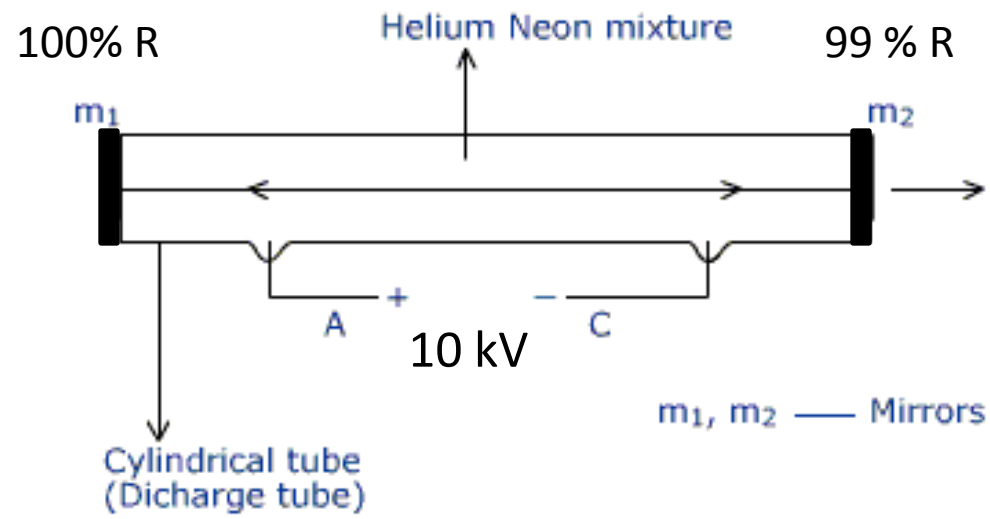


# He-Ne Laser

# Laser system

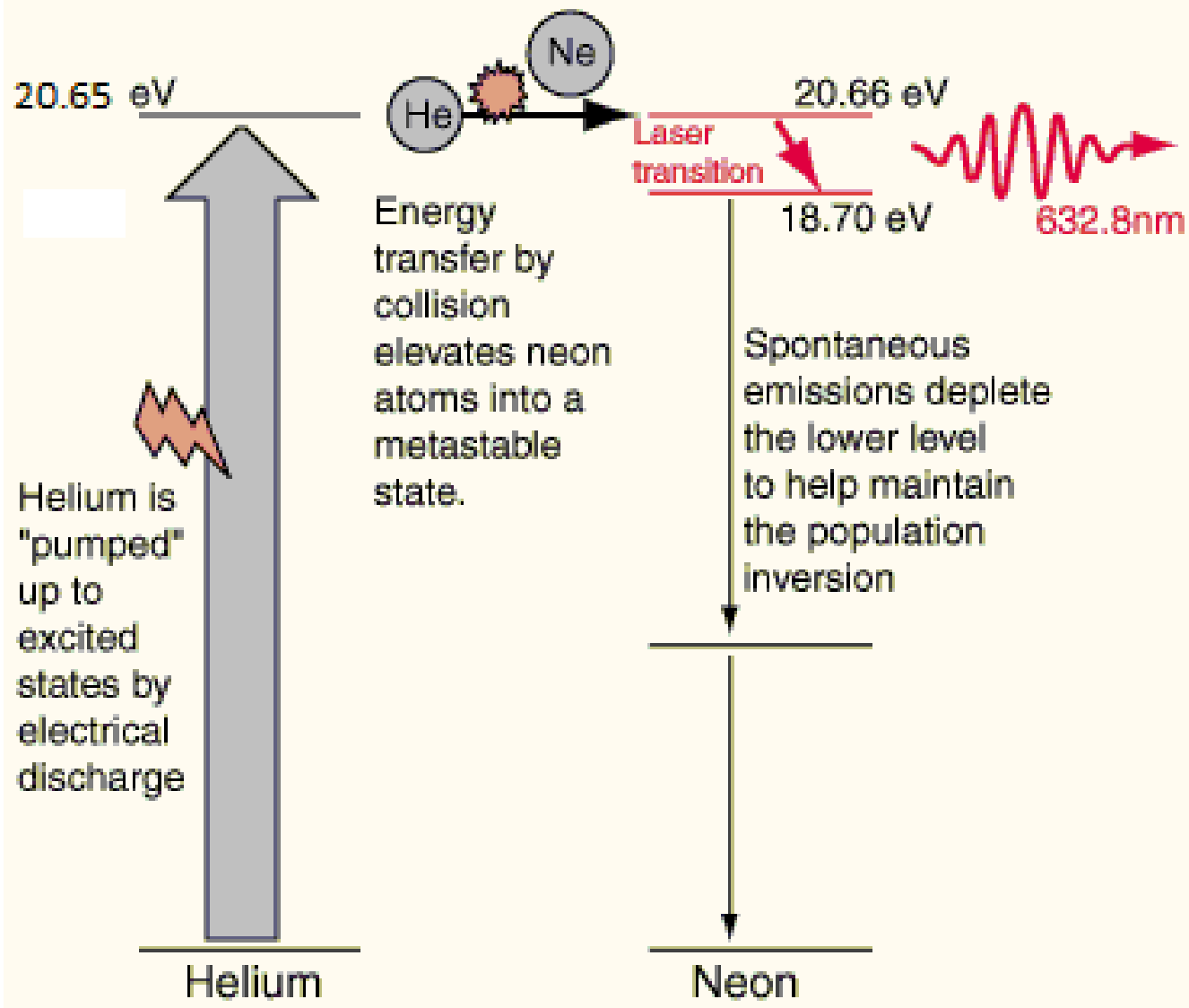
He : Ne  
1 : 0.1 torr

1 torr = 1mm of Hg = 133 Pa



Population inversion  $\longrightarrow$  Atom-atom collision

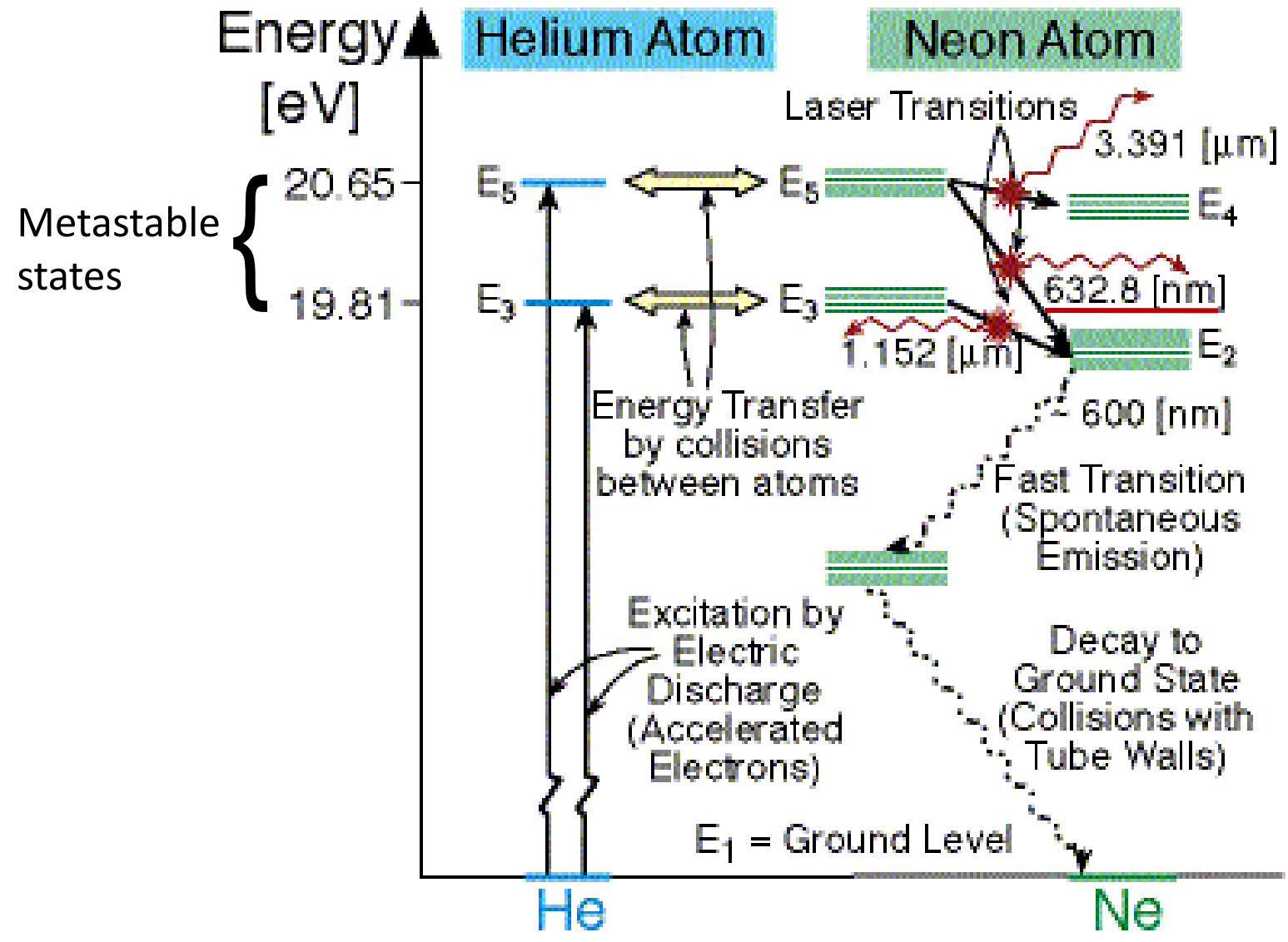
