



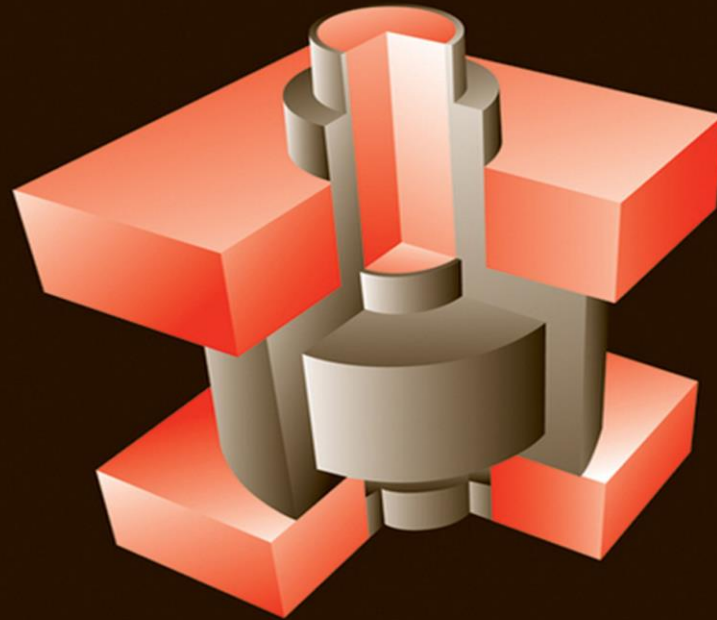
عنوان درس:

فیزیک قطعات نیمرسانا

Semiconductor Devices

Physics and Technology

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EDITION

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CHAPTER

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Why add a chapter 0 ??

Introduction

- ▶ **0.1 SEMICONDUCTOR DEVICES**
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 - ▶ **SUMMARY**
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- ❖ As an undergraduate in applied physics, electrical engineering, electronics engineering, or materials science, you might ask why you need to study semiconductor devices.
- ❖ The reason is that semiconductor devices are the foundation of the electronics industry, which is the largest industry in the world.
- ❖ A basic knowledge of semiconductor devices is essential to the understanding of advanced courses in electronics.
- ❖ This knowledge will also enable you to contribute to the Information Age(عصر اطلاعات), which is based on electronic technology.

Specifically, we cover the following topics:

- Eighteen important semiconductor devices and their roles in electronic applications.
- Four building blocks of semiconductor devices.
- Twenty three important semiconductor technologies and their roles in device processing.
- Technology trends (رند فناوری) toward high-density, high-speed, low-power consumption, and nonvolatility

➤ 0.1 Semiconductor Devices

❖ Figure 1 shows the sales volume of the semiconductor-device–based electronics industry in the past 30 years and projects sales to the year 2020.

❖ Also shown are the gross world product (GWP) (تولید ناخالص جهانی) and the sales volumes of the automobile, steel, and semiconductor industries. ↓

❖ We note that the electronics industry surpassed the automobile industry in 1998.

❖ If the current trends continue, in year 2020 the sales volume of the electronics industry will reach two trillion dollars and will constitute about 3% of GWP.

❖ It is expected that the electronic industry will remain the largest industry in the world throughout the 21st century. ↓

❖ The semiconductor industry, which is a subset of the electronic industry, will surpass the steel industry around 2010 and constitute 25% of the electronics industry in 2020.

