Photodetectors

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Introduction to photodetectors

■ Photosensors or photodetectors are sensors of light or other electromagnetic energy which convert light signals to a voltage or current.

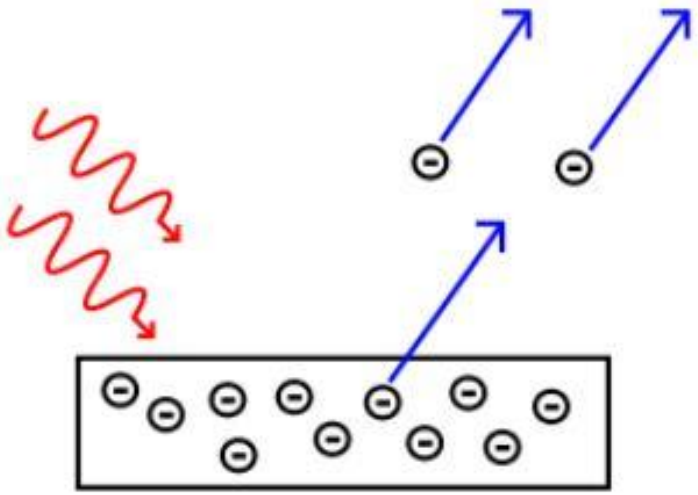
1. Chemical detectors
2. Photomultiplier tubes
3. Photovoltaic cells and photodiodes
4. Charge-coupled devices (CCD)
5. Cryogenic detectors
6. Single photon detectors

Chemical detectors

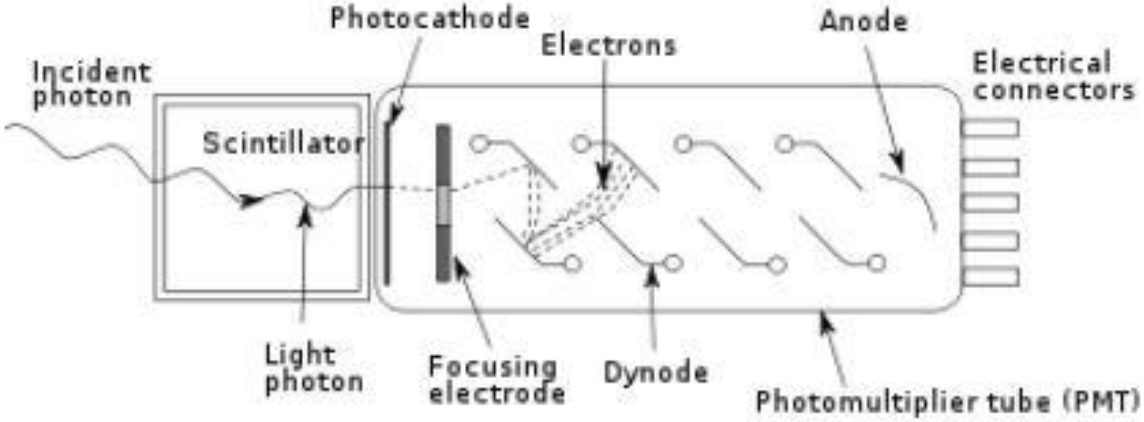
■ Chemical detectors, such as photographic plates, in which a silver halide molecule is split into an atom of metallic silver (which block light and appear as the black part of the film negative) and a halogen atom.

Photomultiplier tubes

■ In the photoelectric effect, electrons are ejected from a material's surface upon exposure to radiation of sufficient energy.



