

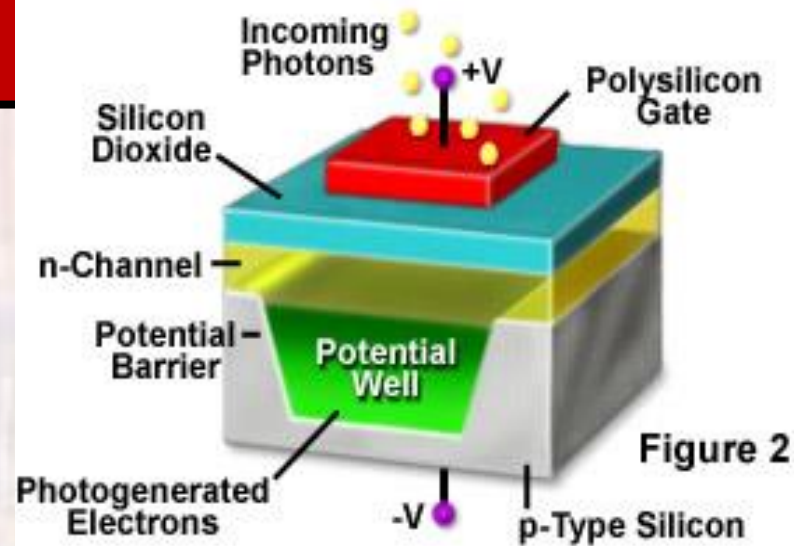
# CCD Imagers

Last modified 3/20/24

# CCD Imagers

- MOS Capacitor Photodetector
- Photo transparent polysilicon gate
- P-type silicon bulk (PMOS Capacitor)
- Biased in depletion mode (holes have been moved out of surface region)
- Incident light creates hole-electron pairs
  - Holes are swept away
  - Electrons are trapped under the gate
- Total charge trapped is proportional to the intensity of the incident light

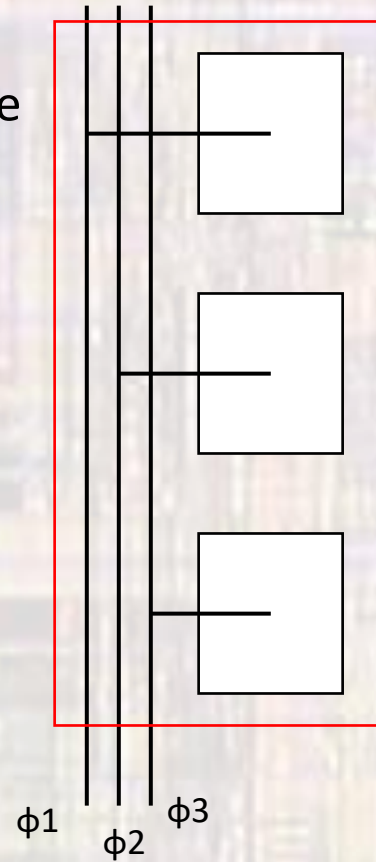
Metal Oxide Semiconductor (MOS) Capacitor



src: Nikon

# CCD Imagers

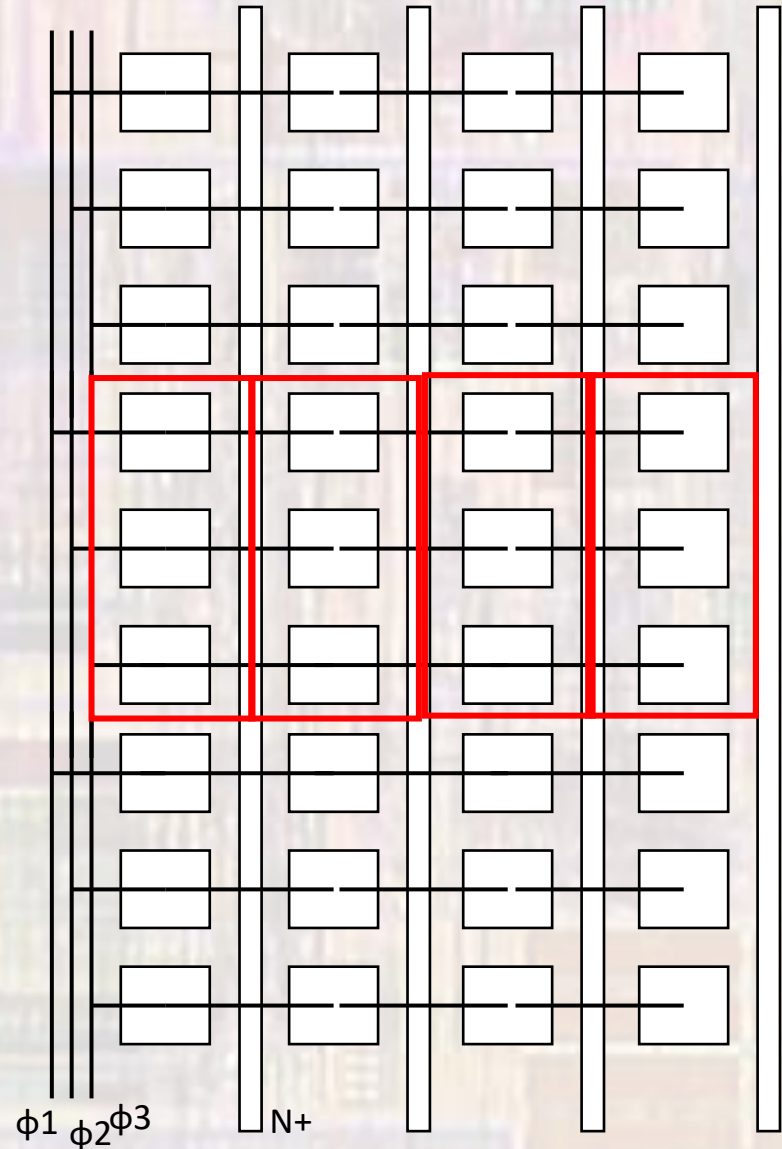
- CCD Pixel Structure
  - Each pixel is configured as 3 gates
  - Each gate as a separate control line



