Primer on Semiconductors

Unit 1: Material Properties

Lecture 1.4: Properties of common semiconductors

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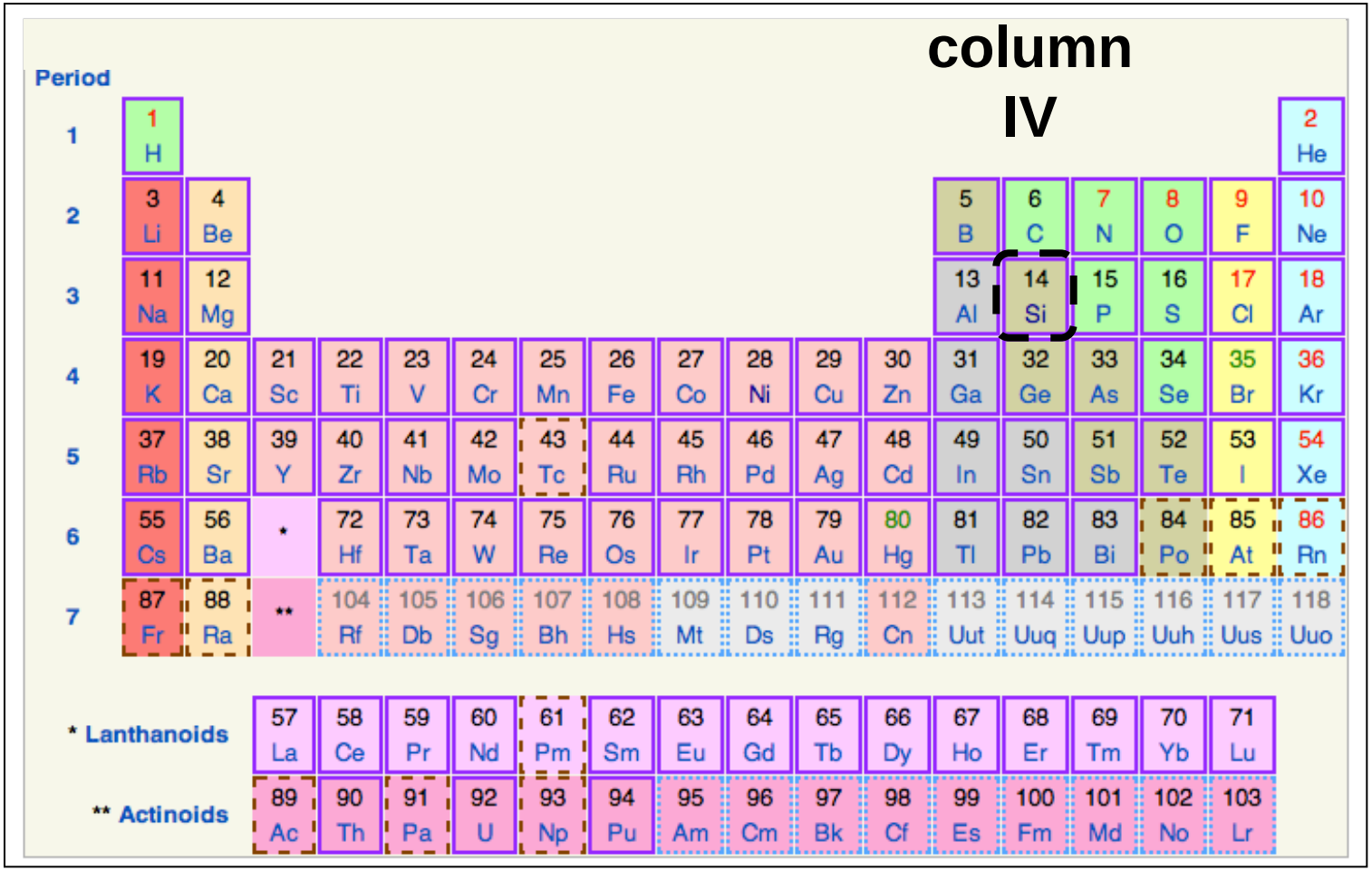
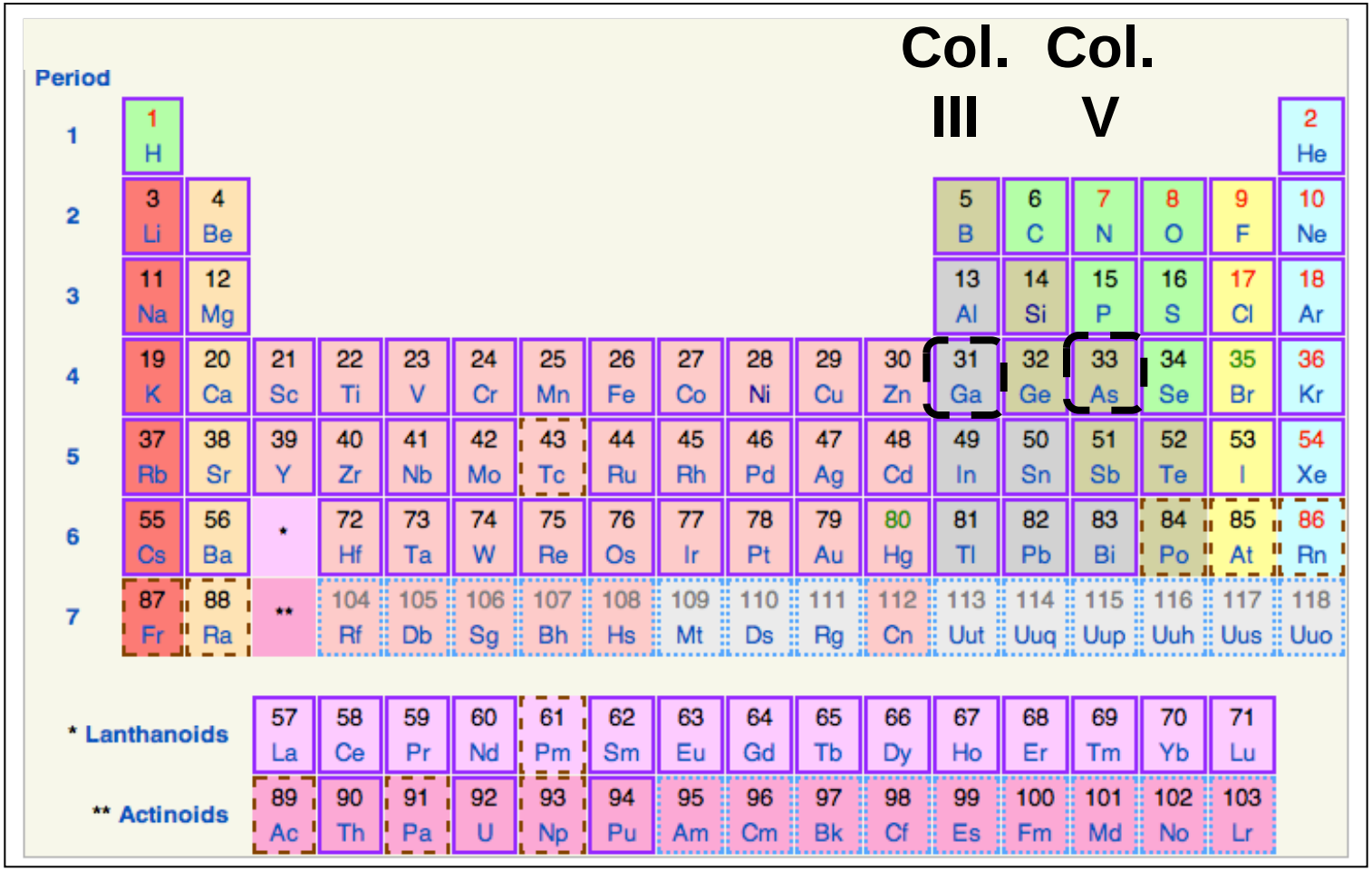
Semiconductors



