

White Paper: China Nanotechnology Industry (2025)

—Global Leadership and Technological Breakthrough

**Empowered by the tiny,
Empowering the industry.**

**National Center for Nanoscience and Technology, China
Nanotechnology Industry Innovation Strategic Alliance**

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Abstract

National Center for Nanoscience and Technology, China, in collaboration with the Nanotechnology Industry Innovation Strategic Alliance, conducted a quantitative analysis of nanotechnology patent data from major countries/regions and enterprise data from China's State Administration for Market Regulation. The study examined the development trends of nanotechnology patents and nanotechnology enterprises over the past 25 years, revealing China's strategic position and growth potential in the global nanotechnology landscape. Below are the key findings from each chapter of the White Paper:

I. Global Development Trends of the Nanotechnology Industry

1. Market Size and Trends

- The global nanotechnology market is projected to reach \$1.5 trillion by the end of 2025, with a compound annual growth rate (CAGR) of over 17% from 2018 to 2025.
- Expanding application portfolio: Core areas include biomedicine, semiconductors, energy, environmental protection, and materials, with growing extension into emerging fields such as artificial intelligence, brain-computer interfaces, and quantum computing.

- Technological innovation drives industrial upgrades, with breakthroughs in nanomaterials and devices revolutionizing multiple sectors.

2. Patent Landscape

- From 2000 to 2025, over 1.078 million nanotechnology-relevant patents were granted globally. China leads with 464,000 patents, accounting for approximately 43% of the total, exceeding the combined numbers of the United States, Japan, and South Korea.
- Key areas: Biomedicine and medical materials, semiconductor devices, and material analysis and measurement technologies dominate patent applications.
- Top patent holder: Chinese Academy of Sciences leads globally with 23,400 patents.

3. Commercialization Strategies of Major Countries and Regions

- United States: Promotes industrialization through collaboration between R&D centers and technology commercialization bases, with a distinctive focus on integrating technology and capital. Demand-side incentives attract investment and drive technology commercialization.
- European Union: Emphasizes application-oriented R&D, encourages participation from small and medium-sized enterprises,

and builds cross-industry, cross-scale, and cross-region networks for innovation.

- Japan: Industry-led approach, with large corporations partnering with universities to facilitate technology commercialization.
- South Korea: Relies on dominant conglomerates such as Samsung, LG, and SK Hynix as core drivers of nanotechnology industrialization, differing from Japan's government-led model.

II. Current Status of Nanotechnology Industry in China

1. Industrial Scale and Talent Pool

- As of May 2025, China has over 34,500 nanotechnology enterprises, including 739 listed companies, employing more than 9.92 million people.
- Significant regional clustering: The Yangtze River Delta, Pearl River Delta, Beijing-Tianjin-Hebei region, and Central China have formed complete industrial chains.

2. Patent Layout and Technological Breakthroughs

- China leads globally in both the number of patent applications and grants.
- Key areas: Semiconductor devices, catalytic chemistry, biomedicine, and new materials.

- Geographical distribution: Beijing, Shanghai, Shenzhen, and Suzhou lead in semiconductor patents, while biomedicine patents are concentrated in Beijing, Shanghai, and Guangzhou.
- Applicant structure: Enterprises, universities, and research institutes hold roughly equal shares of patents, emerging as major drivers of innovation in the nanotechnology industry.
- Technology transfer and licensing account for over 8% of all nanotechnology patents.

3. Representative Regions and Cases

- Suzhou Industrial Park (SIP): After nearly two decades of development, it has built a thriving nanotechnology industry ecosystem, excelling in materials and semiconductors. SIP has incubated 7 listed companies, with nanotechnology industry output exceeding RMB 170 billion in 2024.
- Guangzhou Economic and Technological Development Zone: Implemented the “Five Ones” project aimed at building a trillion-yuan nanotechnology industry cluster. It established the National Nano-Intelligent Manufacturing Industry Innovation Center and incubated numerous high-tech enterprises in information technology, biomedicine, and new materials.
- Jiyuan Industry-City Integration Demonstration Zone: Aims to develop its fourth trillion-yuan industry. Leveraging the National-

Local Joint Engineering Research Center for Applied Technology of Nano Hybrid Materials, it accelerates the commercialization of nanotechnology achievements, with output value nearing RMB 10 billion in 2024.

III. Development Recommendations

- Strengthen basic research: Enhance the quality of nanotechnology patents in biomedicine and high-end semiconductors.
- Promote industry-academia-research-application integration: Establish proof-of-concept, pilot testing, and mid-scale testing service platforms to overcome industrialization bottlenecks and improve the commercialization rate of nanotechnology achievements from universities and research institutes.
- Attract international resources: Build international platforms, foster extensive global collaboration, and attract external resources for innovation and entrepreneurship in China.

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Introduction

The nanometer is a unit of length, equal to one billionth of a meter. Nanoscience is the study of composition, properties, interactions and fabrication methods of matter at the nanoscale (1–100 nanometers). The invention of the scanning tunneling microscope (STM) in 1981 gave rise to nanoscience and technology, which have enabled scientists to explore the microscopic world at the nanoscale. Through nanoscience and technology, humanity's understanding of the world has been extended, and new ways to shape the world at the atomic and molecular levels have been created. The goal of nanotechnology is to produce products with specific functions based on the physical, chemical, and biological properties of matter at the nanoscale.

Scaling down for a Bright Future

Since the 20th century, the field of nanoscience and technology has been expanding rapidly. As a young and dynamic area of research and application, it is transforming the world, bringing revolutionary advances to industries such as information technology, manufacturing, and healthcare. Facilitated by its multidisciplinary, cross-cutting, and fundamental nature, nanoscience and technology have become a driving force in the development of modern science.

Nanotechnology has already established its value across multiple economic sectors. In addition to its role in nanomaterials within the new

materials industry, its applications in biomedicine, information technology, energy and environment, equipment, and green manufacturing are becoming increasingly prominent and hold broad prospects.

In recent years, nanotechnology has been reshaping global industrial chains. The global nanotechnology industry has developed rapidly, with its market size continuously expanding and its applications extending into new fields. In 2023, the market size exceeded \$1.2 trillion, and it is projected to surpass \$1.5 trillion by 2025. This microscopic world, 100,000 times smaller than a strand of human hair, is triggering revolutionary changes in fields such as information technology, healthcare, energy, and materials.

At the same time, China has emerged as a major force in the global development of nanotechnology, achieving remarkable results in patent applications, number of enterprises, talent pool, and more. Nanotechnology has gained a dominant position in several sub-fields and is gradually forming pillar industries. Given the strategic value of nanoscience and technology, assessing and forecasting their development trends in the industrial domain is of vital importance.

This report provides an in-depth analysis of the current state of China's nanotechnology industry.

Chapter 1.

Global Development Trends of the Nanotechnology Industry

1.1 Concept and Characteristics of the Nanotechnology Industry

Nanomaterials are materials with any external dimension, internal or surface structure at the nanoscale.

Nanotechnology involves the manipulation and control of matter at the nanoscale by utilizing size- and structure-dependent properties and phenomena that differ substantially from those of individual atoms, molecules, or bulk materials.

Nanotechnology products are those composed of nanomaterials, possessing nanostructures, incorporating nanomaterials, or exhibiting significantly altered primary properties after processed by nanotechnology.

It is generally recognized that, applying nanotechnology for products as well as achieving batch production, commercialization, and scale-up, forms the nanotechnology-relevant industry. Specifically, the nanotechnology industry refers to nanotechnology and its related sectors, characterized by multidisciplinary integration and cross-industry applicability. The upstream segment of the nanotechnology industry involves multiple disciplines such as materials physics, materials chemistry, electronics, biology, and clinical medicine. The midstream core components mainly include nanomaterials, nanodevices, measurement,

characterization, and standardization for nanotechnology, all closely interconnected through nanofabrication. Among these, nanomaterials serve as the fundamental basis for the existence and development of nanotechnology-relevant industries. Nanodevices are products further processed and assembled from nanomaterials and nanostructures, forming the foundation for extending various information technology products. Measurement instruments and processing equipment for nanotechnology are essential hardware supports for developing nanomaterials, devices, and their derivative products. Nanomaterials and nanodevices are applied across downstream traditional and emerging industries, integrating with sectors such as biomedicine, electronics, information technology, energy and environment, and intelligent manufacturing. This extends into new industries and business models such as nanobiomedicine, nano-energy and environment, and nano-intelligent information technology, giving rise to diverse nanotechnology products (**Figure 1-1**).

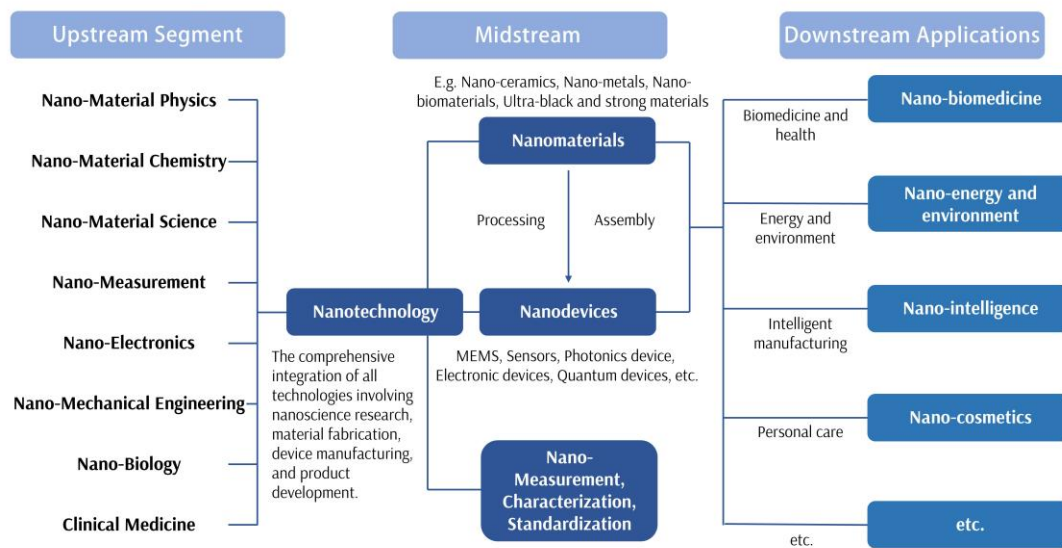


Figure 1-1 Schematic diagram of the nanotechnology industry chain

Based on preparation methods, nanotechnology products can be divided into three categories: first, products composed of or structured from nanomaterials; second, products incorporating nanomaterials; and third, products processed using nanotechnology. Overall, nanotechnology products span multiple sectors across primary, secondary, and tertiary industries (**Figure 1-2**).

