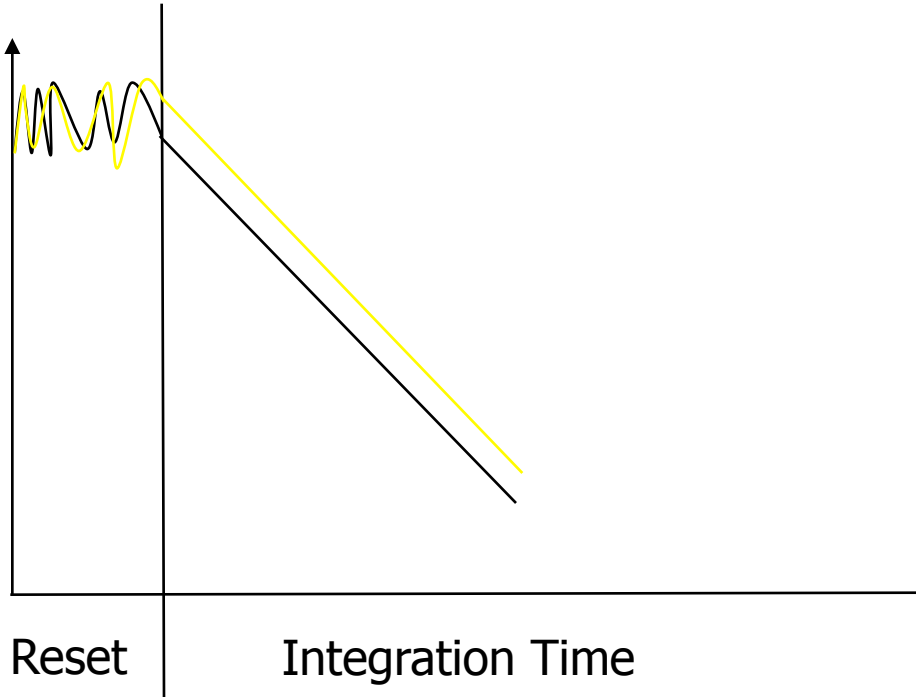
Advantage : only one transistor in the pixel

Disadvantage : a lot of noise in the images produced by PPS image sensor

Architectures of CMOS pixels

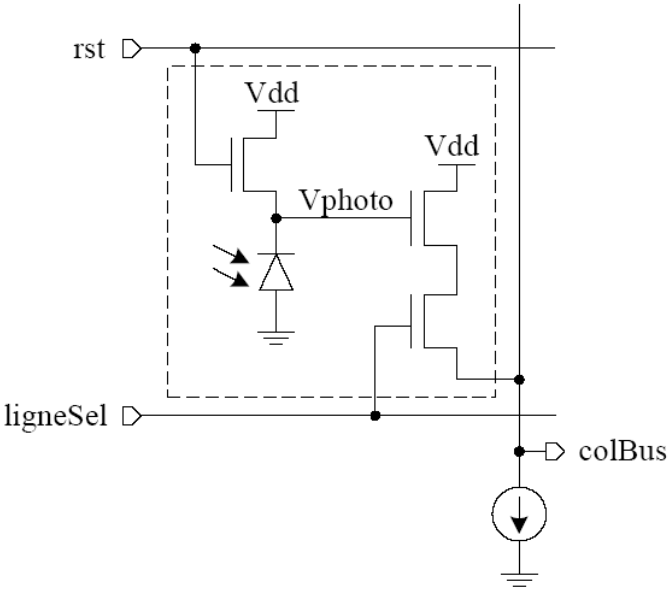
- Active Pixel Sensor
  - Pixel based on 3 transistors

