Optoelectronics
(광전자공학)

Lecture 6. Absorption/Luminescence

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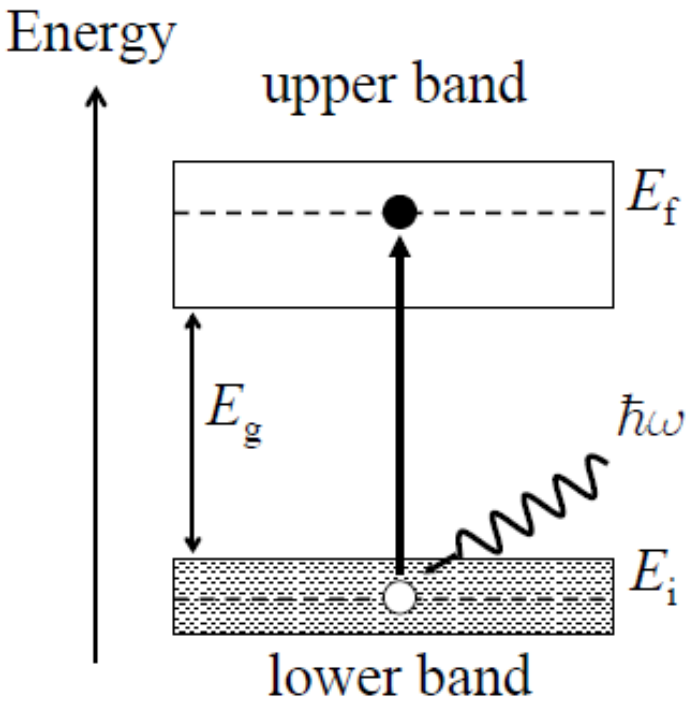
Interband absorption

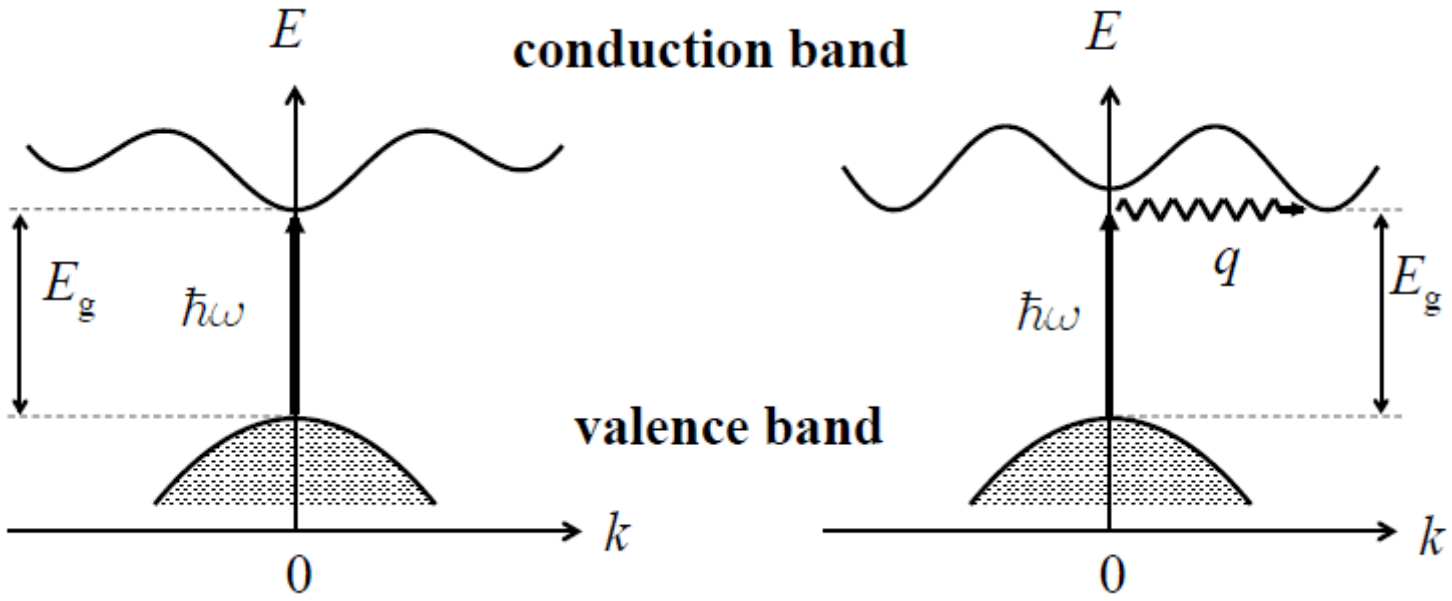


Photon excites electron from filled valence to empty conduction band

Fundamental absorption edge at E_g

Process creates an electron-hole pair

Direct and indirect absorption



- Transitions appear as vertical lines on E-k diagrams.
- Phonon needed to conserve momentum for indirect gap materials.
- Indirect absorption 2nd order process, therefore low probability.

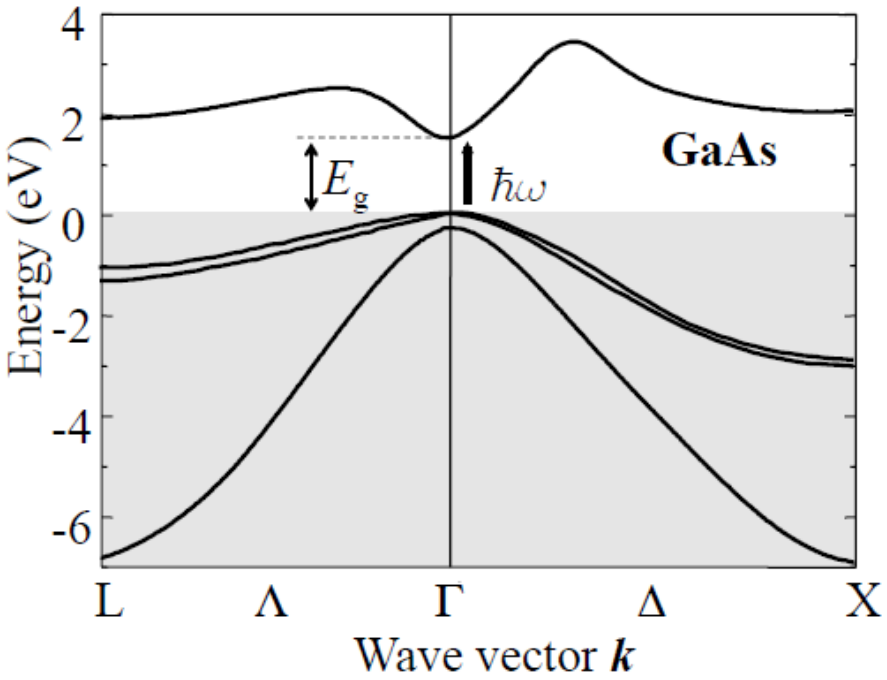
Transition rate for direct absorption

- The optical absorption coefficient is determined by the quantum mechanical transition rate W for exciting an electron in an initial quantum state to a final state by absorption of a photon of angular frequency.
- The transition rate is given by Fermi's golden rule:

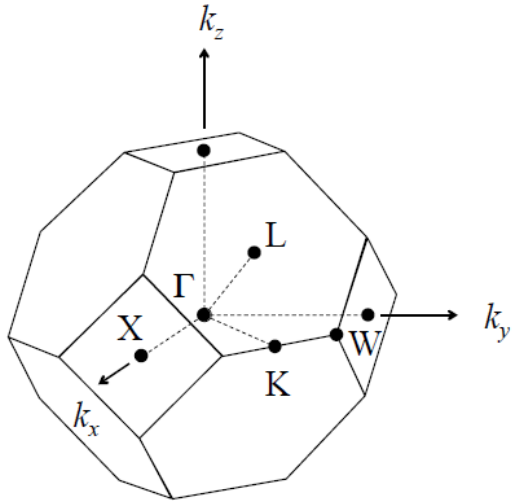
Transition rate for direct absorption

Transition rate for direct absorption

GaAs band structure



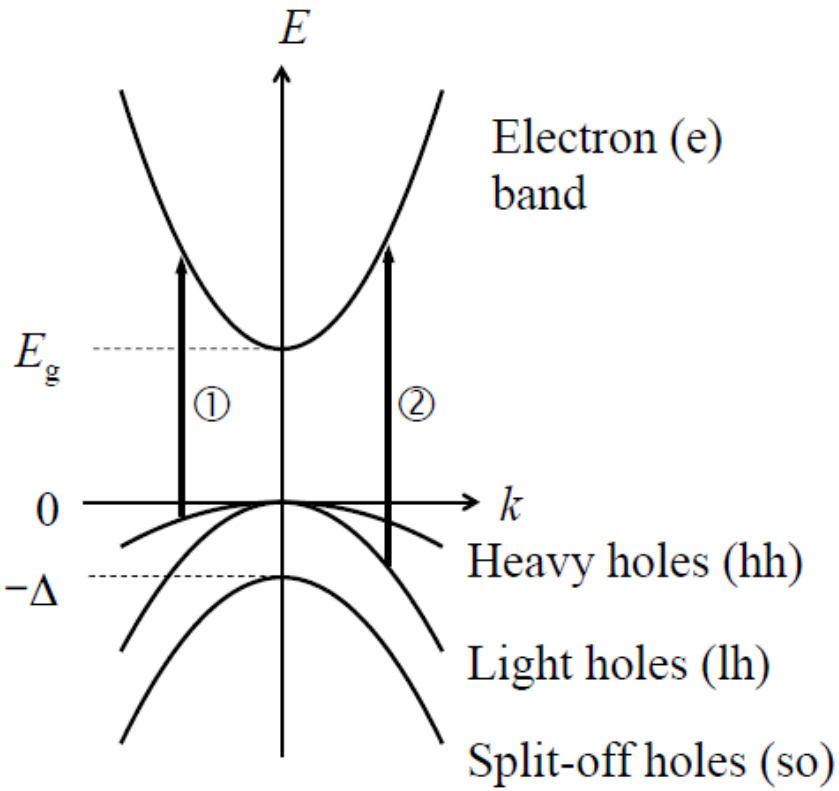
FCC lattice Brillouin zone



Γ	000
X	100
	010
	001
K	110
L	111

- Direct gap at 1.5 eV
- Very important optoelectronic material
- Strong absorption