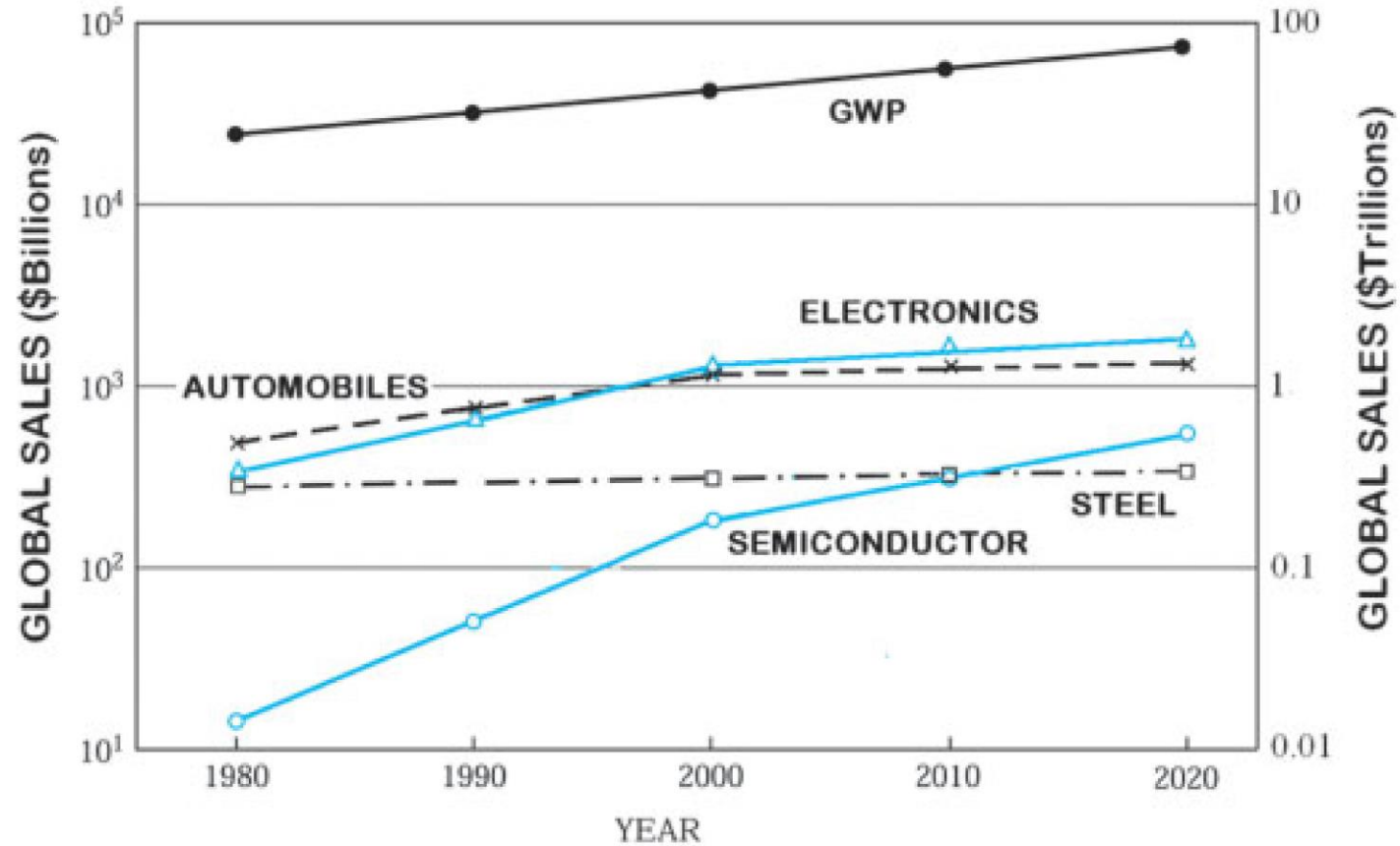


Fig. 1 Gross world product (GWP) and sales volumes of the electronics, automobile, semiconductor, and steel industries from 1980 to 2010 and projected to 2020.^{1,2}

0.1.1 Device Building Blocks

- ❖ Semiconductor devices have been studied for over 135 years. ↓
- ❖ To date, there are 18 major devices, with over 140 device variations related to them. All these devices can be constructed from a small number of device building blocks.
- ❖ Figure 2a is the metal-semiconductor interface, which is an intimate (مانوس) contact between a metal and a semiconductor.
- ❖ This building block was the first semiconductor device ever studied (in the year 1874).

