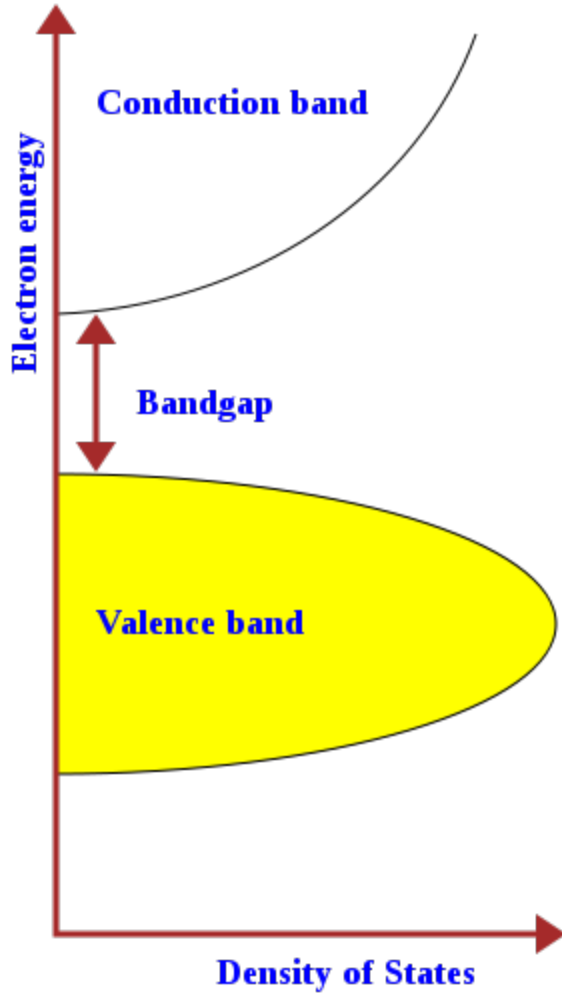


Noise in CCDs

- Read noise
 - Electronic amplifiers have noise
 - Every time one reads the value of a pixel, some random number of electrons are added or lost
- Dark current
 - Band structure of Silicon
 - Thermal fluctuations

Band Structure



- Silicon is a semiconductor.
 - Electrons can conduct, or not.
- Electrons in valence band do not conduct.
- Electrons in conduction band do conduct.
- Bands are separated in energy by the 'band gap' = E_g .

Dark Current

- If we apply an electric field to the silicon, we will collect electrons in the conduction band.
- Even in the absence of photons, there will be some electrons in the conduction band due to thermal fluctuations – these make 'dark current'.
- Need to know how many electrons are in the conduction band.

Boltzmann Factor

- Consider an ensemble of identical systems with two energy levels.
- At low temperatures, how many in state 1 versus 2?
- At high temperatures?

- Boltzmann factor
$$\frac{N_2}{N_1} = e^{-\Delta E/kT}$$

- Dark current $\sim \exp(-E_g/kT)$

- With an extra factor due to the fact that there are more states at higher energies.

