

Research on New Material Power Strategy by 2035

Xie Man ¹, Gan Yong ², Wang Hui ¹

1. Central Iron & Steel Research Institute, Beijing 100081, China

2. Chinese Academy of Engineering, Beijing 100088, China

Abstract: The material industry provides the material basis for national economic development, social progress, and national defense security. Materials are particularly important for China as it now enters the middle and late stages of industrialization. Conducting strategic research on new materials will help strengthen China's manufacturing sector. In this article, we systematically analyze the development status, trends, and challenges of the new material industry in China and abroad and summarize domestic and foreign policies for the industry. After analyzing the future strategic demands for new materials, we propose overall concepts, characteristics, and goals for a new material power strategy. The key direction of the strategy needs to focus on fields such as advanced basic materials, key strategic materials, and frontier materials. An evaluation–characterization–standards platform should be established for new materials. Furthermore, we propose some policy suggestions to facilitate the development of China's new material industry and provide a reference for decision-making by relevant government departments. Specifically, an independent innovation system for new materials should be constructed; platforms for digital R&D, production application demonstration, and resource sharing should also be established; the quality and technology infrastructure should be improved; and talent teams dedicated to the development of the new material industry should be created.

Keywords: strategic materials; basic materials; frontier materials; industrial policy; strategy for strengthening the nation

1 Introduction

Materials serve all fields of the national economy, social development, national defense construction, and people's lives. They are the material basis and forerunner of economic construction, social progress, and national security, and they support the whole social economy and national defense construction. New generation information technology and new materials are the two fundamental technologies of the manufacturing industry [1]. New generation information technology is the driving force of the fourth industrial revolution, and new materials serve as the indispensable material foundation supporting strategic emerging industries and major projects. The deep integration of information technology and new materials will jointly promote the high-end development of the manufacturing industry.

In recent years, under the background of the new scientific, technological, and industrial revolution, new material technology has made novel breakthroughs. With the emergence of new materials and material structures, the global new material industry has maintained a trend of rapid growth. Compared with developed countries, the new material industry in China started late and had a weak foundation. Since the 12th Five-Year Plan, China has issued a number of policy documents to promote comprehensive deployment in the field of materials to match the progress of

Received date: August 20, 2020; **Revised date:** September 15, 2020

Corresponding author: Gan Yong, professor level senior engineer of General Iron and Steel Research Institute, member of Chinese Academy of Engineering. Major research fields include metallurgy, new materials, and modern iron and steel process technology. E-mail: 15711125328@126.com

Funding program: CAE Advisory Project "Research on New Material Power Strategy by 2035" (2018-ZD-03)

Chinese version: Strategic Study of CAE 2020, 22 (5): 001–009

Cited item: Xie Man et al. Research on New Material Power Strategy by 2035. *Strategic Study of CAE*, <https://doi.org/10.15302/J-SSCAE-2020.05.001>

developed countries. Through unremitting efforts, China has become a strong material power and made great progress in system construction, industrial scaling, technological progress, and cluster effects, which have had important impacts on the national economy and national defense construction. However, there are still many challenges facing the development of China's new material industry, and there is a long way to go.

With the aim of promoting the high-quality development of the new material industry and supporting the implementation of the manufacturing power strategy, in December 2017, the Chinese Academy of Engineering officially launched a major consulting project titled "Research on New Material Power Strategy by 2035" focused on the top-level design of China's new material industry development. The project organized research groups in the fields of advanced basic materials, key strategic materials, and cutting-edge new materials as well as focusing on new material evaluation, characterization, and standard platform construction to draw attention to key areas, formulate a development strategy for new material power for 2035, and provide advice for the country to accelerate the promotion of independent innovation ability and the industrial core competitiveness of new materials.

As a display of the academic achievements of the "Research on New Material Power Strategy by 2035" project, this paper analyzes the development status, trends, and remaining challenges of the new material industry, explores the policies governing the new material industry, and investigates the general concepts, characteristics, and development goals of the development strategy for new material power based on the strategic needs of new material power. In view of the key areas of the new material industry, this paper proposes key development directions, studies, and relevant policies and measures to provide support and a reference for the development of the new material industry and the decision-making of relevant government departments.