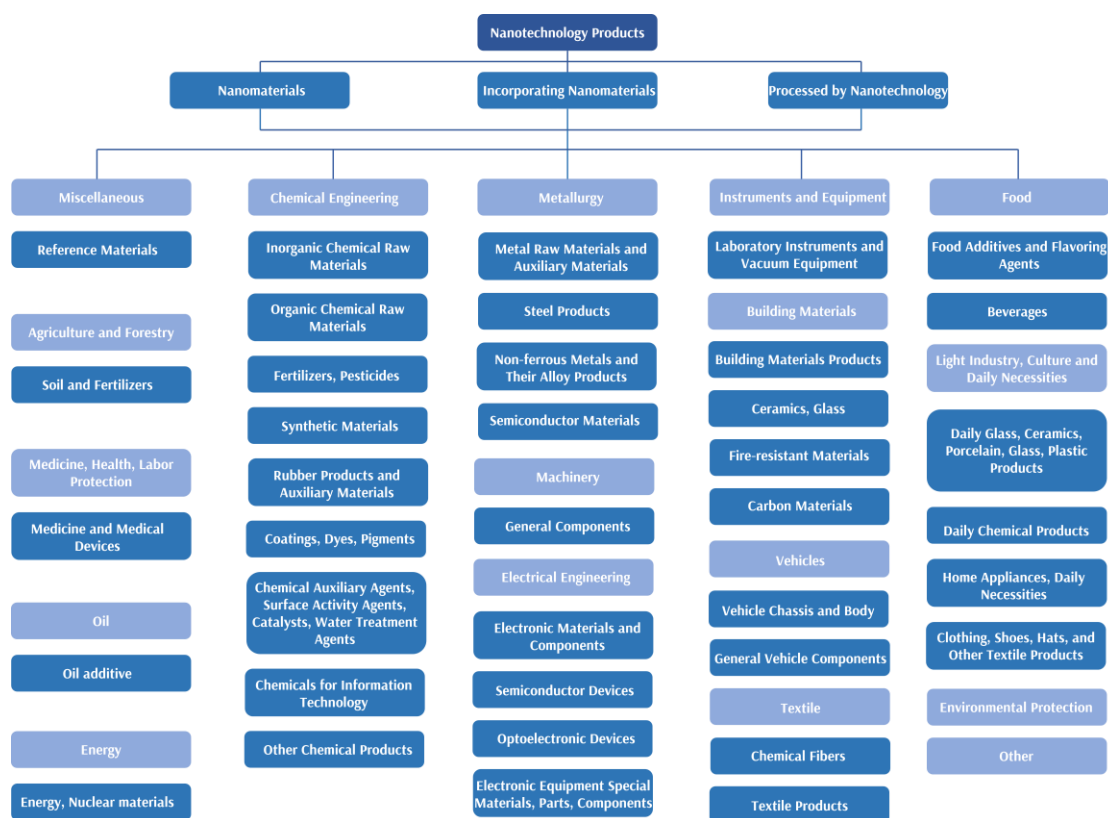


Figure 1-2 Classification of nanotechnology products

Nanotechnology, treasured by its multidisciplinary integration, is gradually becoming a core driver of future transformative technologies and holds significant strategic importance. The uniqueness of nanotechnology lies in its foundational, interdisciplinary, pioneering, and transformative nature. These characteristics not only propel the rapid development of multiple disciplines and cutting-edge fields but also serve as a new engine for scientific progress. At the scientific frontier, nanoscience converges key issues from chemistry, physics, biology, materials science, and other disciplines, making it one of the most active and innovative research areas in modern science. According to statistical data from the “Big Data Analysis of Nanoscience Bibliometrics, Patent, and Funding Data”

published by Science Press, nearly 90% of the hottest research topics globally in the past five years were related to nanotechnology, demonstrating its broad and profound impact. Simultaneously, nanotechnology output has experienced explosive growth, with a significant increase in the number of researchers, further confirming its critical role in scientific research.

1.2 Global Development Trends of Nanotechnology

At the national strategic level, major countries and economies worldwide are actively deploying nanotechnology to secure a leading position in future technological, industrial, and economic competition. Developed countries such as the United States, Japan, and South Korea aim to lead the next industrial revolution through nanotechnology, while developing countries like China, India, Russia, and Brazil hope to achieve leapfrog development through it. The United States launched the National Nanotechnology Initiative (NNI) in the early 21st century, and the European Union and Japan have continuously deployed nanotechnology research within their framework programs. Currently, China has advanced to the global forefront in nanotechnology research, which is becoming one of the most promising fields for achieving transformative development. It has made multiple original innovations and contributed significantly to areas such as COVID-19 response, aerospace, and national defense security. Meanwhile, the international competitiveness of China's

nanoscience research institutions is steadily improving, with high-quality research continuously emerging.

At the technological level, the disruptive and transformative characteristics of nanotechnology on industries are increasingly prominent, making it a vital source of technological innovation and industrial upgrading. Disruptive technological innovations such as oil separation membranes, wet-process silicone rubber, supramolecular materials, and flexible electronic materials continue to emerge. Additionally, under the impact of the COVID-19 pandemic, new type of nanomaterials and technologies played a key role in the development of vaccines, protective masks, protective clothing, testing kits, etc.

Looking ahead, nanotechnology will be deeply applied in fields such as information technology, energy, and environmental protection, forming emerging industries based on nanotechnology and bringing better lives.

At the industrial level, the following characteristics are observed:

Sustained market growth: The global nanotechnology market is expected to reach \$1.5 trillion by 2025, with a compound annual growth rate (CAGR) of over 17% from 2018 to 2025.

Expanding application fields: Nanotechnology is widely used in biomedicine, semiconductors, energy, environmental protection, materials, and other fields, and is continuously expanding into new application areas

such as artificial intelligence, brain-computer interfaces, and quantum computing.

Continuous technological innovations: Technological innovations in nanomaterials, nanodevices, nanomanufacturing, nanobiomedicine, and other fields are continuously emerging, driving the rapid development of the nanotechnology industry.

Chapter 2.

Analysis of Global Nanotechnology Patents

2.1 Overview of Global Nanotechnology Patents

According to data from major patent offices worldwide, nanotechnology patents have experienced explosive growth, with leading countries and regions such as China, the United States, Europe, Japan, and South Korea dominating the field. The total number of global patents **exceeds 1.078 million**, covering multiple fields including materials science, biomedicine, and electronic devices.

2.2 Distribution of Nanotechnology Patents in Major Countries and Regions

Based on statistics from 2000 to 2025 from patent databases of major countries and regions (**Figure 2-1**, **Table 2-1**, and **Table 2-2**), China, the United States, Japan, and South Korea rank among the top four in terms of nanotechnology patent numbers.

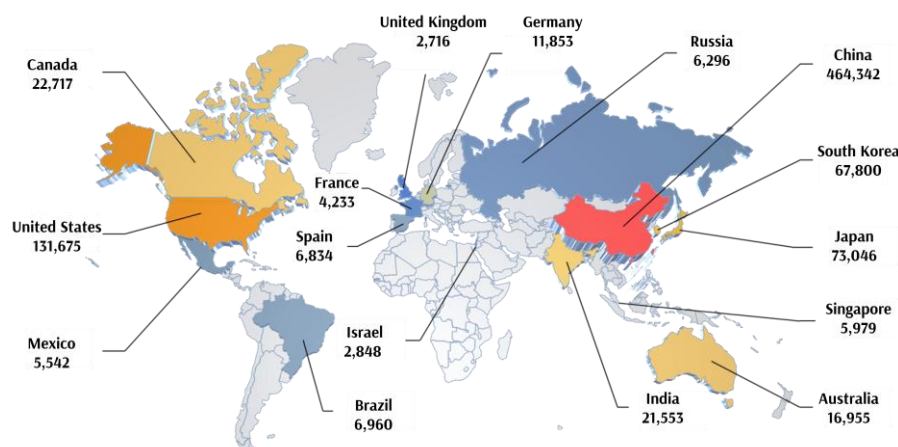


Figure 2-1 Distribution of nanotechnology patents in major countries

and regions

Table 2-1 Countries with over 10,000 nanotechnology patents

Country	Number of Patents	Global Share	Characteristics
China	464,342	43.0%	Accounts for over two-fifths of global total, covering almost all R&D fields in nanotechnology.
United States	131,675	12.2%	Holds numerous original patents, focused on electronic information technology, high-end materials, medical devices, energy, environment, etc.
Japan	73,046	6.8%	Concentrated in electronic materials, equipment, energy, environment, etc.
South Korea	67,800	6.3%	Concentrated in semiconductor display, storage, etc.
Canada	22,717	3.0%	Strong in energy nanomaterials patents.
India	21,553	2.9%	Significant advantage in pharmaceutical nanotechnology, large number of patents of delivery systems.
Australia	16,955	2.3%	Prominent in mineral and environmental monitoring technologies.
Germany	11,753	1.6%	Focused on biomedicine, nanocomposite materials, etc.

Table 2-2 Countries with 1,000 to 10,000 nanotechnology patents

Country	Number of Patents	Characteristics
Brazil	6,960	Bio-nanotechnology accounts for over 70% of its total.
Spain	6,834	Concentrated in nanosensor patents.
Russia	6,269	Primarily focused on military nanomaterials (e.g., stealth coatings).
Mexico	5,542	Leading in manufacturing nano-applications (e.g., automotive and electronics).
France	4,233	Strong accumulation in microelectronics technology.
Israel	2,848	Prominent in photocatalysis, chip manufacturing, agricultural applications.
United Kingdom	2,716	Strong in nanomaterial synthesis, nanophotonics.
Indonesia	1,652	Focused on natural nanomaterials (e.g., palm oil derivatives).
Ukraine	1,131	Prominent in nanocatalytic materials.

2.3 Continental-level Analysis of Global Nanotechnology Patents

Asia:

Asia is the main force in nanotechnology patent applications, with a total of over **600,000 patents** (China, Japan, South Korea, India, etc.), holding the most spots among the top 10 countries and accounting for approximately **59% of the global total nanotechnology patents**.

