

# Image Sensors

CCD image sensors

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**Master**

# Historical background

- CCD sensors

- 1970 :

- W.S.BOYLE and G.G. AMELIO create CCD process

- 1971:

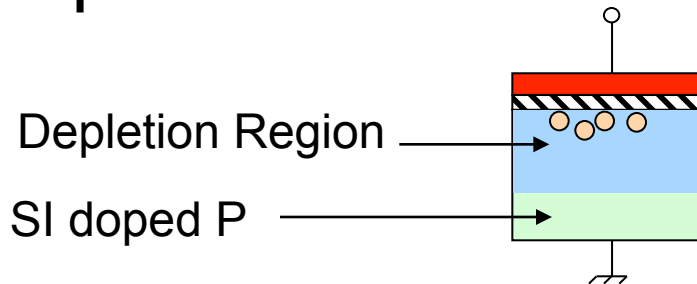
- **C.I.D.I.S.** by PHILLIPS, Charge Injection Device Image Sensor : first image sensor based on photocell pixels.

- 1973 :

- RCA produced the first CCD image sensor : 120.000 pixels

# The photo-element

## ■ The photocell

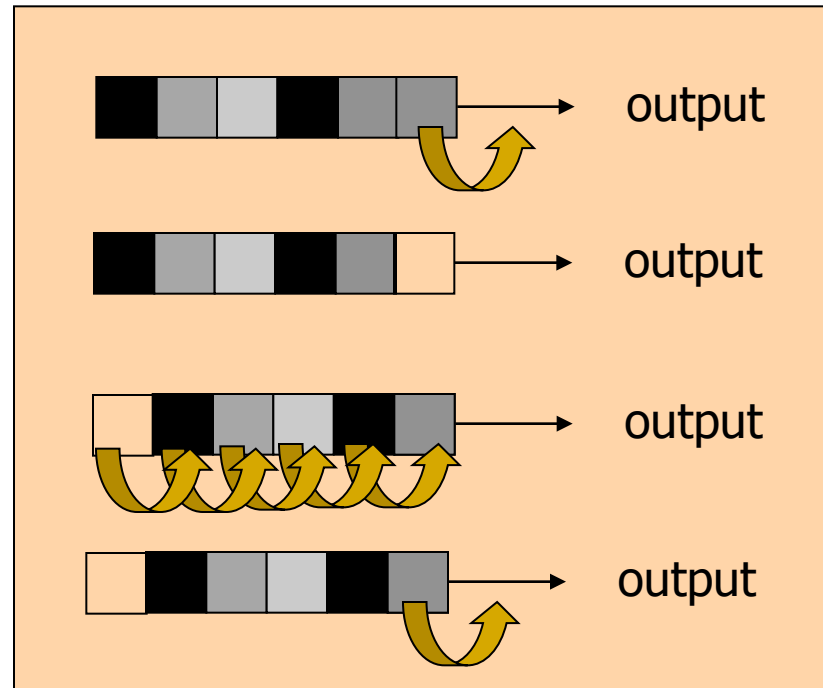


## ■ Particularity of CCD sensors

- The originality of CCD image sensor is that to read one pixel, we need to read all the pixels. The electrons created by the photons during the integration time are transferred step by step to the output of the sensor.