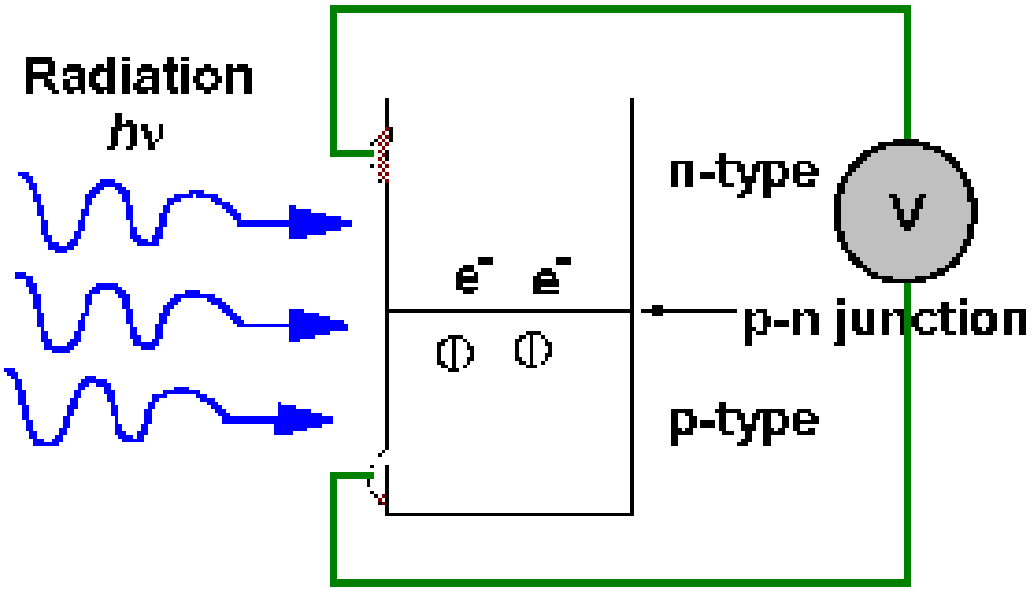
Light-matter interaction



Photovoltaic cells and photodiodes

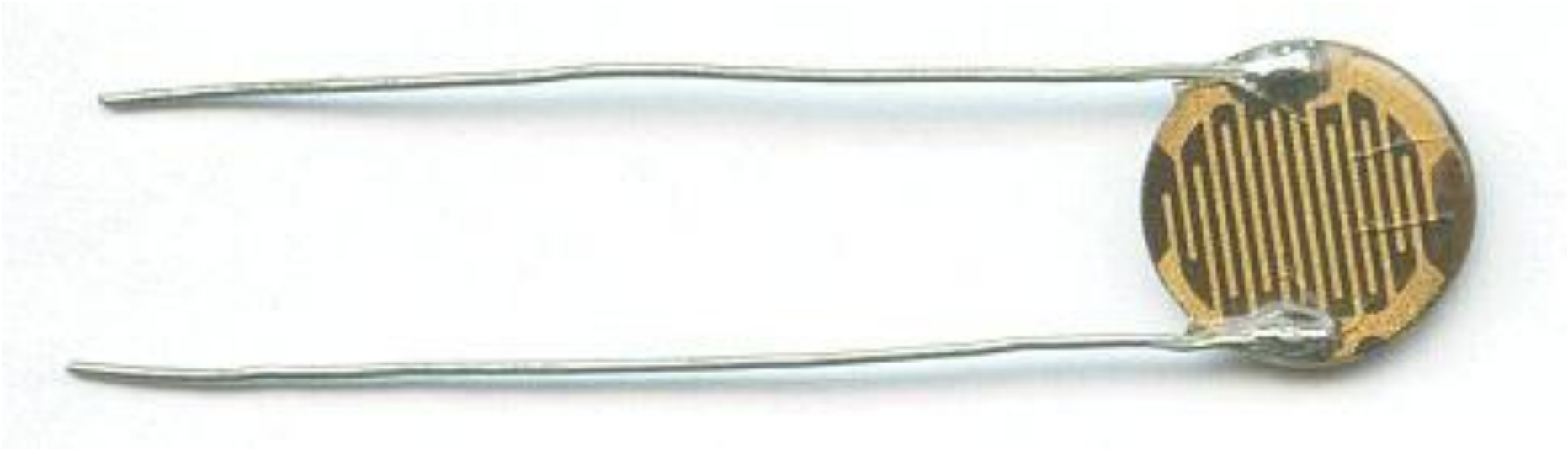
■ In the photoelectric effect, electrons are ejected from a material's surface upon exposure to radiation of sufficient energy.