China, with 464,000 patents, forms a “unipolar pattern” and the number of patent transfers and licenses has been steadily increasing in recent years.

America:

Total around **182,000 patents** (United States, Canada, Brazil, Mexico, etc.), accounting for approximately **16.9%** of global nanotechnology patents.

The United States and Canada have strong technology output, while Brazil focuses on localized applications.

Europe:

Total around **34,000 patents** (Germany, France, Italy, UK, Spain, Sweden, Russia, etc.), accounting for approximately **3.2%** of global nanotechnology patents.

Close industry-academia-research collaboration, with Germany as the core, accounting for 33% of European patents.

Oceania:

Total around **18,000 patents** (Australia, New Zealand), accounting for approximately **1.7%** of global nanotechnology patents.

Australia focuses on resource-related nanotechnology patents (e.g., minerals, marine).

2.4 Global Nanotechnology Patent Applications by Field

2.4.1 General Field Distribution Characteristics

Data from **Figure 2-2** shows that global nanotechnology patent applications exhibit **significant field concentration**. The top five fields, including Biomedicine & Medical Materials, Semiconductor Devices, Material Analysis & Measurement Technology, Catalytic Chemistry & Reaction Engineering, and Non-metallic Material Chemistry, together account for **59.27%**. Among them:

- **Biomedicine & Medical Materials** (19.12%) and **Semiconductor Devices** (17.53%) form the first tier, with a combined total of **274,000 patent** applications, nearly 40% of the overall share;
- **Material Analysis & Measurement Technology** (11.75%), as a foundational technology field, constitutes the second tier;
- The remaining fields each account for less than 10%, but cover diverse areas such as catalytic chemistry, energy storage, and building materials.

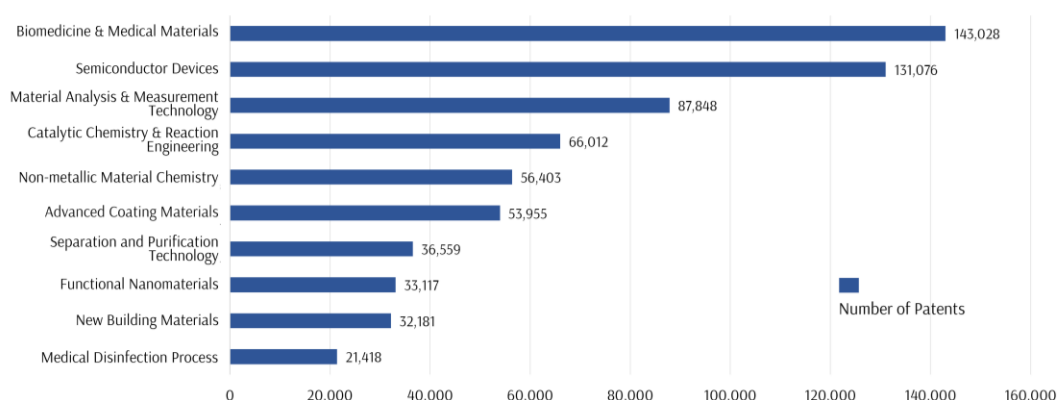


Figure 2-2 Global distribution of nanotechnology patents by field

2.4.2 In-depth Analysis of Key Fields

2.4.2.1 Biomedicine & Medical Materials

- Number of patents: Approximately **140,000**;
- Core areas: drug nanocarriers, medical polymer materials, sensitive materials for biosensors, etc.;
- Growth driving factors: Surging demand for precision medicine and personalized treatment; nanotechnology enhances drug targeting and biocompatibility.

2.4.2.2 Semiconductor Devices

- Number of patents: Approximately **131,000**;
- Core technologies: Nanoscale chip manufacturing, quantum dot display technology, flexible electronic materials, etc.;
- Growth driving factors: Demand driven by the continuation of Moore's Law and hardware upgrades for 5G/6G technology and artificial intelligence (AI).

2.4.2.3 Material Analysis & Measurement Technology

- Number of patents: Approximately **88,000**;
- Core technologies: Nanoscale characterization (AFM/STM), defect detection, component analysis, etc.;
- Growth driving factors: Quality control demands in high-precision manufacturing fields like semiconductors and energy sectors.

2.5 Annual Application Trends for Global Nanotechnology Patents

2.5.1 General Trend Characteristics

Global nanotechnology patent applications show a phased characteristic of “**rapid growth in both applications and grants in the early stage, divergence between applications and grants after 2018**”, while China’s patent landscape shows a trend of “**continuous rise in both applications and grants in the early stage, both entering a plateau after 2018**” (Data for 2023 and beyond are not included in the analysis due to delayed publication affecting authenticity):

- Global data: From 2000 to 2022, the number of patent applications increased from 5,968 in 2000 to a peak of 70,251 in 2022, while the number of grants began to decline after 2018 (**Figure 2-3**).
- China data: From 2000 to 2022, the number of patent applications increased continuously from 375 in 2000 to 38,283 in 2022. After exceeding 30,000 applications in 2018, both application and grant numbers entered a plateau (**Figure 2-4**). This trend is highly correlated with the government's requirement to “improve patent quality and benefit”.

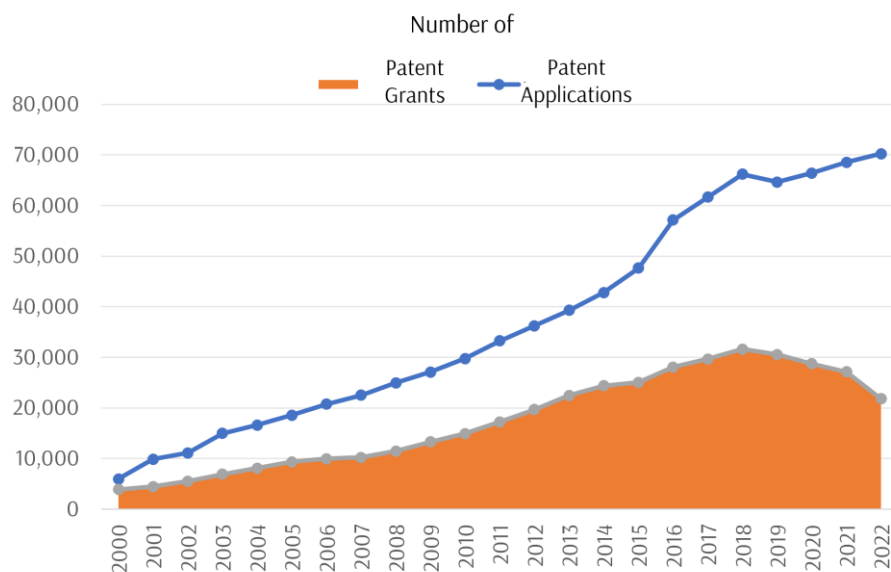


Figure 2-3 Trends in global nanotechnology patent applications and grants from 2000 to 2022

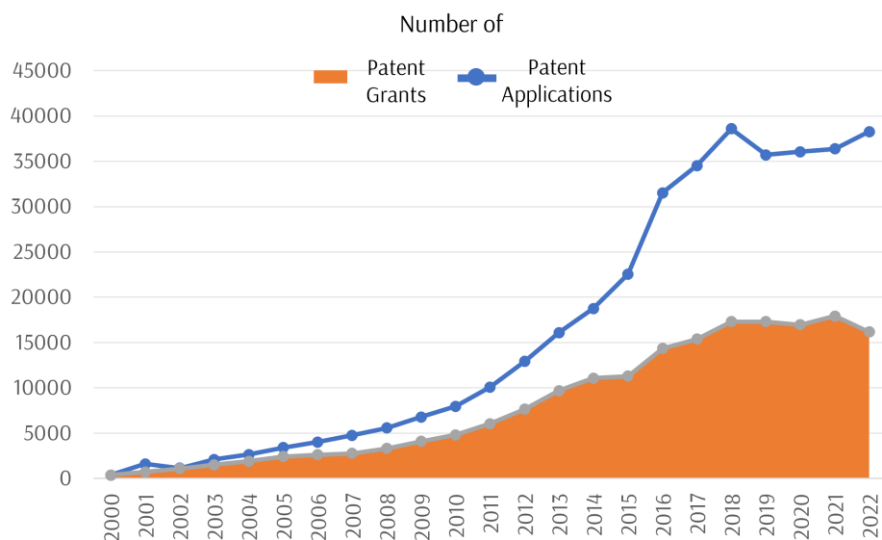


Figure 2-4 Trends in China nanotechnology patent applications and grants from 2000 to 2022

2.5.2 Analysis of Key Growth Phases

2.5.2.1 Global Boom Period (2010-2018)

- Applications surged from 29,766 to 66,206, with an average annual growth rate of 11.6%.
- Driving factors: Breakthroughs in graphene technology (Nobel Prize in Physics, 2010), EU's Horizon 2020 program promoting industrial development.

2.5.2.2 China's Acceleration Period (2015-2018)

- Applications increased from 16,083 to 39,529, with an average annual growth rate of 24.7%.
- Policy support: The “13th Five-Year” Special Plan for Scientific and Technological Innovation in the Materials Field (2017) clarified the development path for nanomaterials.

2.6 Global Nanotechnology Patent Holders

As of May 2025, based on global patent applicants (**Figure 2-5**), the Chinese Academy of Sciences leads with 23,823 nanotechnology patents, followed by international leading corporations and research institutions such as Samsung (14,935 patents) and LG (6,642 patents).

