Unit 7

Section One: Reading Comprehension

Solid-State Semiconductor Devices

Semiconductor materials such as *germanium* and *silicon* are used to construct semiconductor devices like the *diodes, transistors,* and *integrated circuits* (*ICs*). These devices are used in electrical and electronic circuits to control current and voltage, so as to produce a desired result. For example, a diode could be used as the controlling element in a rectifier circuit that would convert ac to pulsating dc. A transistor, on the other hand, could be made to act like a variable resistance so it could amplify a radio signal. Conversely, an integrated circuit could be used to generate an oscillating signal or be made to perform arithmetic operations.

The most significant development in electronics since World War II has been a small semiconductor device called the transistor. It was first introduced in 1948 by its inventors William Schockley, Walter Bratten, and John Bardeen in the Bell Telephone Laboratories and was described as a **solid-state device**. This term was used because the transistor contained a solid semiconductor material between its input and output pins, unlike its predecessor the vacuum tube which had a vacuum between its input and output pins.

The first *point-contact transistor* unveiled in 1948 was extremely unreliable, and it took its inventors another twelve years to develop the superior *bipolar junction transistor (BJT)* and make it available in commercial quantities.

In 1960, many electronic system manufacturers began to use the bipolar junction transistor instead of the vacuum tube in low-power and low-frequency applications. Research and development into semiconductor or solid-state devices mushroomed and a variety of semiconductor devices began to appear. A different type of transistor emerged called the *field effect transistor (FET),* which had characteristics similar to those of the vacuum tube. Once it was discovered that semiconductor materials could also generate and sense light, a new line of *optoelectronic devices* became available. Later it was discovered that semiconductor materials could sense magnetism, temperature, and pressure and, as a result, a variety of sensor devices or transducers (energy converters) appeared on the market. Along with all these different types of semiconductor devices, a wide variety of semiconductor diodes emerged that could rectify, regulate, and oscillate at high frequencies. Even to this day it is clear that we have not yet seen all the potential value of semiconductors. Figure 7-1 illustrates many of these semiconductor or solid-state devices.

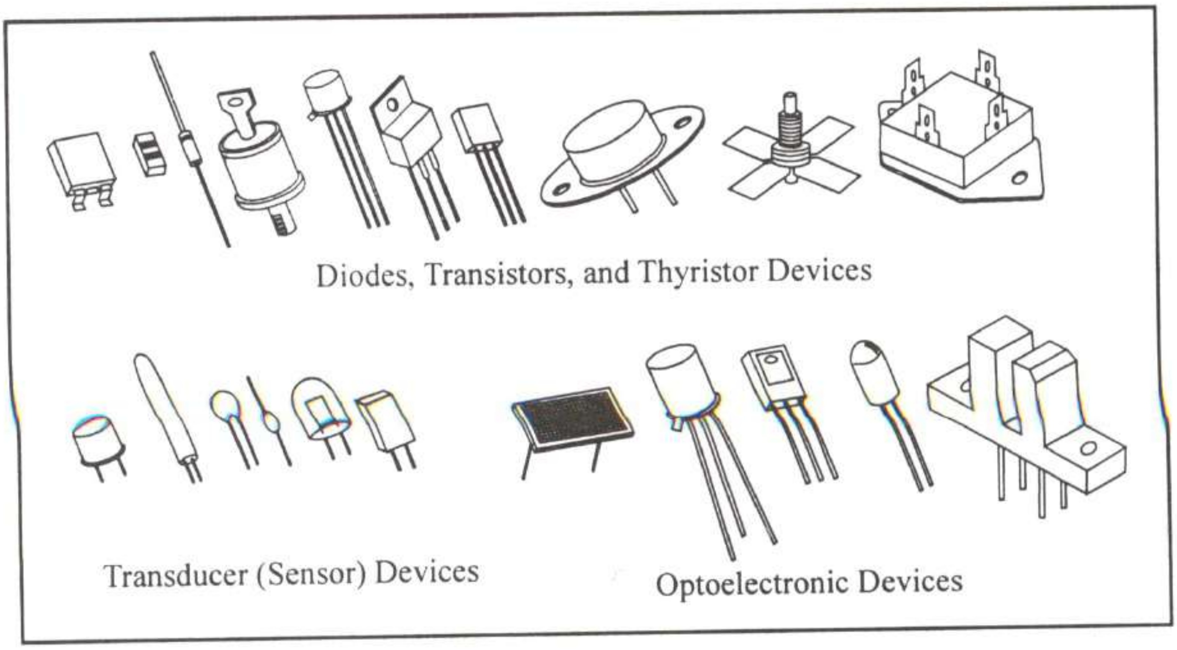

Figure 7-1. Discrete Semiconductor (Solid-State) Devices.