# Energy level diagram-1



$$1 \text{ eV} = 1.60217 \times 10^{-19} \text{ J}$$

$$\Delta E = 1.96 \text{ eV} = \frac{hc}{\lambda}$$

# Energy level diagram-2



Windows absorb 1.152  $\mu\text{m}$  and 3.391  $\mu\text{m}$  radiations

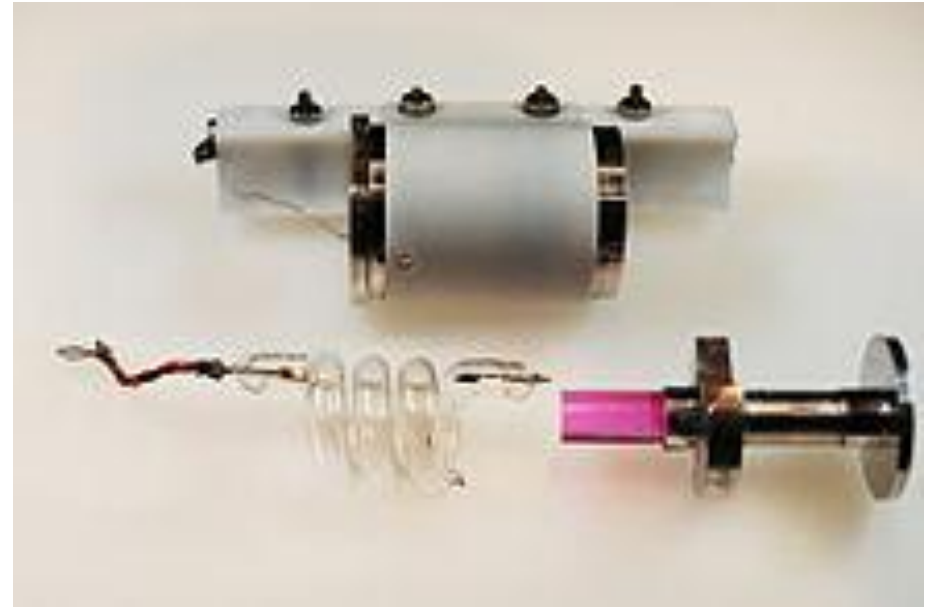