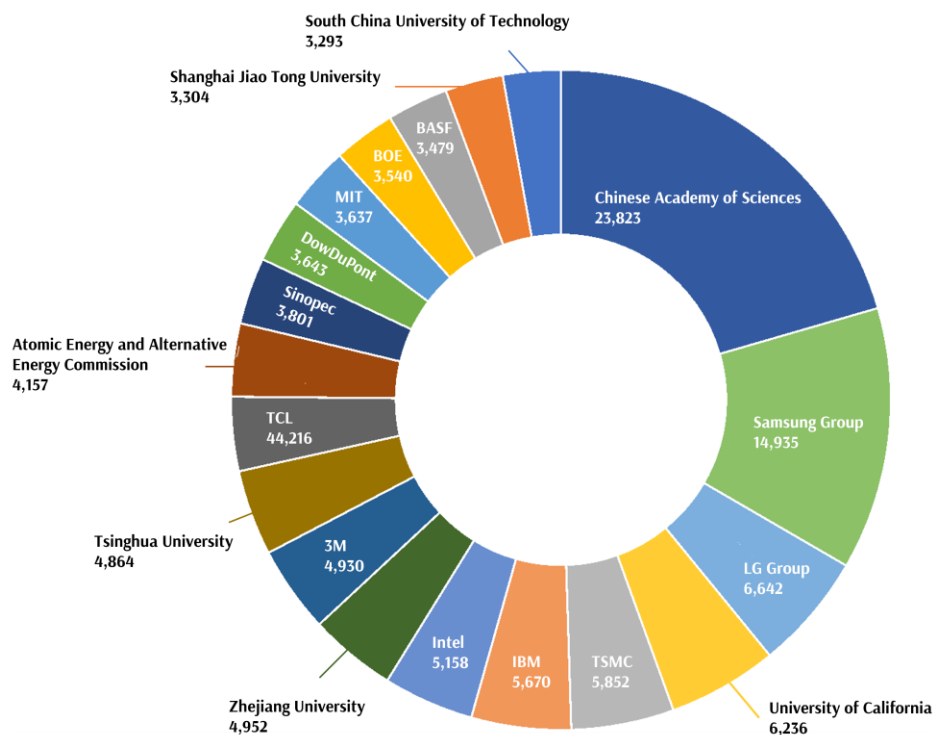


Figure 2-5 Global nanotechnology patent holders

2.6.1 Competitive Landscape

- **Chinese Academy of Sciences:** Leads with 23,823 patents, covering multiple fields like electronic information technology, materials science, biomedicine, and energy.
- **Samsung Group:** Ranks second with 14,935 patents, focusing on semiconductor nanomanufacturing processes (e.g., 3nm GAAFET technology) and flexible displays (UTG ultra-thin glass), etc.
- **Other Enterprises and Institutions:** LG Group (6,642 patents), University of California (6,236 patents), TSMC (5,852 patents), etc., form the second tier.

2.6.2 Distribution by Institution Type

- Academic Research Institutions (~42%): e.g., Chinese Academy of Sciences, University of California.
- Enterprises (~58%): e.g., Samsung Group, LG Group, TSMC.

2.7 Comparison of Chinese and International Nanotechnology Patent Numbers in Selected Fields

In industries where patents from China dominate, its global patent share is approximately 86.4% for new building materials, 81.93% for advanced coating materials, and 77.7% for catalytic chemistry and reaction engineering (Figure 2-6).

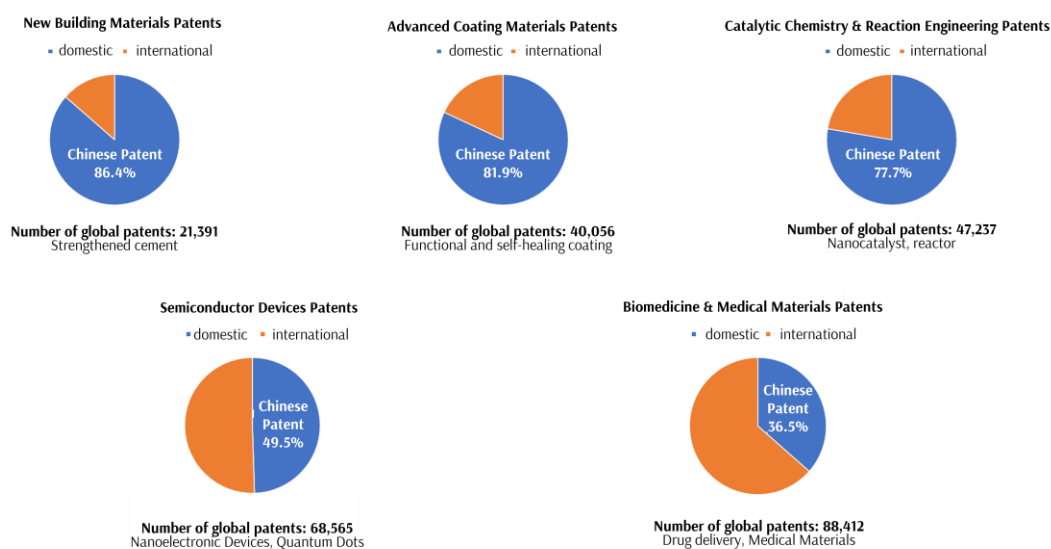


Figure 2-6 Comparison of Chinese and international nanotechnology patent numbers in selected fields

For key development industries, such as semiconductor devices and biomedicine, the global patent numbers are 68,565 and 88,412 respectively, with China's share being approximately 49.5% and 36.5%.

Chapter 3.

Nanotechnology Industry Development in Major Countries and Regions

3.1 United States

The U.S. government established nanotechnology R&D centers in 2000, composed of multiple universities, research institutions, and large corporations. It attracted high-tech multinational giants like IBM, AMD, and Intel to join, comprehensively promoting nanotechnology innovation and R&D. Furthermore, to accelerate the transfer of nanotechnology achievements to industry, the U.S. federal government and the California government jointly established the “Nanotechnology Transfer Center” in 2001. The federal and state governments funded the center at a 2:1 ratio to support its collaboration with large enterprises, facilitating the timely and effective translation of basic research findings in nanotechnology into industrial applications.

The U.S. boasts world-renowned hubs for nanotechnology commercialization, providing an excellent environment for innovation, R&D, and industrial development. Notably, the College of Nanoscale Science and Engineering (CNSE) at the State University of New York at Albany, which underpins the Albany NanoTech Complex (one of the world’s largest nanotech R&D centers), was also the first institution globally to offer specialized education in nanotechnology, making it

distinctive in talent cultivation. Thus, the success of U.S. nanotechnology industrialization is largely attributed to a virtuous cycle of technology, capital, and talent. Since its completion in 2001, the complex has been managed and operated by IBM, focusing on accelerating the commercialization of high-tech nanotechnology products. As a world-class base for nanotechnology R&D, testing, incubation, and application, it offers services like technology incubation and integrated testing to companies, provides access to well-equipped laboratories, and has attracted over 250 domestic and international partners. This has formed a large-scale layout for R&D and production of nanotechnology products, becoming a successful model of collaboration among various levels of government, universities, research institutes, and industry.

Beyond government, academia, research institutions, and enterprises, industrial investment also plays a key role in the development of the U.S. nanotechnology industry. The operating model of the California NanoSystems Institute (CNSI) is another epitome of this development model. Established by the California government to promote nanotechnology research and commercialization, CNSI adopts an innovative operational model. With technical support from UC Los Angeles and UC Santa Barbara, it built platforms for technology transfer and industrial investment by forming industry alliances and investment alliances. Its most innovative aspect is the integration of scientific research,

technology transfer, and industrial investment, achieving close coupling between technology and industry. The industry alliance has attracted over 31 world-renowned companies including Merck, Intel, Oracle, HP, and IBM; the investment alliance has attracted 17 well-known investment firms such as J.P. Morgan, APEX Investment Fund, and Eastman Fund. The early involvement of industry and investment prevents research institutions from working in isolation and developing technologies disconnected from market needs. Simultaneously, leveraging the powerful resources and advantages of these alliances accelerates the industrialization of research achievement.

3.2 European Union

The EU maintains a world-leading position in nanotechnology innovation and R&D but has long faced challenges in technology commercialization capability and weak industrialization capacity. To address these issues, the EU has gradually shifted its focus towards application-oriented nanotechnology R&D to enhance its technology commercialization capability and move nanotechnology development from laboratories to various industrial application sectors. Furthermore, it particularly emphasizes the role of small- and medium-sized enterprises (SMEs) in nanotechnology development, encouraging their participation in R&D and ensuring their role in undertaking project industrialization. It stresses the establishment of vertical industry-academia-research-

application innovation alliances and horizontal cross-sectoral R&D innovation network platforms. The emphasis on SME participation and maintaining close-knit innovative public-private partnerships effectively promotes the expansion of nanotechnology applications and the extension of the value chain.

Europe is particularly prominent in the application of nanomaterials, with leading enterprises emerging in fields such as chip equipment manufacturing, aerospace, cosmetics, food packaging, drug delivery systems, and biosensors. Among these, the application of nanomaterials in personal care products, involving functions like sterilization, sun protection, and whitening using nano-powders, yields the highest market return on investment. Regarding leading companies, two of Germany's "big three" in the chemical industry, BASF and Bayer, started early in nanomaterial research and application. BASF's nanomaterial applications include personal care, paint additives, printing inks, engineering plastics, liquid coatings, and thermal insulation materials. Bayer's nanomaterials are mainly applied in inks, nanopores, and nano-polymer functional films. The Finnish new materials technology company Ahlstrom-Munksjö is a globally leading supplier of high-performance fiber materials and fiber-based materials. Its nano-filter materials (nano alumina fiber filter paper) hold a high global market share, and it has recently expanded the application of its non-woven filter materials in water filtration, potentially

further expanding its market. The French chemical company Arkema is a supplier of high-performance materials, industrial specialty products, and coating solutions. The Dutch company ASML monopolizes the global market for extreme ultraviolet (EUV) lithography machines.

3.3 Japan

In Japan, the corporate sector is the main force driving nanotechnology development. According to a survey by Nikkei Inc., among 80 large companies involved in nanotechnology, about 40% have established specialized organizations for nanotechnology research, including Hitachi Group's Nanotechnology Management Promotion Center, NEC Corporation's Fundamental Research Laboratory, NTT's Atsugi Laboratory, Fujitsu's Nanotechnology Research Center, and Toray's Nanotechnology Research Institute. Simultaneously, companies extensively collaborate with universities and research institutes on nanotechnology R&D. For example, Showa Denko K.K. collaborates with the National Institute of Advanced Industrial Science and Technology (AIST) to develop mass production technologies for new nanomaterials; Fujitsu collaborates with four research institutions including the Technical University of Munich; companies like Panasonic and Takeda Pharmaceutical have established collaborative organizations with Kyoto University and Osaka University; Mitsubishi Chemical Corporation

conducts collaborative research focused on nanotechnology with Kyoto University.

