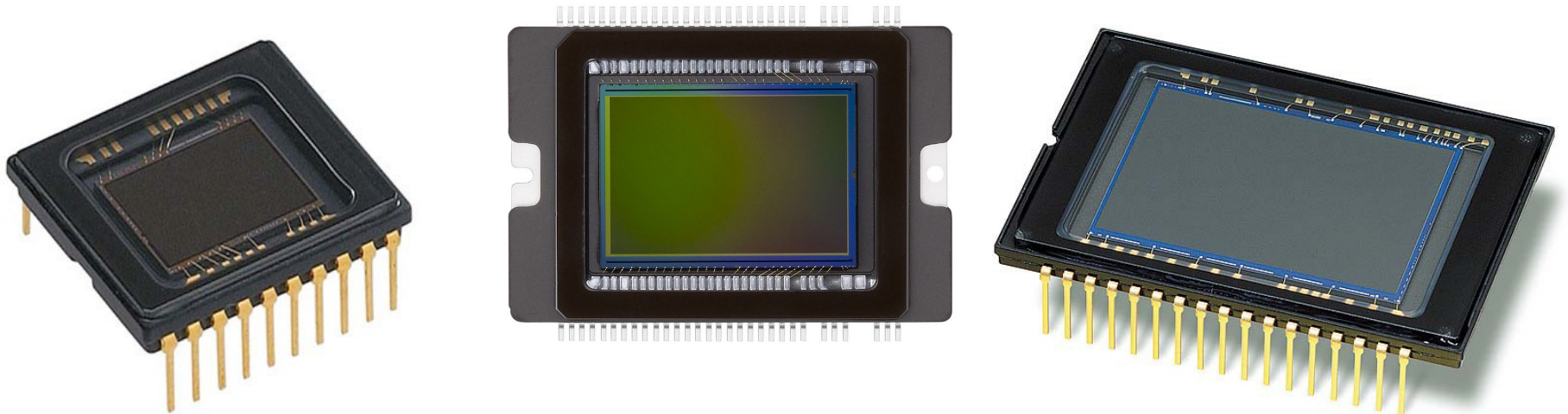


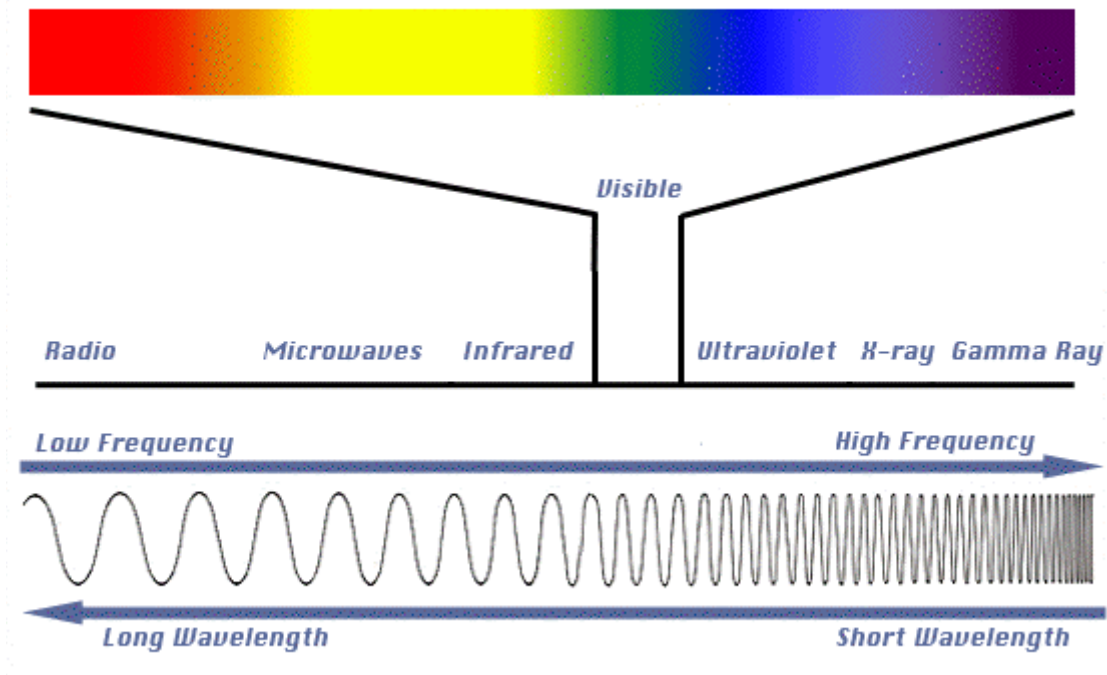
Processing Digital Camera Images

Camera Sensors

Michael Thomas



- Many image sensors: Infrared, gamma ray, x-rays etc.
- Focus on sensors for visible light (slightly into infrared and uv light)



