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Research Progress on Key Technologies of Microelectronics for Industry 4.0

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Abstract: With the continuous improvement of China's science and technology and economic development level, automatic control runs through all walks of life in China, and the Industry 4.0 era dominated by Internet of Things and intelligent manufacturing has gradually matured. Therefore, according to the changing market requirements, automatic control requirements have become higher and higher, and it is more and more common to integrate automatic control technology in the field of microelectronics. With the use of microelectronic technology, electrical control can be carried out more accurately, and the volume of equipment can be reduced, thus serving the future development of automatic control field. This paper analyzes the key technology of microelectronics.

Keywords: Industry 4.0, Microelectronics, The key technology.

1. Introduction

As the latest product of the development of science and technology, microelectronic technology has a direct and important impact on the field of production and life of human beings. In the late 1940s, the invention of the transistor made the development of microelectronics technology into the era. After half a century of unremitting efforts and scientific and technological innovation, modern microelectronics technology has been widely used in various fields. Microelectronics technology is not only the basis of scientific development, but also the high and new technology of The Times. In the era of industry 4.0, the development of microelectronics technology will establish a new mode of deep interaction between human and technology, to ensure that mechanical production meets the actual needs of human beings, meet the development and change of the market, and achieve personalized production and manufacturing. Industry 4.0 can fully integrate people, IT systems, automation components and mechanical information to ensure that the production of enterprises is more coordinated, reduce the consumption of human and material resources and financial resources, improve work efficiency and enhance the competitive strength of enterprises. The emergence of microelectronics technology has greatly promoted the rapid development of communication technology, telemetry and sensing technology, computer technology, aerospace technology, network technology and household electrical appliances industry.[1]

2. Overview and Development Status of Microelectronics Technology

The development of microelectronics technology has greatly changed people's life style. The core content of microelectronics technology lies in the design and manufacture of integrated circuits. The development of integrated circuits is the continuous evolution of semiconductor devices. Microelectronic technology has advantages and characteristics that traditional electronic technology does not have: microelectronic technology mainly realizes information processing or information processing through the microscopic electron movement in the solid; Microelectronic signal transmission can be carried out on a very small scale; Microelectronic technology can integrate a subsystem or electronic functional component into the chip, which has higher integration and more comprehensive functionality.[2] Microelectronics can work in lattice-level microregions.

The importance of microelectronics technology is increasing. At present, all countries in the world are actively laying out efforts, including EDA design tools, core IP, cutting-edge materials, high-end semiconductor manufacturing equipment and so on.[3] In March 2021, the European Union released "Digital Compass 2030: A Decade of digitalization in Europe", proposing the latest goal for the development of the next 10 years: "By 2030, the gross value of advanced and sustainable semiconductors in Europe will account for at least 20% of the global gross product; Conquer 2nm process, energy efficiency at least 10 times"; In May, the South Korean government and chip companies announced plans to spend about 510 trillion won (2.9 trillion yuan) over the next decade to build the world's largest chip manufacturing base in a bid to become the world's leading chipmaker. In June, the US Senate voted to pass the American Innovation and Competition Act of 2021, allocating 52.7 billion US dollars to set up the "US Chip Fund", "US Chip Defense Fund" and "US Chip International Technology Security and Innovation Fund",[4] to stimulate the research and development and production of chips in the US. In September the European Union announced a new European Chip Act; In November, Japan's Ministry of Economy, Trade and Industry held the fourth "Semiconductor and Digital Industry Strategy Seminar" and put forward the "three-step" implementation plan to strengthen the foundation of Japan's semiconductor industry. Thanks to the active efforts of all countries, important breakthroughs have been made in some key technologies.

At the Massachusetts institute of technology with the core firm cooperation, realize the whole breakthrough silicon-based optoelectronic integration, design a micron grade size forward biased all silicon-based light emitting diode (LED), on the basis of fully integrated in the 55 - nm commercial chip to realize the low voltage, high speed highlighting the near-

infrared light, its luminous intensity modulation and demodulation speed can reach more than ten times the previous record at the same time. The National Institute of Standards and Technology (NIST), in collaboration with a Canadian company, has developed a programmable optical quantum chip that works with a microscopic resonator at room temperature and performs continuously variable quantum calculations; Cerabras has launched a 7nm AI chip called WaferScaleEngine2 with 2.6 trillion transistors to process information faster and speed up AI computing. IBM released the world's first 2nm chip manufacturing process, which integrates 333 million transistors per square millimeter. Compared with 7nm chip, the performance of the same power is improved by 45%, and the power consumption is reduced by 75%. It is the most integrated and powerful chip to date.[5]