3.4 South Korea

Among universities and research institutes in South Korea, the Korea Institute of Science and Technology (KIST) possesses the strongest nanotechnology R&D capability. KIST hosts the National Nanofab Center (NNFC) and has achieved significant research results in nanotechnology in recent years. In 2018, KIST successfully developed nanoparticles that effectively activate immune cells *in vivo* and has transferred this technology to companies for industrialization; in 2020, KIST announced the development of a new technology for manufacturing large-area wavy silver nanowire network electrodes, expected to greatly impact the wearable electronics market.

Driven vigorously by the South Korean government, large enterprises, based on their own sector needs, develop application-oriented nanotechnology through funding or joint research with institutions and achieve its transfer, resulting in significant nanotechnology industrialization. They hold industrially advantageous positions in semiconductor memory and display technology, and nanochip manufacturing. In this process, large enterprises led by Samsung Electronics have played a crucial role in the development of South Korea's nanotechnology industry. Samsung Electronics was one of the world's

earliest companies to initiate applied research in nanotechnology and had already possessed 5-nm chip manufacturing capability by 2018. South Korea's SK Hynix is the world's third-largest DRAM manufacturer and ranks ninth among global semiconductor companies. It has begun R&D on the 4th generation 10-nm class (1a) DRAM process, intending to introduce EUV lithography technology into the process. LG Chem is South Korea's most representative chemical company. In the field of nanotechnology, LG has achieved the industrialization of OLED materials and is currently targeting the carbon nanotube market.

Chapter 4.

Analysis of Nanotechnology Industry in China

4.1 Current Development Status of China's Nanotechnology Industry

- **Leading Patent Numbers:** As of May 2025, China's nanotechnology patents account for approximately 43.06% of the global total, significantly higher than traditional technology powerhouses such as the United States (12.2%), Japan (6.8%), South Korea (6.2%), and Germany (1.1%).
- **Rapid Growth in Number of Enterprises:** As of May 2025, China has approximately 35,000 nanotechnology-relevant enterprises. Micro- and small-sized enterprises account for over 70% of this total, and their growth rate is similarly significant, exceeding 15%.
- **Abundant Talent Pool:** The number of employees in nanotechnology-relevant enterprises reached 9.92 million (based on social insurance contribution statistics), an increase of nearly 98.4% compared to 2000.
- **Pronounced Advantages in Key Fields:** China holds a dominant position in the number of patents in fields such as new building materials, advanced coating materials, and catalytic chemistry & reaction engineering. Great progress has also been made in areas like semiconductor devices and biomedicine.

- **Distinctive Regional Development:** Cities like Beijing, Shanghai, Shenzhen, and Suzhou perform prominently in the semiconductor field. Beijing, Shanghai, and Guangzhou hold advantages in biomedicine. Cities like Suzhou, Nanjing, Hangzhou, and Jiyuan have distinctive strengths in nanomaterials.

4.2 Explosive Growth in the Scale of China's Nanotechnology Enterprises

Number of Enterprises: Increased from 3,015 in 2000 to approximately 35,000 by May 2025, an over 11-fold increase, with an average annual growth rate of about 10% (**Figure 4-1**).

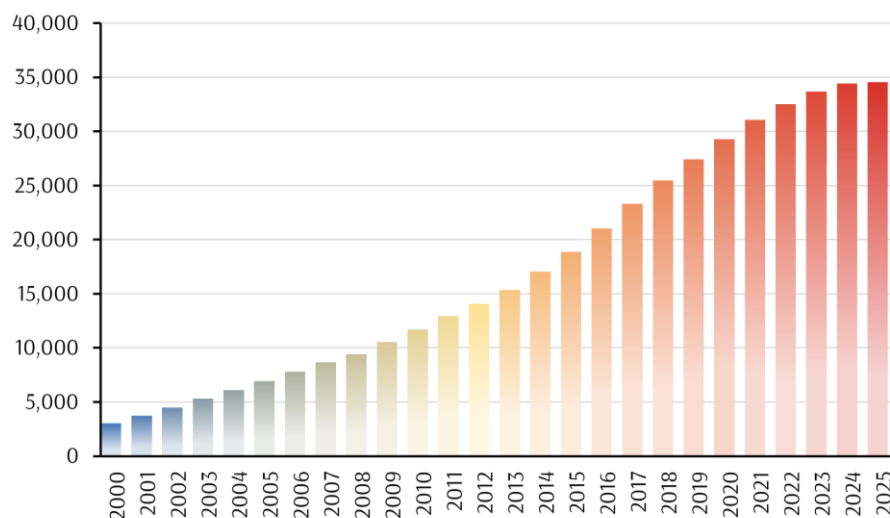


Figure 4-1 Annual number of nanotechnology enterprises in China

4.3 Clustering of Nanotechnology Enterprises in China

Jiangsu Province (6,931 enterprises), Guangdong Province (6,157 enterprises), and Zhejiang Province (3,315 enterprises) rank top three in

terms of enterprise numbers, collectively accounting for about 47% of the national total (**Figure 4-2**).

From a regional perspective:

- The Yangtze River Delta region (Jiangsu, Shanghai, Zhejiang), leveraging bases like the Suzhou Industrial Park and Zhangjiang Hi-Tech Park, has formed a complete industrial chain from material preparation to device application.
- The Greater Bay Area (Guangdong, Hong Kong, Macao), capitalizing on its electronics industry strength, focuses on the application of nanomaterials in electronic information technology and biomedicine.
- The Beijing-Tianjin-Hebei region, supported by resources from the Chinese Academy of Sciences and universities, develops nanobiomedicine, environmental protection materials, semiconductor devices and display equipment.
- Central China (e.g., Henan, Hubei, Anhui, Shandong) focuses on the nanomaterials field, integrating the application of nanomaterials in traditional industries.



Figure 4-2 Geographical distribution of nanotechnology enterprises in China (Data excludes Taiwan Province and Macao SAR, China)

4.4 Employment in China's Nanotechnology Enterprises

- Employees: Increased from approximately 5 million in 2000 to 9.92 million by May 2025, a growth of 98.4%, with an average annual growth rate of about 2.8% (Figure 4-3).
- Growth has been relatively steady.

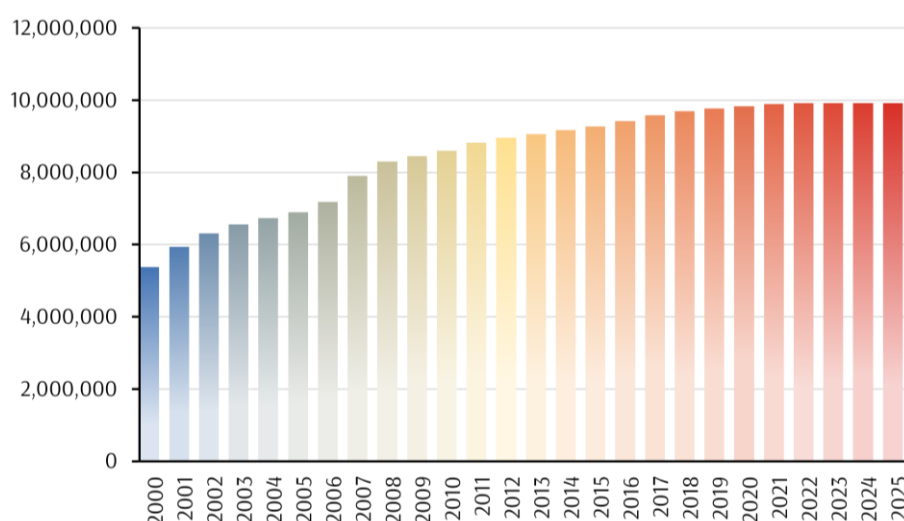


Figure 4-3 Number of employees in China's nanotechnology enterprises (Excluding universities and research institutes)

4.5 Structure of China's Nanotechnology Enterprises

- Micro-sized enterprises: Numbers surged from the 2000 baseline to 9,045 by May 2025, with their share of the total enterprises increasing from 15% to about 26% (**Figure 4-4**).
- Small-sized enterprises: Grew simultaneously to 15,794, accounting for about 46% of the total. Together with micro-sized enterprises, they form the foundation of the industry, and the enterprise structure is becoming increasingly healthy.
- Medium- and large-sized enterprises: Numbered 4,015 and 1,270 respectively, collectively accounting for about 28% of the total. Their average output value per enterprise is 5-8 times that of small and micro enterprises.

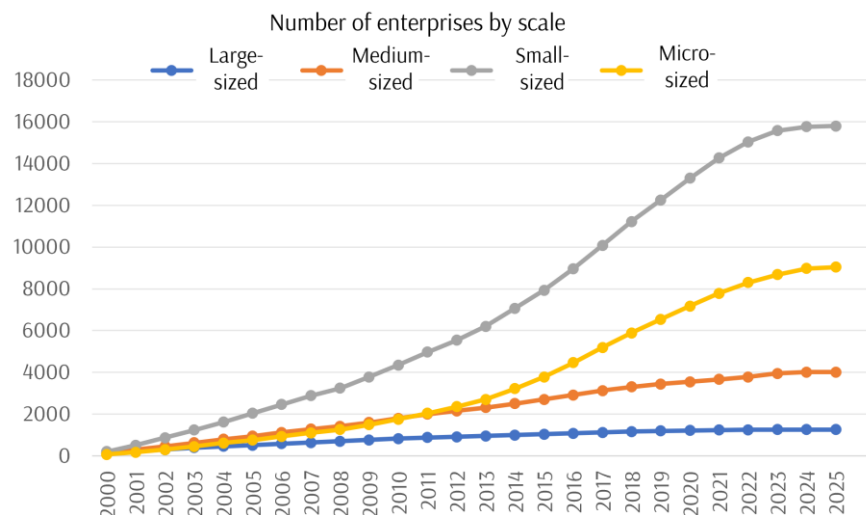


Figure 4-4 Classification of China's nanotechnology enterprises by size

4.6 Listed Nanotechnology Enterprises and Foreign-invested

Nanotechnology Enterprises in China

- The number of listed enterprises has continued to increase, growing from 50 in 2000 to 739 by May 2025 (**Figure 4-5**). Their total market capitalization exceeded \$1 trillion (2025). The proportion of nanotechnology enterprise IPOs in the technology sector reached 15% from 2015-2025, higher than that in traditional industries.
- The number of foreign-invested enterprises reached 2,191, about 7 times higher than in 2000, and has been consistently growing.