# CCD Imagers

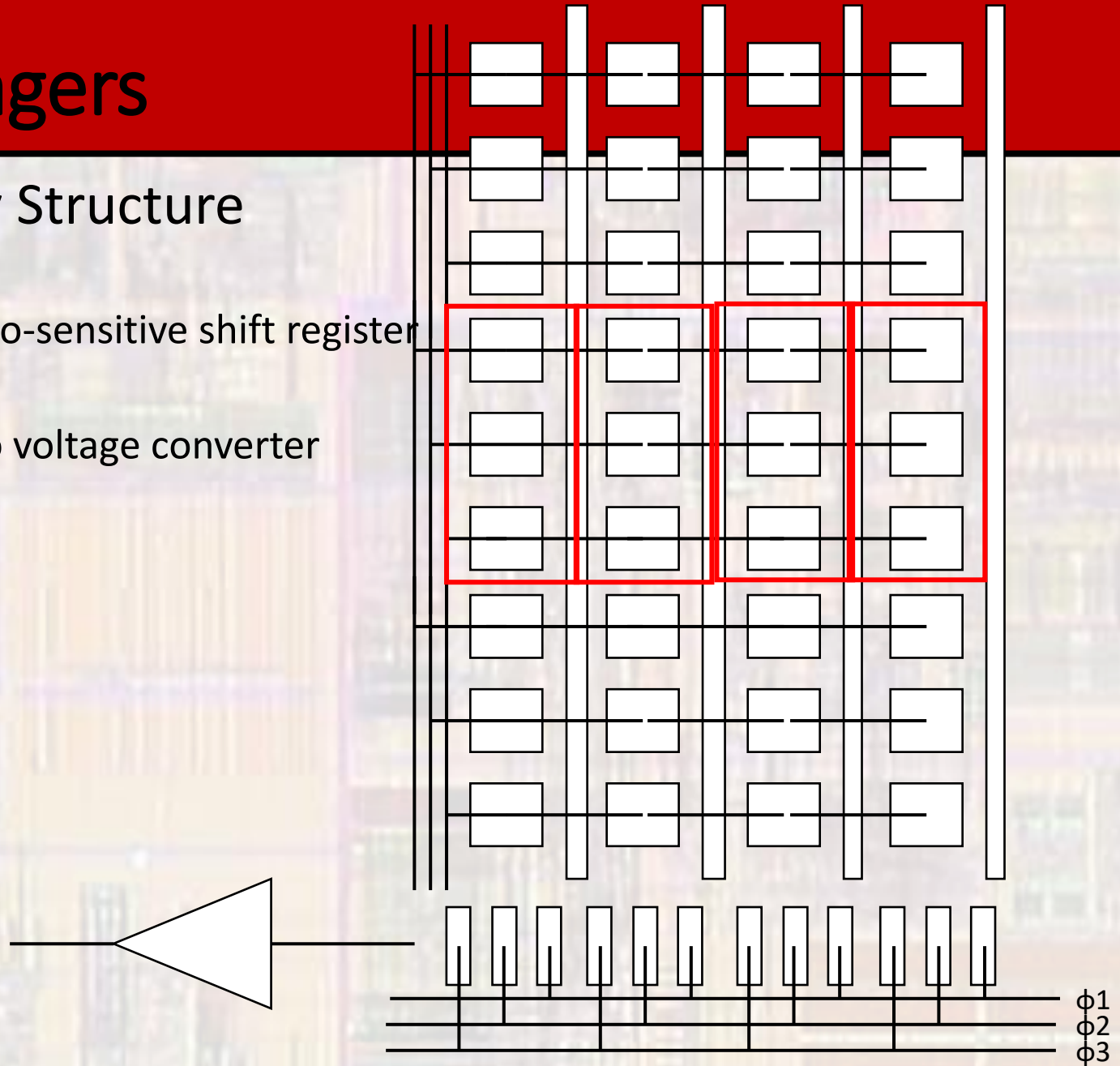
- CCD Array Structure

- Columns of pixels
  - Separated by barrier stops