2 Development status and trends of the new material industry

2.1 Development status and trends of foreign new material industries

2.1.1 Current situation and trends in industrial development

The global new material industry is developing rapidly, and its scale is expanding. The global output of new materials is estimated to have reached a value of USD 2.82 trillion in 2019. The global new material industry has formed a three-tier competition pattern, and each country has its own advantages in industrial development. The first echelon comprises developed countries and regions, including the United States, Japan, and Europe, which have absolute advantages in terms of economic strength, core technology, R&D capacity, market share, etc. The second tier includes South Korea, Russia, and China, whose new material industries are in a period of rapid development. The third tier includes Brazil and India. From a global perspective, the monopoly of the new material industry is intensifying, and high-end material technology barriers are becoming increasingly apparent. With the advantages of technology research and development, capital, and talent, large multinational companies wield technology and patents as barriers and occupy a dominant position over most high-tech and high-value-added new material products.

At present, with the rapid progress in new generation information technology, new energy, intelligent manufacturing, and other emerging industries, higher requirements have been established for materials such as ultra-high purity, ultra-high performance, ultra-low defects, high-speed iteration, multi-function, high durability, low cost, easy recovery, and excellent equipment. The development of new materials is unprecedented [2]. The new material industry is developing in the direction of green and low-carbon processes, increased fineness, and greater savings. The research and development of new materials and the innovation of preparation methods have accelerated. The emergence of new material design methods represented by material genetic engineering has greatly reduced the R&D cycle and cost of new materials and accelerated the innovation of new materials. The rapid development of the Internet of Things, artificial intelligence, cloud computing, and other new generation information and Internet technologies, together with the application of new sensing and automation technologies, has promoted the R&D process of the new material industry.

2.1.2 New material industry policies

In recent years, several foreign developed countries have issued relevant special policies governing the key areas of new materials, implemented long-term accurate support and early strategic layouts for the key areas of new materials, and promoted the rapid development of the domestic new material industry; as a result, these nations occupy a leading position in the international new material industry. For example, in the third-generation

semiconductor field, the United States, Europe, the United Kingdom, Japan, South Korea, and other countries and regions have issued more than 60 policies in recent years. The total investment of these countries was USD 3.7 billion, mainly focused on developing SiC substrates, GaN radio-frequency (RF) devices, GaN light-emitting diodes (LEDs), SiC and Si-based GaN power devices, organic light-emitting diodes (OLEDs), and power electronic devices in fields such as power electronics, optoelectronics, microwave RF, and semiconductor lighting [3].

For key material fields, foreign countries have actively implemented trade policies to protect their own interests. As of August 2020, the United States has imposed tariffs on approximately USD 550 billion of Chinese goods exported to the United States. The tariff list covers a wide range of products, such as communications, electronics, mechanical equipment, automobiles, and furniture. These industries directly or indirectly affect the profits of upstream new material enterprises, particularly those with low added value.

Developed countries are constantly erecting barriers to the export of key technologies and products. In August 2018, the president of the United States signed the *Export Control Reform Act*. In November of the same year, the Bureau of Industry and Security of the Department of Commerce of the United States put forward an export control framework for key technologies and related products, listing 14 areas to be considered for control, including advanced material technology, equipment, and testing instruments related to the preparation of new materials [4].

2.2 Development status and challenges of the new material industry in China

2.2.1 Current situation of industrial development

The production system of the new material industry is basically complete, and the industrial scale is growing. China has developed a material industry system with the most complete categories and largest scale in the world. R&D and production systems covering metals, polymers, ceramics, and other structural and functional materials have been established, and a huge scale of material production has been put in place. This production system in China has the greatest global output of more than 100 types of materials, including steel, non-ferrous metals, rare earth metals, cement, glass, chemical fibers, advanced energy storage materials, photovoltaic materials, silicone, super-hard materials, and special stainless steel [5]. According to statistics, since the 12th Five-Year Plan, the output value of China's new material industry has expanded rapidly, from 0.65 trillion CNY in 2010 to 4.57 trillion CNY in 2019. China has gradually established a new material innovation system with enterprises as the main body, market as the guidance, and the combination of production, education, and research [6]. Relying on the advantages of regional resources, new material industrial clusters have been formed in the Bohai Sea Region, Yangtze River Delta, Pearl River Delta, central and western regions, and Northeast China [7].