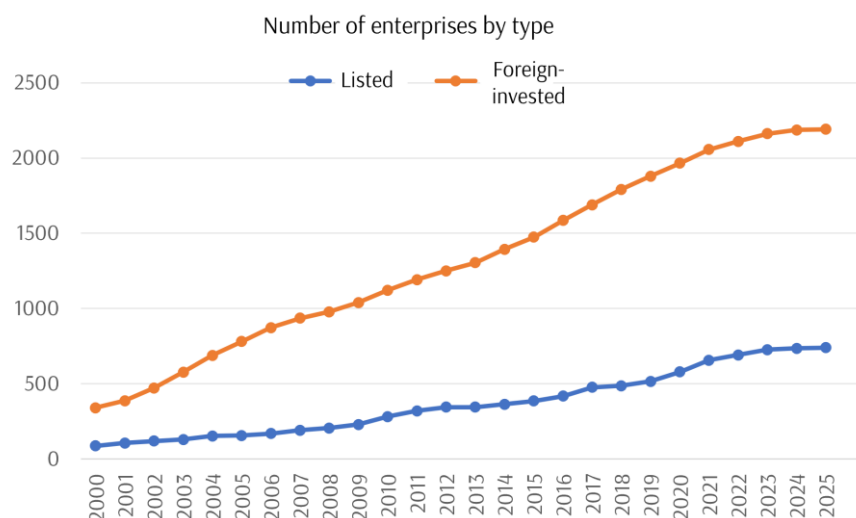


Figure 4-5 Listed nanotechnology enterprises and foreign-invested nanotechnology enterprises in China

Chapter 5.

Analysis of Nanotechnology Patents in China

5.1 Distribution of China's Nanotechnology Patents by Field

Semiconductor Devices: Lead absolutely with 50,121 patents, accounting for approximately 22.3% of the total, reflecting China's strategic focus in the nanoelectronics field (**Figure 5-1**).

Catalytic Chemistry & Reaction Engineering: 45,100 patents, accounting for about 20.1% of the total, indicating the deep reliance of the chemical industry on nanocatalysts.

Biomedicine & Medical Materials: 42,504 patents, accounting for approximately 18.9% of the total, indicating the accelerated commercialization of drug delivery systems (e.g., liposomes, exosomes)

Batteries & Energy Storage: 12,155 patents, accounting for 5.4% of the total. Although the total number is relatively low, the CAGR from 2020 to 2025 reached 18.7%, indicating significant potential in the new energy sector.

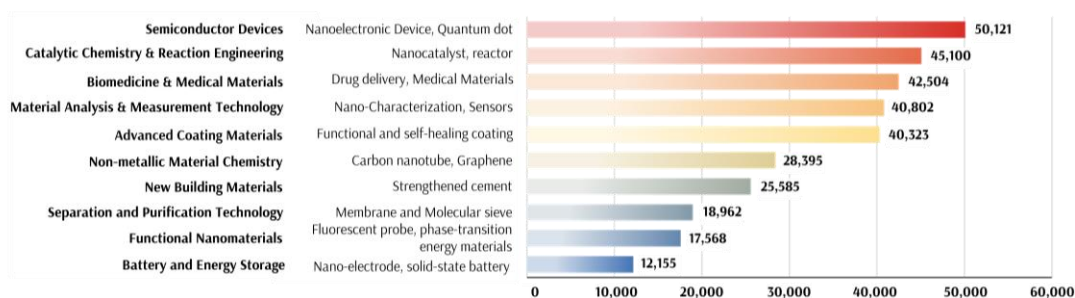


Figure 5-1 Distribution of China's nanotechnology patents by field

5.2 Distribution of China’s Nanotechnology Patents by Field and Region

Beijing, Shanghai, Shenzhen, and Suzhou perform prominently in the semiconductor field. Beijing holds 5,477 semiconductor patents. In biomedicine, patents are mainly distributed in Beijing, Shanghai, and Guangzhou, each with over 1,800 patents (**Figure 5-2**).

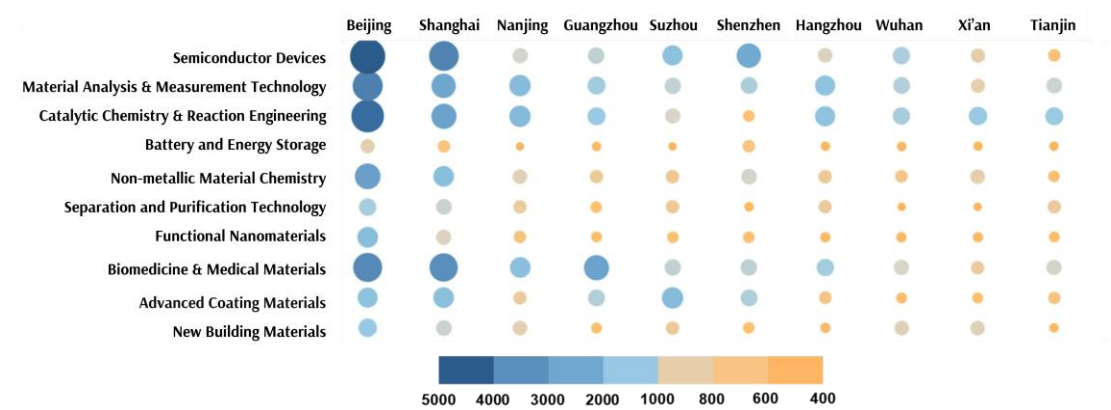


Figure 5-2 Distribution of China’s nanotechnology patents by field and region

5.3 Applicants of Nanotechnology Patents in China

5.3.1 Overview (Figure 5-3)

- Enterprises: Approximately 220,000 patents, accounting for 45.09%, nearly half of the total, constituting the main force in patent applications
- Universities: Approximately 180,000 patents, accounting for 37.43%, demonstrating the core role of universities in basic research.

- Research Institutions: Approximately 40,000 patents, accounting for 8.80%, representing policy-oriented R&D force.
- Individuals: 29,000 patents, accounting for 6.06%, reflecting the innovative vitality of individual inventors.

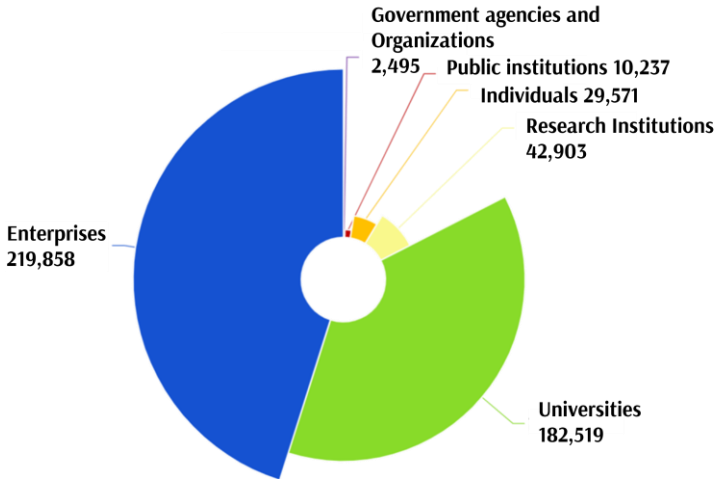


Figure 5-3 Distribution of applicants for China's nanotechnology patents

5.3.2 Detailed Information

- University Sector (**Table 5-1**): Zhejiang University (4,301), South China University of Technology (2,902), and Shanghai Jiao Tong University (2,902) rank top three.

Table 5-1 Number of nanotechnology patents held by selected universities

No.	University	Number of Patents
1	Zhejiang University	4,301
2	South China University of Technology	2,902

3	Shanghai Jiao Tong University	2,902
4	Tianjin University	2,653
5	Jilin University	2,542
6	Fudan University	2,508
7	Tsinghua University	2,391
8	Southeast University	2,350
9	Jiangsu University	2,330
10	Harbin Institute of Technology	2,273
11	Shaanxi University of Science & Technology	2,121
12	Beijing University of Chemical Technology	2,083
13	Sichuan University	2,061
14	Huazhong University of Science & Technology	2,022
15	University of Jinan	1,984
16	Jiangnan University	1,970
17	Shandong University	1,964
18	Peking University	1,954

- Enterprise Sector (**Table 5-2**): Sinopec (3,437), TCL Group (3,193), and Samsung Group (2,076) rank top three. Notably, many large foreign companies have presence of nanotechnology patents in China, underscoring the importance they attach to this field.

Table 5-2 Number of nanotechnology patents held by selected

enterprises

No.	Enterprise	Number of Patents
1	Sinopec	3,437
2	TCL	3,193
3	Samsung	2,076
4	BOE	1,845
5	State Grid Corporation of China	1,278
6	CNPC	1,256
7	SMIC	1,245
8	Foxconn	1,064
9	TSMC	875
10	National Engineering Research Center for Nanotechnology	809
11	CNBM	768
12	Ocean's King Lighting Science & Technology Co., Ltd.	760
13	Intel	665
14	Chengdu NewKeli Chemical Engineering Co., Ltd.	656
15	3M	628
16	LG	618
17	Shanghai Huahong Group	573
18	DowDuPont	492

- Research Institution Sector (**Table 5-3**): The Chinese Academy of Sciences (CAS), with 23,409 patents, ranks first globally. Numerous CAS institutes are engaged in nanotechnology R&D.

Table 5-3 Number of nanotechnology patents held by selected CAS institutes

No.	CAS Institute	Number of Patents
1	Dalian Institute of Chemical Physics	1,779
2	Ningbo Institute of Materials Technology and Engineering	1,167
3	National Center for Nanoscience and Technology	1,056
4	Institute of Chemistry	1,014
5	Shanghai Institute of Ceramics	986
6	Shenzhen Institute of Advanced Technology	956
7	Suzhou Institute of Nano-Tech and Nano-Bionics	944
8	Institute of Microelectronics	941
9	Institute of Metal Research	786
10	Institute of Semiconductors	775
11	Hefei Institutes of Physical Science	735
12	Shanghai Institute of Microsystem and Information Technology	705
13	Changchun Institute of Applied Chemistry	702
14	Technical Institute of Physics and Chemistry	701
15	Lanzhou Institute of Chemical Physics	570
16	Institute of Process Engineering	542

17	Fujian Institute of Research on the Structure of Matter	495
18	Institute of Physics	456

5.4 Technology Transfer and Licensing of China's Nanotechnology Patents

From 2000 to 2025, the number of patents involved in transfers and licenses accounted for about 8% of the total nanotechnology patents in China. Transfers accounted for 7.4% of the total, while licenses accounted for 0.7%.