# CCD Imagers

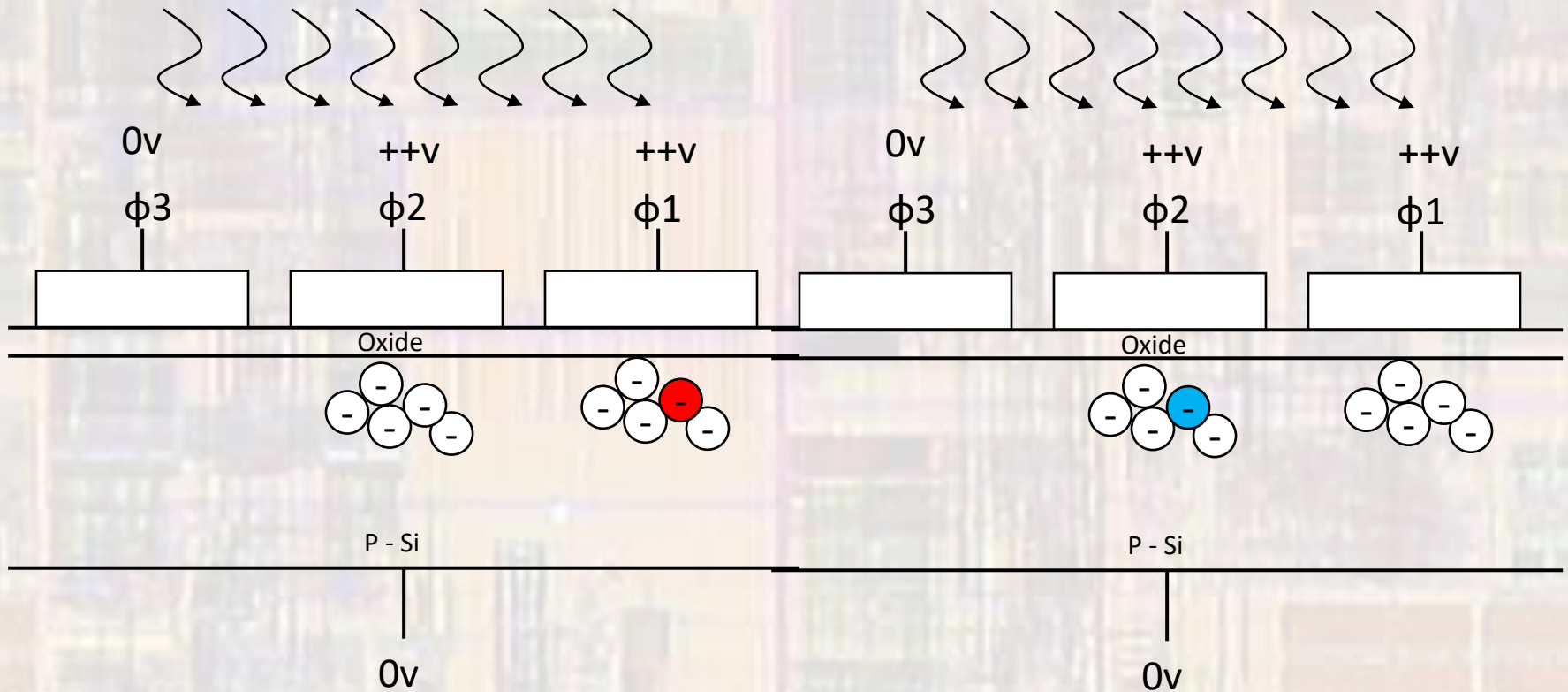
- CCD Array Structure
  - Non photo-sensitive shift register
  - Charge to voltage converter