■ The photovoltaic effect is different in that the generated electrons are transferred between different bands (i.e., from the valence to conduction bands) within the material, resulting in the buildup of a voltage between two electrodes



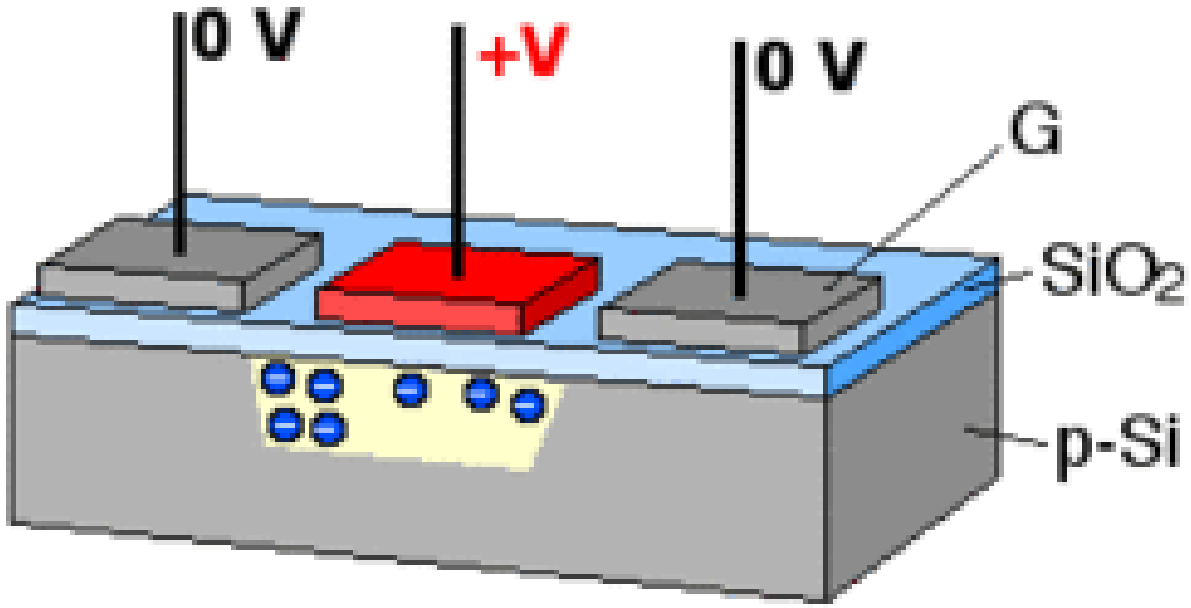
Photoresistor

■ A photoresistor is made of a high resistance semiconductor in which photons absorbed by the semiconductor give bound electrons enough energy to jump into the conduction band. The resulting free electron (and its hole partner) conduct electricity, thereby lowers the resistance.