5.4.1 Patent Transfer

5.4.1.1 Rapid Growth Period (2000-2010)

Increased from 37 assigned patents in 2000 to over 330 in 2005 (a ~9-fold growth), reaching 840 in 2010.

5.4.1.2 Industrial Boom Period (2011-2018)

Surpassed 2,496 assignments in 2014, with an average annual growth rate of 24%; peaked at 3,600 assignments in 2018.

5.4.1.3 Structural Adjustment Period (2019-2022)

Dropped to 2,854 assignments in 2019, down about 21% from the peak; plummeted to 1,542 assignments in 2022, only about 42.8% of the peak value. This indicates, on one hand, that enterprises are gradually becoming the main body of innovation, implementing patent technologies themselves rather than acquiring them through purchase; on the other hand,

it suggests that many technologies have entered the large-scale industrialization stage with stable production processes, reducing the need to absorb external patents.

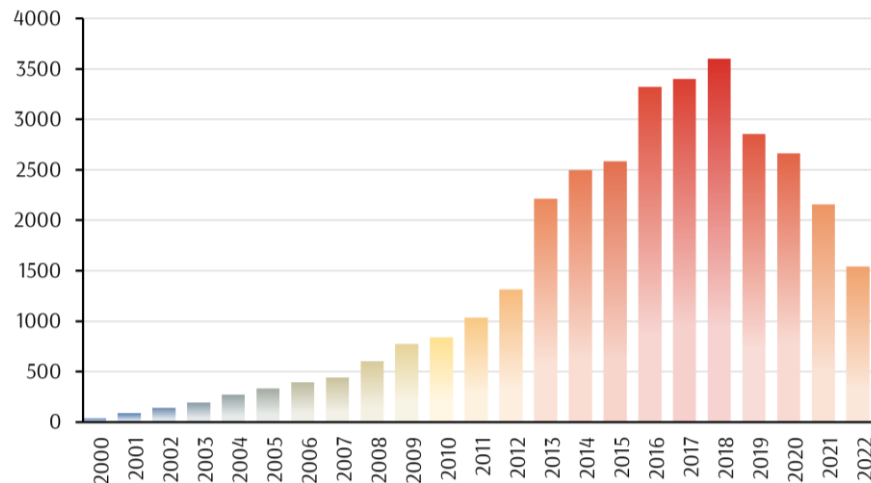


Figure 5-4 Annual assignments of China's nanotechnology patents

5.4.2 Patent Licensing

5.4.2.1 Technology Accumulation Period (2000-2010)

Increased from 3 licenses in 2000 to 101 in 2010. The absolute number was small, but the 10-year CAGR was about 42%.

5.4.2.2 Industrialization Boom Period (2011-2020)

Exceeded 150 licenses in 2015, a 149% increase from 2010; peaked at 330 licenses in 2019, with a 10-year CAGR of 12.3%.

5.4.2.3 Structural Optimization Period (2021-2022)

Dropped to 186 licenses in 2022, a 57% decrease from the peak, for reasons similar to those for patent assignments.

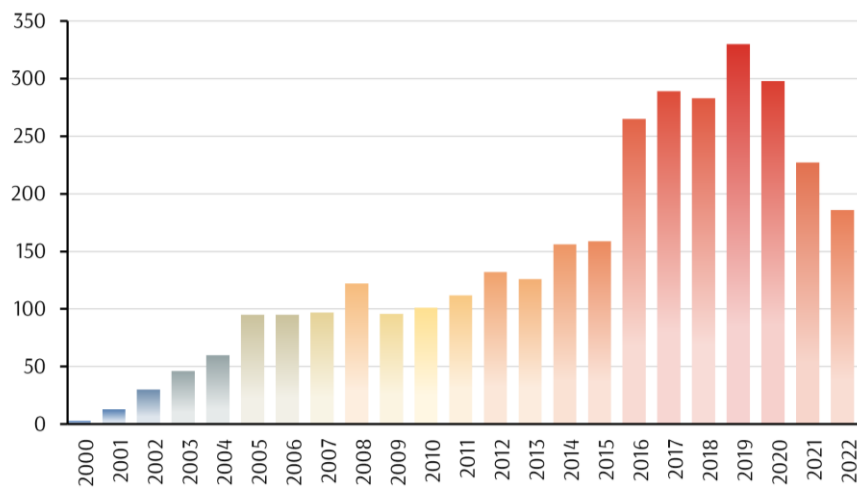


Figure 5-5 Annual licensing of China's nanotechnology patents

Chapter 6.

Development of Representative Domestic Nanotechnology Industrial Parks

6.1 Suzhou Industrial Park

In 2006, Suzhou Industrial Park (SIP) identified nanotechnology applications as a key industry for development. In 2010, it further actively elevated nanotechnology to a regional strategic emerging industry. Through the implementation of the “Three-Year Double Growth Plan on Nanotechnology”, the “Leadership Plan for Nanotechnology Industry” and the “Leading Talent Program in Nanoscience and Technology”, SIP has attracted a large number of high-level innovation resources from home and abroad. To date, the park has introduced and incubated a total of 784 related enterprises, gathered nearly 20 Chinese and foreign academicians, and formed advantageous industrial fields such as micro-nano manufacturing, nanomaterials, micro-electro-mechanical systems (MEMS), and gallium nitride semiconductor materials and devices. It has become the region with the highest concentration of nanotechnology industries and talent in China. Specifically, in the micro-nano manufacturing field, it has gathered 14 national-level talents and 18 provincial-level talents, hosted 144 various enterprises and institutions, and achieved an annual output value of approximately 30 billion RMB. A complete industrial chain has been formed, encompassing device design, foundry platforms, packaging and

testing, integration and application, as well as materials and equipment. It has nurtured a group of leading enterprises such as OFILM, NanoMicro, MEMSensing, and Microarray. Five of these companies were listed in the “Top 10 Enterprises of Semiconductor MEMS in China, 2019”, accounting for half of the list. Simultaneously, the park has amassed a significant number of innovation platforms, introducing research institutions including the Suzhou Institute of Nano-Tech and Nano-Bionics (SINANO) of the Chinese Academy of Sciences, the Collaborative Innovation Center of Suzhou Nano Science and Technology, and the National Center of Technology Innovation for Advanced Semiconductor. It has established over 20 public technical service platforms, including the Vacuum Interconnected Nano-X Research Facility, and introduced five international nano innovation centers, including the Sino-Finnish Nano Innovation Center. In 2021, the Suzhou Nano New Materials Cluster, with SIP at its core, was successfully selected as one of the first national advanced manufacturing clusters. Nanopolis Suzhou, as the core agglomeration area for SIP’s nano technology industry development, covers an area of nearly 1,800 acres and gathers nearly 60% of the park’s nano technology enterprises, currently standing as the world’s largest comprehensive zone for nanotechnology application industries. In 2024, SIP’s nanotechnology industry experienced steady growth, with industrial output value exceeding 170 billion RMB.

6.2 Guangzhou Economic and Technological Development Zone

As one of the first national-level economic and technological development zones in China, Guangzhou Development District has always emphasized the fundamental and leading role of science and technology. In July 2019, the “Several Measures of Guangzhou Development District on Promoting Innovation and Enhancement to Build a New Highland of Reform and Opening Up” proposed plans to concentrate efforts on overcoming a batch of key common technologies, cutting-edge leading technologies, modern engineering technologies, and disruptive technologies. To promote the development of the nanotechnology industry, Guangzhou Development District proposed focusing on the “Five Ones” project: establishing one research institution, one industrial park, one set of policies, one nanotechnology corporation, and one “nano” fund. It mobilized the entire district to create an internationally influential Nano Innovation Industry Cluster in the Guangdong-Hong Kong-Macao Greater Bay Area, aiming to form a trillion-yuan level nano technology industrial cluster. In December 2019, it issued the “Measures of Huangpu District, Guangzhou Municipality and Guangzhou Development District for Promoting the Development of the Nanotechnology Industry”, providing support in seven areas including R&D platform rewards, financial support and incentives, major industrial project construction rewards, special awards for technology R&D and industrialization, the “Nano Star”

competition awards, office space subsidies, and major promotion and exchange subsidies, with maximum support funding exceeding 100 million RMB. In June 2020, it released the “Implementation Rules for the Measures of Huangpu District, Guangzhou Municipality and Guangzhou Development District for Promoting the Development of the Nano Technology Industry”, further facilitating the implementation of relevant policies for the development of the nanotechnology industry in Huangpu District. It has incubated a number of high-tech enterprises producing nano products such as quantum dot diffusion plates and AR glasses lenses. In April 2022, the National Development and Reform Commission approved the “Construction Plan for Building the Guangdong-Hong Kong-Macao Greater Bay Area into a Highland of Nanoindustry Innovation”. In June 2023, the National Nano-Intelligent Manufacturing Industry Innovation Center was established in Guangzhou, targeting three major development directions: “nanomaterial innovation and upgrading, electronic nanodevice innovation, and nanomedical technology breakthrough”, to carry out nanotechnology R&D.

6.3 Jiyuan Industry-City Integration Demonstration Zone

The pilot-scale base of Henan University was established in the Jiyuan High-tech Industrial Development Zone in 2003. It set up experimental platforms for small-scale trial (20-50 liters), pilot-scale trial (500-2000 liters), engineering verification (12,000-16,000 liters), as well as material

performance testing and evaluation. This formed an experimental base covering the entire technical R&D process of nanomaterials from “small-scale trial to pilot-scale trial to technical verification”, enhancing the speed and success rate of technology commercialization. Among its achievements, 35 patented technologies have achieved industrial application, 15 enterprises have been incubated or received technology transfer, and over 70 million RMB in various technical R&D funds has been obtained from technology transfers and commissioned development projects, generating economic benefits exceeding 2 billion RMB. In 2015, the National-Local Joint Engineering Research Center for Applied Technology of Nano Hybrid Materials was established in Jiyuan. In 2016, the patented technology for “Special Functional Silica” was transferred, incubating Jiyuan Hybsil New Material Technology Co., Ltd. In 2017, it took the lead in establishing the “Henan Province Nano Material Industry Technology Innovation Strategic Alliance”. In 2018, “Henan Wangwu Nano Technology Co., Ltd.” was recognized as one of the first “Major New R&D Institutions of Henan Province” and a “Henan Province Specialized Maker Space for Nano Hybrid Materials”. In 2019, project “Key Technology and Industrialization of High-Performance Energy-Saving Anti-Wear Nano Lubricating Grease” from Professor Zhang Zhijun’s team won the second prize of the National Technology Invention Award. In September 2019, the Henan Jiyuan Nanomaterials Industrial Park and the

annual 200,000-ton special functional nano silica project commenced construction. The first phase of the production line (40,000 tons) officially went into operation in 2021.