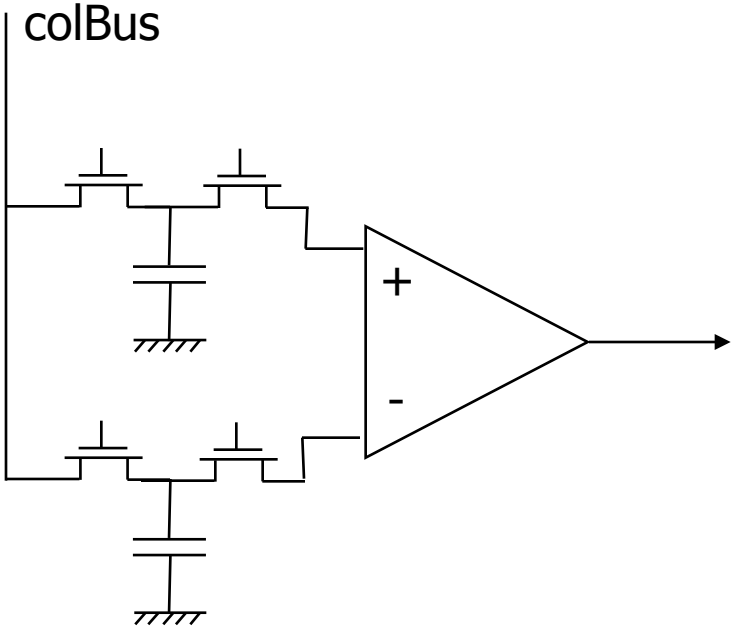




Architectures of CMOS pixels

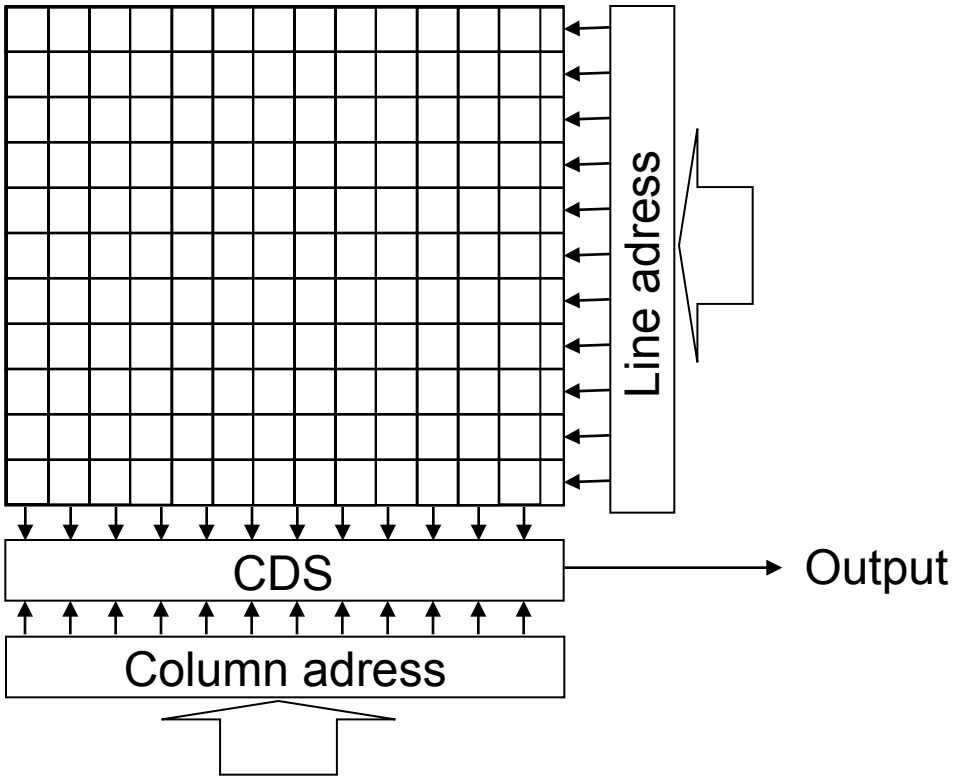
- Active Pixel Sensor
  - Correlated Double Sampling