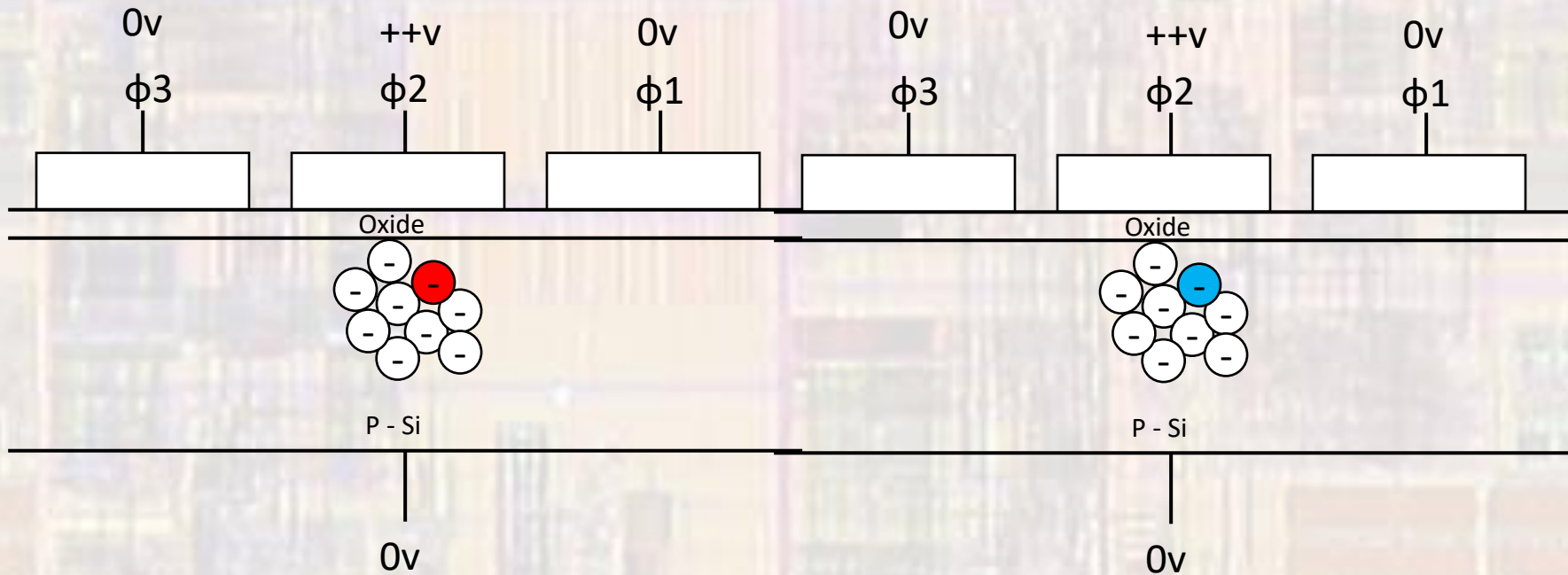
# CCD Imagers

- CCD Operation



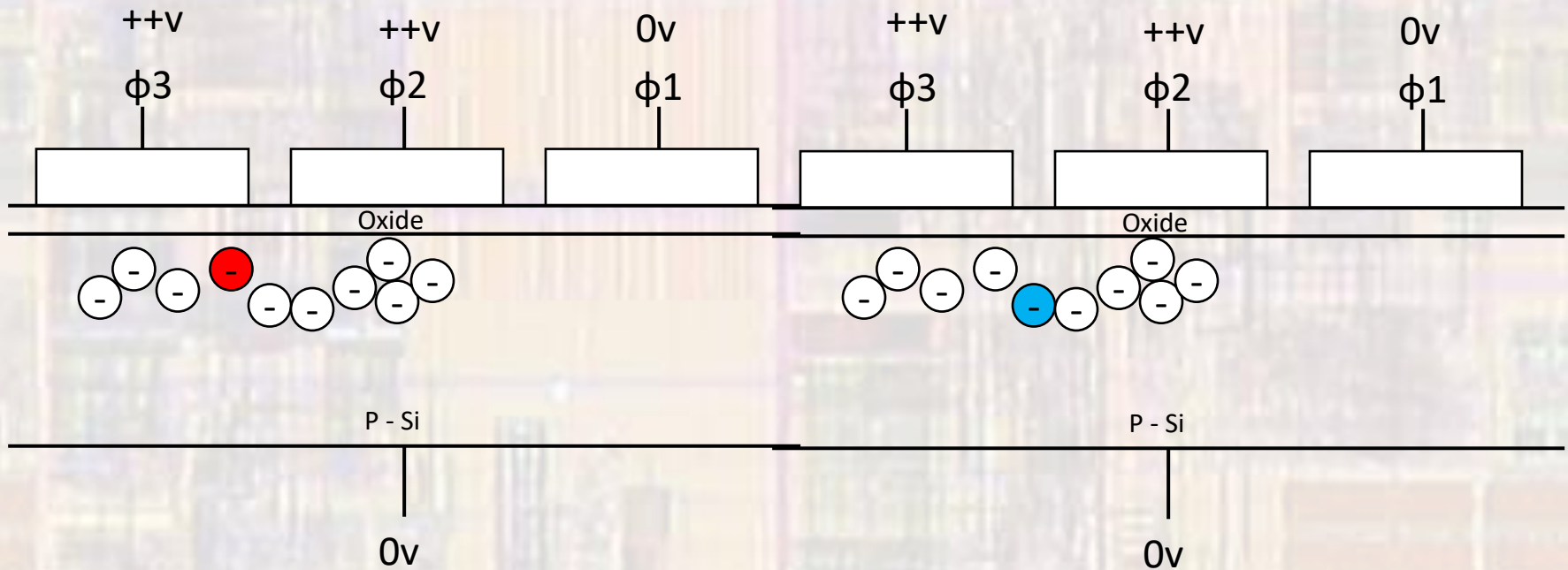
# CCD Imagers

- CCD Operation
  - Shutter light - off