- First Video camera tube sensors in the 1930s
- Cathode Ray Tube (CRT) sensor
- Vidicon and Plumbicon for TV-Broadcasting in the 1950s – 1980s
- Vidicon sensors on Galileo-spacecraft to Jupiter in 1980s

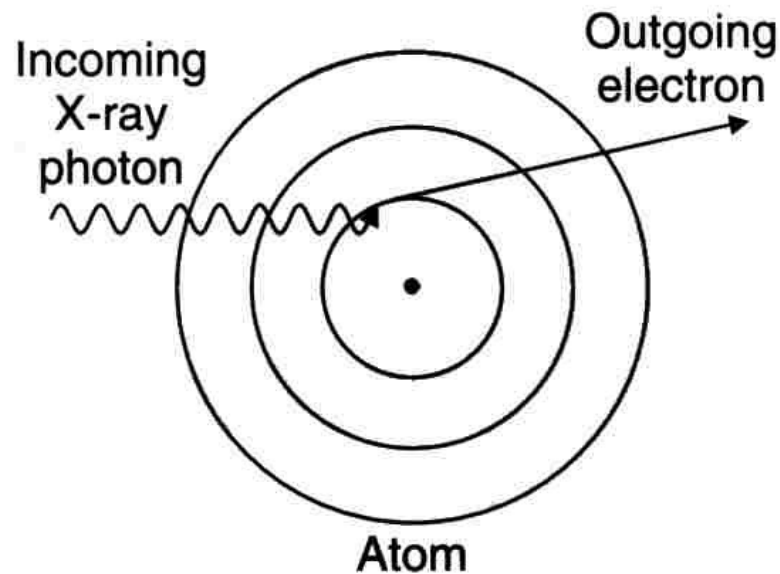


The Photoelectric-Effect

How to convert light to electric charge?

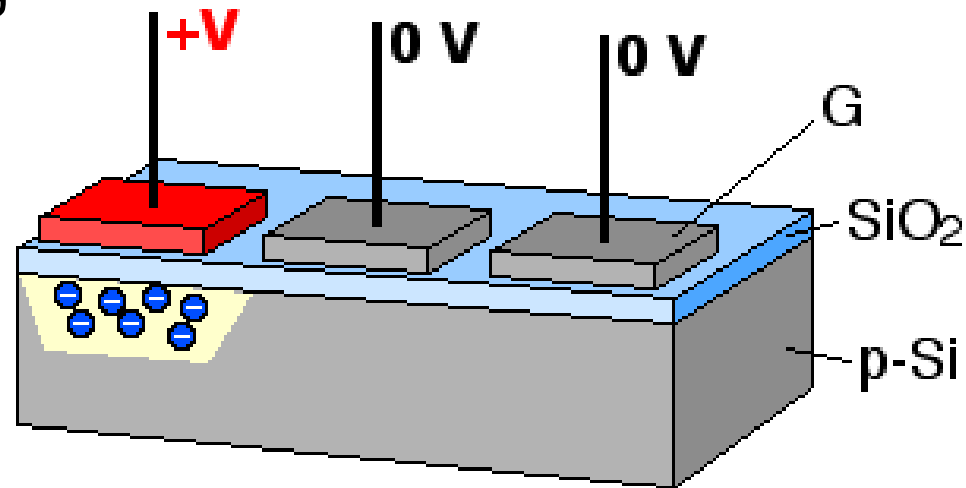
- Inner photoelectric-effect at a photodiode:
- Photon excites electron creating a free electron and a hole
- The hole moves towards the anode, the electron towards the cathode

Now we have our charge!