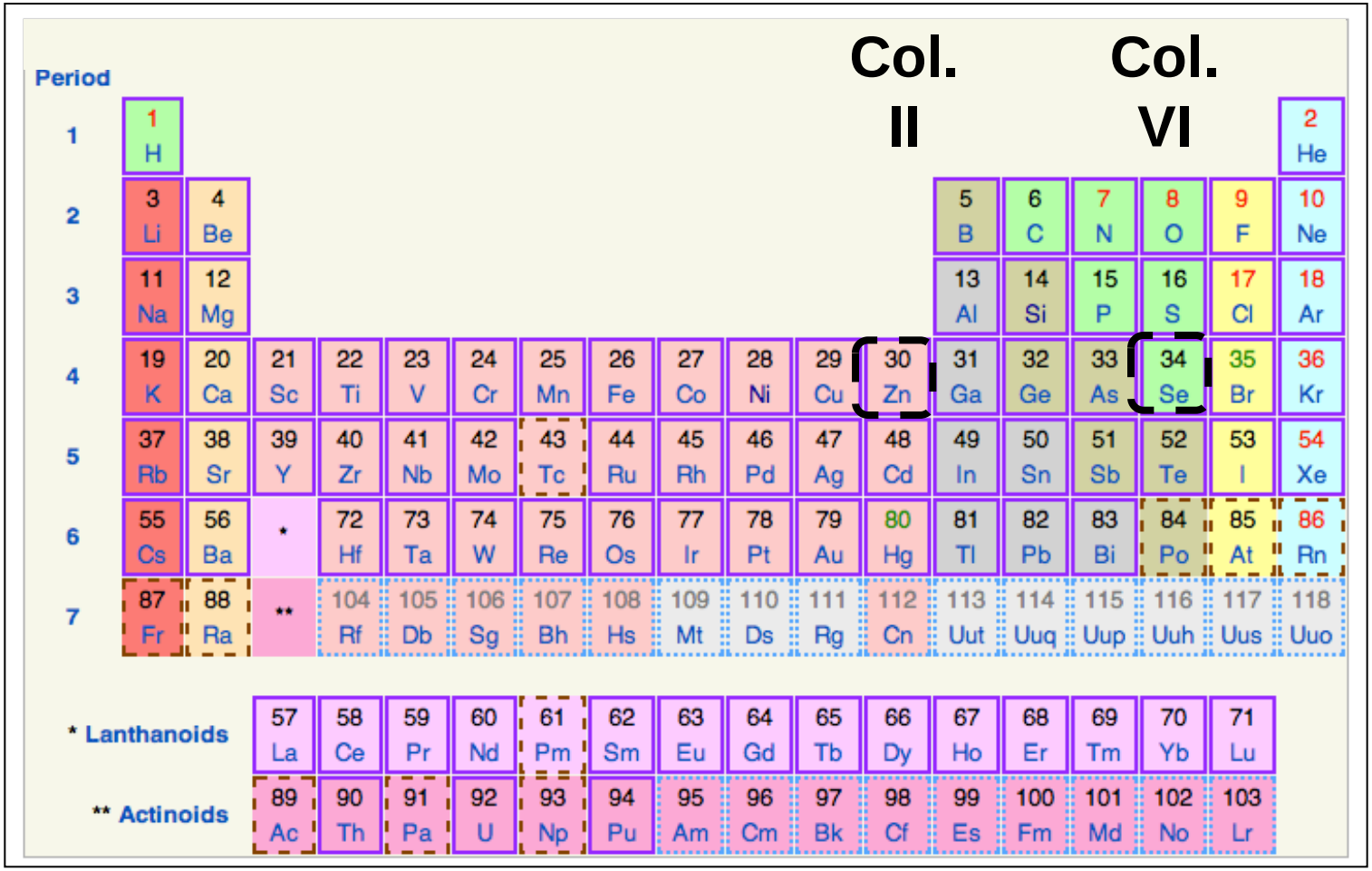
http://en.wikipedia.org/wiki/Periodic_table