# CCD Imagers

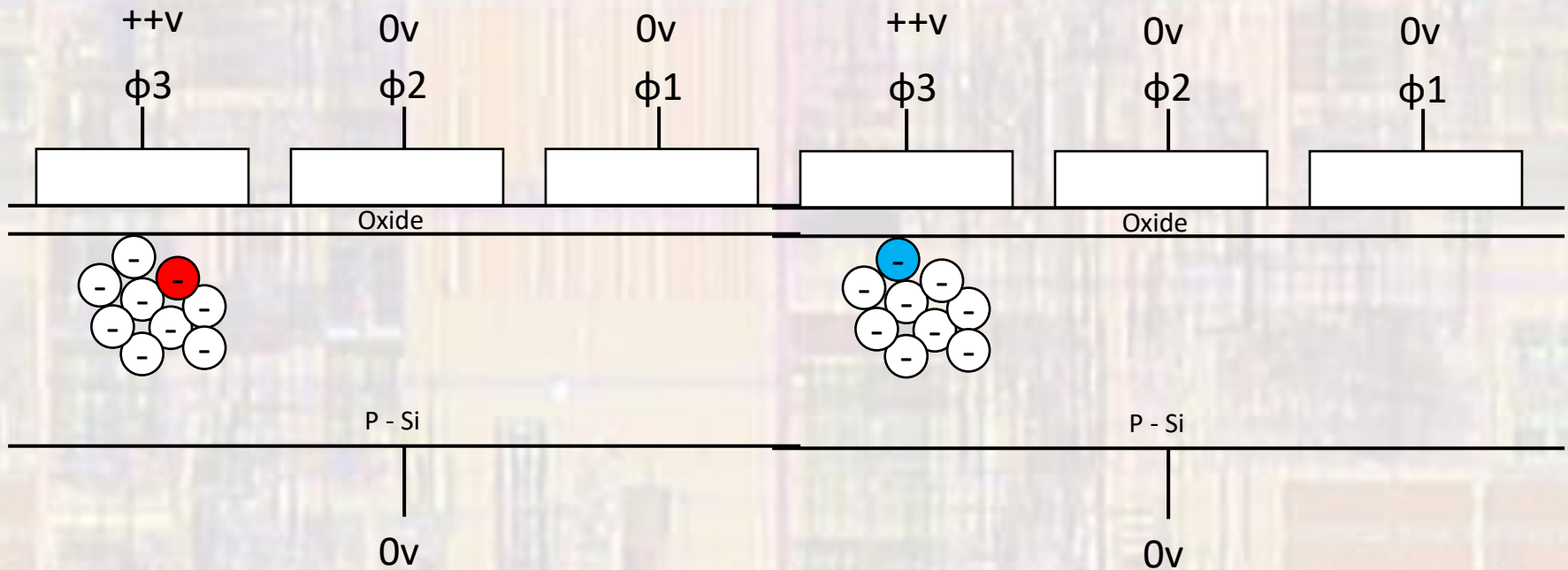
- CCD Operation





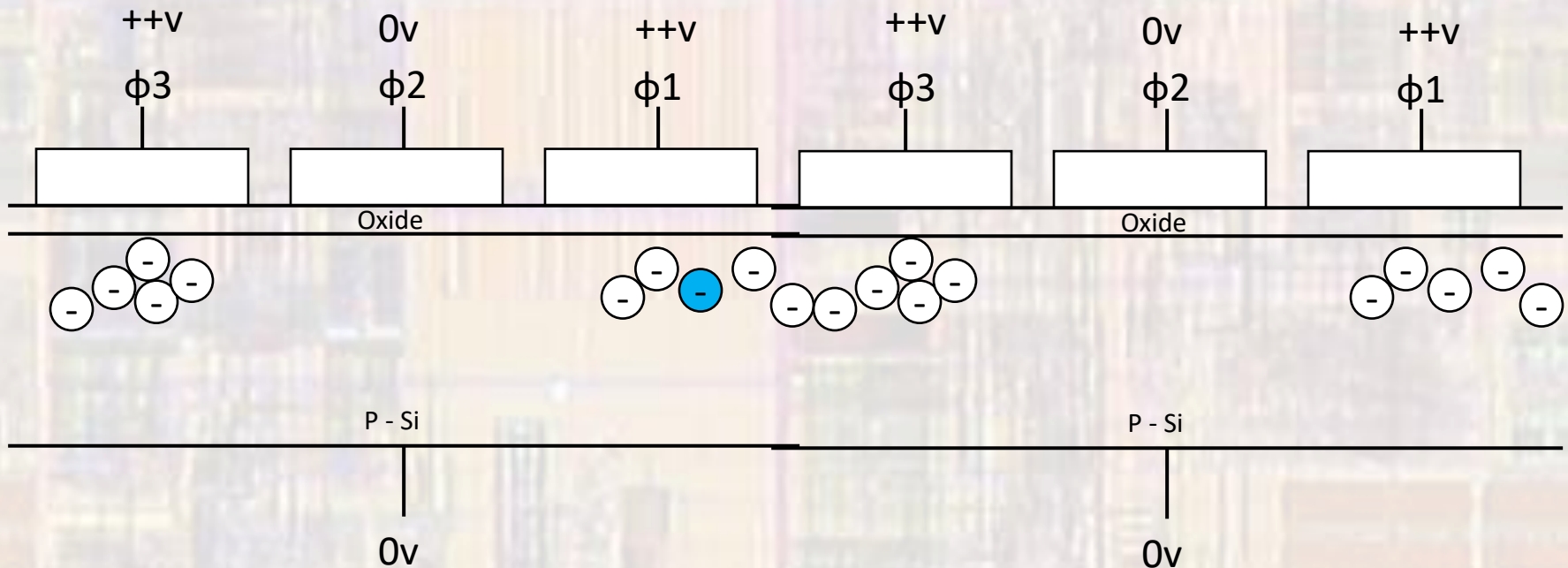
# CCD Imagers

- CCD Operation



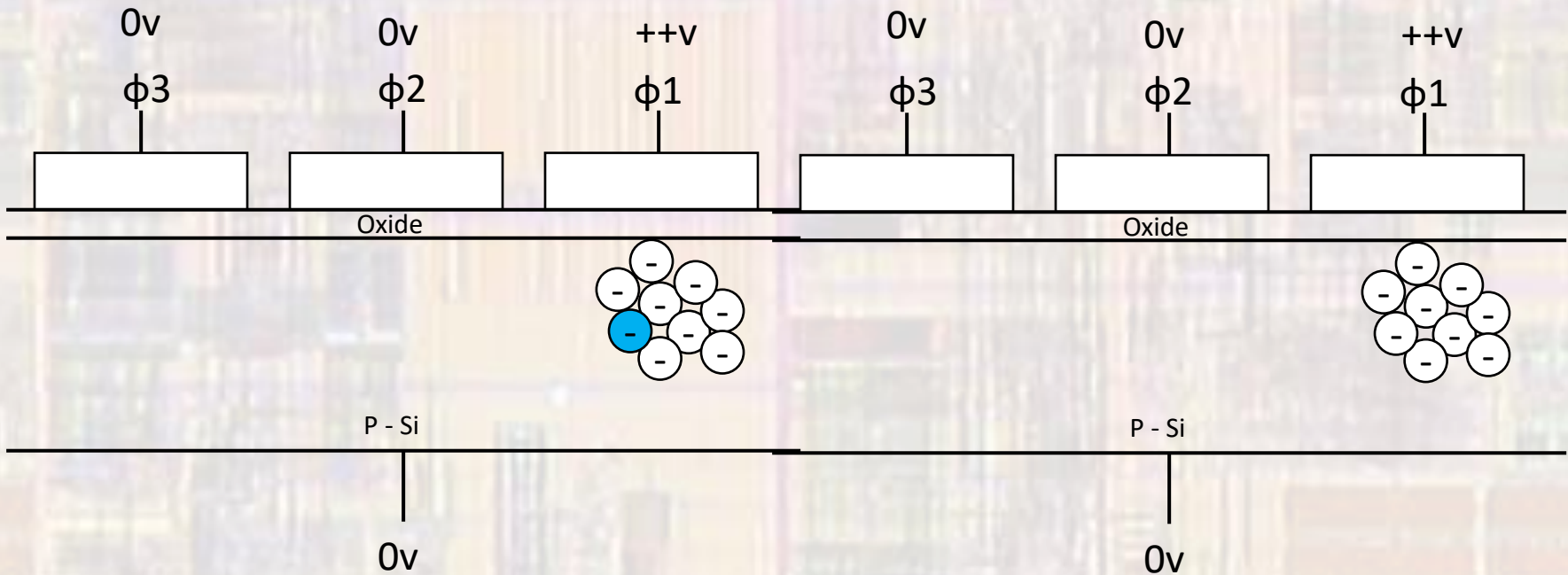