The rapid development of new material science and technology has continuously promoted the optimization of industrial structures [8]. Breakthroughs in key industrialization technologies, such as super steel, electrolytic aluminum, low environmental load cement, perfluorinated ion-exchange membranes, and polyolefin catalysts, have promoted the transformation and upgrading of traditional industries such as steel, non-ferrous metals, building materials, and petrochemicals. New materials provide an indispensable material basis and enable the implementation of a series of major national projects in the fields of aerospace, energy transportation, engineering construction, resource conservation, and environmental governance. For example, the product structure of high-performance steel materials, light alloy materials, and engineering plastics has been continuously optimized, which strongly supports and promotes the globalization of high-speed railways, manned spaceflight, ocean engineering, and energy equipment, as well as the successful application of third-generation Al-Li alloys in large aircraft [9].

2.2.2 New material industry policy

In recent years, the state has attached great importance to the development of the new materials industry, and relevant ministries and commissions have successively launched a series of policy documents, including the *Three-Year Action Plan to Enhance the Core Competitiveness of the Manufacturing Industry (2018–2020)*, the *13th Five-Year Plan for Science and Technology Innovation in the Field of Advanced Manufacturing Technology*, the *13th Five-Year Plan for Science and Technology Innovation in the Field of Materials*, the *Development Guide for New Materials Industry*, the *Construction Scheme of National Demonstration Platform for New Material Production and Application*, the *Construction Scheme of National New Material Testing and Evaluation Platform*,

the *Action Plan for New Material Standard Pilot (2018–2020)*, and the *Demonstration and Guidance Catalogue for the First Batch of Application of Key New Materials (2019 Edition)*. These policies have greatly promoted the rapid development of the new material industry.

At the same time, local governments and relevant departments are also very concerned about the new material industry and have formulated a number of local new material industry policies. For example, Beijing, Inner Mongolia, Anhui, Hebei, Guangdong, and other provinces (autonomous regions) and cities with separate planning departments have also issued guidance, development plans, action plans, and implementation plans for the new material industry, highlighting local characteristics and promoting the rapid development of the new material industry. Based on preliminary statistics, 63 policies have been issued, which include not only comprehensive plans but also special plans with local characteristics, such as the “*Henan Nylon New Material Industry Development Action Plan*, *Anhui Semiconductor Industry Development Plan (2018–2021)*, and *Jiangsu Additive Manufacturing Industry Development Three-Year Action Plan (2018–2020)*. Some local governments have also specifically identified new material enterprises. In particular, the insurance compensation mechanism for the first batch of new materials has been vigorously promoted, and many provinces (autonomous regions and cities) such as Guangdong, Jiangxi, Sichuan, Hunan, Gansu, Shandong, Jilin, Shanghai, Ningbo, and Xiamen have introduced local insurance compensation policies.

2.2.3 Challenges in industrial development

Currently, the material support ability is not strong, the problem of being controlled by others is prominent, and the independent controllability of the industrial chain is poor [5]. This is because for a long time, with the explosive growth of China’s economy, materials have been bought as they can be obtained, and insufficient attention has been paid to the originality, foundation, and support of materials. As a result, the foundation of the new materials industry is weak, and it has become a severe problem, posing a major risk to industrial safety and key areas.

The ability to lead development is insufficient, and the innovation chain is not smooth; therefore, it is difficult to seize a strategic commanding height [10]. Insufficient integration of R&D and application of materials, inadequate engineering application research, and a severe lack of data accumulation have not only led to the lack of targeted research oriented to the actual service environment of materials, but also resulted in the instability of material quality and technology, incomplete performance data, unmatched technical standards, and insufficient assessment and verification. As a result, it is difficult for a large number of new materials to cross the “valley of death” from development to application, and the problem of “impossibility or inability to apply the materials” is very prominent.

The input mode of new materials R&D is single, insufficient, and scattered, with a weak ability for original innovation. The nation lacks long-term and stable support for basic research on new materials, and financial investment is too scattered to concentrate on science and technology projects. In addition, independent investment into new material enterprises is insufficient. Moreover, most new material enterprises attach primary importance to immediate interests, thus neglecting original innovation.

The quality and technology of infrastructure construction is weak, and the industrial support system is imperfect [5]. There is a severe lack of material evaluation standards, certification and accreditation quality assurance services are insufficient, and a perfect material standards system has not been established. The basic ability of material inspection and testing is poor, the optimal allocation of inspection and testing resources is insufficient, detection abilities are inadequate, the detection market mechanism is imperfect, inspection and testing service abilities cannot satisfy the overall demand of industry, and the inspection and testing technology level and service ability cannot meet international requirements.