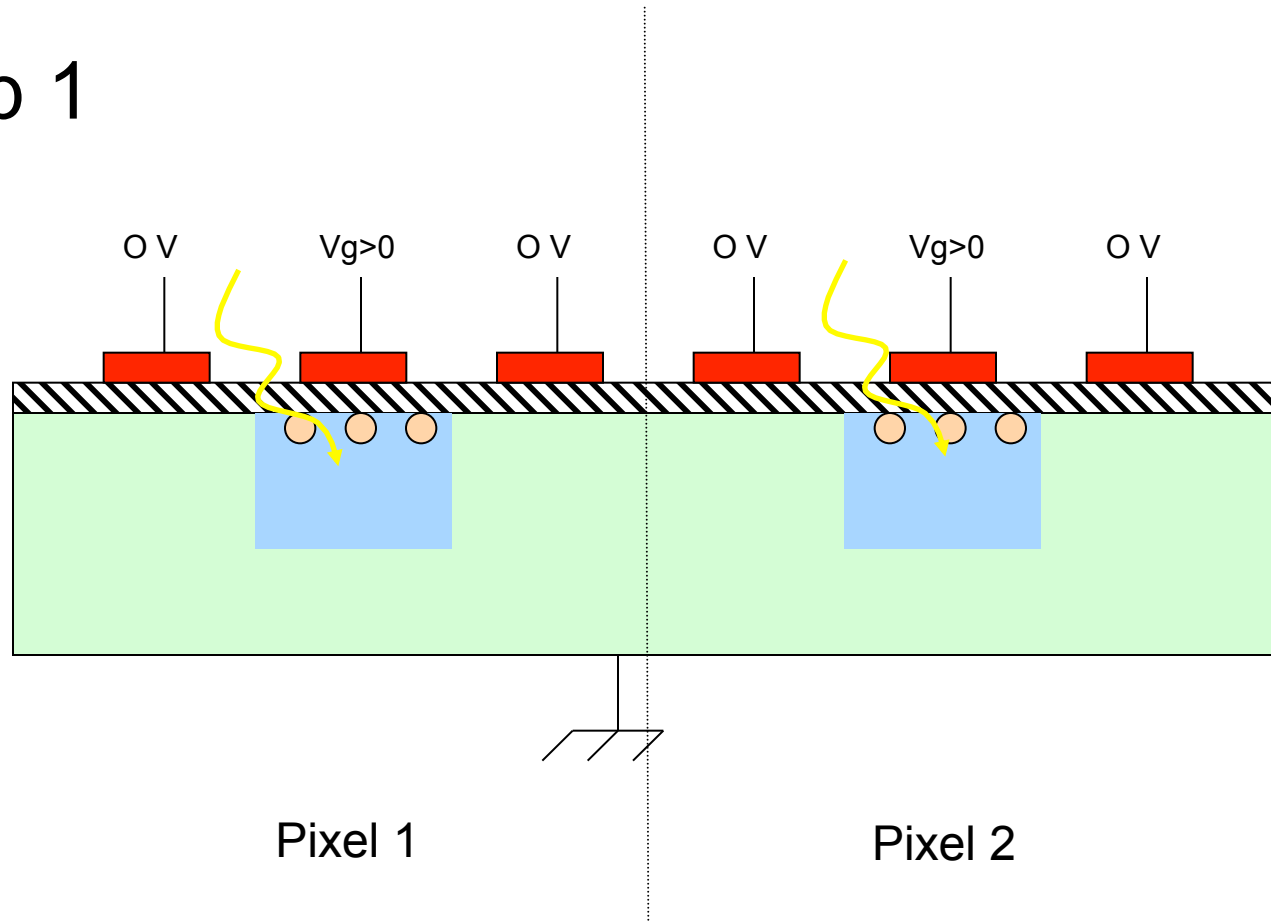
# CCD process

## ■ Principle of the CCD process



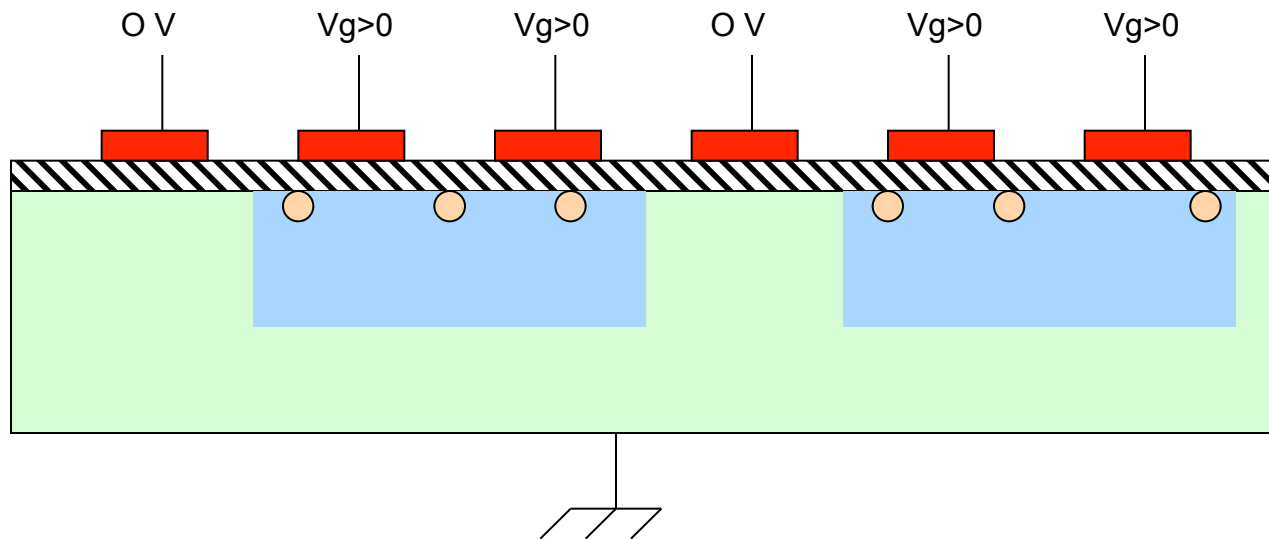
# CCD process

## ■ Step 1



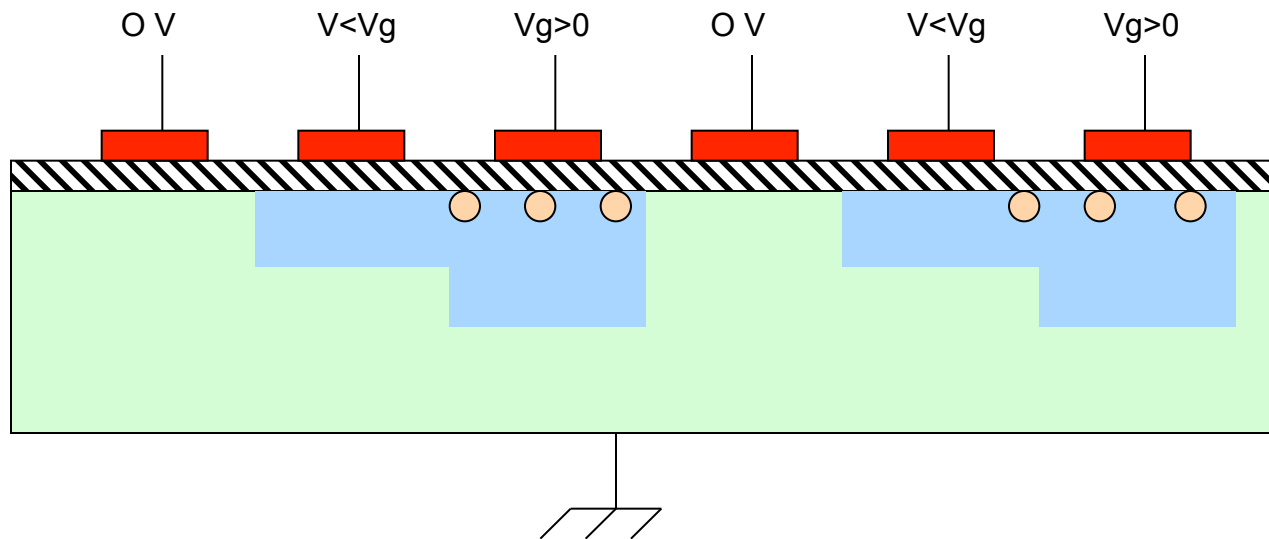
# CCD process

## ■ Step 2



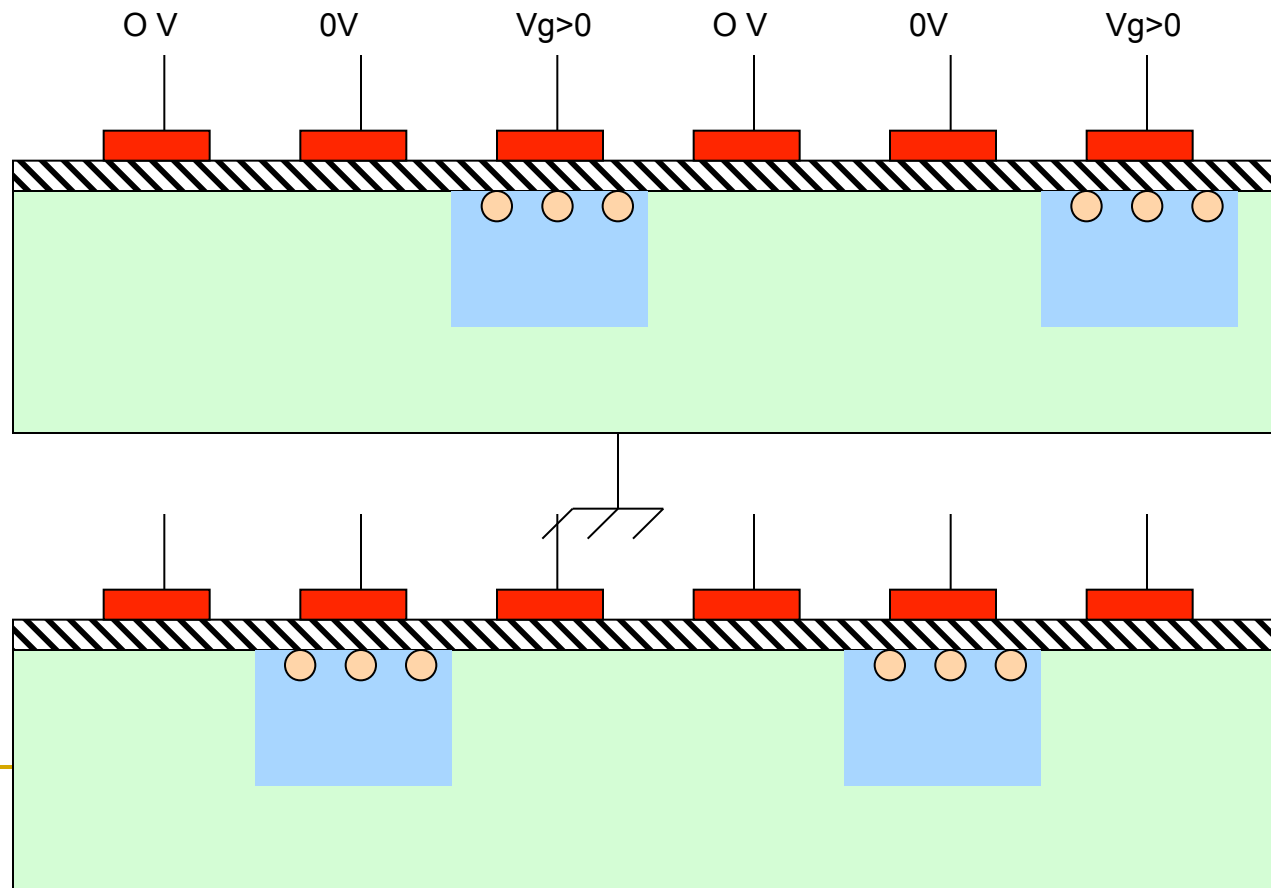