Architectures of CMOS pixels

- Active Pixel Sensor



Reading line by line

Architectures of CMOS image sensors

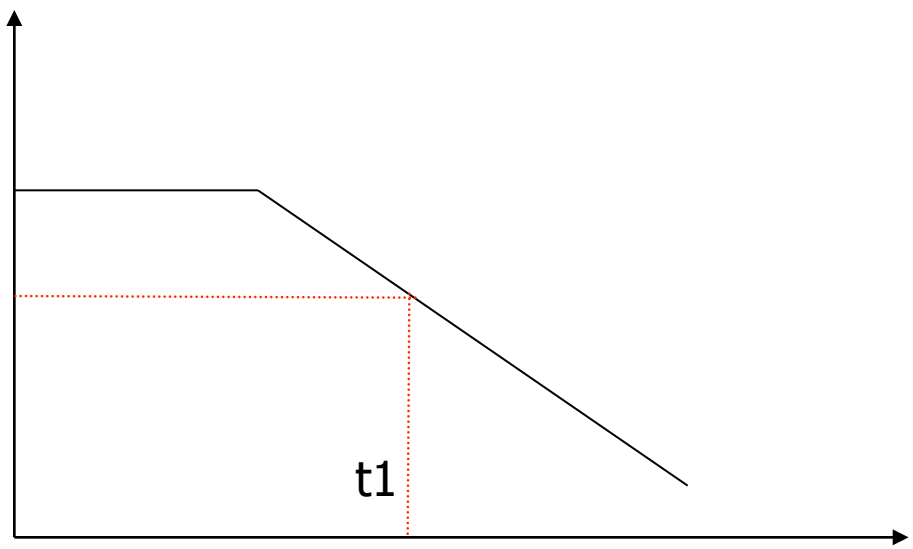
- General problem of 3T APS

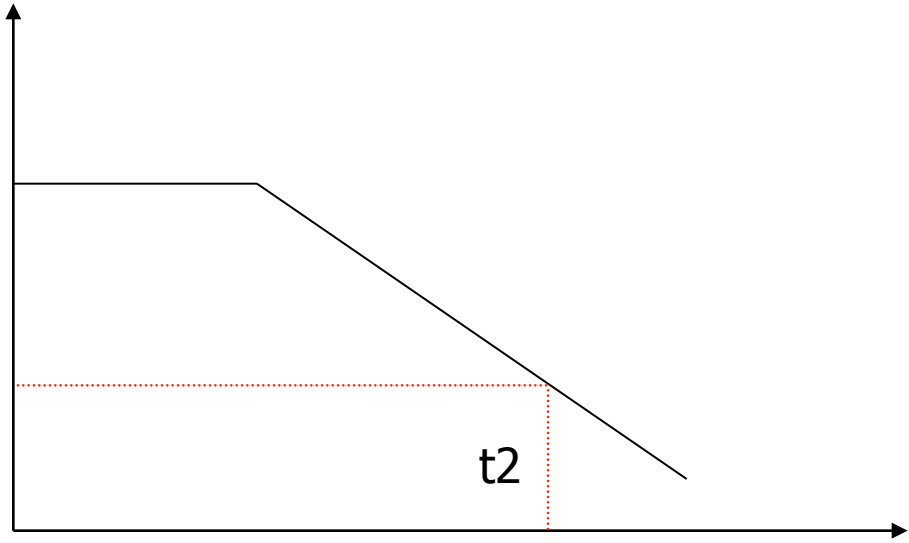
Image projected on the sensor

Image generated by the sensor

Architectures of CMOS image sensors

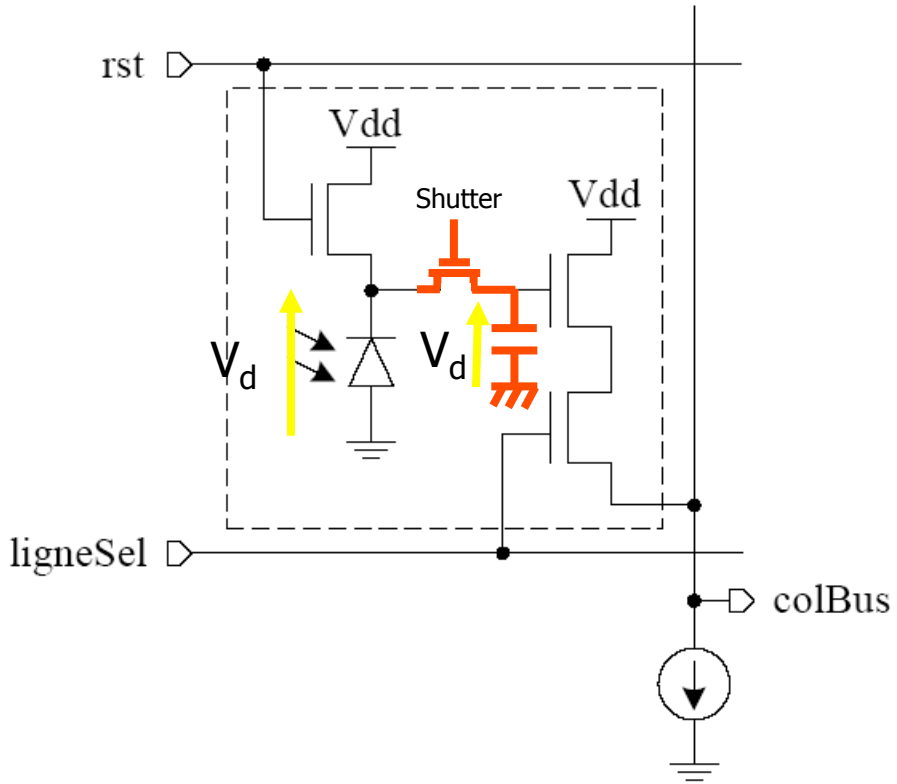
- Why this effect ?