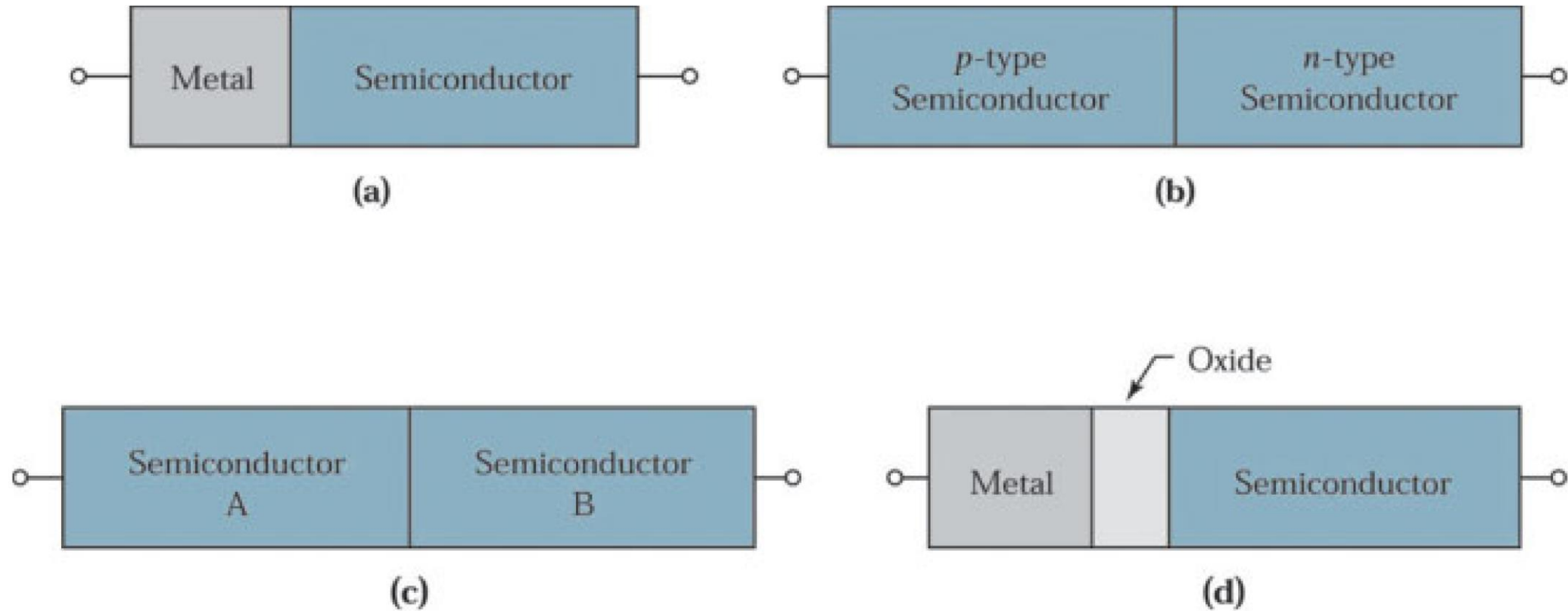


Fig. 2 Basic device building blocks. (a) Metal-semiconductor interface; (b) p - n junction; (c) heterojunction interface; and (d) metal-oxide-semiconductor structure.

❖ This interface can be used as a rectifying (یکسوکننده) contact; that is, the device allows electrical current to flow easily only in one direction, or as an ohmic contact, which can pass current in either direction (هر جهت) with a negligibly small voltage drop.

❖ We can use this interface to form many useful devices. For example, by using a rectifying contact as the gate and two ohmic contacts as the source and drain, we can form a MESFET (metal-semiconductor field-effect transistor), an important microwave device.

- ❖ The second building block is the p–n junction (Fig. 2b), which is formed between a p-type (with positively charged carriers) and an n-type (with negatively charged carriers) semiconductor.
- ❖ The p–n junction is a key building block for most semiconductor devices, and p–n junction theory serves as the foundation of the physics of semiconductor devices.
- ❖ By combining two p–n junctions, that is, by adding another p-type semiconductor, we form the p–n–p bipolar transistor, which was invented in 1947 and had an unprecedented (بی سابقه) impact on the electronic industry.

- ❖ If we combine three p–n junctions to form a p–n–p–n structure, it becomes -a switching device called a thyristor.(تریستور)
- ❖ The third building block (Fig. 2c) is the heterojunction interface(فصل مشترک پیوند ناهمگون), that is, an interface formed between two dissimilar semiconductors. For example, we can use gallium arsenide (GaAs) and aluminum arsenide (AlAs) to form a heterojunction. ↓
- ❖ Heterojunctions are the key components for high-speed and photonic devices.
- ❖ Figure 2d shows the metal-oxide-semiconductor (MOS) structure. The structure can be considered a combination of a metal-oxide interface and an oxide-semiconductor interface.

- ❖ By using the MOS structure as the gate and two p–n junctions as the source and drain, we can form a MOSFET (MOS field-effect transistor).
- ❖ The MOSFET is the most important device for advanced integrated circuits, which contains tens of thousands of devices per integrated circuit chip.