# CCD process

## ■ Step 3



# CCD process

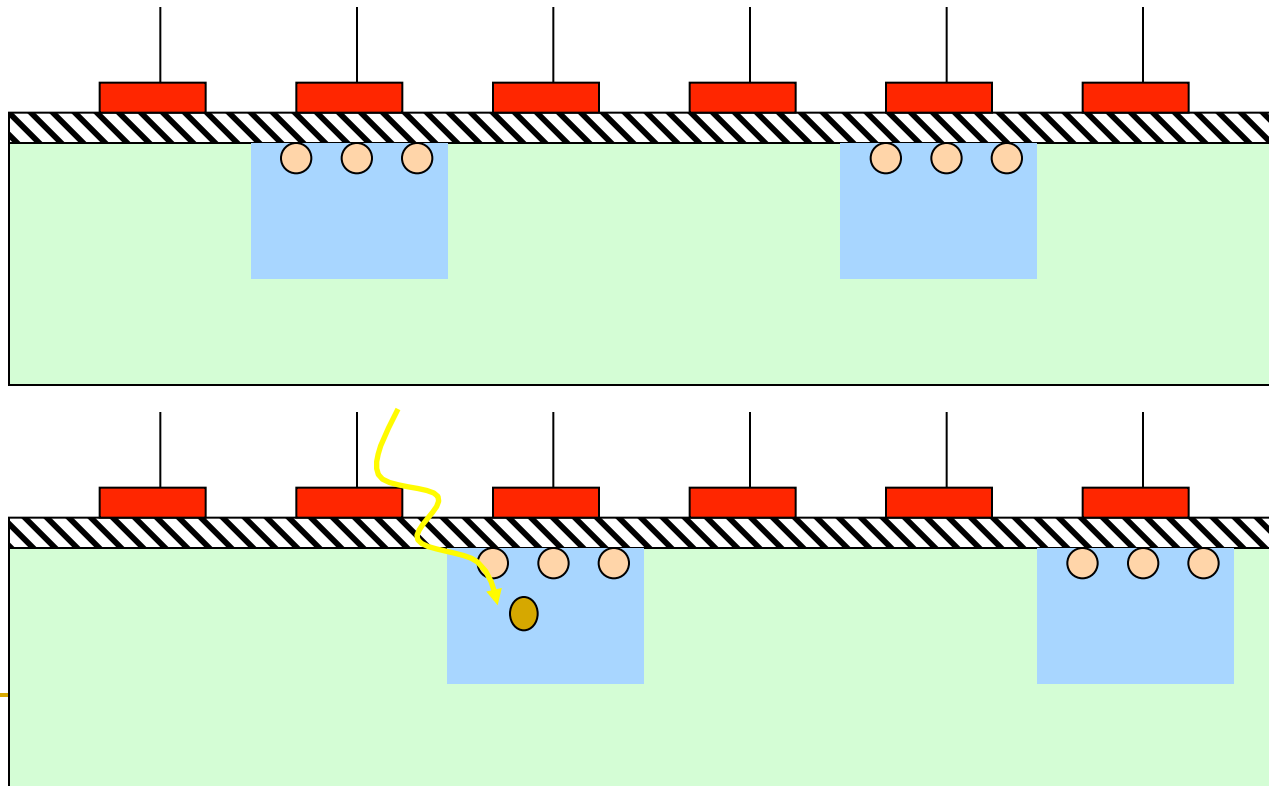
## ■ Step 4





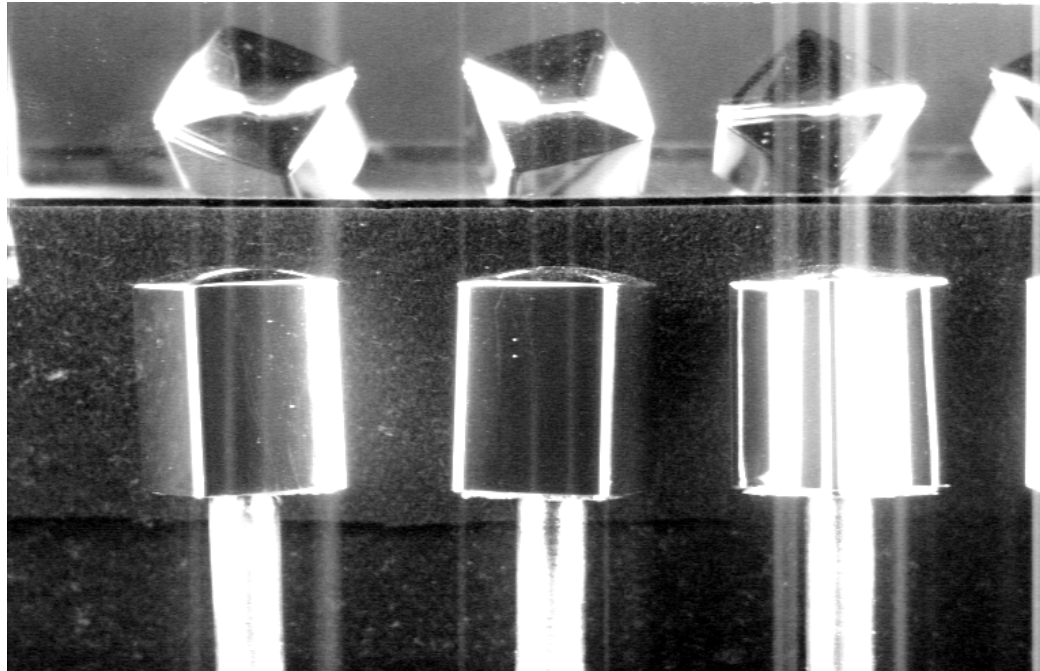
# CCD process

During the transfert of the electrons, photons should not come in the depletions regions



