Solids may be:

1- conductors

2- insulators

3- semiconductors

1- conductors

Conductors are materials that easily conduct electrical current. This is because the conductor has many free electrons. The best conductors are single- element, such as copper, silver and gold. They only have one valence electron very loosely bound to the atom that can break away and become free electrons, see Figure 1.

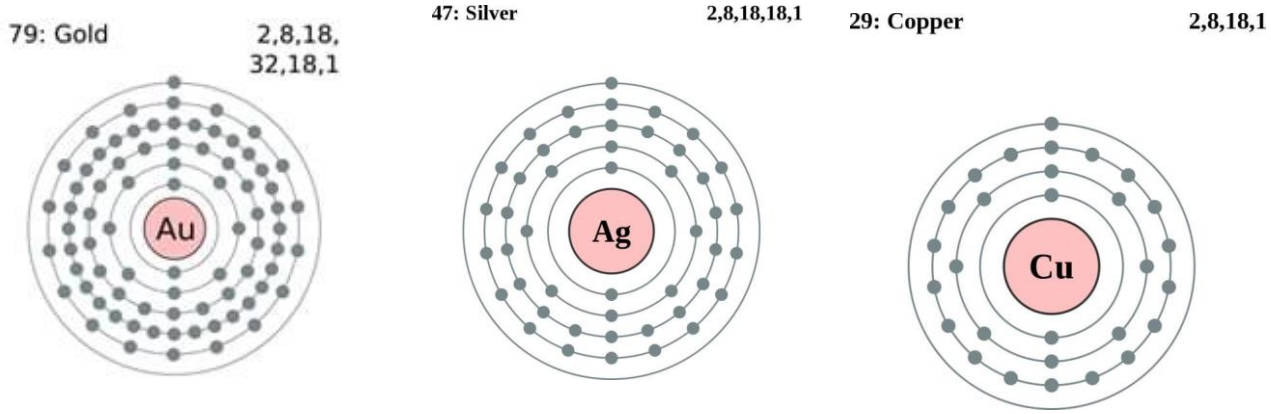

Figure 1.

2- Insulators

Isolators are materials that do not conduct electrical current under normal conditions. They have very few free electrons. Most good insulators are compounds rather than single-element materials, such as plastic.

3- Semiconductors

Semiconductor is a material that is between conductors and insulators in its ability to conduct electrical current. A semiconductor in its pure (intrinsic) state is neither good conductor nor good insulator. The most common single- element semiconductors are silicon and germanium. Compound semiconductors such as gallium arsenide are also commonly used. The single-element semiconductors, such as silicon and germanium are characterized by atoms with four valence electrons, see Figure 2. The valence electrons in (Ge) are in the fourth shell while those in (Si) are in the third shell, closer to the nucleus. Ge requires a smaller amount of additional energy to escape from the atom in comparison with Si. This property makes (Ge) more unstable at high temperatures, and this is basic reason why (Si) is the most widely used in semi conductive material like the diodes and transistors.