III-V semiconductors



http://en.wikipedia.org/wiki/Periodic_table

II-VI semiconductors



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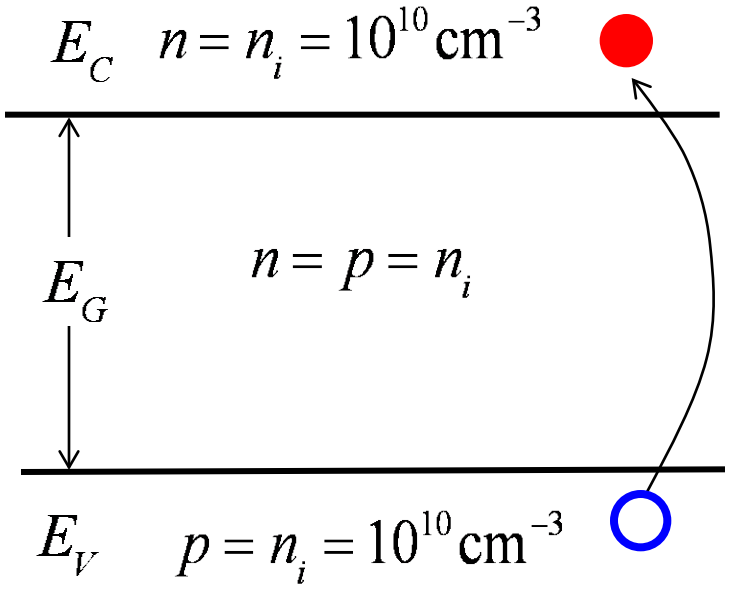
Two key numbers

Intrinsic Si



$$E_G(\mathrm{Si}) = 1.1\,\mathrm{eV}$$

$$n_i(\mathrm{Si}) = 1\times 10^{10}\ \mathrm{cm}^{-3} \quad (T = 300\ \mathrm{K})$$