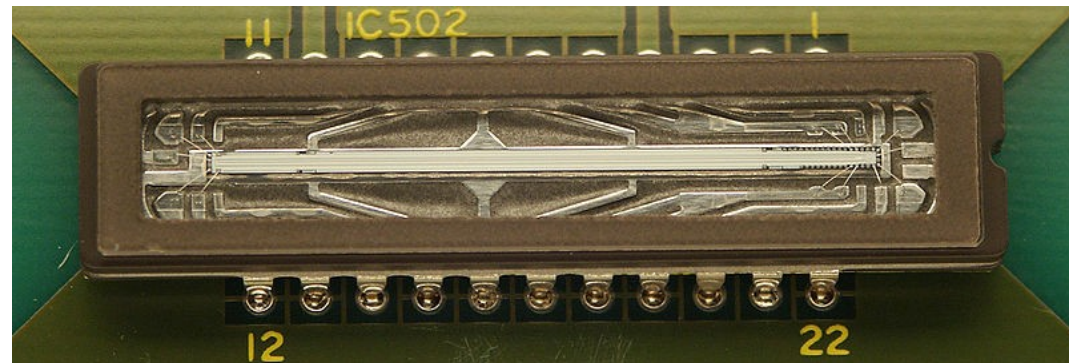
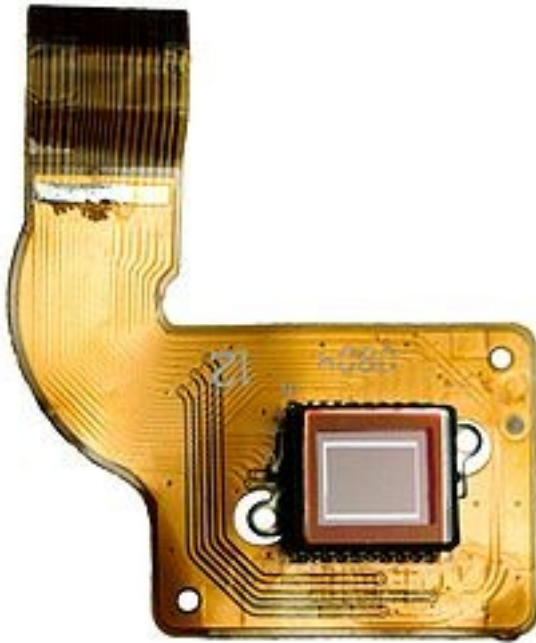
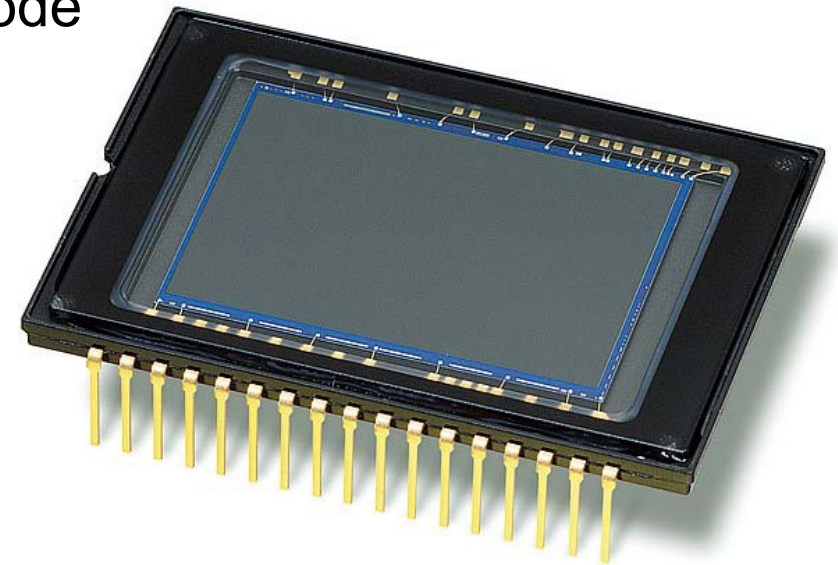


Charge-Coupled Device (CCD)