Currently, the Jiyuan Nanomaterials Industrial Park has completed preliminary planning and construction, with a total area of 4,000 acres, divided into three major sections: an industrial zone, a startup incubation zone, and public service platforms. The first phase of the startup incubation zone covers 146 acres, with designed construction of over 10 standardized factory buildings, office buildings, R&D centers, and other public facilities, achieving an occupancy rate of 90% (including production lines under construction). The second phase of incubation covers 170 acres, scheduled for delivery in March 2025, with 10 companies having signed agreements to move in and 80% of the factory space pre-booked by projects. The third phase of incubation covers 200 acres and is currently under planning and design. Hongxin Rubber Composite Material Technology Co., Ltd.

built the nation's first set of continuous production lines for nano wet-mixed rubber. Xinghan Technology's low-temperature silver paste and silver-coated copper paste boast internationally leading performance, breaking foreign monopolies and achieving independent control of related technologies; its ultra-fine silver-coated copper powder product was recognized as one of the nation's first-batch new materials. Longxing Titanium Industry's titanium dioxide broke technological monopolies held

by the US, Japan, and others, and its current production capacity accounts for over one-third of the national total. According to statistics, the output value in 2024 approached 10 billion RMB.

Postscript

This White Paper is jointly released by the National Center for Nanoscience and Technology, China, and the Nanotechnology Industry Innovation Strategic Alliance. NanoData (Suzhou) Intelligent Technology Co., Ltd. provided data support for this report. Employing quantitative research methods, this report aims to systematically analyze and evaluate the status of the nanotechnology industry globally and in major countries/regions, presenting a comprehensive panorama of the current landscape and development trends of the nanotechnology industry worldwide and in China.

The report conducts a macroscopic metrological analysis of the nanotechnology industry from dimensions such as patents, number of enterprises, and talent pool. The selection of indicators is constrained by the measurability of research performance and indicator construction methods, and external factors may also introduce systematic bias. Over the past decade, best practices in international bibliometrics have provided norms for interpreting indicators and clarified the applicable premises for various evaluation contexts. The analytical framework of this report is derived from these best practices and expert consensus, and is constructed based on a substantial body of authoritative literature. Although the indicator selection and analysis process inevitably have limitations, it can still provide a valuable macro-perspective on the global nanotechnology

industry landscape.

The analysis in this report references over 1.07 million nanotechnology-relevant patents globally and data from 35,000 industrially and commercially registered enterprises in China. Although the search scope covers all “nano”-related enterprises and patents, gaps remain in industrial input data. Nevertheless, the vast sample size is sufficient to support a reliable depiction of the actual situation of the nanotechnology industry.

Finally, due to time constraints in completing this report, inevitable errors or omissions may exist.

Appendix A. Data Sources

1. Patent Data Sources

Patent data was sourced from patent databases of countries/regions/international organizations worldwide:

ARIPO (African Regional IP Org)	Argentina	Austria
Australia	Brazil	Canada
Chile	China	Colombia
Croatia	Czech Republic	Denmark
Eurasian Patent Office	European Patent Office	Finland
France	Germany	Hong Kong SAR, China
Hungary	India	Indonesia
Israel	Italy	Japan
Malaysia	Mexico	Netherlands
New Zealand	Norway	Peru
Philippines	Poland	Portugal
Romania	Russia	Singapore
Slovakia	Slovenia	South Korea
Spain	Spain	Taiwan, China
Thailand	Turkey	Ukraine
United Kingdom	United States	Uruguay
Vietnam	WIPO (World IP Org)	

2. Enterprise Data

Enterprise data was sourced from the enterprise database of the State Administration for Market Regulation (SAMR). The identification criterion was whether the enterprise possessed nanotechnology patents; sales companies were excluded. The data includes the enterprise's establishment time, registered capital, enterprise type, intellectual property, social security contributions, etc.

Appendix B. Subject Classification of Patents

The subject classification of patents is primarily standardized through the International Patent Classification (IPC) system. Its structure is divided into eight sections (A-H), covering all technical fields. As of 2025, version IPC2025.01 includes the following main classifications:

Section Divisions

Section A: Human Necessities

Section B: Performing Operations; Transporting

Section C: Chemistry; Metallurgy

Section D: Textiles; Paper

Section E: Fixed Constructions

Section F: Mechanical Engineering; Lighting; Heating; Weapons; Blasting

Section G: Physics

Section H: Electricity

Each section is further subdivided into classes, subclasses, and main groups/subgroups. For example, A01 represents Agriculture, B01 represents Physical or chemical processes or apparatus in general, C07 represents Organic chemistry, etc.

Appendix C. Search Methodology

This report analyzed the characteristics of the nanotechnology industry primarily using the following search strategy:

1. A divide-and-conquer search approach was adopted, completing the retrieval in steps: preliminary searching via conventional keywords, further expanding keywords using nanotechnology domain-specific terms or functional limitations; refining the expansion of IPC classification codes; conducting combined searches using the expanded keywords and classification codes. After completing the searches for each branch, the datasets were merged to obtain the patent database for the nanotechnology industry.

2. Use of search elements: Early in the search process, this report compiled IPC classification codes related to various technical branches, as well as keyword expressions for each technical branch, including classification codes and keywords used for noise reduction. Overall, both Chinese and English searches relied primarily on keyword expressions, supplemented by classification codes for noise reduction. Based on the above search elements, patent searches were conducted (covering global patent literature published before May 10, 2025). The search results were then cleaned through manual review and data indexing, and the cleaned data served as the final dataset for analysis.

Brief Introduction

of

National Center for Nanoscience and Technology, China

The National Center for Nanoscience and Technology, China (hereinafter referred to as “NCNST”) was established in December 2003. It is a public institution directly under the Chinese Academy of Sciences (CAS), jointly established by CAS and the Ministry of Education, China.

NCNST is dedicated to pioneering basic research in nanoscience and transformative industrial technologies. Its goal is to build a world-class hub for nanoscience and technology innovation, talent aggregation, and technology transfer.

While striving to support the development of nanotechnology in China, NCNST is also committed to promoting the standardization of the national nanotechnology industry, contributing to the healthy and orderly growth of nanotechnology in China. It actively engages in domestic and international scientific collaborations and exchanges, integrates into the global innovation network, and aims to become a world-leading research institution.

NCNST currently hosts five laboratories: Laboratory for Biological Effects of Nanomaterials and Nanosafety, Laboratory of Standardization and Measurement for Nanotechnology, Laboratory of Nanosystem and Hierarchical Fabrication, Laboratory of Theoretical and Computational

Nanoscience, and Nanofabrication Laboratory. It has also established a Division of Nanotechnology Development focused on building public-open platforms to support nanotechnology research, primarily engaged in nano fabrication and technical services for testing, as well as training and R&D activities.

In 2005, NCNST was authorized by the Office of the State Council Academic Degrees Committee to confer doctoral and master's degrees. It currently offers doctoral programs in three first-level disciplines: Chemistry, Materials Science, and Physics, and master's programs in four first-level (or second-level) disciplines: Chemistry, Materials Science, Physics, and Biology. It also hosts a postdoctoral research station. On September 13, 2022, "Nanoscience and Engineering" was approved as a new first-level discipline under the interdisciplinary category.

As of the end of 2024, NCNST had 270 permanent staff and 42 project-based employees. Among the permanent staff, 199 are scientific researchers and 27 are technical-support personnel, including 3 Members of CAS, 1 Fellow of TWAS (The World Academy of Sciences for the advancement of science in developing countries), 97 Professors and Senior Engineers (Professor-level), and 111 Associate Professors and Senior Engineers.

Over the past two decades, NCNST has focused on addressing global scientific frontiers, crucial national needs, the main field of the national

economy, and the health and well-being of the people. It has made significant breakthroughs in key technologies and achieved a series of major innovations, markedly enhancing its scientific competitiveness. In basic research, NCNST pioneered the field of “biological effects of nanomaterials and nanosafety”, opening up the new research area of “nanotoxicology”. It overcame methodological bottlenecks in the quantitative measurement of nanomaterials *in vivo* and developed *in situ* quantitative and imaging methods with femtogram and nanoscale resolution for “nano-protein corona-bio” interfaces. For the first time internationally, it achieved direct imaging of local interactions between molecules, providing direct evidence for the long-debated question of the “nature of hydrogen bonds” in chemistry, which had been disputed for over 80 years. It also created new methods for the precise and controllable self-assembly and preparation of nanoparticles, providing a theoretical foundation for the construction, performance optimization, functional regulation, and practical application of nanoparticle self-assemblies.

In terms of technology transfer and commercialization, the anti-tumor new drug “Irinotecan Hydrochloride (Nano) Micelles for Injection” was approved for clinical trials, becoming the first therapeutic new drug containing the word “nano” in its name to enter clinical trials in China. The nano-composite ultra-black coating material was successfully applied to the optical systems of the Test-6 03 satellite and the Sustainable

Development Science Satellite 1, significantly enhancing the detection capability for faint targets. To support the high-quality development of the nanotechnology industry, NCNST has initially established nanotechnology standard system in China, achieving serialization and diversification in the development of reference materials and standard methods, making China one of the countries with the richest resources of nanotechnology standards in the world.

NCNST hosts the National Technical Committee for Nanotechnology Standardization (SAC/TC279), the National Technical Committee for Microfine Bubble Technology Standardization (SAC/TC584), the Subcommittee for Particle Standardization (SAC/TC168/SC1), the National Standard Verification Point (Nanomaterials Field), and the Special Committee for Laboratories of the China National Accreditation Service for Conformity Assessment (CNAS).

The English journals, *Nanoscale*, *Nanoscale Horizons*, and *Nanoscale Advances*, co-organized by NCNST and the Royal Society of Chemistry, have garnered widespread attention from the academic community.