# CCD process

- Smearing



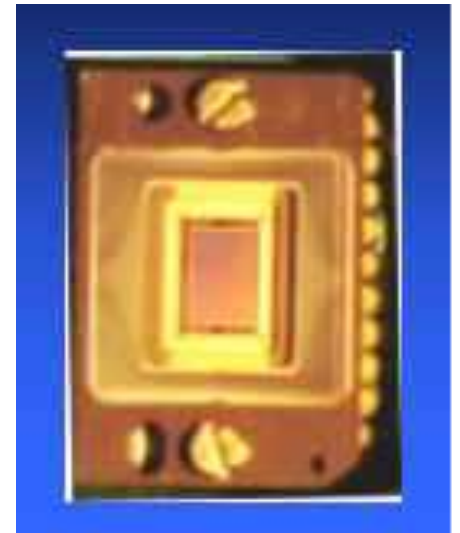
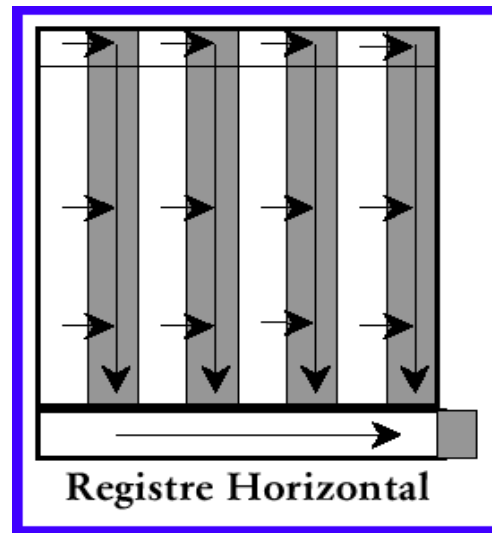
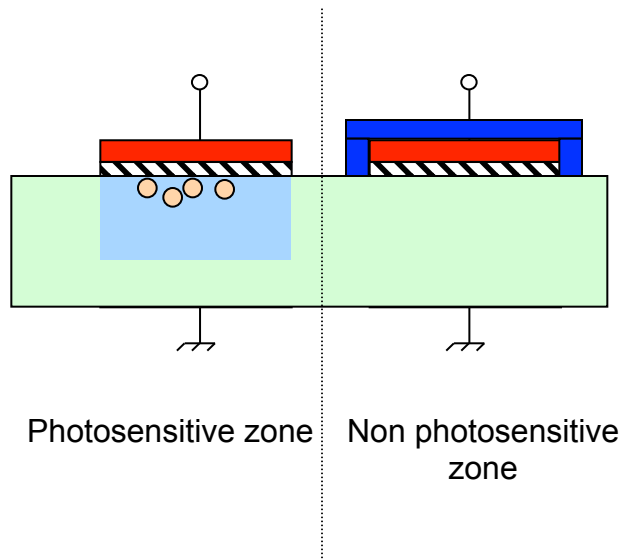
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# CCD technology

- 2 solutions
    - Mechanical shutter
    - Electronic shutter
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# CCD technology