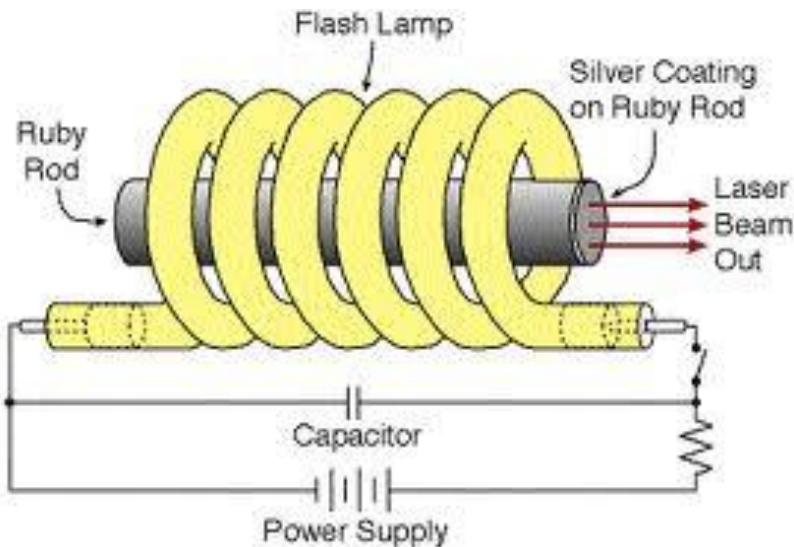
# Ruby Laser

# Laser System

T.H. Maiman, Stimulated optical radiation in ruby, Nature, vol. 187, 493-494 (1960)

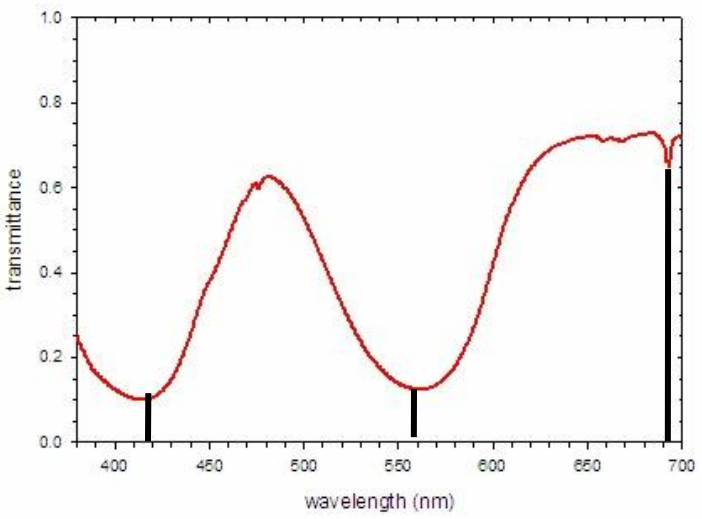
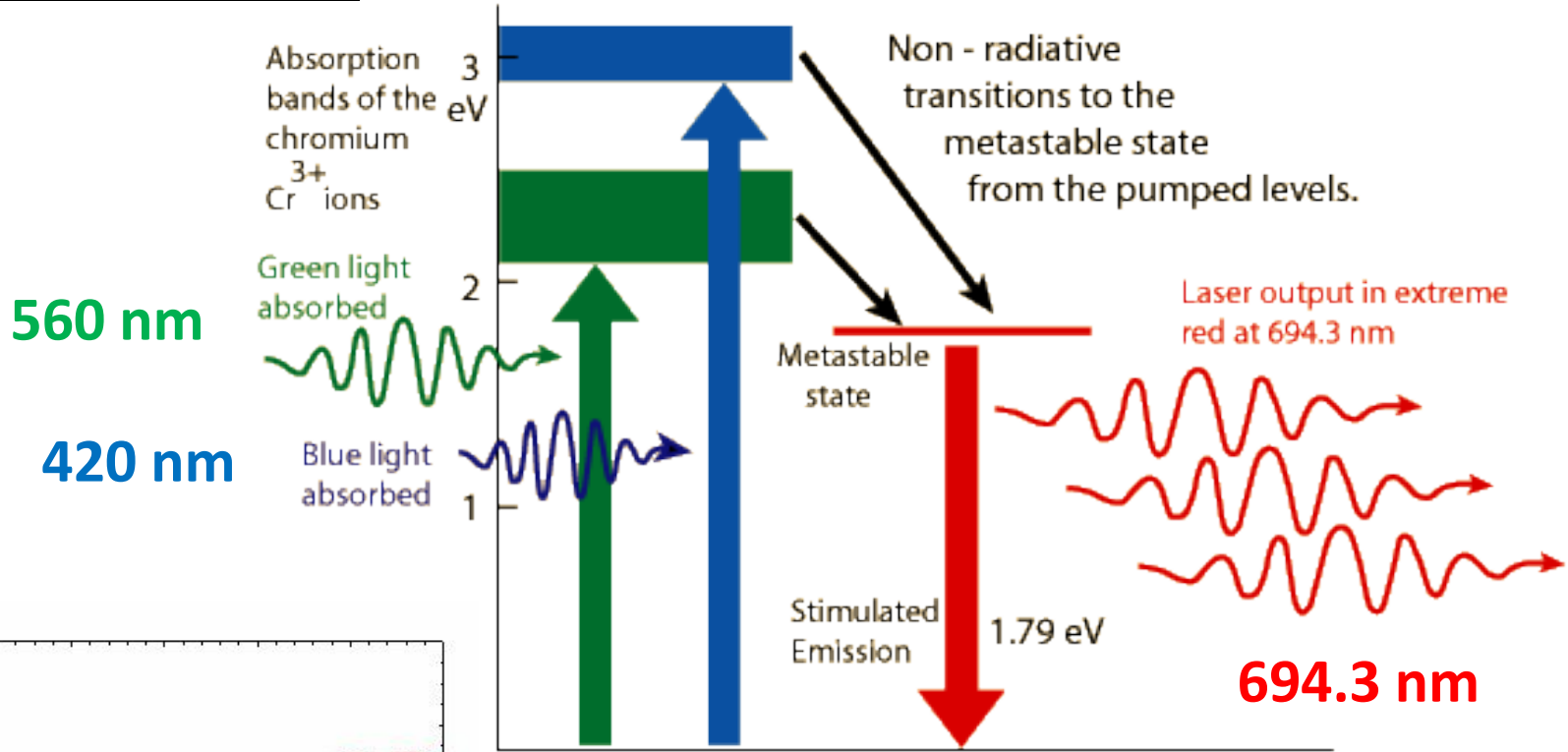
*Ruby –  $Al_2O_3 : Cr$*