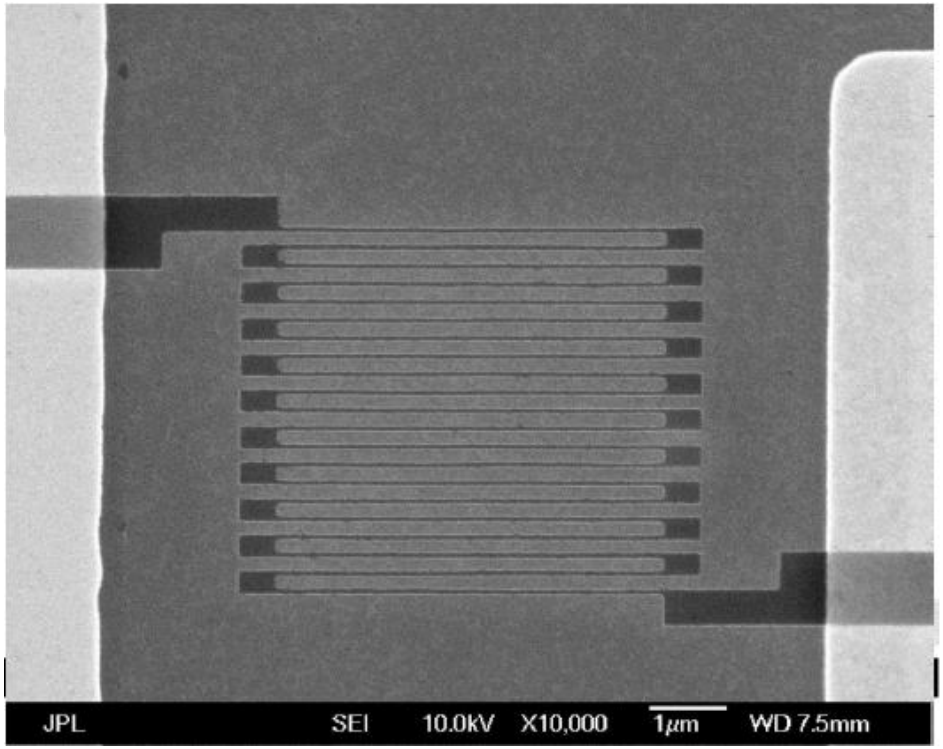
Charge-coupled devices (CCD)

■ A charge-coupled device (CCD) is a device for the movement of electrical charge, usually from within the device to an area where the charge can be manipulated, for example conversion into a digital value.



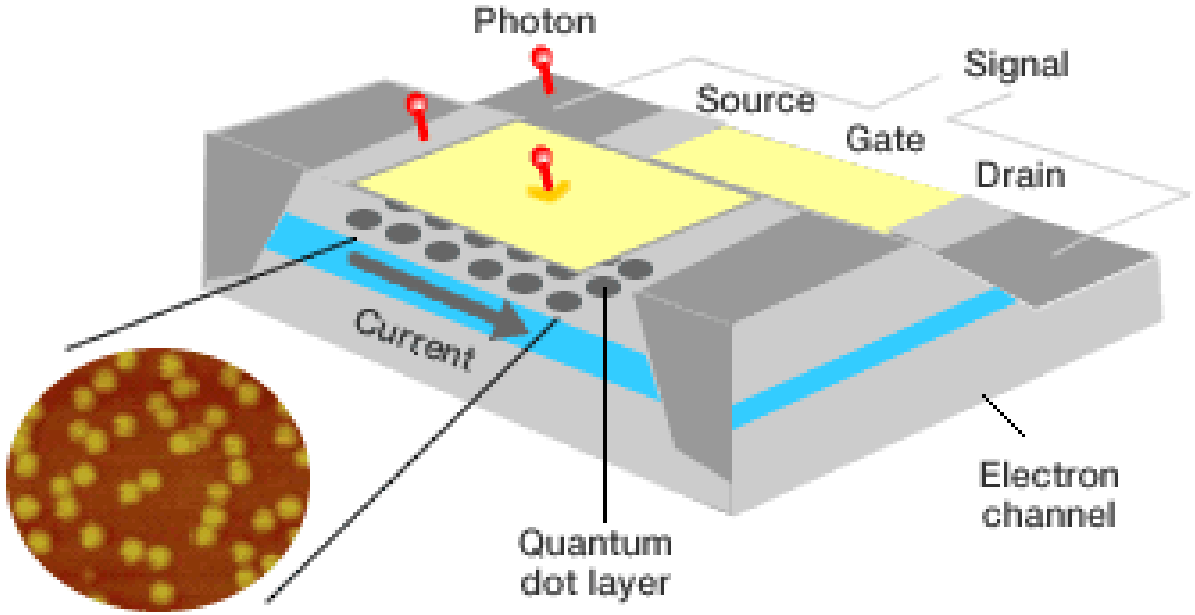
Cryogenic detectors

■ Superconducting nanowire single photon detectors - Absorption of a photon destroys a number of Cooper pairs, enough to reduce the critical current below the bias current. Which leads to a detectable voltage pulse of a duration of about 1 ns.