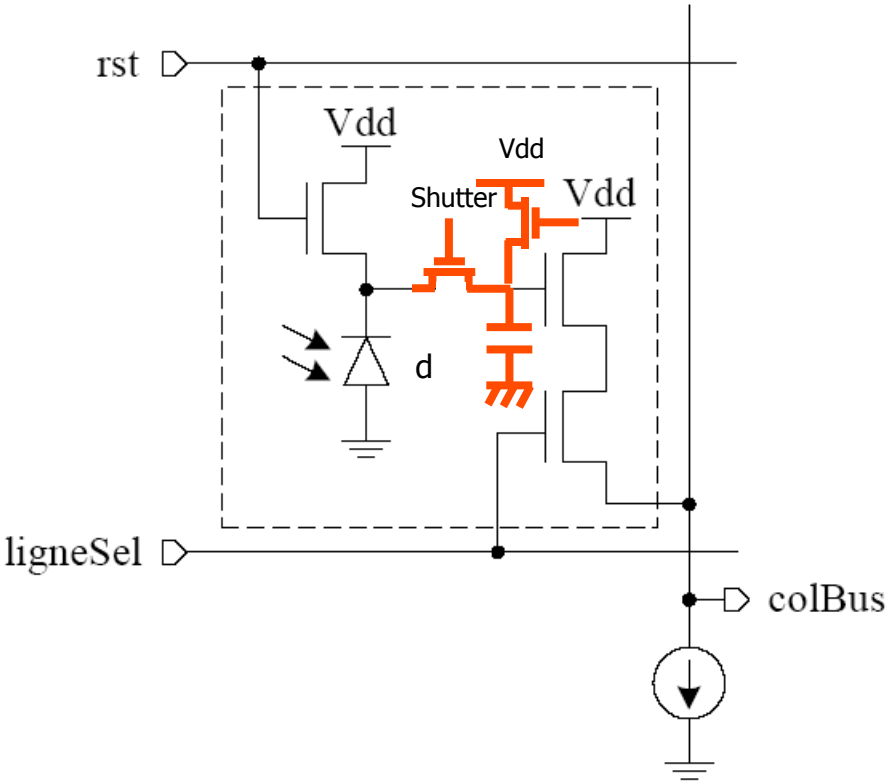
Architectures of CMOS image sensors

- 4T Active Pixel Sensor



Architectures of CMOS image sensors

- 5T Active Pixel Sensor



Architectures of CMOS image sensors

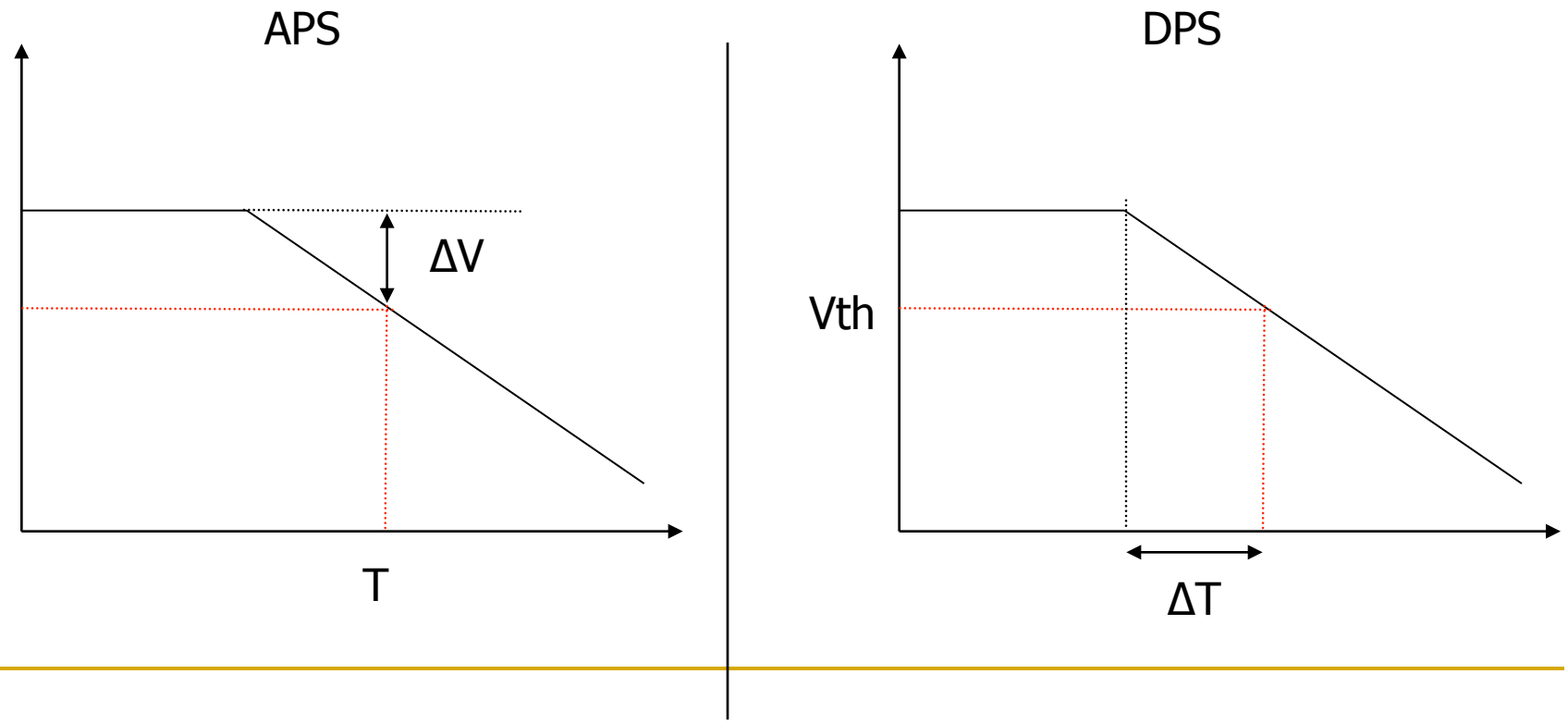
	Advantage	Disadvantage
3T APS	Low noise image sensor	No Electronic Shutter (Rolling Shutter)
4T APS	Electronic Shutter	No CDS
5T APS	Electronic Shutter	No CDS

Architectures of CMOS image sensors

- We have seen here the 3 most popular architectures of APS. But it's interisting to know that architectures of APS can be more complex, using 6 or more transistors.