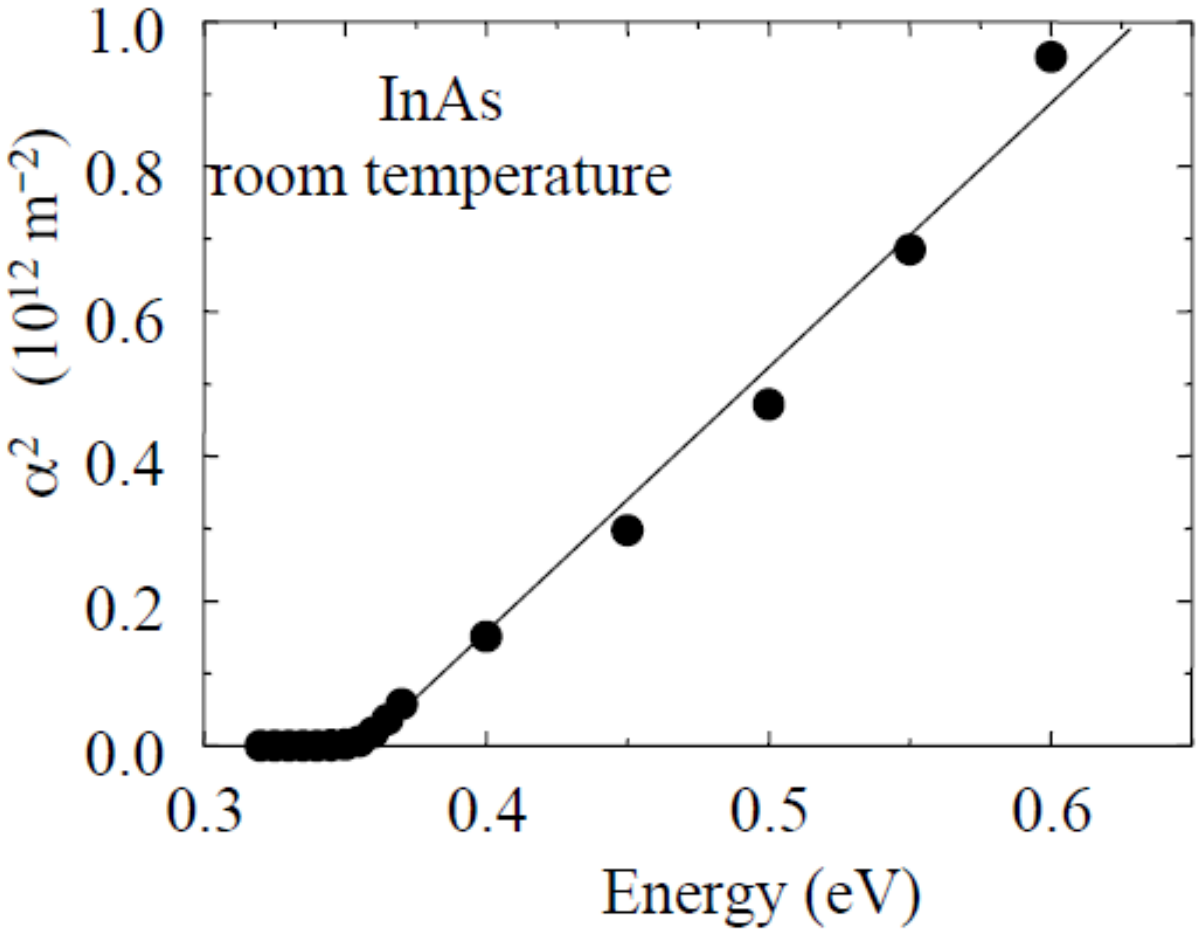
Four-band model



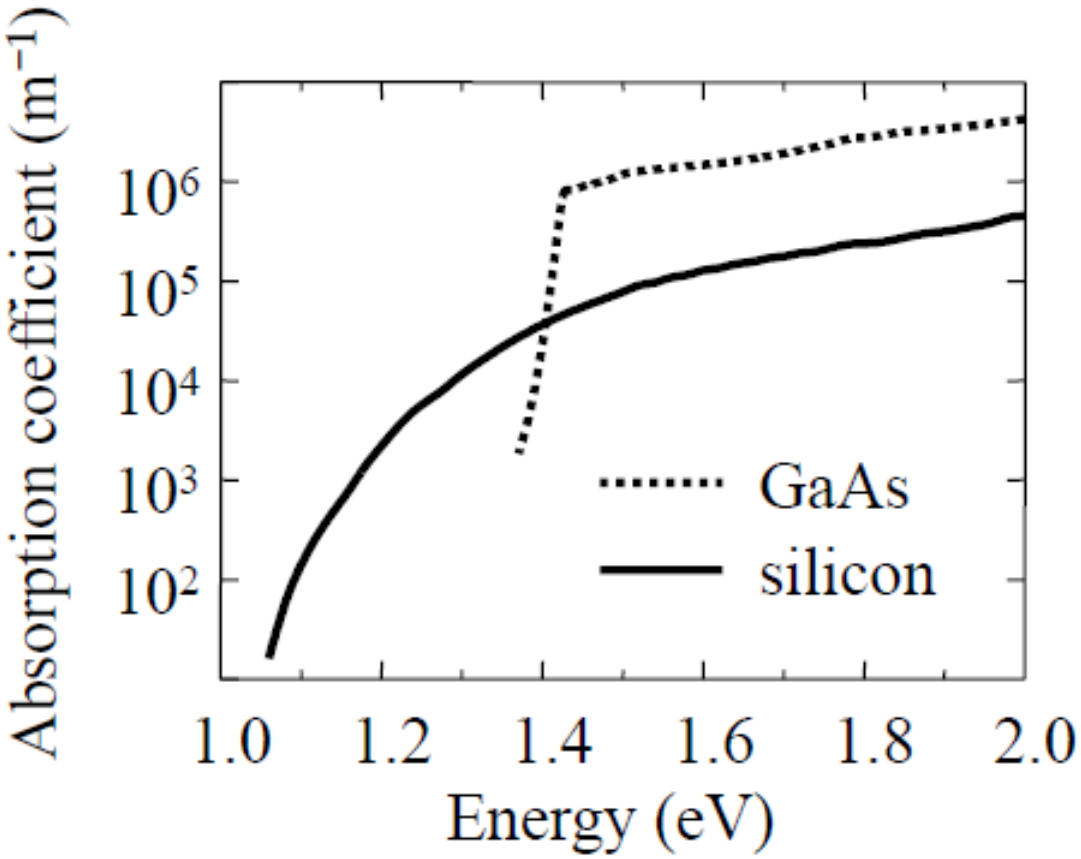
- Simplified band structure first proposed by Kane (1957)
- Valid near k = 0
- (1) Heavy hole transition
- (2) Light hole transition