## ■ Interline Transfert Matrix



# CCD technology

## ■ Full frame CCD



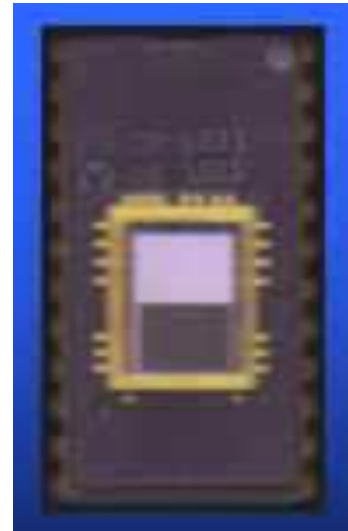
2D analog memory



horizontal analog register

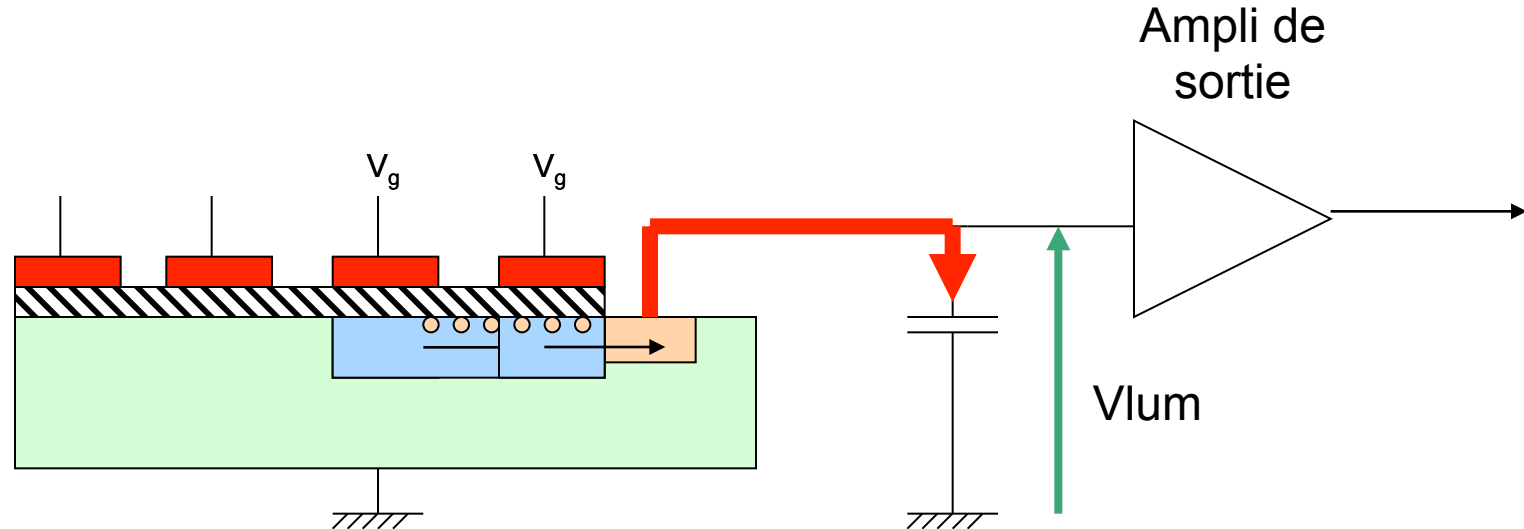


output



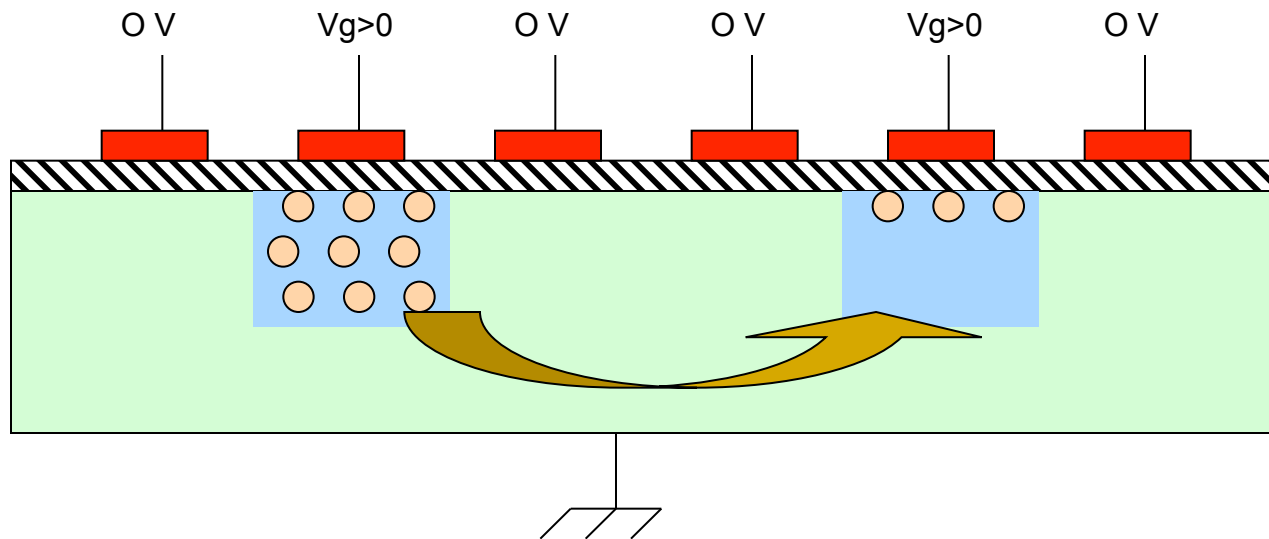
# CCD technology

## ■ Output Amplifier



# CCD Technology

## ■ Blooming



# Troubles of CCD

- Blooming



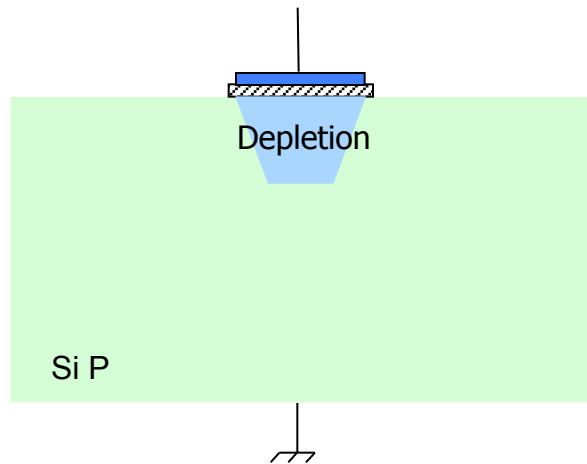


# CCD based on photodiodes elements

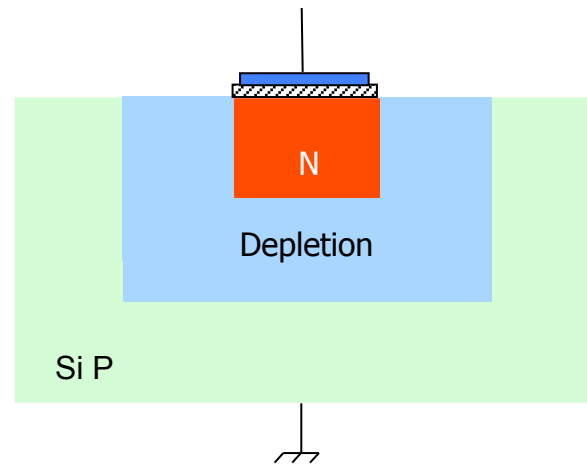
- To improve the quality of images produced, manufacturers of CCD look at the photodiodes to realise photoelements.
  - Improvement of the sensitivity
  - Limitation of blooming and smearing effects