*Some of the Al atoms are replaced by  $Cr^{3+}$  (0.05 %)*



Population inversion → Optical pumping

# Energy level diagram



$$\Delta E = 1.79 \text{ eV} = \frac{hc}{\lambda}$$

# **Semiconductor Laser**



# Semiconductors

Elemental semiconductors  
C(diamond), Si, Ge

B  
P-type dopant for C

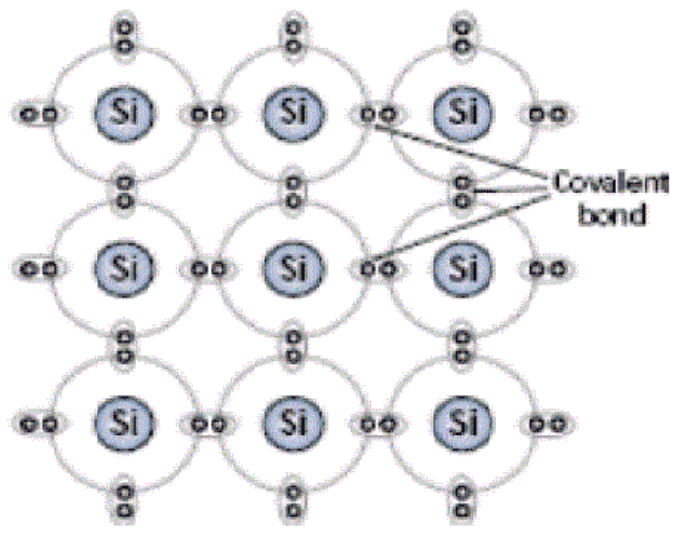
B, Al, Ga, In  
P-type dopant for Si

Al, Ga, In  
P-type dopant for Ge

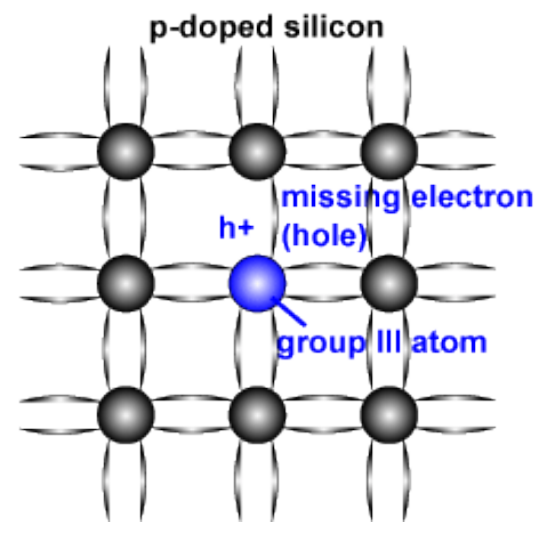
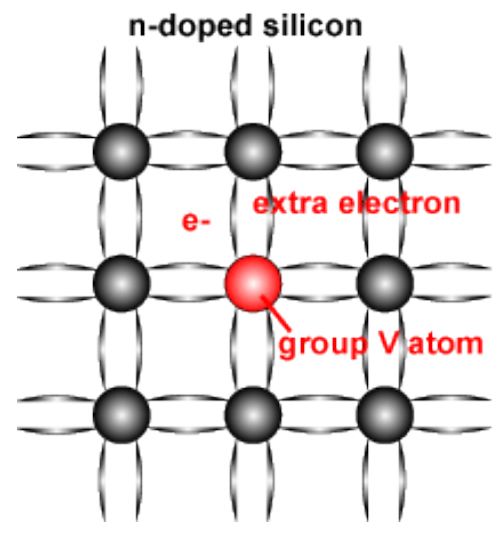
13	IIIA	14	IVA	15	VA
B Boron 10.81 2p <sup>1</sup>		C Carbon 12.011 2p <sup>2</sup>		N Nitrogen 14.0067 2p <sup>3</sup>	
Al Aluminum 26.9815 3p <sup>1</sup>		Si Silicon 28.0855 3p <sup>2</sup>		P Phosphorus 30.9738 3p <sup>3</sup>	
Ga Gallium 69.723 4p <sup>1</sup>		Ge Germanium 72.61 4p <sup>2</sup>		As Arsenic 74.92159 4p <sup>3</sup>	
In Indium 114.82 5p <sup>1</sup>				Sb Antimony 121.75 5p <sup>3</sup>	