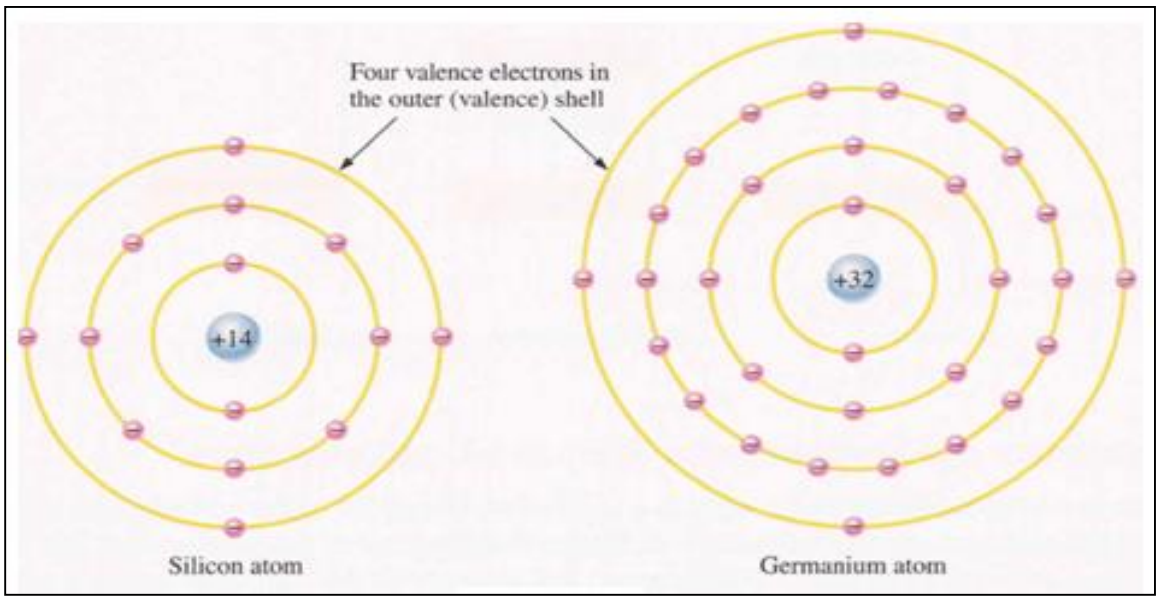

Figure 2.

Covalent bonds

When atoms combine to form a solid, crystalline material, they arrange themselves in a symmetrical pattern. The atoms within the crystal structure are hold together by covalent bonds, which are created by the interaction of the valence electrons of the atoms, as shown in Figure 3.

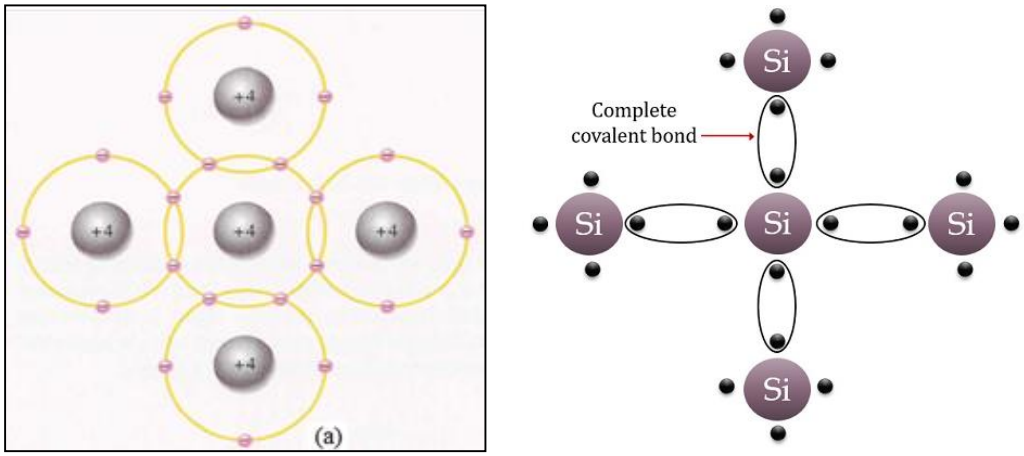

Figure 3.

Covalent bonding in an intrinsic silicon crystal is shows in Figure 4.

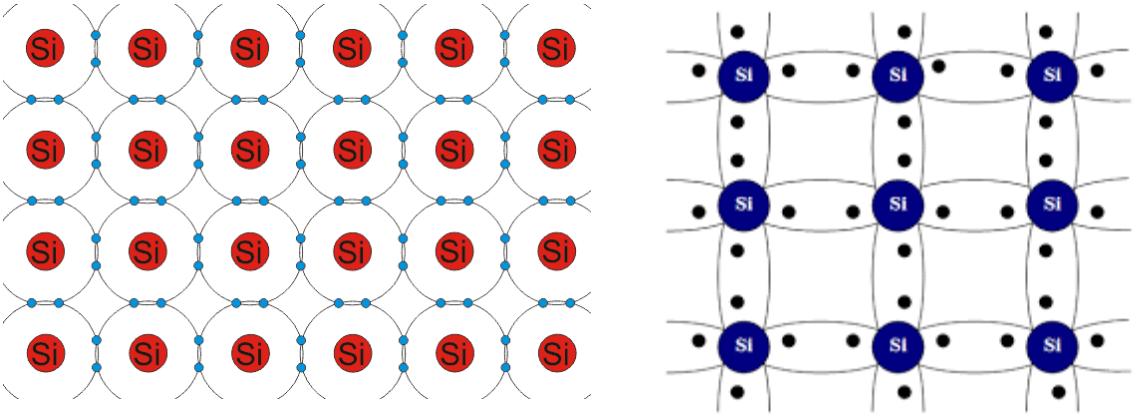

Figure 4.