Joint density of states

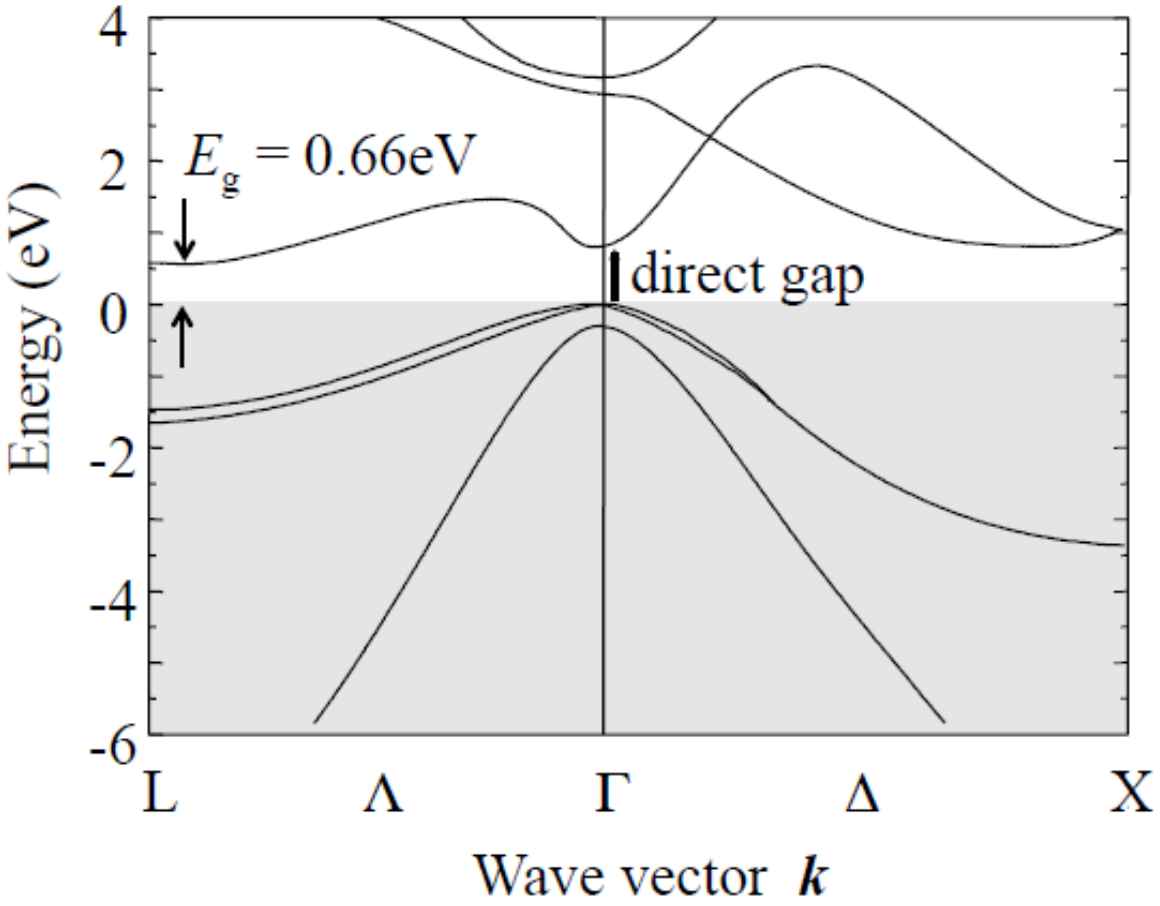
InAs band edge absorption



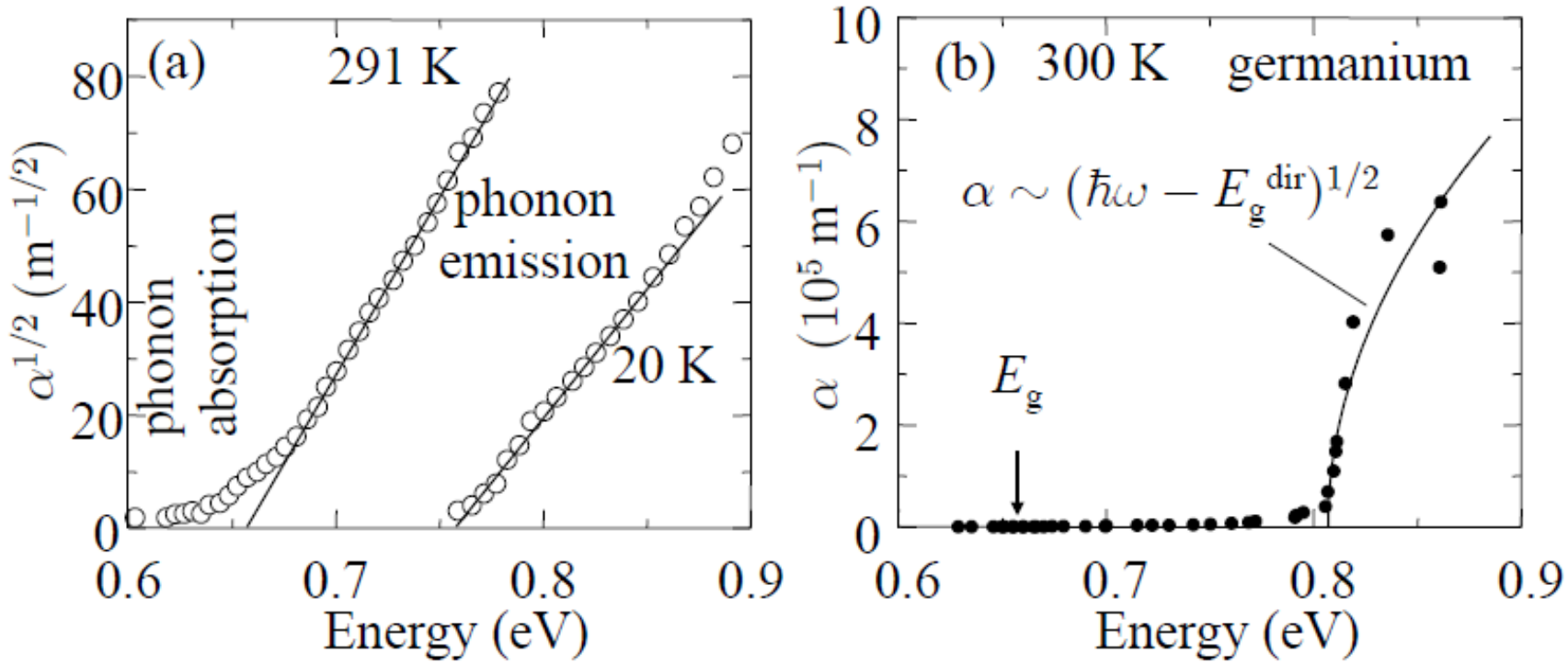
Direct versus indirect absorption



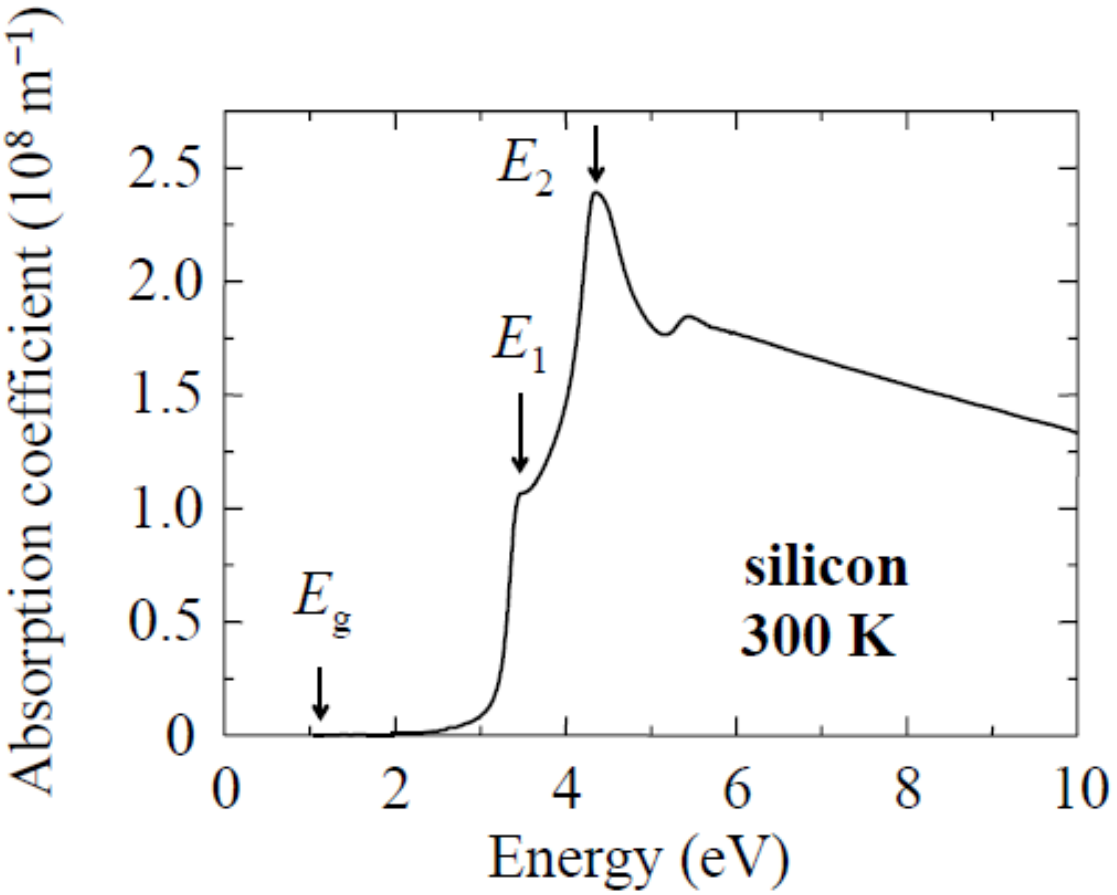
Germanium band structure



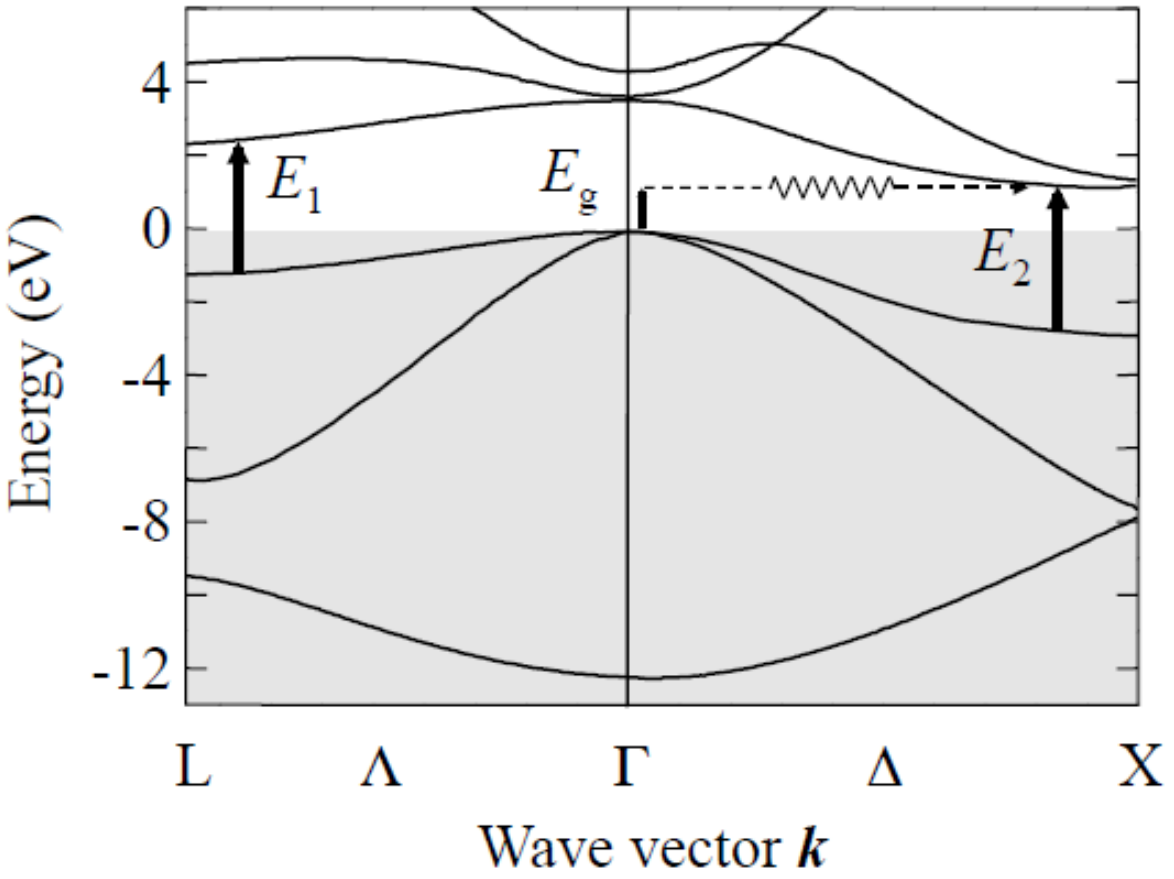