Quantum dot single photon detector

■ The quantum dot single photon detector is based upon a transistor structure in which the conducting channel is closely spaced from a layer of quantum dots. Where absorption of a photon creates carriers in the semiconductor, which after capture by a dot, produce a detectable change in the resistance of the channel of the transistor..



CCD cameras

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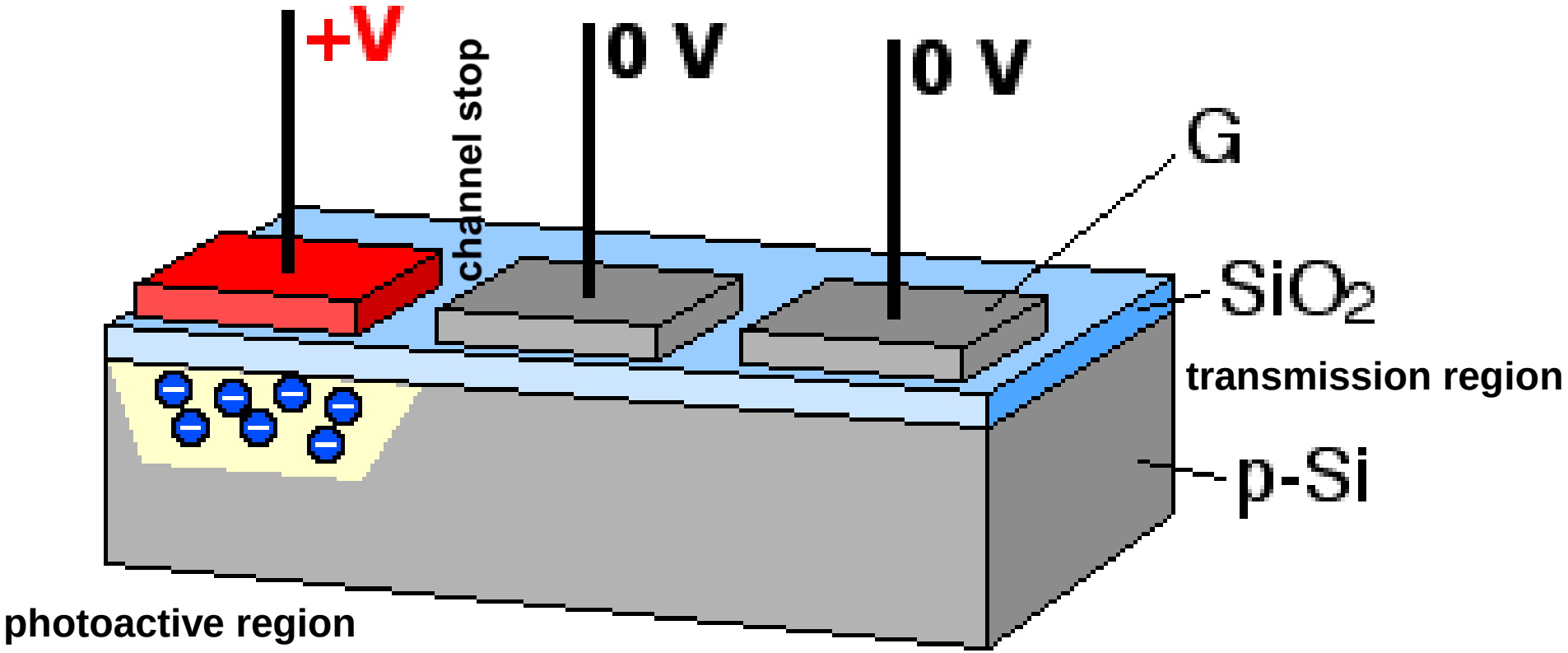
CCD basics