Intrinsic Semiconductor materials

Semiconductor materials are found in column IV and neighboring columns of the periodic table (Table).

(a)	II	III	IV	V	VI
		B	C	N	
		Al	Si	P	S
	Zn	Ga	Ge	As	Se
	Cd	In		Sb	Te

(b)	Elemental	IV compounds	Binary III–V compounds	Binary II–VI compounds
	Si	SiC	AlP	ZnS
	Ge	SiGe	AlAs	ZnSe
			AlSb	ZnTe
			GaN	CdS
			GaP	CdSe
			GaAs	CdTe
			GaSb	
			InP	
			InAs	
			InSb	

Semiconducting materials are divided into groups:

1. **Single-element semiconductors** are in column IV (such as, silicon and germanium).
2. **Compound semiconductors** compound from materials column III and column V atoms, as well as certain combinations from II and VI, and from IV.

Note: Many conductors convert to semiconductors when they interact with elements such as Oxygen (O). For example, when the copper (Cu) interacts with O, the result is CuO or Cu2O with having semiconductor behavior.

The conductivity of semiconductors

Figure 5 shows the conductivities σ (and the corresponding to resistivity ρ = 1/σ) for insulators, semiconductors and conductors. Insulators, such as glass, have very low conductivity, which is between 10^{-18} and 10^{-8} Siemens per centimeter. Conductors, such as aluminium, have high conductivity higher than 10^{4} to 10^{6} Siemens per centimeter. The conductivity of semiconductors is between these two groups of materials.

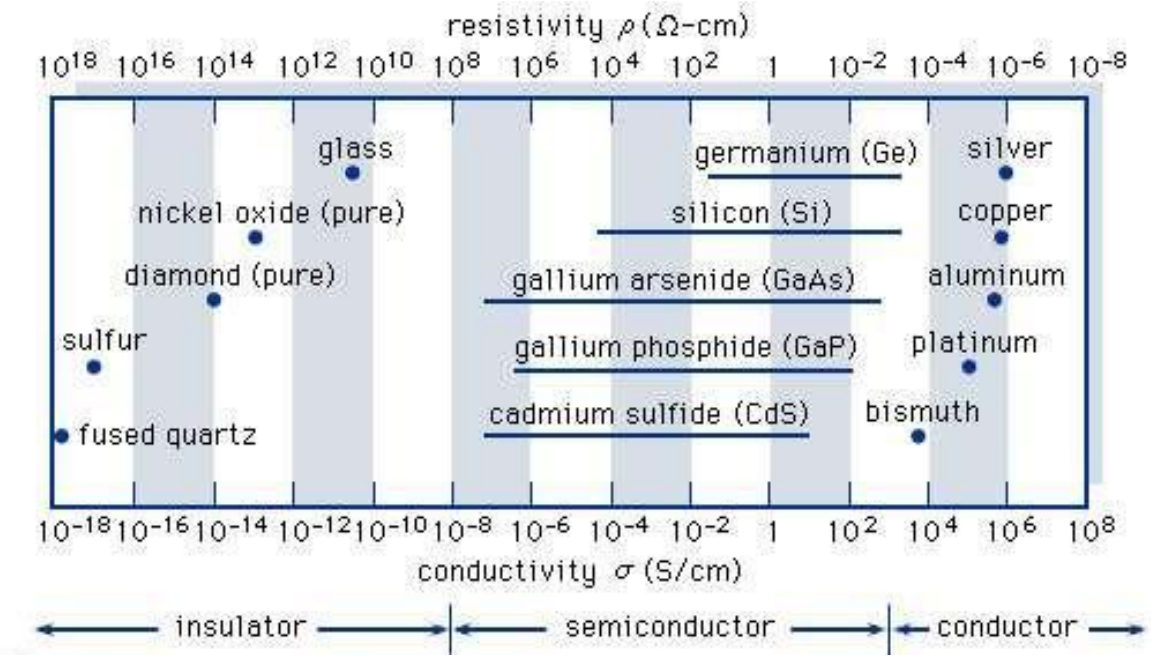

Figure 5.

The conductivity of semiconducting materials can be changed by any changing in temperature, optical excitation, and impurity content. For example, the addition of about 10 atoms of boron (known as dopants) per million atoms of silicon can increase its electrical conductivity a thousandfold.