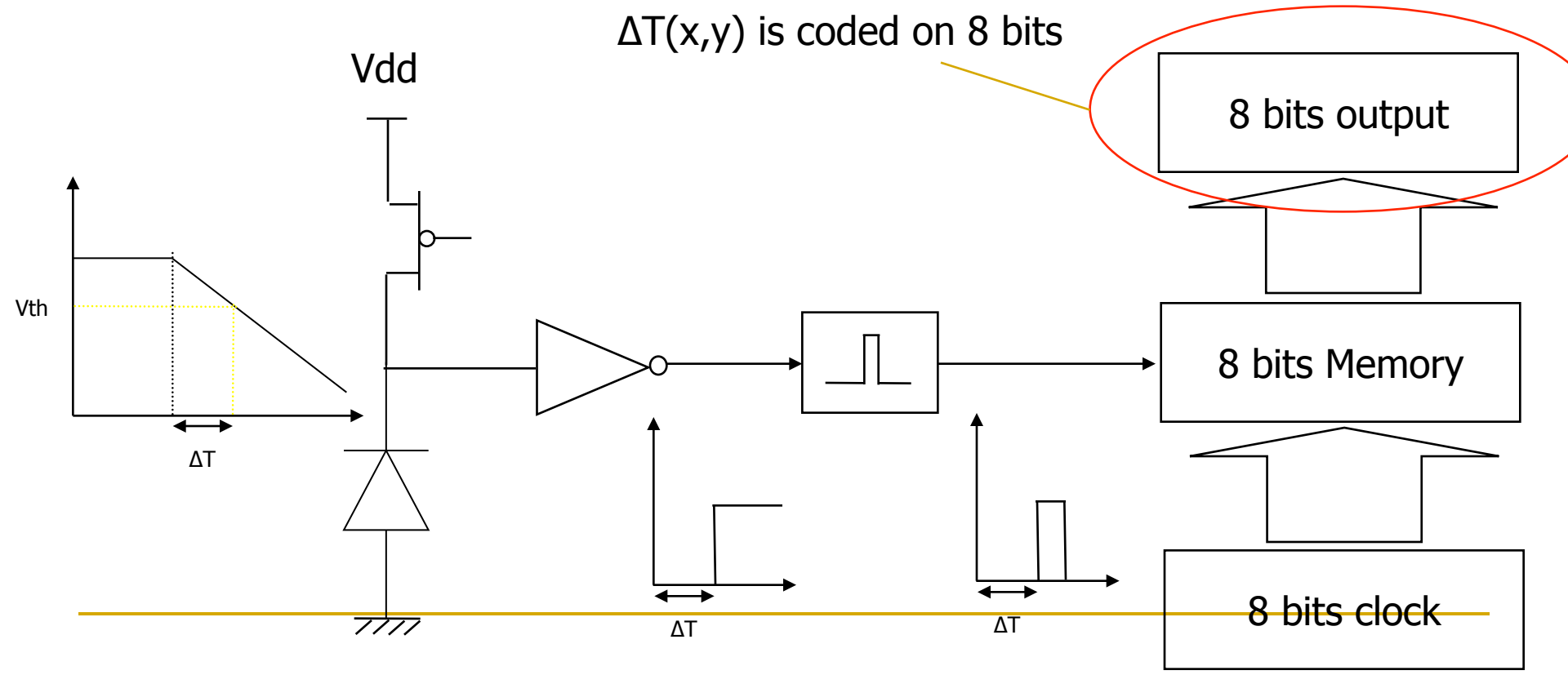
Architectures of CMOS image sensors

- Digital Pixel Sensors (DPS)