Germanium band edge absorption



Silicon absorption



Silicon band structure



Luminescence

- Luminescence : Spontaneous emission in solids

- Fluorescence : Fast luminescence
  electric-dipole allowed

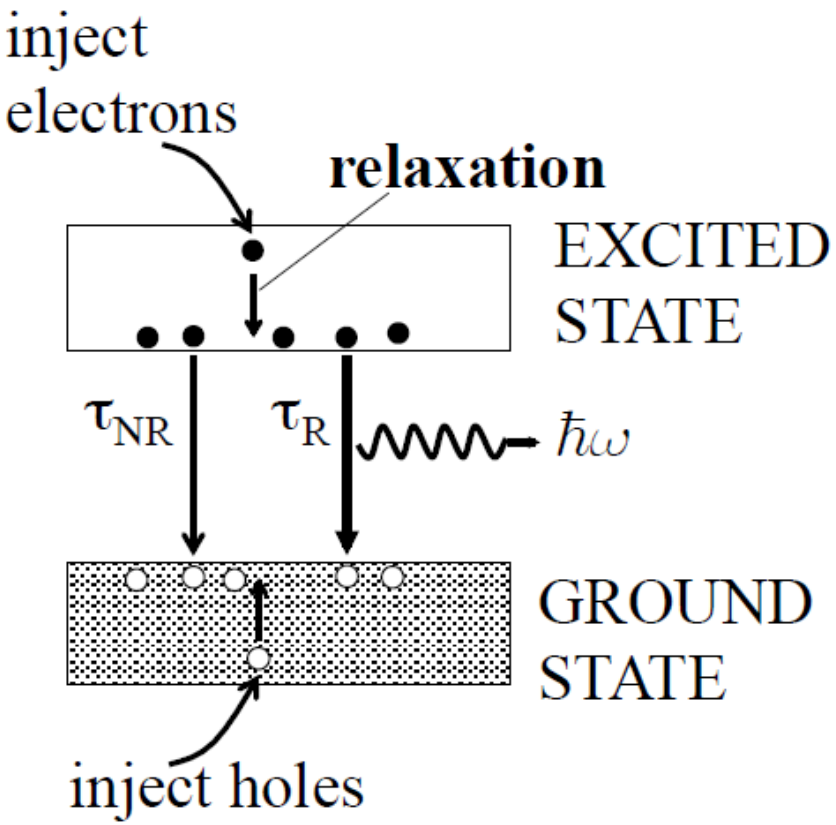
- Phosphorescence : Slow luminescence