# CCD Imagers

- CCD Operation



# CCD Imagers

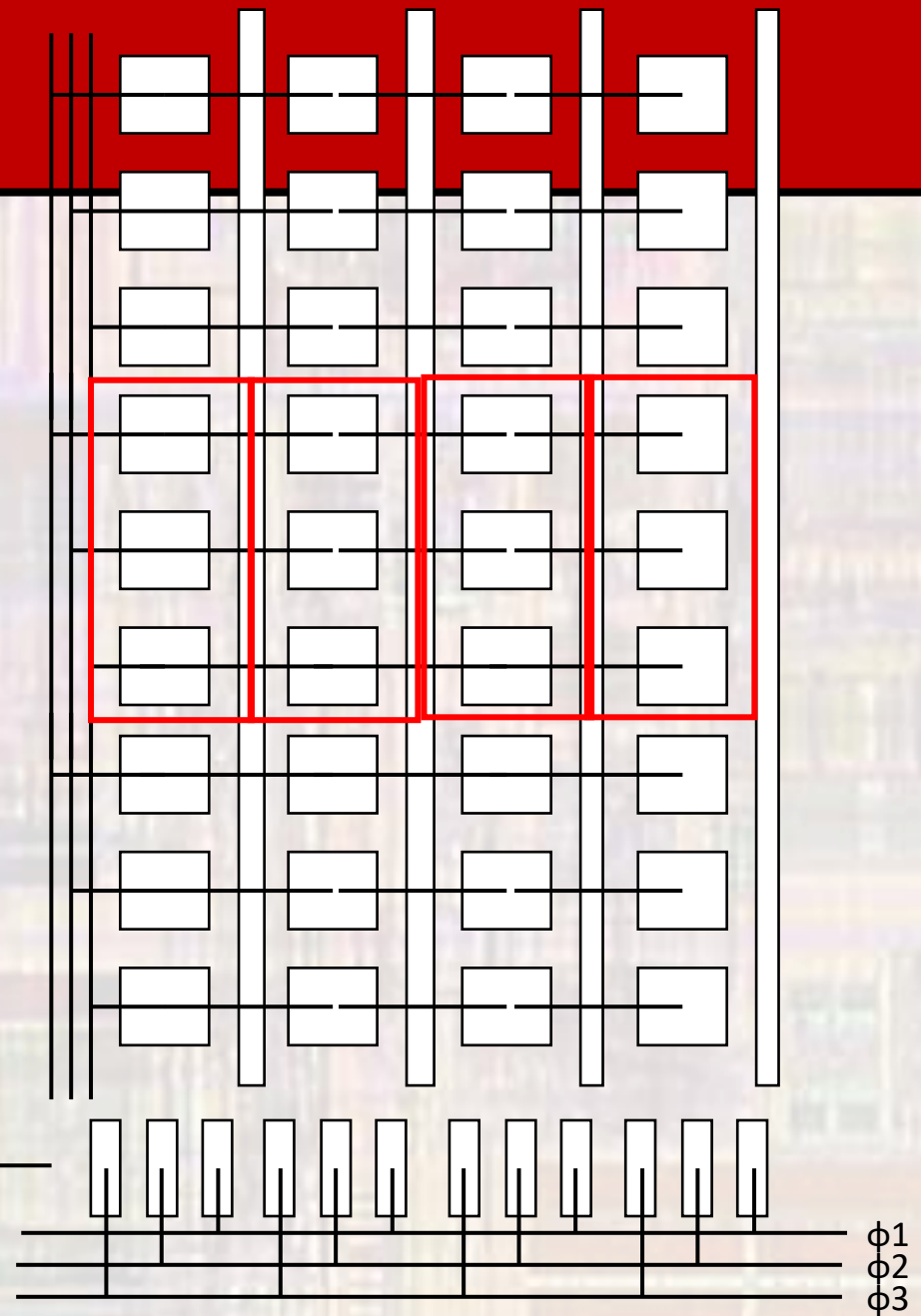
- CCD Operation



# CCD Imagers

- CCD Array Structure

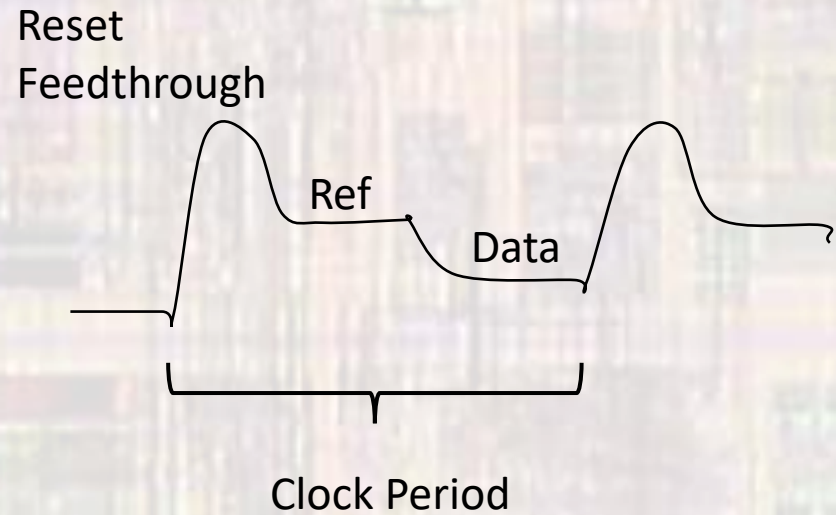