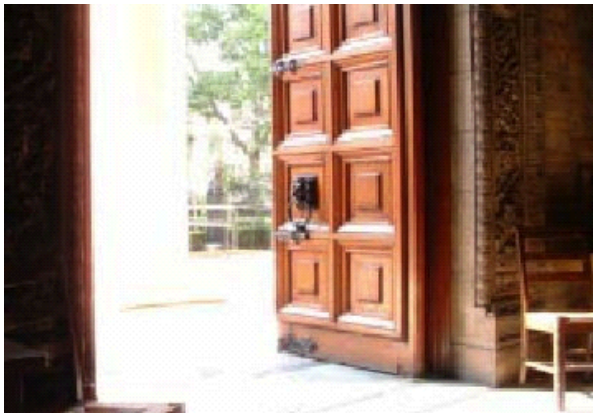
Architectures of CMOS image sensors

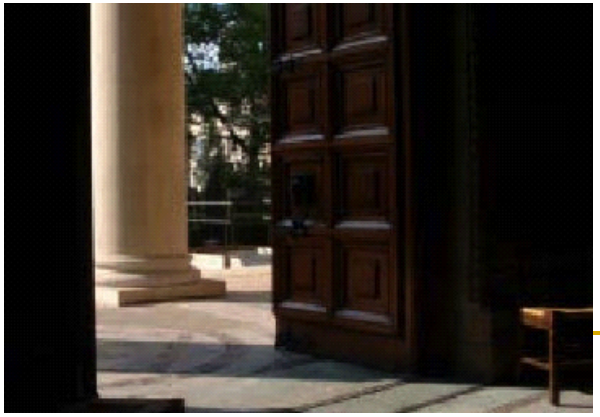
- DPS : Architecture of the pixel

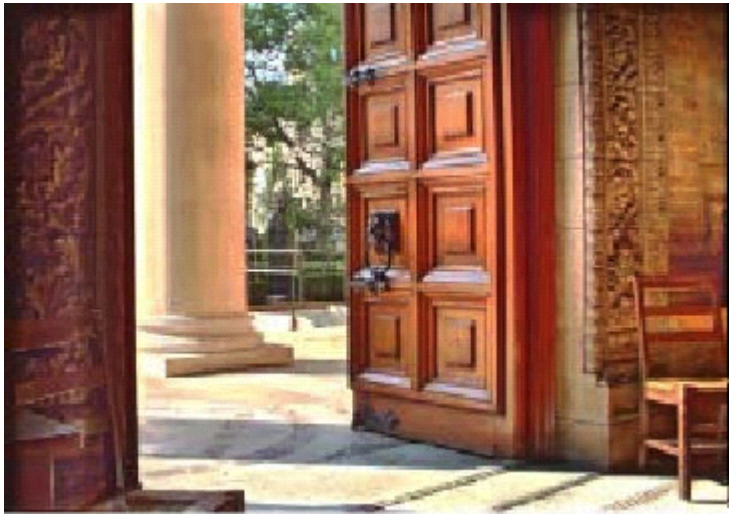


Architectures of CMOS image sensors

- Logarithmic Image Sensors

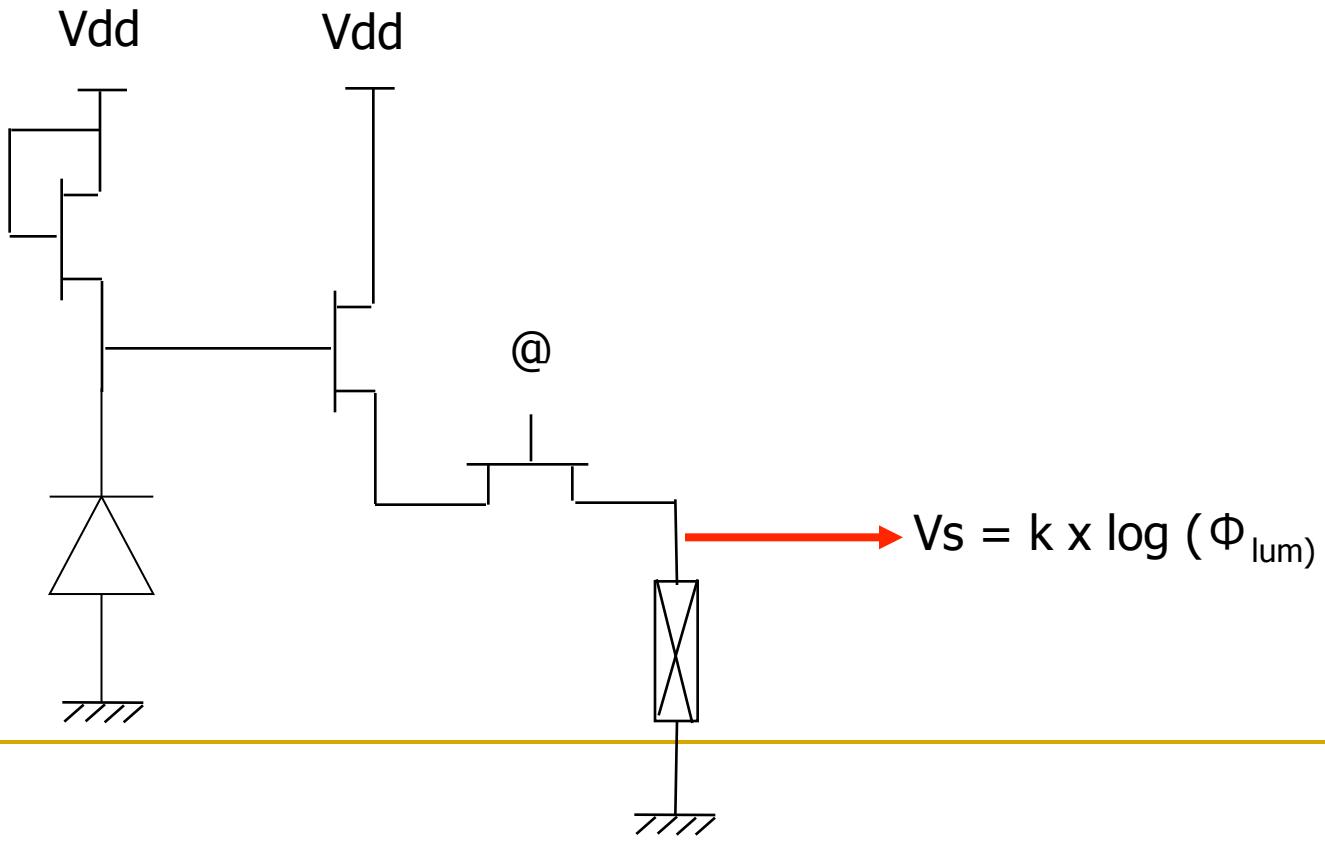






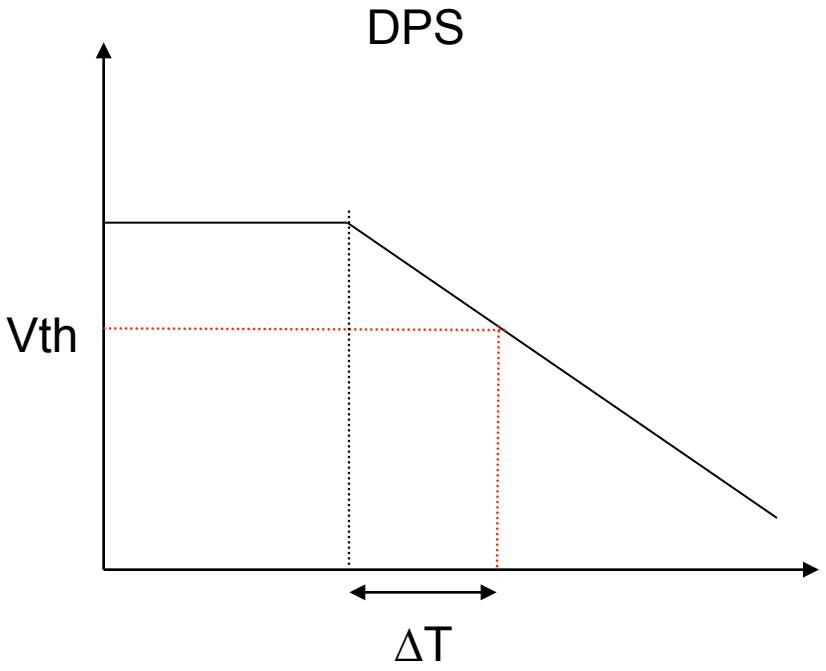
Architectures of CMOS image sensors

- Logarithmic Pixel