  electric-dipole forbidden

- Electroluminescence : electrical excitation

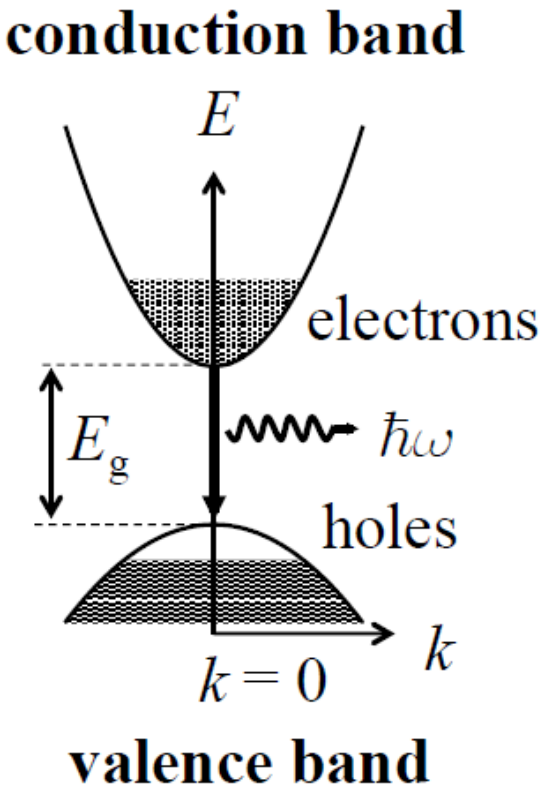
- Photoluminescence : optical excitation

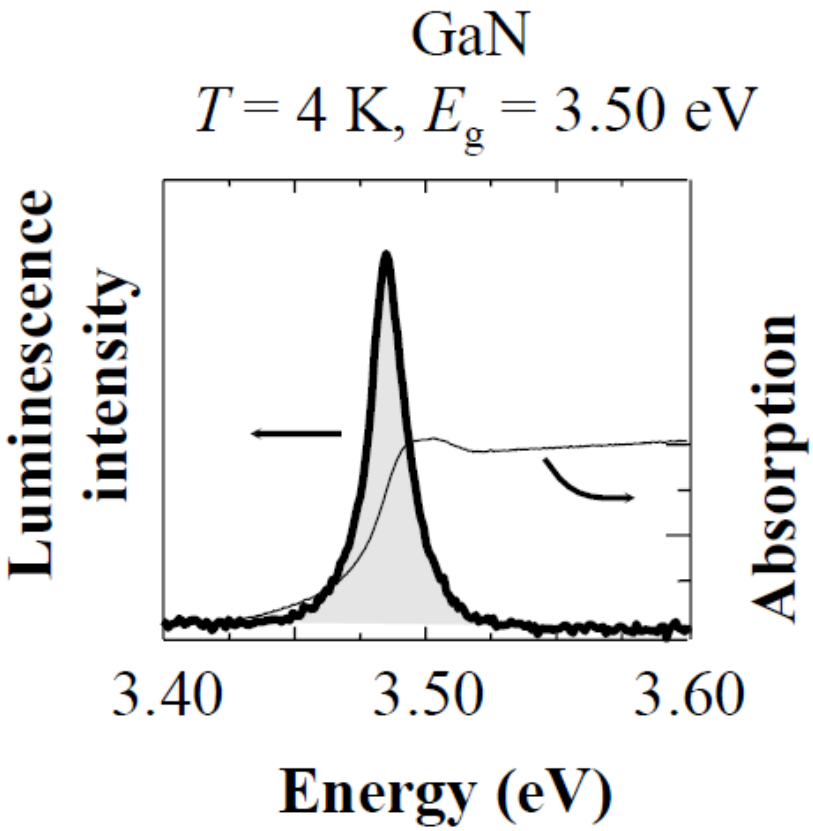
- Cathodoluminescence : cathode ray (e-beam) excitation