# CCD based on photodiodes elements

## ■ CCD based on photodiodes elements



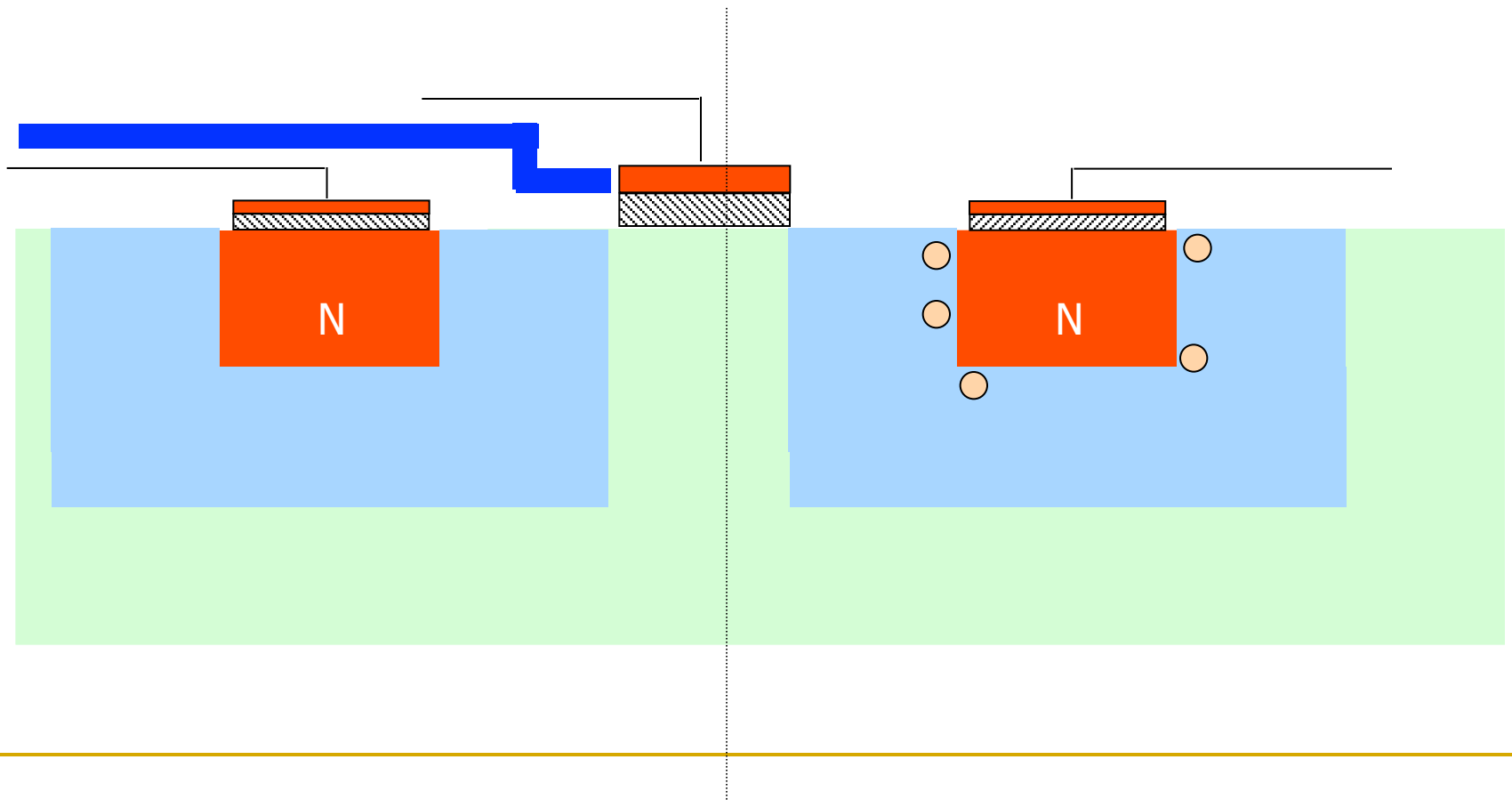
Photocell



Photodiode

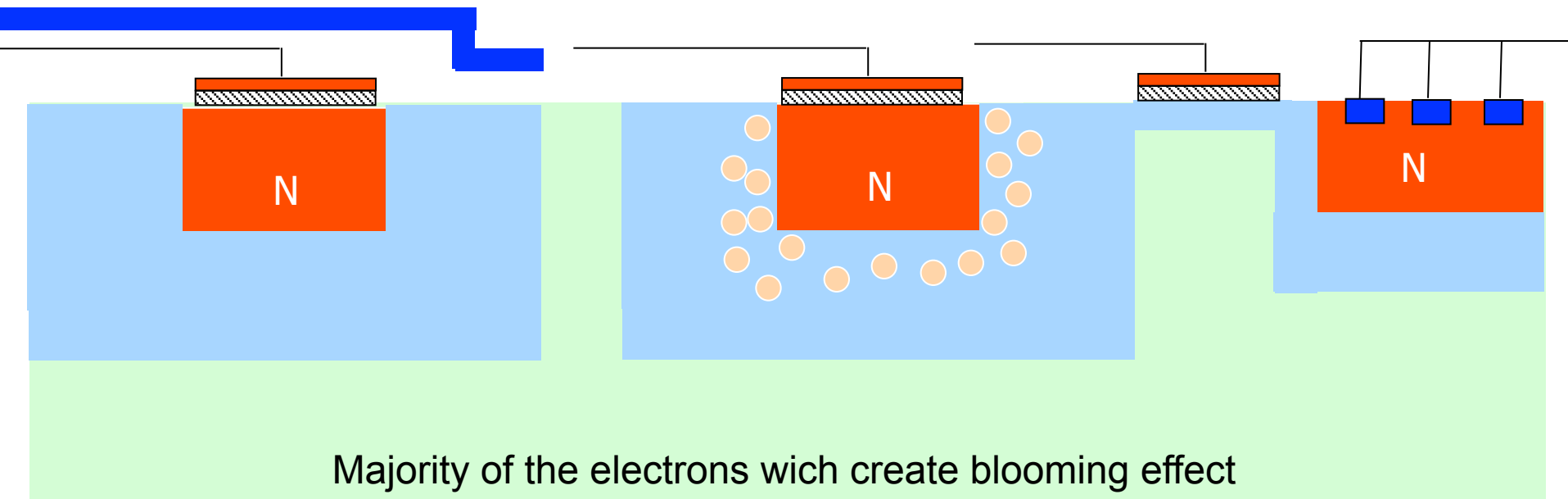
# CCD based on photodiodes elements

- CCD based on photodiodes elements



# CCD based on photodiodes elements

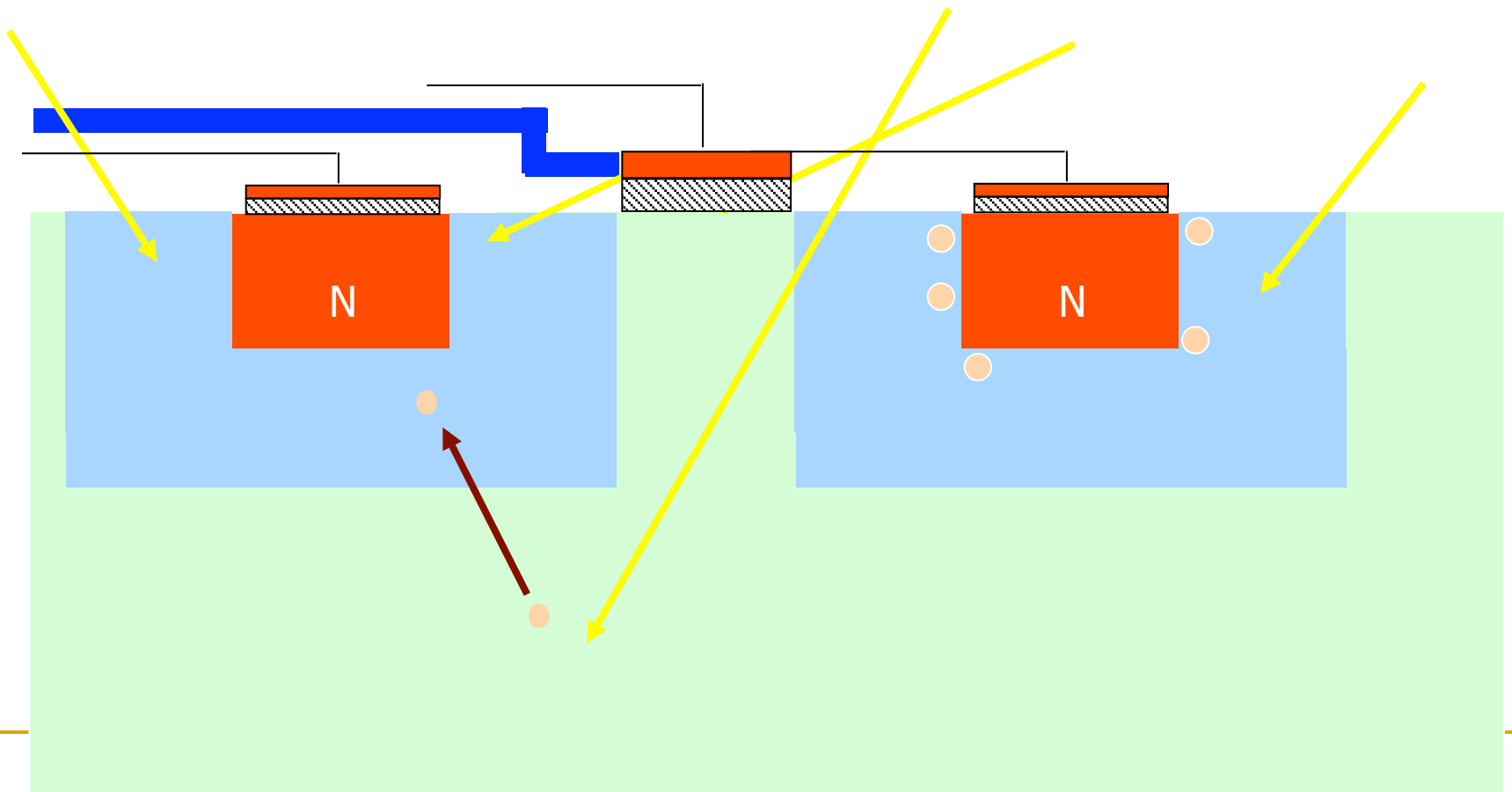
- Lateral PN junction to limit effect of blooming



Majority of the electrons which create blooming effect  
in classical CCD sensor are drained in the lateral junction