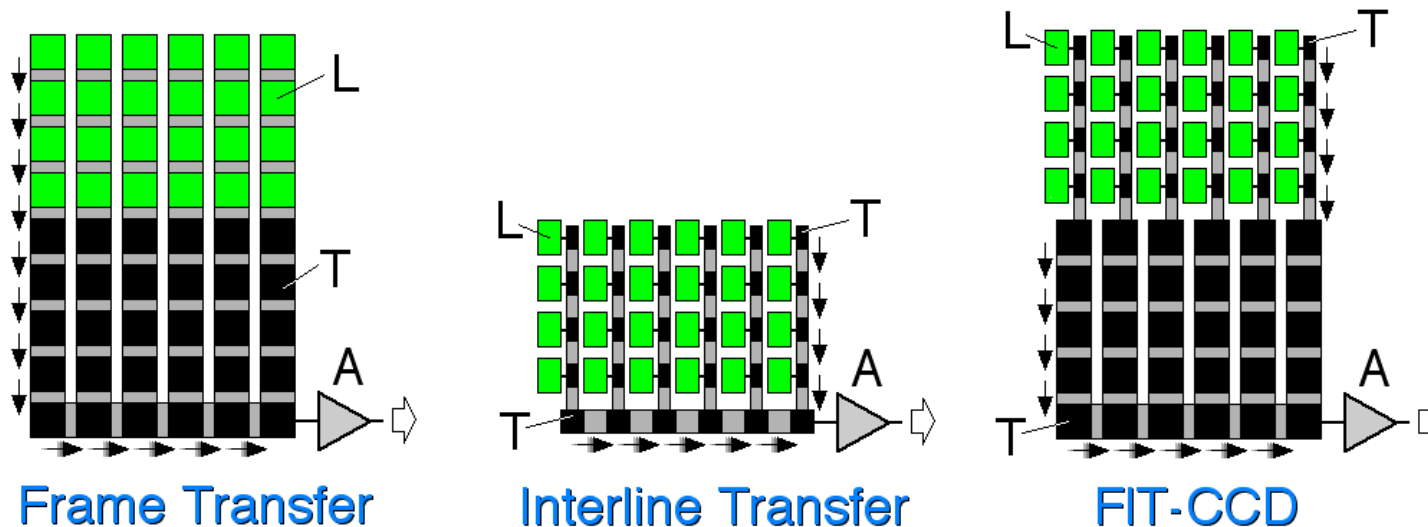
- Integrated circuit
- Array of connected capacitors (Shift register)
- Charge of capacitor is transferred to neighbour capacitor
- At the end of chain, charge is converted into voltage by charge amplifier
- Transfer stepped by Clock-Signal
- Serial charge processing



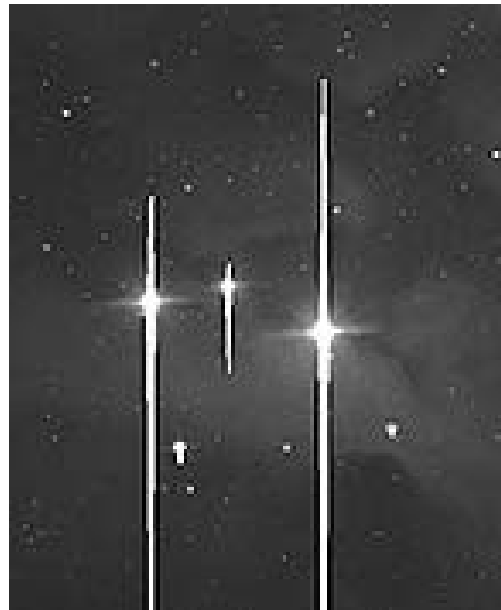
- Each capacitor is coupled with a photodiode
- All capacitors are charged parallelly
- Charges are transferred serially