Luminescence

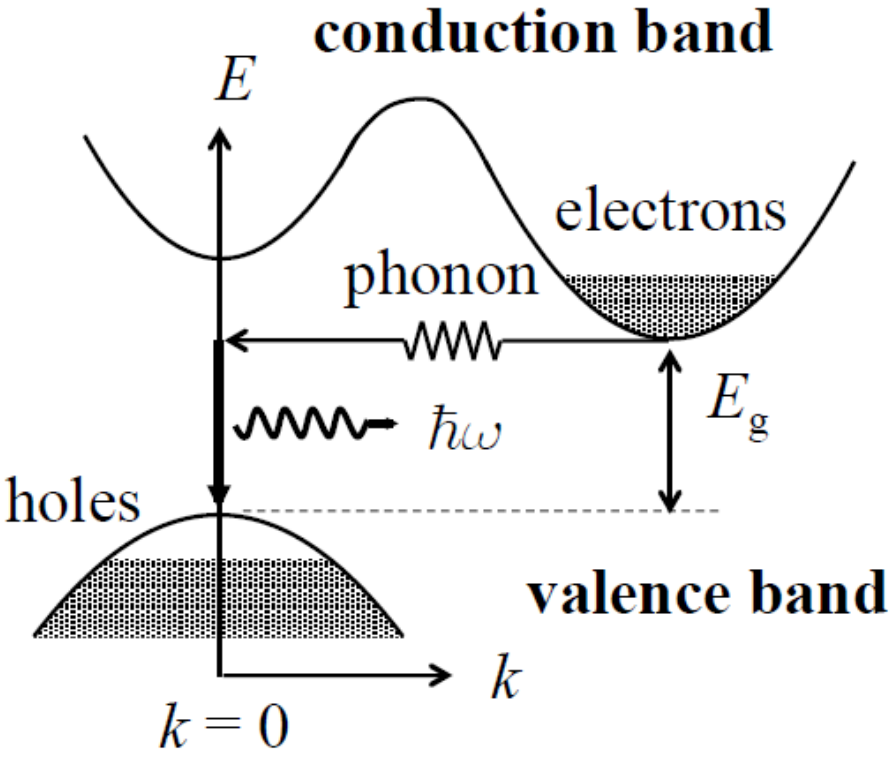


Direct gap materials

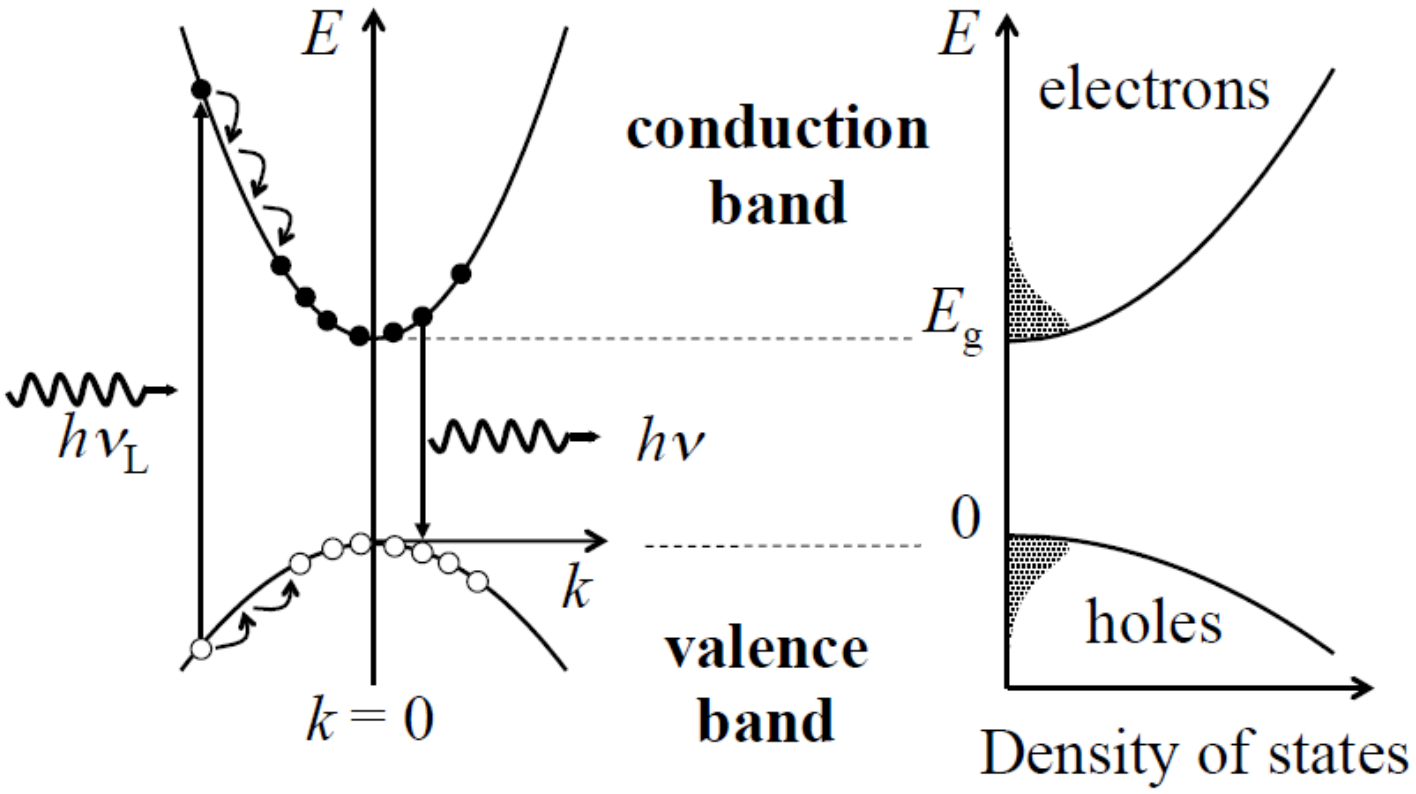




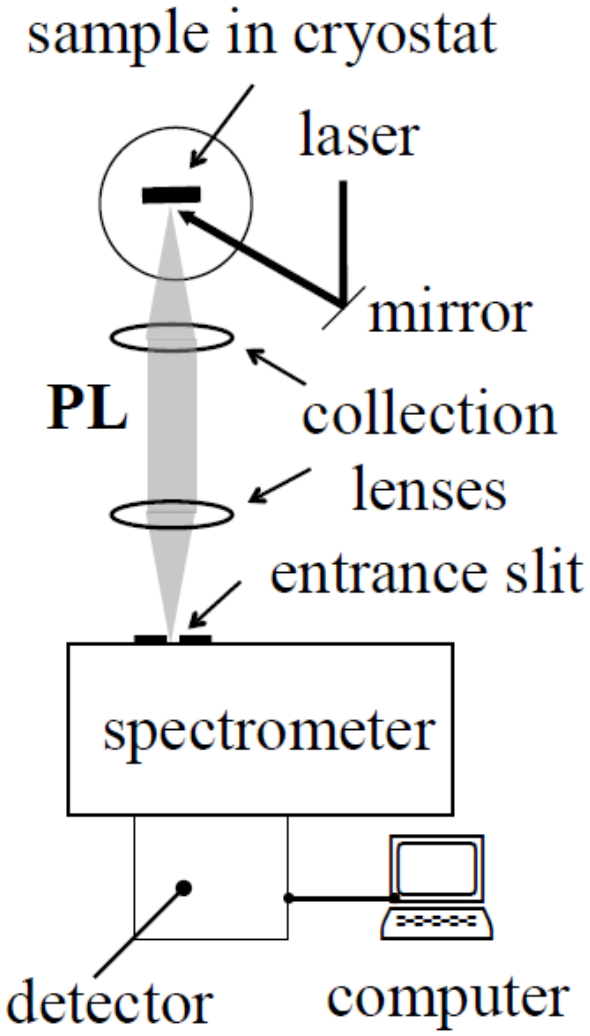
Indirect gap materials



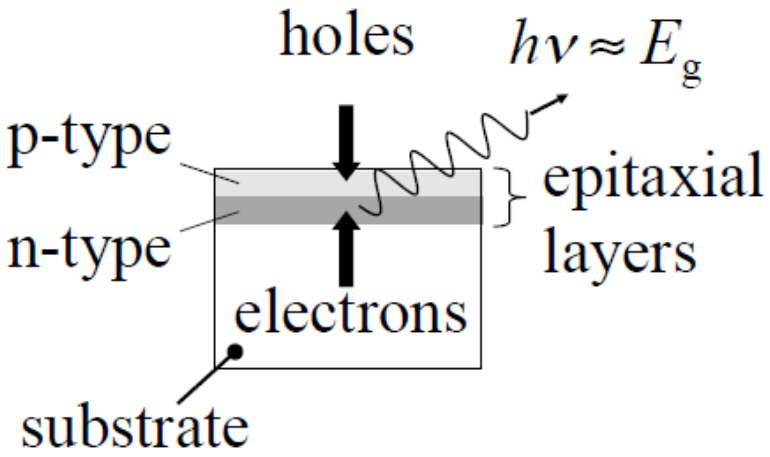