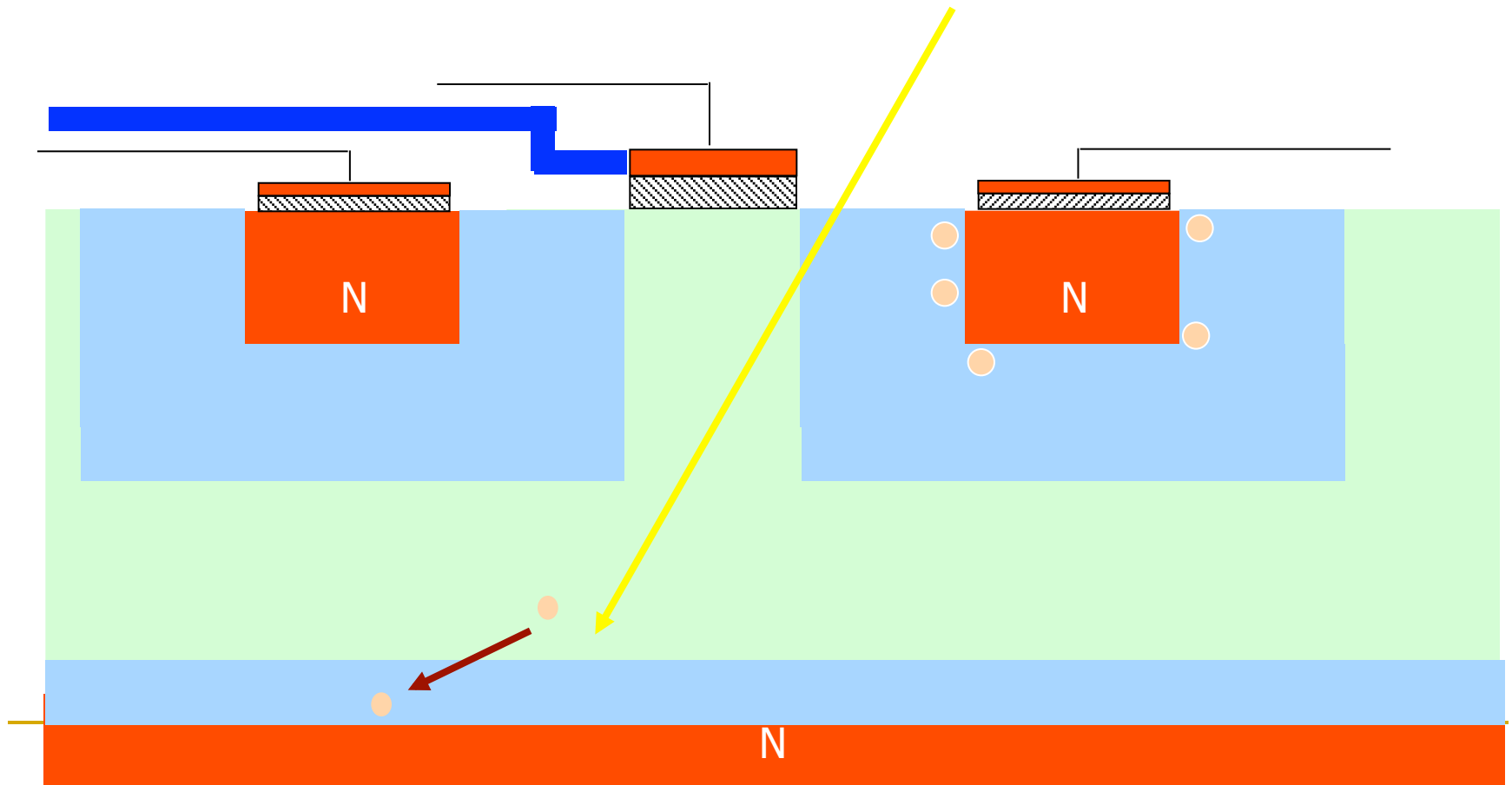
# CCD based on photodiodes elements

## ■ Limitation of the smearing effect



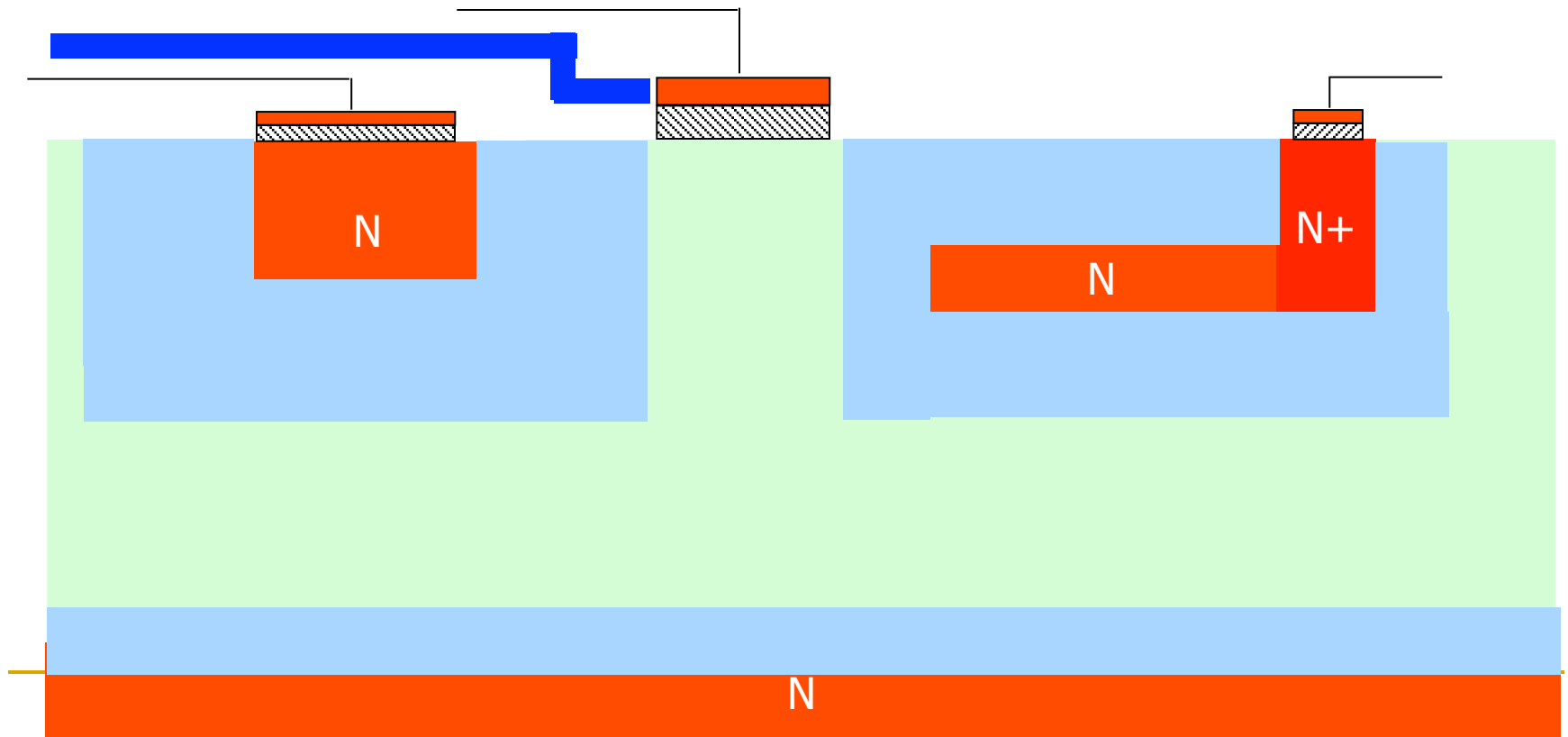
# CCD based on photodiodes elements

## ■ Limitation of the smearing effect



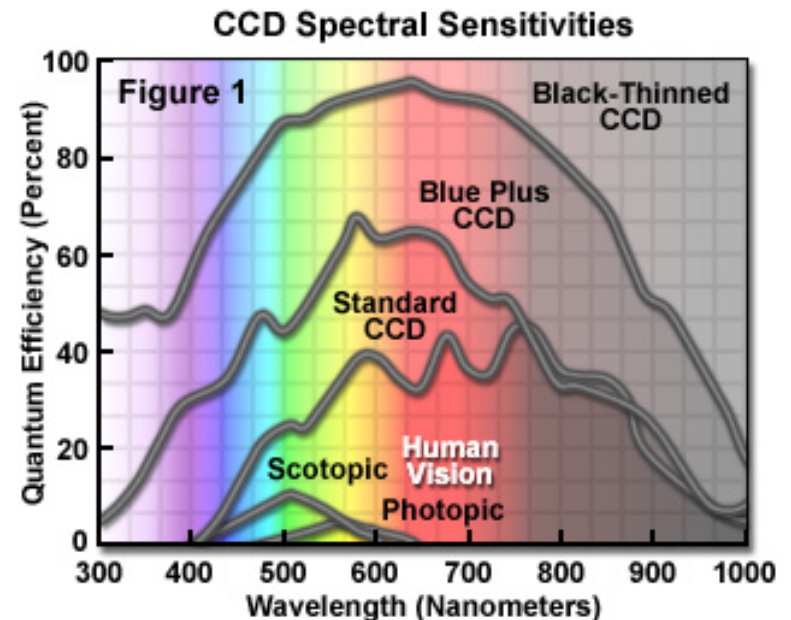
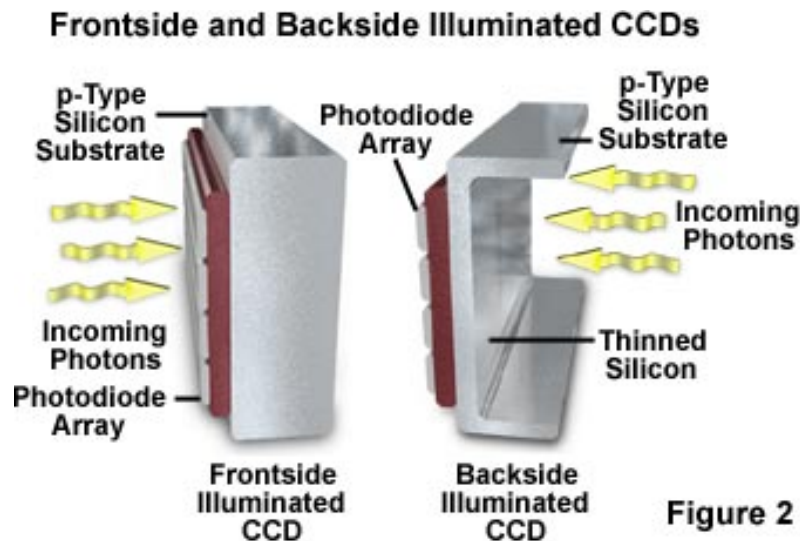
# CCD based on photodiodes elements

- HAD technology (SONY)



# CCD based on photodiodes elements

## ■ Backside Illuminated CCDs





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# Conclusion

- CCD technology is a relatively old technology. With almost 40 years of existence it has seen several changes that allow it to reach maturity today.
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