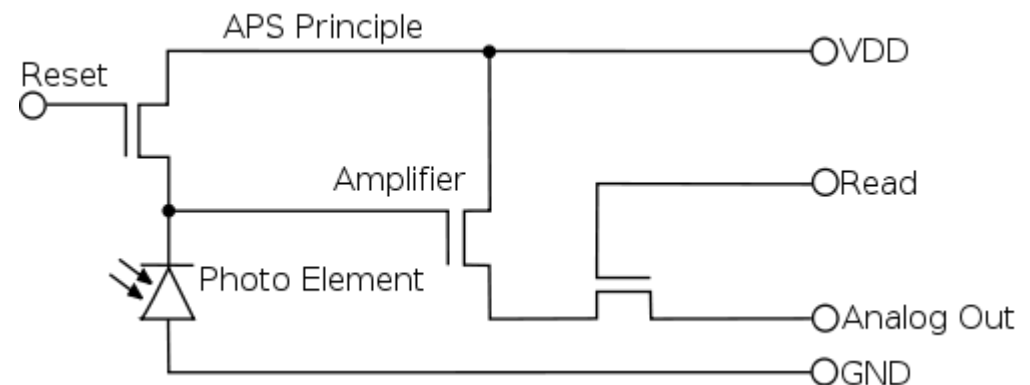
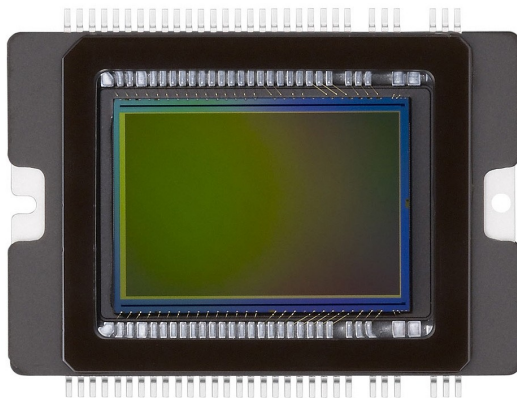
- But how to prevent light to charge up the capacitors while transferring?
 - Mechanical shutter
 - Buffer of capacitors that store the charge until it is transferred
 - Loss of resolution or larger sensor → more expensive



- What happens, if too much light hits the sensor?
 - Capacitors overload
 - Charge “spills” over to neighbour capacitors
 - Blooming effect occurs



- Integrated circuit
- Active pixel sensor
- Array of pixel sensors each coupled with a photodiode
- Each pixel sensor has additional abilities (e.g. Analog-Digital-Conversion)



- Each pixel can be addressed separately
 - But this takes time, so the motive or the camera can move
- Rolling-shutter effect
 - Must be corrected by software



Plain sensor can only detect brightness

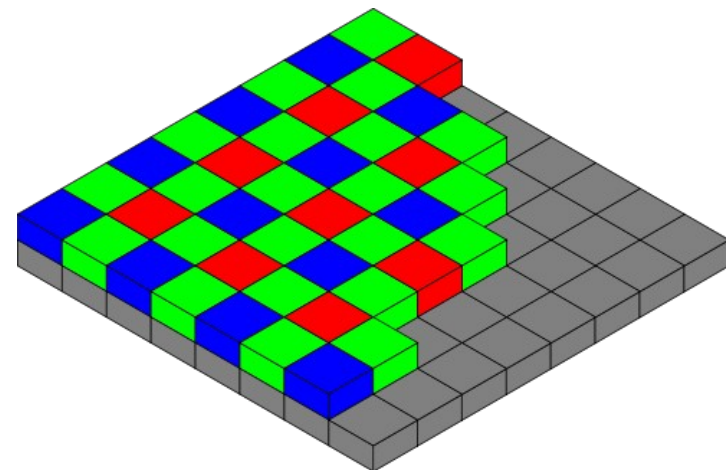
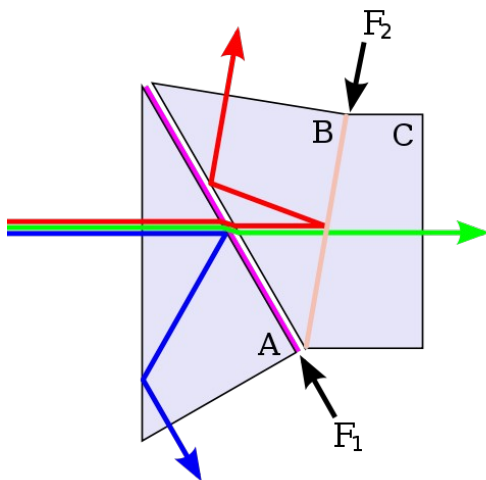
→ Split colors up

Three-Sensors:

- 3 CCD or CMOS sensors receive red, green oder blue light
- Light split by a dichroic prism

Bayer-Filter:

- Color filter on each pixel is used to make block out certain wavelenghtes of light



CCD:

Pro:

- No rolling shutter
- Lower noise
- Good image quality

Con:

- Analog device!
- Blooming effect

CMOS:

Pro:

- No blooming
- Cheaper
- Lower power consumption
- Faster readout

Con:

- Rolling shutter
- Variations in brightness (per Pixel)

Q&A

Thank you for your attention!

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