Photoluminescence

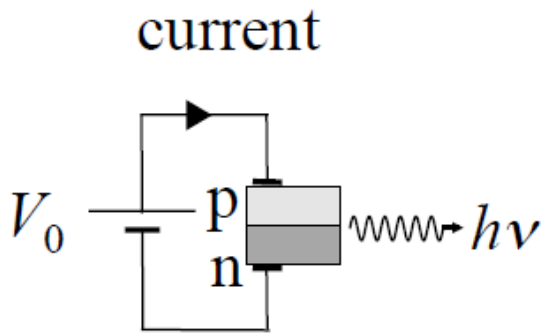


Photoluminescence spectroscopy

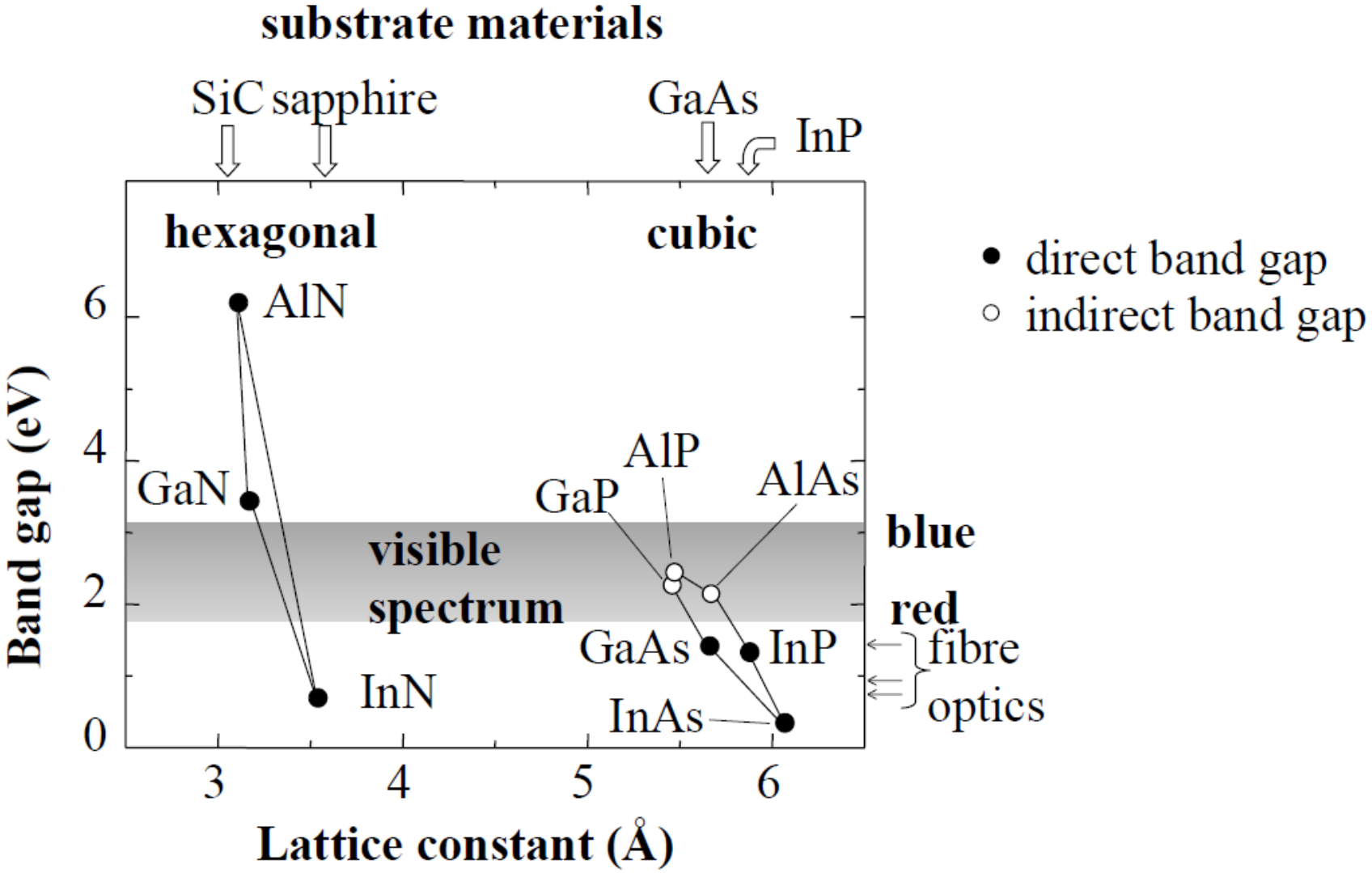


Electroluminescence





Lattice matching



Question or Comment?