N, P  
N-type dopant for C

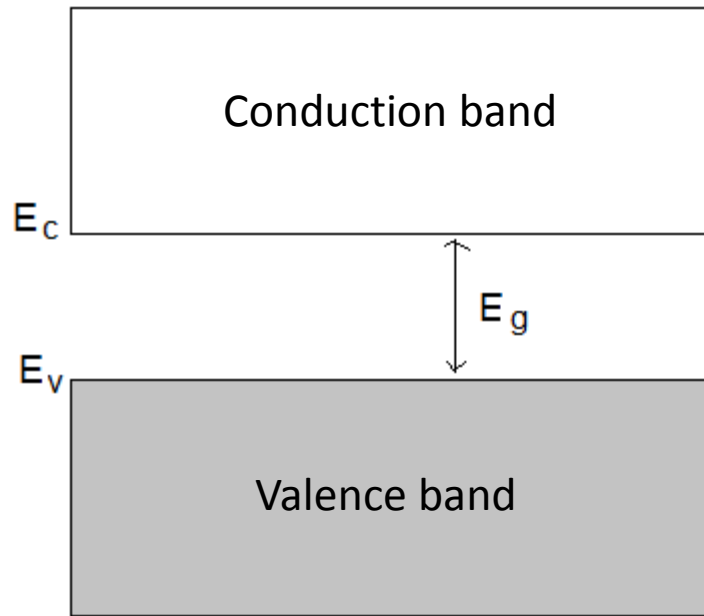
P, As, Sb  
N-type dopant for Si, Ge



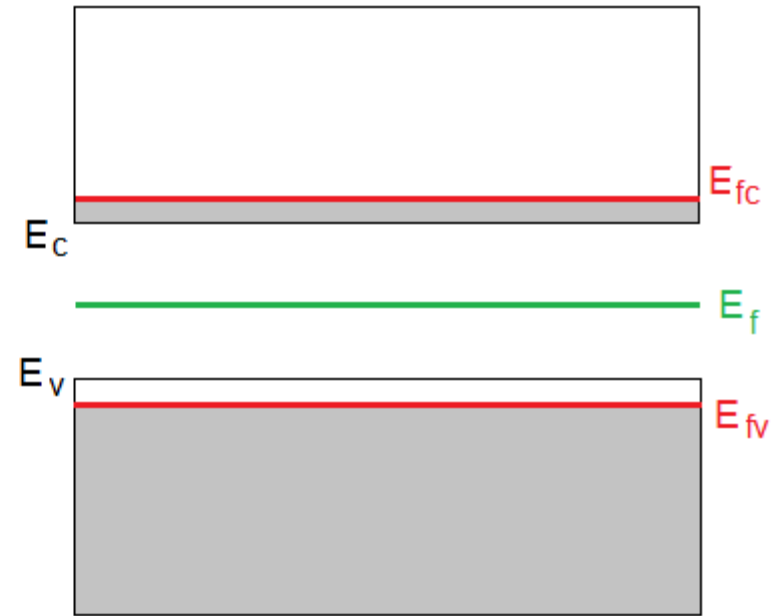
2D representation of pure Si crystal



# Energy Bands of Pure (Intrinsic) Semiconductor



T = 0 K

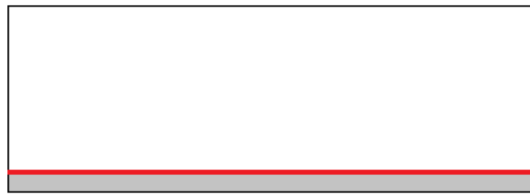


T = 300 K

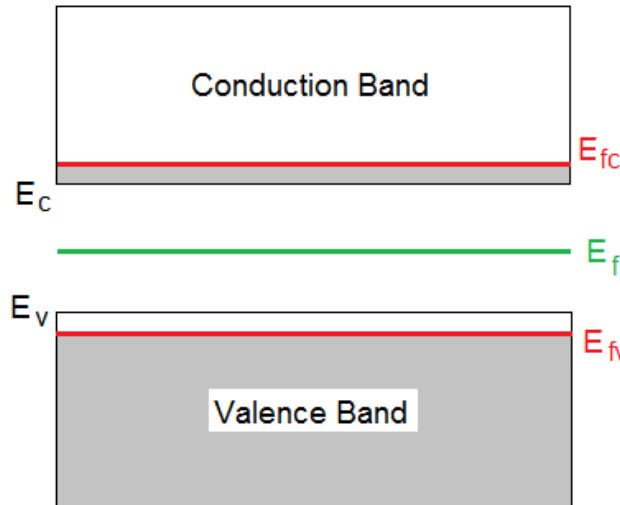
**Fermi Energy,**

$$E_f = \frac{1}{2} (E_{fc} + E_{fv})$$

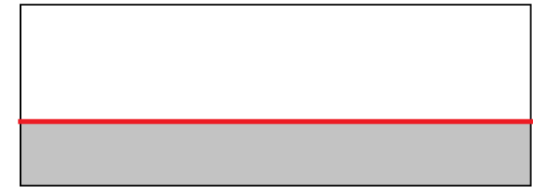
# Energy Bands of Impure (Extrinsic) Semiconductor