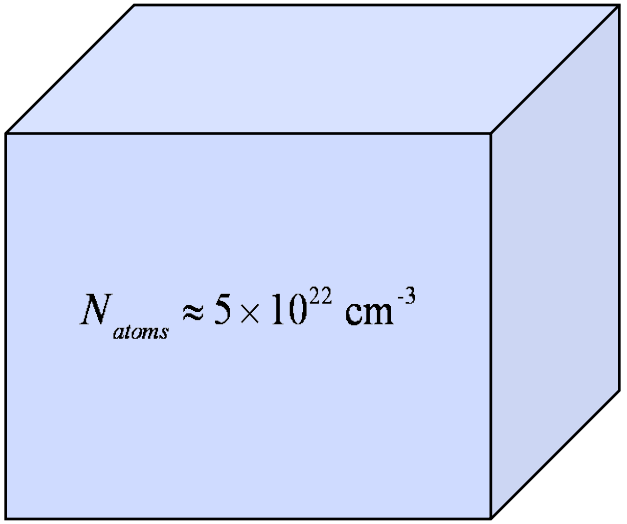
$$n_i \propto e^{-E_G/2k_BT}$$

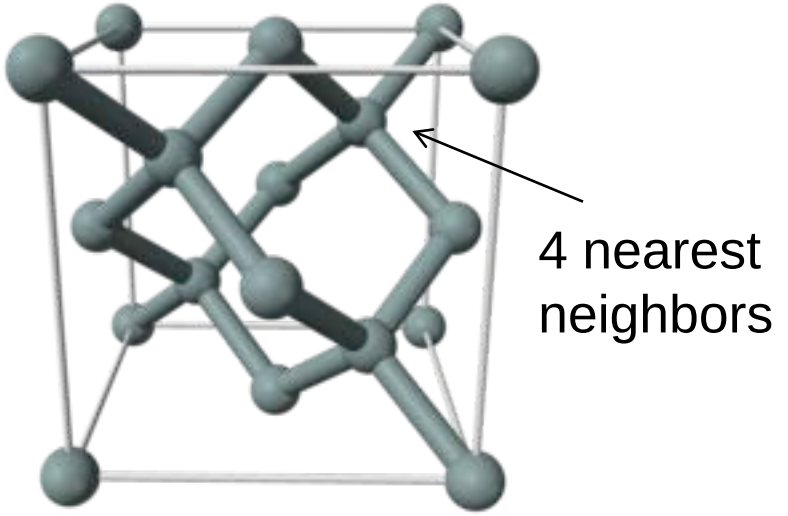
A few common semiconductors

Semiconductor	Band gap (eV)	intrinsic density
Ge	0.663	2.0×10^{13} cm^{-3}
Si	1.125	1.0×10^{10} cm^{-3}
InP	1.344	
GaAs	1.422	2.3×10^{6} cm^{-3}
CdTe	1.5	
6H SiC	2.99	
4H SiC	3.26	
GaN	3.4	

Later, we will learn how to calculate n_i.

Why is Si so common in electronics?



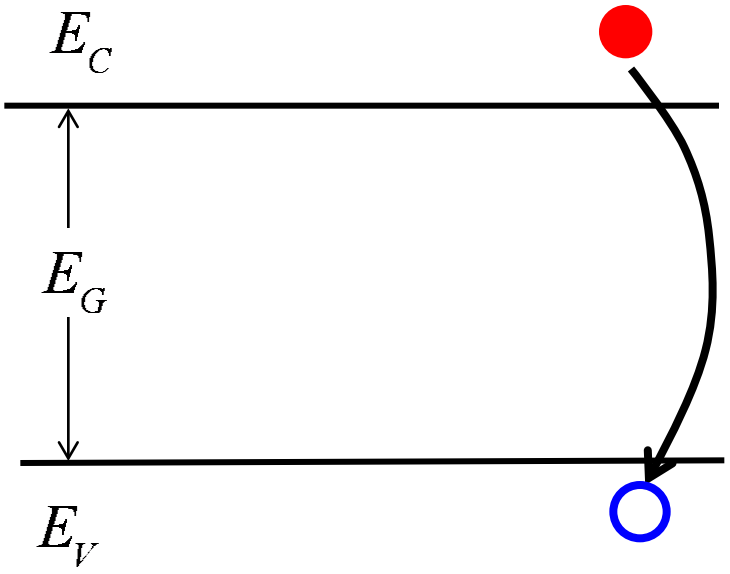


Inside the crystal, each atom has four nearest neighbors and all bonds are satisfied.

Surfaces are defects with many “dangling bonds”.

Silicon has a “native oxide” (SiO_2) that ties up dangling bonds and “passivates” the surface.

Recombination



light

(e.g. GaAs)

"direct gap semiconductor"

heat

(e.g. Si)

"indirect gap semiconductor"

Other properties

How fast do charge carriers move (mobility)?

What is the thermal conductivity?

At what electric field does the semiconductor “break down”?

Effective mass?

etc.

Summary

Silicon is the most commonly used semiconductor because it has a native oxide that passivates the surface.

Other semiconductors are used when Si isn't suitable (e.g. to make light-emitting devices).

The **bandgap and intrinsic carrier concentration** are two key (related) parameters for a semiconductor. We will encounter several other important parameters later.