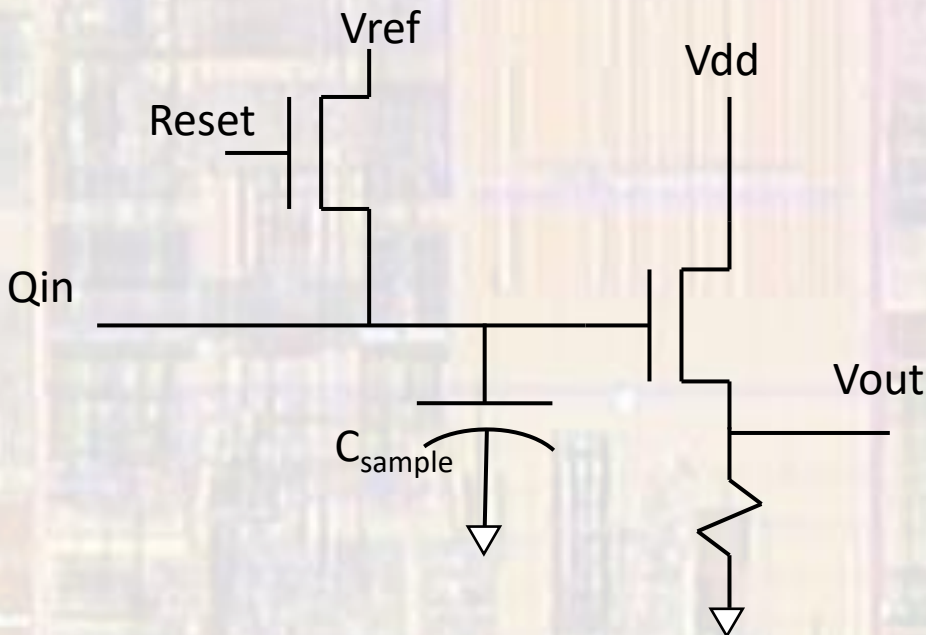
- One row transferred down to the shift register
- Entire shift register transfer out to the charge converter
- Next row transferred down
- ...