3. Research Trends of Key Microelectronics Technologies for Industry 4.0

3.1. New Materials and New Architectures Become the Focus of Prospective Research

With the development of process technology, transistor size has approached the technological limit and physical limit, further miniaturization has been difficult to sustain, we must seek new technology to make a breakthrough, new materials, new structure has become the development focus. First, the development of new material technology is accelerating, and the industrialization is advancing. In February 2021, the European Union's "Two-Dimensional Experimental Pilot Line" project developed electronic/photonic prototype devices based on two-dimensional materials and realized small batch production; In May, TSMC and MIT demonstrated the first MOS2 transistor using semi-metallic bismuth as a contact electrode, reducing the contact resistance to the quantum limit and significantly increasing the open-state current. In June, NCT announced the mass production of 4-inch gallium oxide epitaxial wafers, and the device yield exceeded 70%. In December Intel demonstrated the world's first magnetoelectric spin orbit (MESO) logic device at room temperature, demonstrating the feasibility of building new transistors based on switching nanomagnetics. Second, innovation and development of new computing architectures. Released recently, the company called "HBM-PIM" (High-bandwidthmemory,processing-in-memory, HBM-PIM) memory architecture, this architecture can be connected to the system of some computing work to a remote database, lighten the burden of CPU processing, improve the processing Speed.[6]

3.2. Improve the Traditional Manufacturing Process

With the innovation of new technology, the manufacturing process of microelectronics technology has made a leap forward. From the original traditional single-layer plane distribution to the current multi-layer process containing multi-layer high-density and multi-layer multi-function, the micro-electronic manufacturing technology has developed to the direction of low cost and multi-function. Devices produced by artificial superlattice technology are called superlattice semiconductor devices, superlattice semiconductor devices

Its biggest advantage is that its speed is 10 to 100 times faster than that of ordinary silicon semiconductors. Reducing the volume of microelectronic devices by using sensitive integrated circuits can not only save the production cost, but also improve the overall stability of the device performance. The development of modern integrated circuit tends to the planning structure of Moore's law, from the two-dimensional integration of system structure to the three-dimensional integration, to achieve a new breakthrough in circuit integration, vigorously promote the development of integrated circuit in microelectronics technology.

3.3. The Core Driver of Semiconductor Technology Development Has Changed

Over the past decade, global innovation in semiconductor technology has spawned a series of transformative technological developments, including 5G, artificial intelligence (AI), autonomous driving, and the Internet of Things. In the next 10 years, the growth of computing power due to transistor scaling will flatten out, and the development of semiconductors will be driven by three factors: application drivers, such as passive sensing and adaptive electrosub-warfare; The second is technology driven, such as new computing, advanced manufacturing and original design; The third is industrial driven, such as the reshoring of manufacturing and the surge in demand for emerging applications. Among them, emerging applications will become one of the most important thrust for the development of the semiconductor industry. For example, with the accelerated application of artificial intelligence in various fields, augmented reality, virtual reality, voice and facial recognition technology, computer vision and natural language processing require high processing speed and dedicated components to perform complex mathematical calculations, accelerating the development of intelligent processing technology on chips. A McKinsey study predicts that AI-related semiconductors could grow 18% in the next few years; Ai semi-conductors will account for 20% of overall semiconductor demand. For example, the Internet of Things (iot) is also being used in smart cities, supply chain management, healthcare, agriculture, manufacturing and consumer electronics. There are more than 11.7 billion iot devices worldwide and this number is expected to increase to 30 billion by 2025, which will give a big boost to the semiconductor industry.

3.4. Industrial Internet of Things

Digitization and the Industrial Internet of Things are the cornerstones supporting informationized manufacturing, while the technology of big data and artificial intelligence is Industry 4.0

The most promising development direction of intelligent manufacturing. MES data is transmitted through the Industrial Internet of Things. The goal of the Industrial Internet of Things is to connect things with things and things with people. On the basis of the traditional automation network, the electronic industrial iot mainly solves the problems of interconnection, wireless transmission and perception, which mainly includes:

1) Fieldbus FCS: control system connecting various equipment of various production lines and warehouse logistics systems, such as SMT production line Ethercat bus, robot final assembly line CC-link bus, warehouse Lonwork bus connection, etc.

2) Wireless Internet of Things (IoT) : It mainly completes

the information management of RFID wireless monitoring (patrol control) in warehouse and 5G wireless monitoring of AVG vehicles in logistics, so as to realize the connection between things and things and things and people.

3) Industrial ether-CAT: to realize the connection between the workshop management end and the manufacturing end. MES workstation can be connected to various production line main (line) controllers, warehouse logistics system master controllers, wireless industrial Internet of Things master controllers, workshop workstations, process workstations, etc.

4) The factory Internet network Ether-net: connects the factory management end and the workshop management end. The ERP workstation can be connected to MES workstation, sales workstation, financial workstation, etc., and can be connected to the cloud computing network platform and big data platform.

4. Conclusion

The global shortage of basic electronic devices in 2021 highlights the indispensability of basic electronic technology in today's society and accelerates the reshaping of the global semiconductor supply chain. Due to the advantages of high flexibility, low cost and high integration, microelectronics technology has become an important technology in related fields. Through the development of microelectronics technology, a better platform can be expanded to serve the automatic control system, so as to promote the technological progress in the era of industry 4.0.

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