Although semiconductor diodes and transistors are still widely used as individual or **discrete components**, in 1959 Robert Noyce discovered that more than one transistor could be constructed on a single piece of semiconductor material. Soon other components such as resistors, capacitors, and diodes were added with transistors and then interconnected to form a complete circuit on a single chip or piece of semiconductor material. This integrating of various components on a single chip of semiconductor material was called an *integrated circuit (IC)* or *IC chip*. Today the IC is used extensively in every branch of electronics with hundreds of thousands of transistors and other components being placed on a chip of semiconductor material no bigger than this ■. Figure 7-2 illustrates some of the different types of integrated circuits.

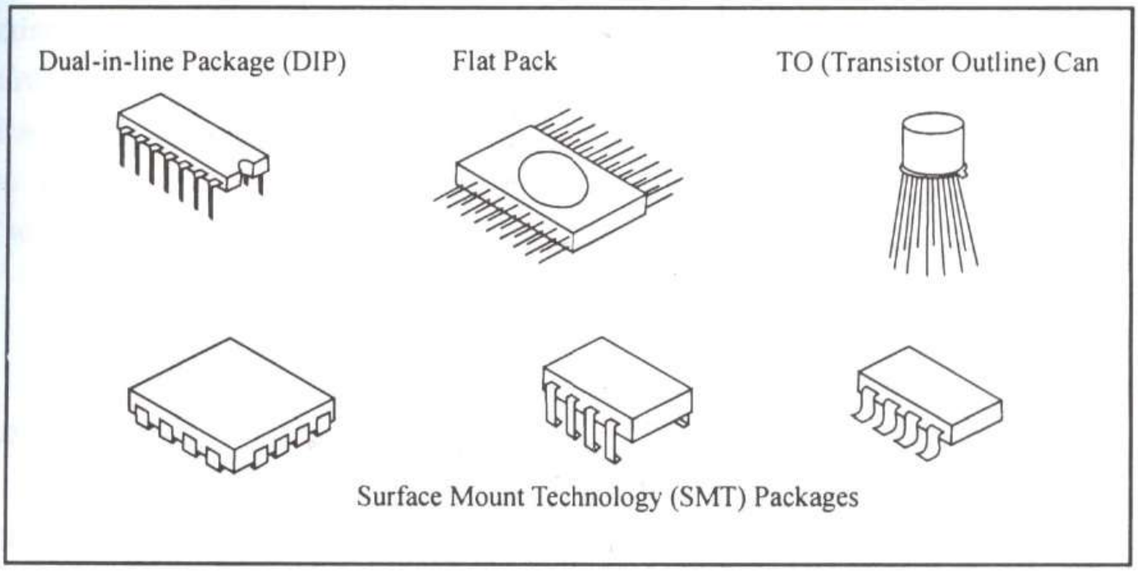

Figure 7-2. Semiconductor Integrated Circuits (ICs).

Temperature Effects on Semiconductor

Materials. At extremely low temperatures the valence electrons are tightly bound to their parent atoms, preventing valence electrons from drifting between atoms. Therefore, pure or intrinsic semiconductor materials function as insulators at temperatures close to absolute zero (–273.16°C or –459.69°F).