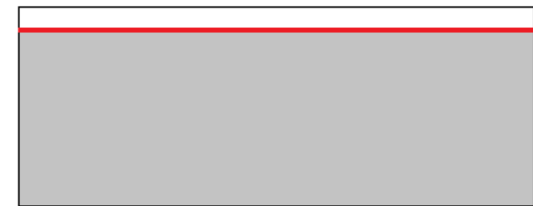
p - type



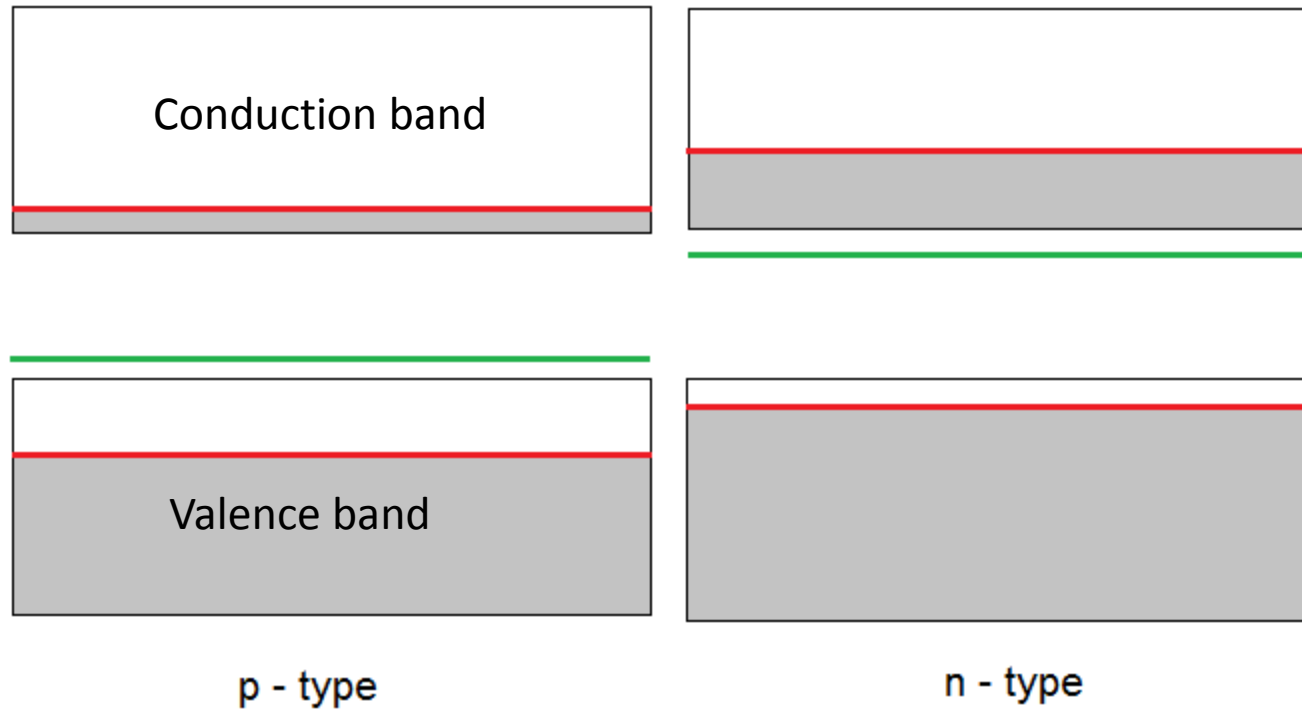
Intrinsic



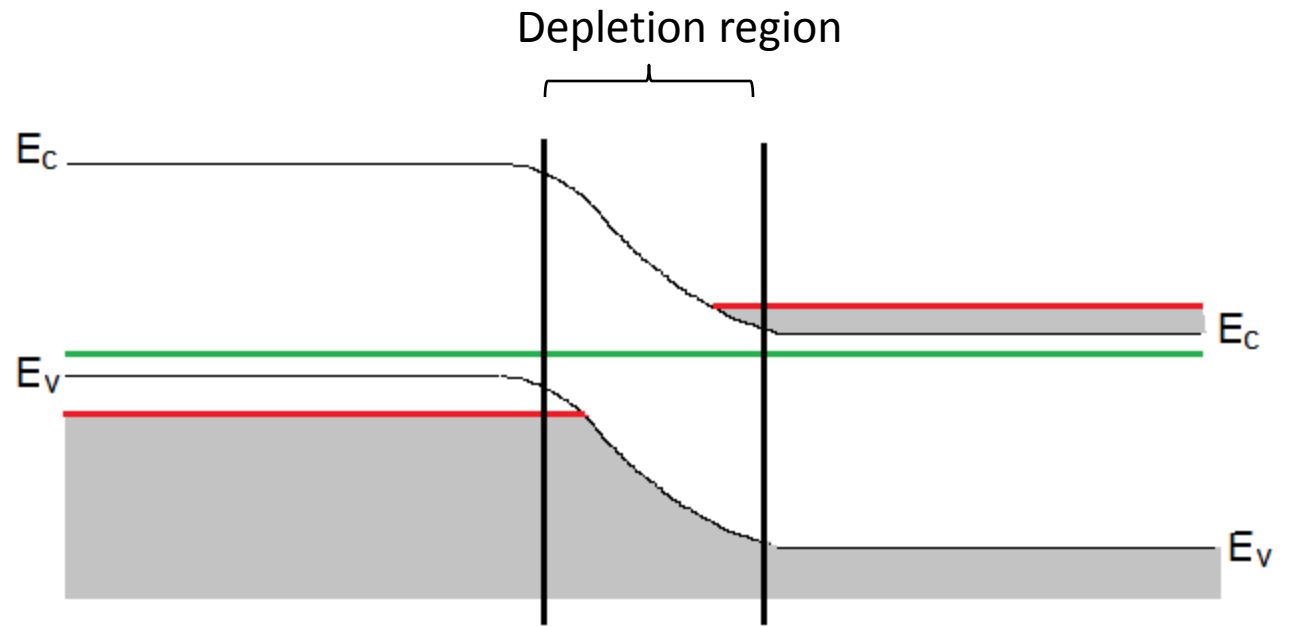
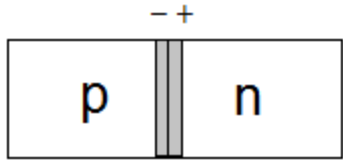
n - type