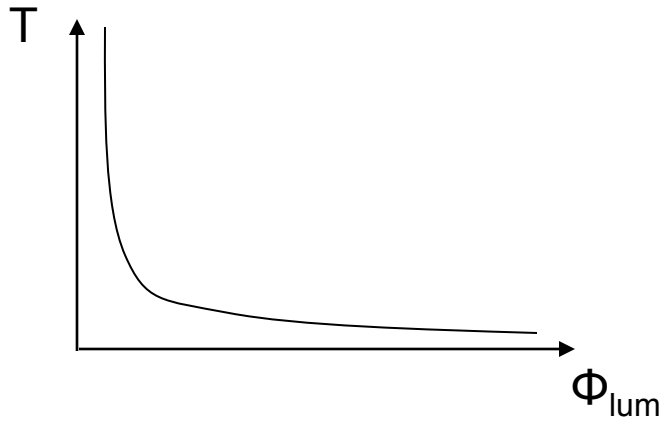


Architectures of CMOS image sensors

- DPS for Logarithmic Image Sensor



$$\frac{\Delta V}{\Delta t} = \frac{V_{th}}{T} = k \cdot \phi_{lum}$$

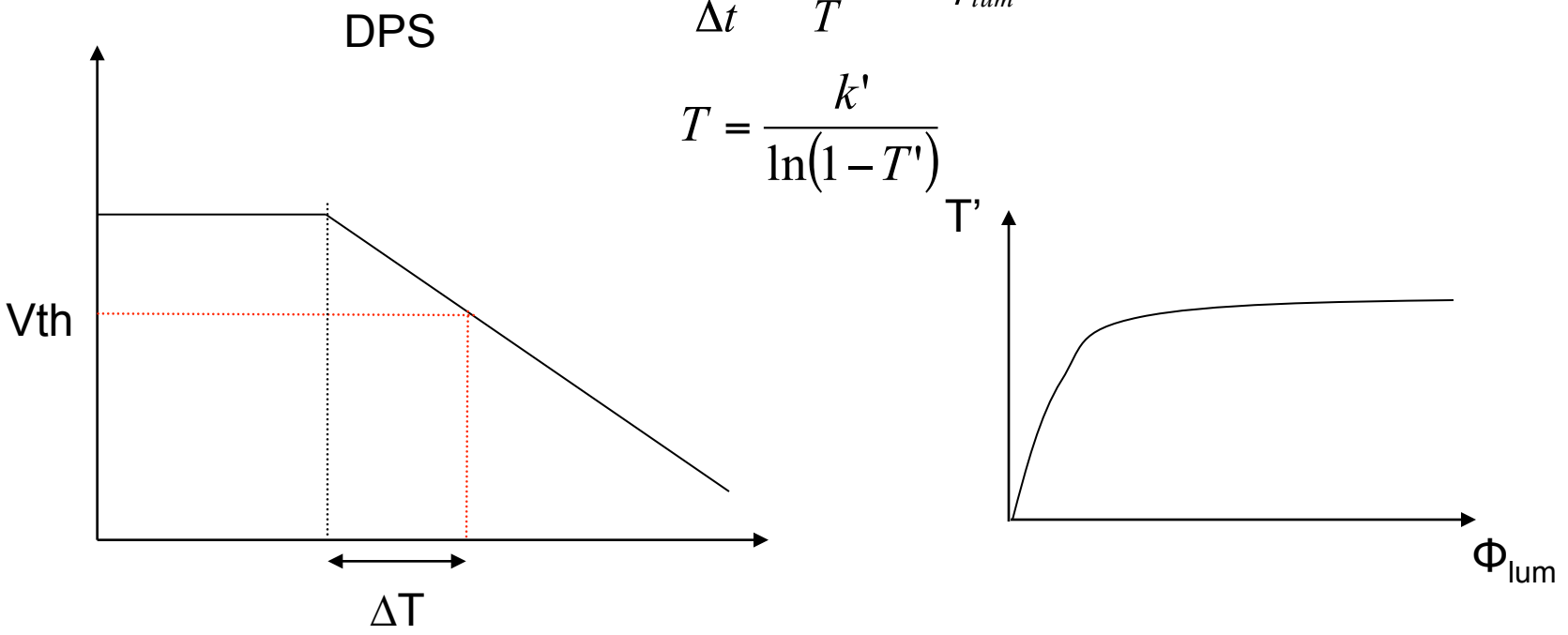


Architectures of CMOS image sensors

- DPS for Logarithmic Image Sensor

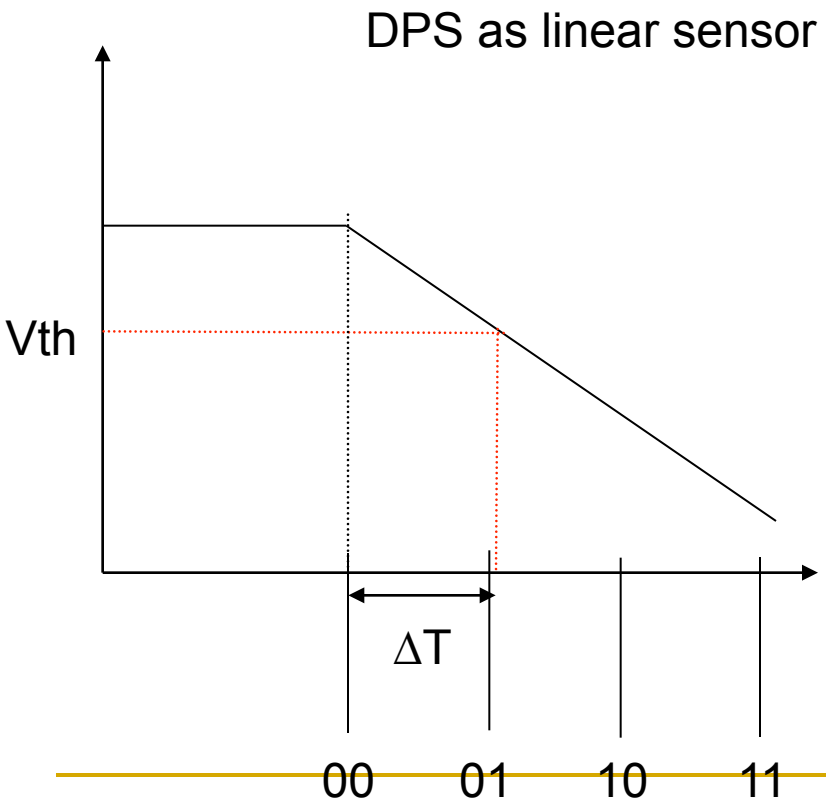
$$\frac{\Delta V}{\Delta t} = \frac{V_{th}}{T} = k \cdot \phi_{lum}$$