The industrial development ecology has not been well established [5], and thus the industrial development environment needs to be optimized. There is a lack of innovation investment and financing environment in the new material industry and a shortage of innovative talent in the new material field. The policy system governing the importing and exporting of new materials as well as the legal system of intellectual property rights are still to be perfected.

3 Strategic demands of new material industry development for 2035

At present, China is in a period of strategic transformation. It is urgent to open up new economic growth points and improve the environmental carrying capacity, which provides a rare historical opportunity for the development of new materials in China. In the current period of transformation, upgrading, and development of new industrialization, the strategic demand for new materials is particularly prominent.

3.1 Vehicles

Made in China 2025 proposes to vigorously develop new energy along with high-efficiency and high-safety system technology and equipment; improve China’s modern transportation core technology system; develop 400 km/h high-speed trains, long-distance wide-body passenger planes, new energy vehicles, and other means of transportation; and enhance the sustainable development ability of transportation and the strategic support ability of globalization. Therefore, research and development of the core components and key materials for heavy helicopters, high-speed trains, long-range wide-body airliners, new energy vehicles, heavy launch vehicles, spacecraft, etc. are urgently needed to enable the independent support capability of core components (Table 1).

Table 1. Demand for new materials in the vehicle field.

Equipment	Application system	Demand for new materials
Aerospace equipment	Heavy helicopter	Aluminum–lithium alloys with high strength, high toughness, and damage resistance
	Long-range wide-body airliner	Key raw materials, such as high-strength medium-modulus carbon fiber and its composites, carbon–carbon composites, superalloys, and high-temperature resistant and ultra-high-strength aluminum alloys/aluminum–lithium alloys/magnesium alloys
	Heavy-lift carrier rocket	New materials such as high-strength oxygen-enriched ablation-resistant superalloys, light-weight high-strength aluminum–lithium alloys, and magnetic valve hot-pressed radial permanent magnet rings
	Spacecraft	High-strength and high-modulus carbon fiber, etc. Third-generation semiconductor materials, etc.
Energy saving and new energy vehicles	Energy saving vehicle	High-strength steel, aluminum alloys, magnesium alloys, carbon fiber reinforced composites, etc.
	New energy vehicles	Carbon fiber and its composites for lightweight car bodies, ultra-high strength steel, aluminum alloy sheets, high-strength weldable aluminum alloy forgings/profiles, fatigue-resistant and high thermal conductivity magnesium alloys, rare earth magnesium–aluminum alloys, carbon fiber composites for high-pressure hydrogen storage cylinders, high-capacity rare earth hydrogen storage alloys, power semiconductor chips for electric control systems, magnetic circuit components for drive systems, rare earth fluorides for night vision system coatings, battery–electric control–motor system, etc.
High-speed trains		Wheel steel, axle steel, bearing steel, gear steel, carbon fiber composites, flame-retardant interior composites, high-strength wear-resistant composites, aluminum alloys, magnesium alloys, highly wear-resistant die steel, high-conductivity light pantograph and catenary materials, high-performance rare earth magnets, silicon carbide, etc.

3.2 Energy and power

The current energy structure dominated by coal and the shortage of oil and gas resources mean that the development focus of China’s national energy strategy is to develop a new generation of efficient and clean coal-fired power generation technologies and deep-sea oil and gas resource development technologies. Special alloys for advanced energy and power systems represent the core competitiveness of national high-end equipment and belong to the category of national strategic new materials, which is a major opportunity for China to seize the technological commanding height. Major projects in the energy field, such as nuclear power and oil and gas development, have an urgent demand for new materials such as special alloys, rare earth materials, amorphous materials, superconducting materials, and composite materials (Table 2).

Table 2. Demand for new materials in the field of energy and power.