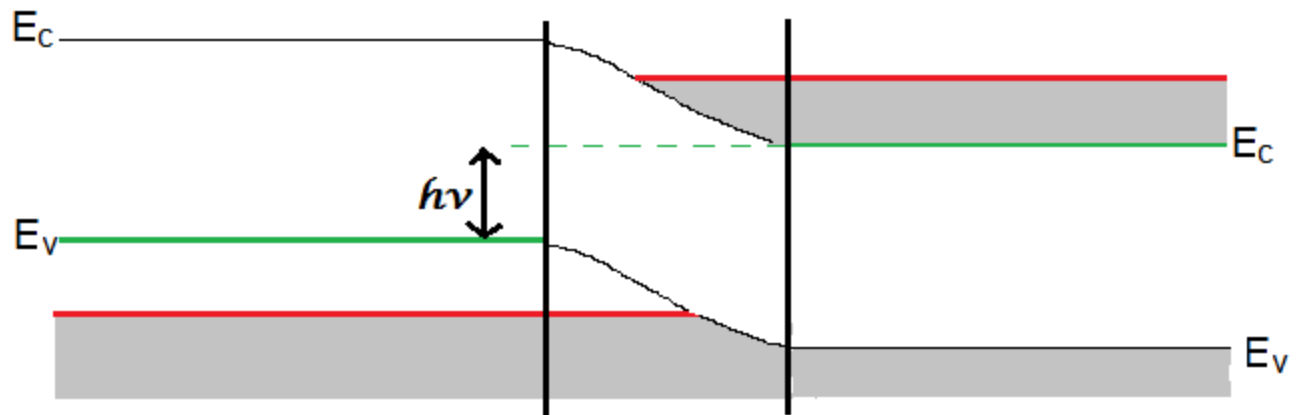
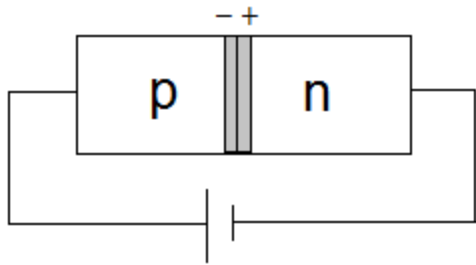
# Energy Bands of Impure (Extrinsic) Semiconductor