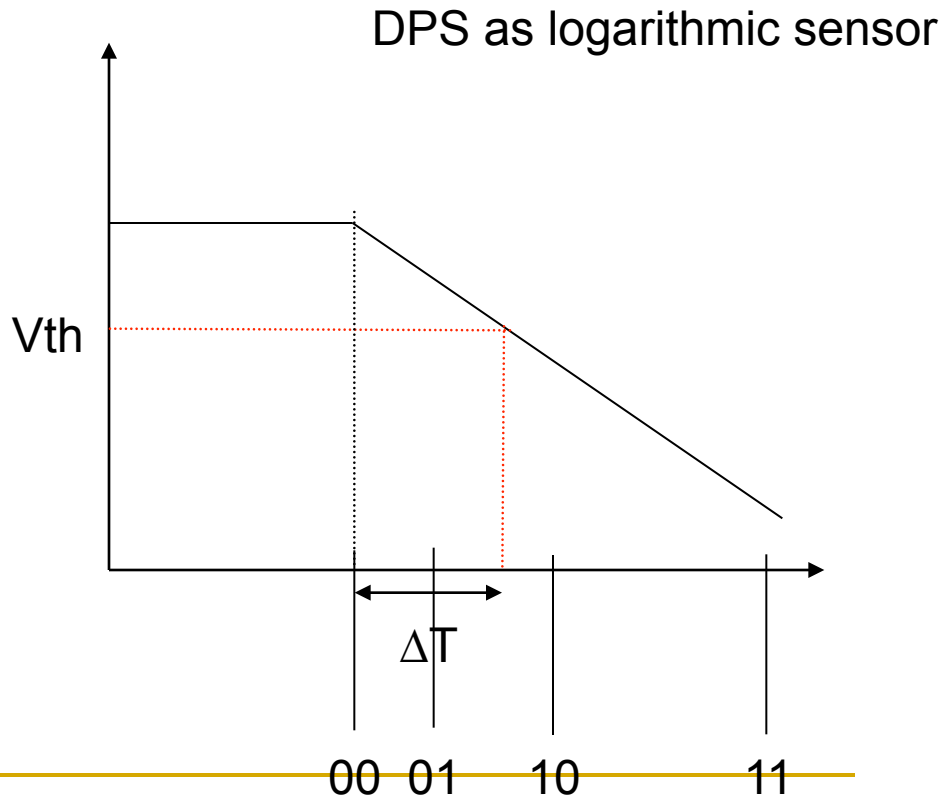
$$T = \frac{k'}{\ln(1 - T')}$$



Architectures of CMOS image sensors

- DPS for Logarithmic Image Sensor





Conclusion

- A lot of architectures of CMOS image sensors have been developed during the 10 years.
- Each of these has some advantages compared to the others.
- The goal of CMOS image sensors manufacturers is to produce sensors with caracteristics wich are equivalent to CCD image sensors.