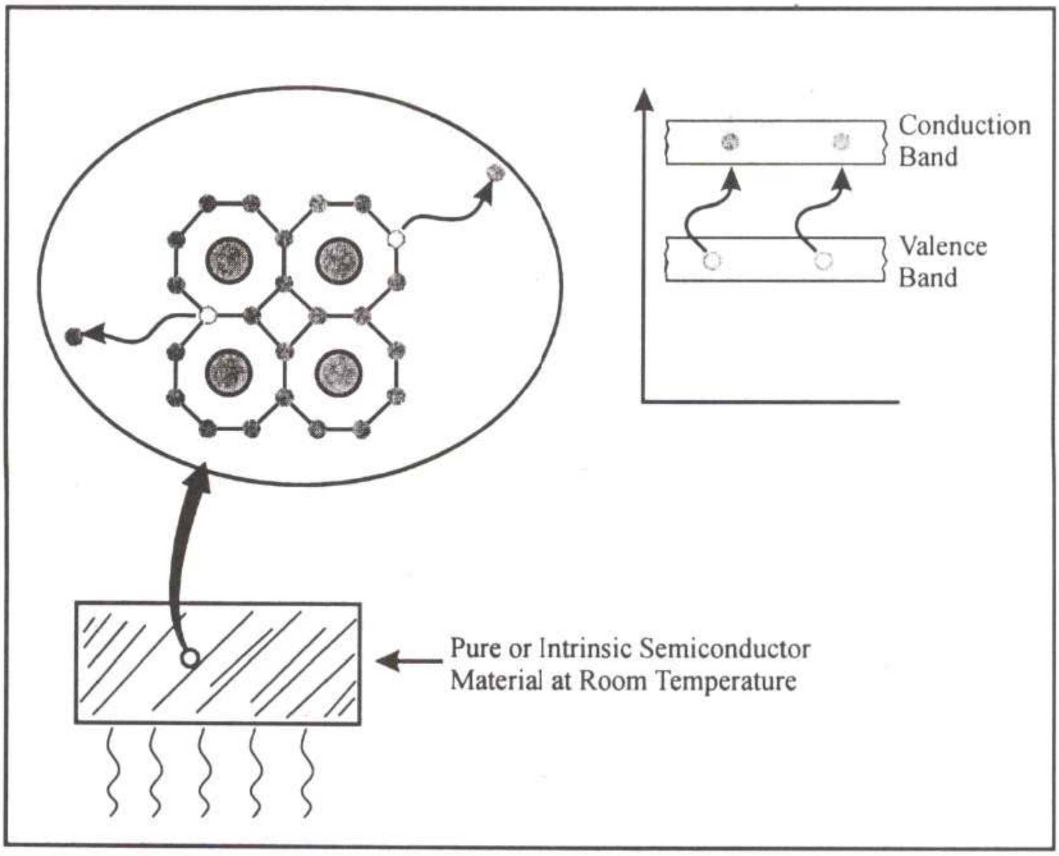

Figure 7-3. Temperature Effects on Semiconductor Materials.

At room temperature, however, the valence electrons absorb enough heat energy to break free of their covalent bonds creating electron-hole pairs, as shown in Figure 7-3. Therefore, *the conductivity of a semiconductor material is directly proportional to temperature, in that an increase in temperature will cause an increase in the semiconductor material's conductance.* This means, *an increase in temperature (T↑) will cause an increase in a semiconductor's conductivity (C↑) and current (I↑).*

Part I. Comprehension Exercises

A. Put "T" for true and "F" for false statements. Justify your answers.

.... 1. Diodes transistors, and integrated circuits act as complementary elements in a circuit.

.... 2. A transistor, when used as a variable resistor, can function as an amplifier.

.... 3. When first presented on the market, the transistor was known as a solid-state device.

.... 4. The point-contact transistor came into the market in 1948.

.... 5. It can be concluded from the text that circuits containing a semiconductor device tend to consume more current once they have warmed up.

B. Mark the choice that best answers the question.

1. How does the author express the idea of using semiconductor devices in circuits?

a. Through reasoning supported by examples.

b. Through defining diodes, transistors, and integrated circuits.

c. By comparing electrical circuits with electronic circuits.

d. By classifying them into two groups.

2. What method of organization has been used to develop the first paragraph?

a. description b. definition

c. cause and effect d. comparison and contrast

3. Which one of the following questions is answered by the author?

a. Who invented the vacuum tube?

b. When did Bratten first use the transistor?

c. Why is a transistor called a solid-state device?

d. How was the vacuum tube developed?

4. Paragraph 4 is mainly concerned with ....
   a. the rapid development of semiconductor devices
   b. the implementation of bipolar junction transistor
   c. characteristics of solid-state devices compared with those of vacuum tubes
   d. characteristics of optoelectronic devices compared with those of semiconductors
5. The term 'mushroomed' in paragraph 4 can best be replaced with ....
   a. emerged productively   b. grew rapidly
   c. set free potentially   d. appeared largely
6. The author would probably agree that semiconductor technology ....
   a. is on the way   b. is out of the way
   c. has got underway   d. has given way
7. Paragraph 5 mainly discusses ....
   a. separate active and passive devices manufactured prior to being used in a circuit
   b. different types of integrated circuits used to develop complicated devices
   c. the wide use of the integrated circuit in electronics
   d. the development of integrated circuits
8. It can be inferred from the text that ....
   a. the resistance of semiconductor materials is directly proportional to temperature
   b. the temperature of semiconductor materials and therefore semi-conductor devices is in inverse proportion to its resistance
   c. the conductivity of semiconductor materials rises sharply at room temperature
   d. semiconductor materials are of no use at absolute zero

C. Answer the following questions orally.

1. What is the difference between a transistor and a vacuum tube?
2. When was the first reliable transistor developed?
3. Since when has the bipolar junction transistor been used?
4. Who took the first step in the development of the integrated circuit?
5. How would you define an integrated circuit?