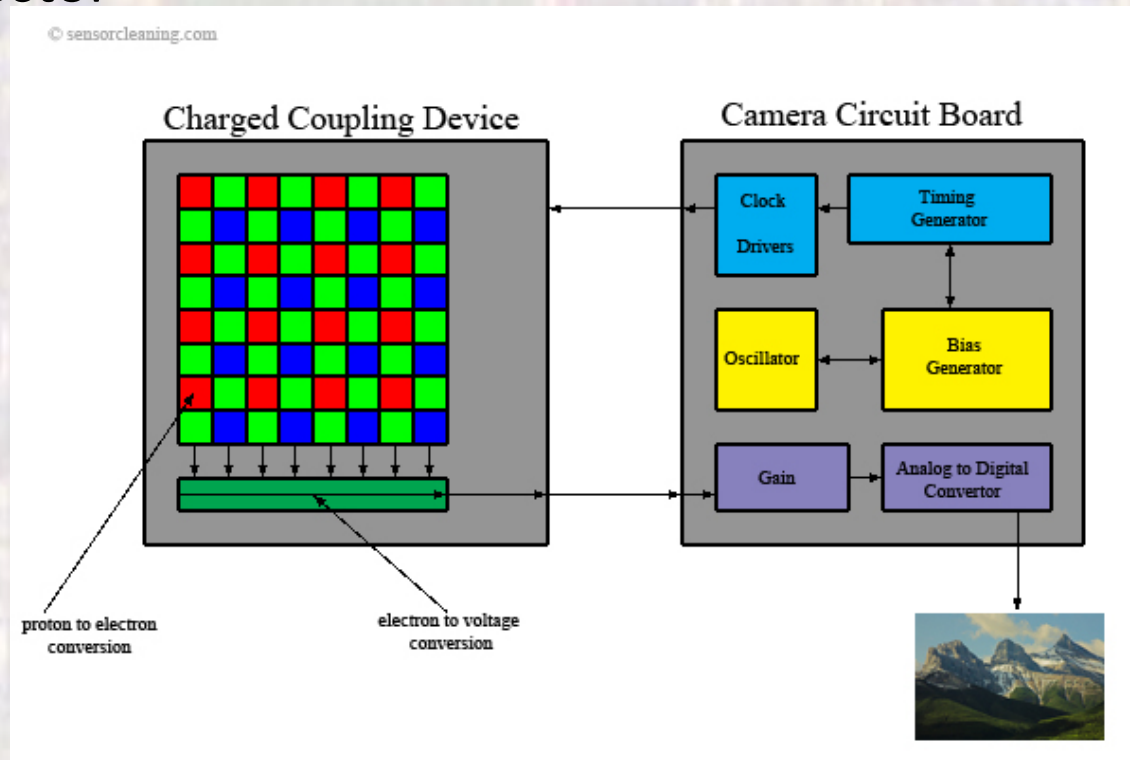
# CCD Imagers

- CCD Array Structure
- Sense amplifier



# CCD Imagers

- CCD - color
- RGB filters used to allow only 1 color to reach the detector

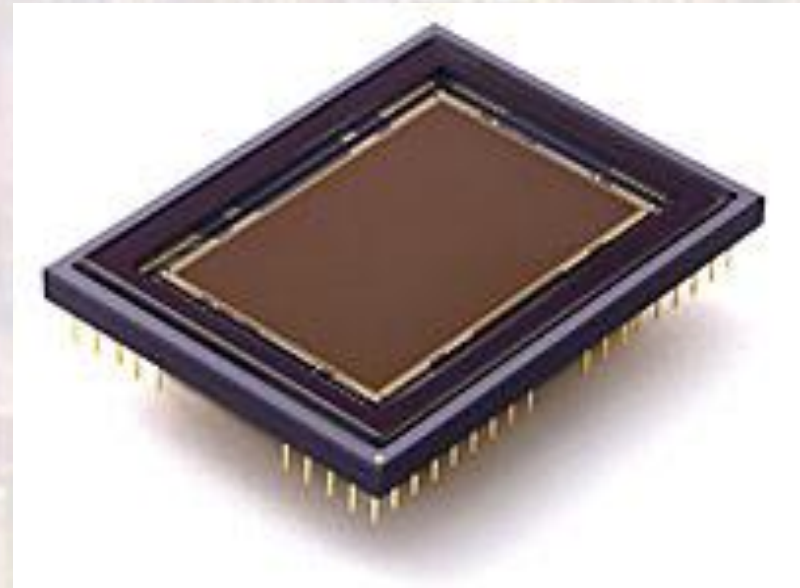


# CCD Imagers

- CCD
  - Dominant structure until 1990+
  - Lowest noise
  - Slow readout
  - Dominates scientific, military applications
  - Common in medical, industrial systems, very high end photography

# CCD Imagers

- CCD
  - Teledyne FTF9168C
    - 60Mpixel
    - 8956 x 6708
    - 6 $\mu$ m x 6 $\mu$ m pixel
    - 95% fill factor





# CCD Imagers

- CCD Sensors
  - Largest single – 111Mpixel
  - Largest array – 3.2Gpixel