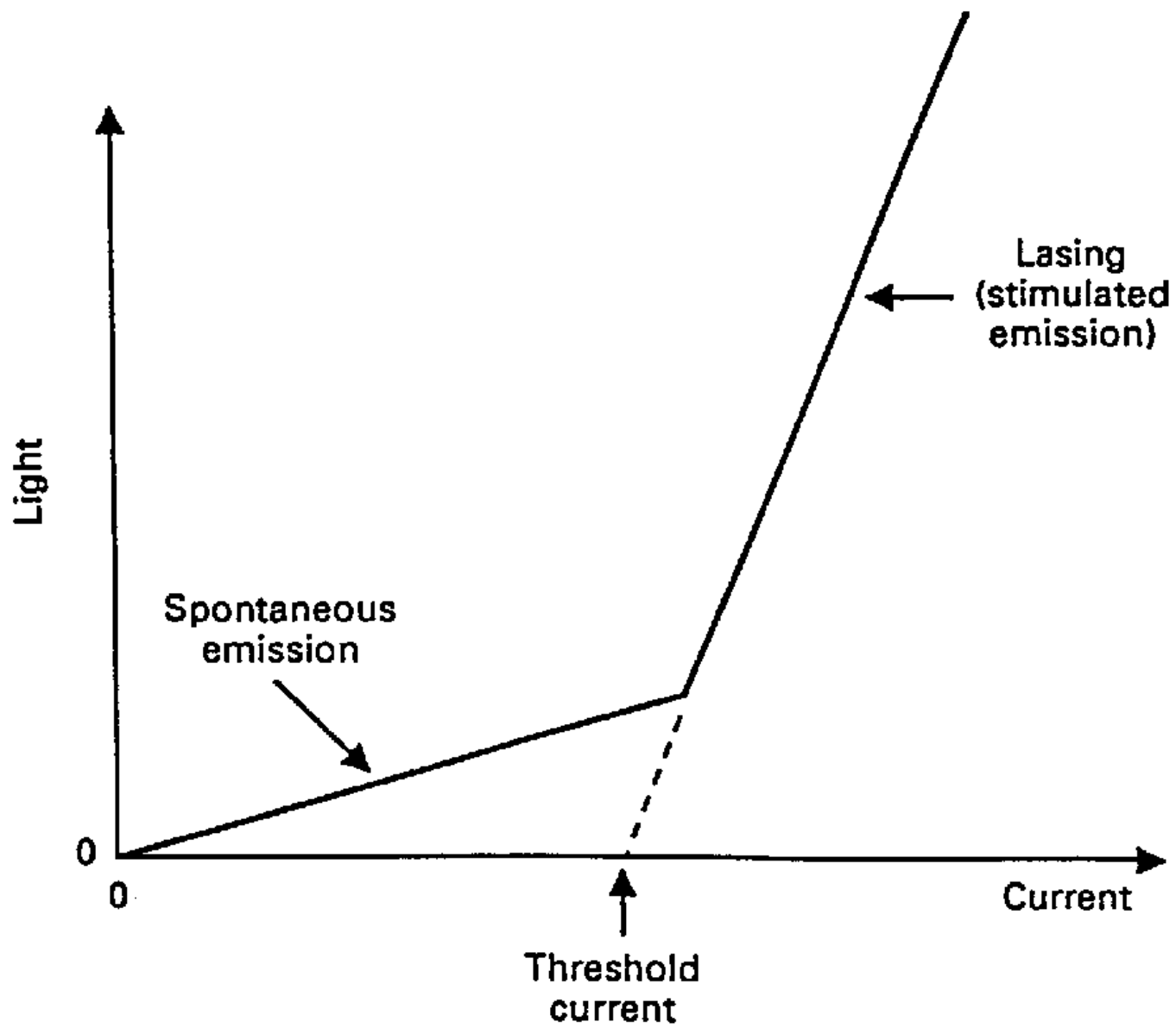


No bias



Forward bias





# Holography

\* Dennis Gabor, *Nature* 161 , 777 (1948).

\* Nobel Prize (1971)



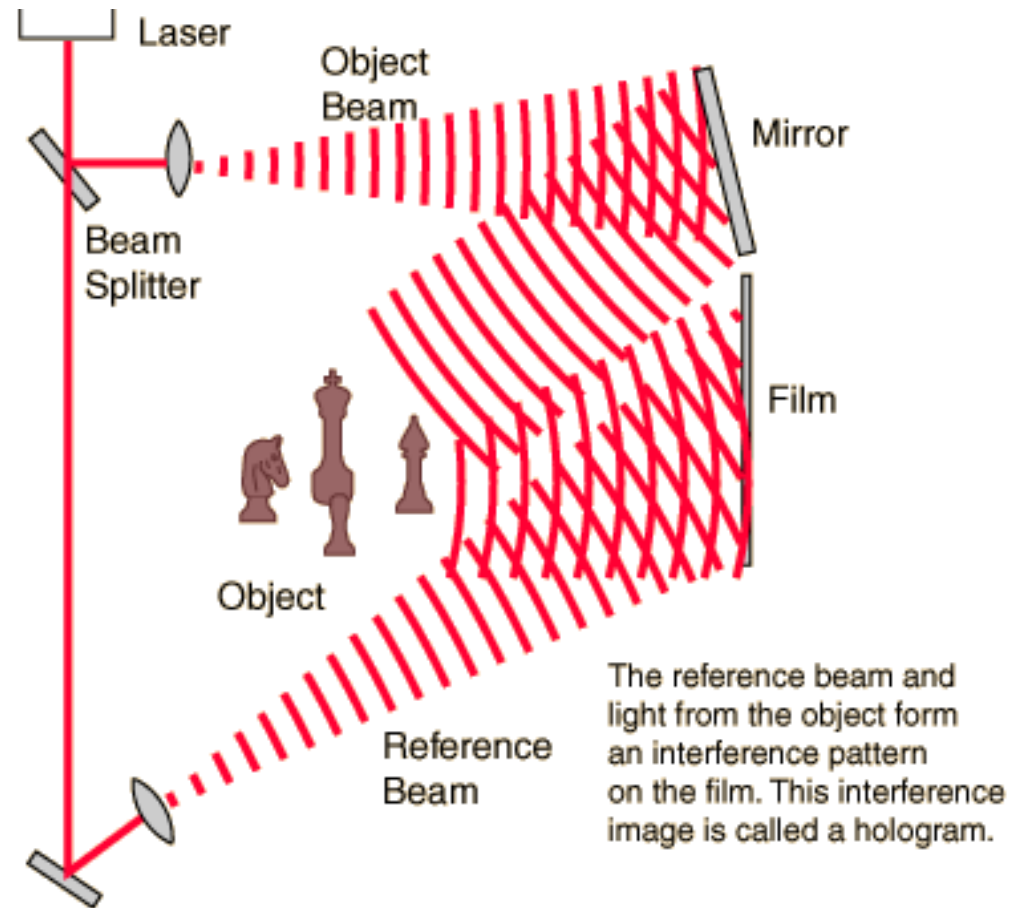
*Lensless photography* in which an image is recorded not as an image focused on film, but as an *interference pattern* on the film, called hologram.

1. Recording Hologram
2. Reconstruction of Image



# 1. Recording Hologram

The coherent light from the laser is split to form an *object beam* and a *reference beam*. The light from the illuminated *object* and the *reference beam* form an interference pattern on the *film*.



## 2. Reconstruction of Image

The image can be reconstructed for viewing by shining the coherent light of a laser on the hologram. The eye is focused behind the film to see the image.