■ CCDs move charge between capacitive *bins* in the device

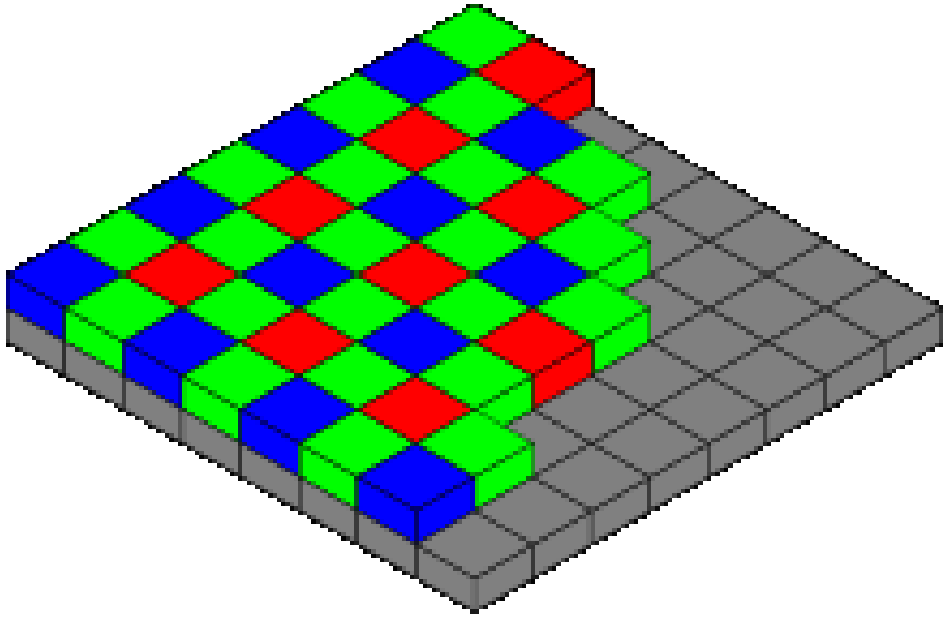


Photoelectric image sensor + shift register

CCD basics

■ Digital color cameras generally use a Bayer mask over the CCD.

■ Better color separation can be reached by three-CCD devices (3CCD) and a dichroic beam splitter prism, that splits the image into red, green and blue components.



CCD features

- Full frame CCD consists of mechanical shutter.
- Frame transfer CCD consists of image area and opaque area.
- Percentage of incident light responded by camera defines quantum efficiency of camera,

  CCD - ~70%
  Photographic film- 2%

- CCDs are sensitive to near-infrared light, hence allows infrared photography and night-vision devices.

CCD features

■ An electron-multiplying CCD (Impactron CCD) is a CCD in which a gain register (avalanche phototdiode) is placed between the shift register and the output amplifier.

■ An intensified charge-coupled device (ICCD) is a CCD that is optically connected to an image intensifier which includes three functional elements: a photocathode, a micro-channel plate (MCP) and a phosphor screen.

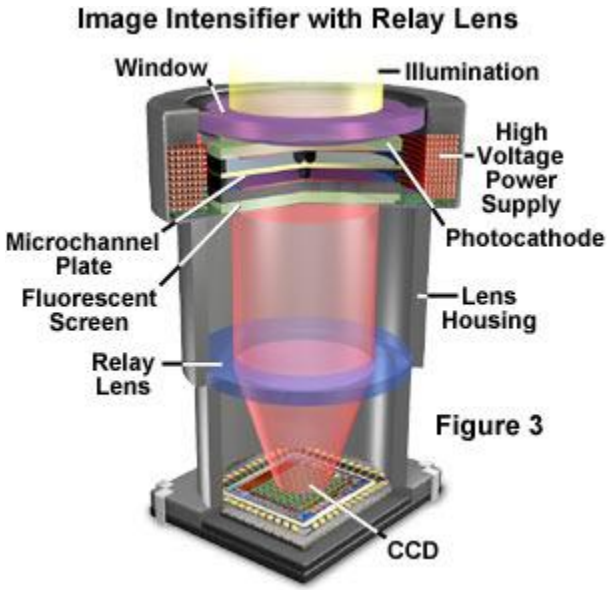


Figure 3

Thank you