Application system	Demand for new materials
700 °C ultra-supercritical thermal power unit	Large nickel-based heat-resistant alloy casting and forging materials, new rare earth materials, etc.
Ground heavy-duty gas turbine	Long-lived and corrosion-resistant single crystal superalloys, directionally solidified superalloys, wrought superalloys, etc.
Deep sea energy drilling and production platform	High-end stainless steel, weathering steel, corrosion-resistant alloys, cemented carbide, anti-corrosion coatings, nickel-based superalloys, magnetic materials, carbon fiber and its composite materials, etc.
Magnetic power transmission system	New types of magnetic power control systems with integrated functional and structural magnetic devices and core magnetic materials
Flexible power transmission and transformation system	Super high-power silicon carbide materials

3.3 Information display

As two of the few hundred-billion-dollar industries in the information field, integrated circuits and information displays are the two cornerstones of China's electronic information industry. These industries have a strong driving force and radiation power and occupy an extremely important strategic position in China's national economy. The demand for new materials in the information display field is summarized in Table 3. The development of new information technologies and industries requires the support of electronic information materials. At present, there is a huge gap in the R&D of electronic information materials between China and developed countries.

Table 3. Demand for new materials in the information display field.

Equipment	Application system	Demand for new materials
Integrated circuit		Silicon-based integrated circuit chips, micro electromechanical system device packaging glass powders, high-performance nitride ceramic powders and substrates, photoresistors, gallium oxide single crystals, UV-grade calcium fluoride crystals for lithography machines, high-purity quartz glass and products, large-size ultra-high purity non-ferrous metal target materials, wet electronic chemicals, etc.
Information display	Print display	OLED/QLED LED/QLED display core materials and ink for printing, 65 in 8K OLED/QLED printing preparation technology and spray printing equipment technology, 100 in 8K winding printing display preparation technology, roll-to-roll printing preparation technology, etc.
	Laser display	Short-wavelength red-light LD (AlGaInP) and blue-green light LD (InGaN) materials
	Micro-LED display	Micron-scale GaN polychromatic LED materials, chip technology and ultra-small space chip mass transfer processes, etc.
	Special light source	New narrow-band phosphors, new phosphors for solar-like full-spectrum light sources, high-efficiency rare earth phosphors and other rare earth luminescent materials, high light yield/fast decay rare earth scintillation crystals, nitride-based third-generation wide band gap semiconductor materials, etc.

Note: QLED is a quantum dot light-emitting diode, LD is a laser diode, and LED is a light-emitting diode.

3.4 Life and health

With the increased aging of the global population, people are increasingly focused on their own health; as a result, the health industry has entered a period of accelerated development. Rapid breakthroughs in biomedical materials will provide benefits to humans in allowing for the rapid diagnosis of diseases and the repair and transplantation of human organs, which will have a crucial impact on the country's medical safety and people's health. The demand for new materials in the fields of life and health is summarized in Table 4.

Table 4. Demand for new materials in the fields of life and health.

Application system	Demand for new materials
Bone regeneration and repair	Second-generation bioactive biomedical materials, including two types of inorganic non-metallic materials, i.e., bioactive ceramics and bioactive glass; and degradable metals and high polymer material such as magnesium alloys and polylactic acid
Dental implants	Titanium and titanium alloys
Vascular stent	Biodegradable poly (lactic acid) stents and biodegradable magnesium alloy stents

4 Development strategy for new material power

4.1 General concept

Guided by Xi Jinping's thoughts on the diplomacy of socialism with Chinese characteristics for a new era, we should comprehensively implement the spirit of the 19th National Congress of the Communist Party of China (CPC) and create a strategic blueprint for building a nation dominant in science and technology to make China a powerful country. We must focus on the major needs of the national economy and national defense and consider improvement of the independent innovation capability of new materials as the core of the strategy, with advanced basic materials, key strategic materials, and new frontier materials as the major development directions. The focus is to adhere to supply-side structural reform; promote sustainable development; vigorously develop new technologies, models, and formats; realize the transformation, upgrading, and structural adjustment of the new materials industry; drive development through innovation; establish an independent innovation system for new materials with enterprises as the main body and a deep integration of production, education, research, and application; and comprehensively enhance the independent supply and market competitiveness of new materials in China, thus building China into a new material power.

4.2 Development goals

By 2025, the overall technology and application of key new materials in China will keep pace with the advanced level internationally, and some aspects will reach a leading international level. In addition, the quality and stability of new material products will be comprehensively improved, the proportion of middle- and high-end products will be greatly increased, and the overall level will enter the middle and high-end links of the global value chain. The independent research and development level and independent support ability of key high-end materials and equipment will be significantly improved, and the problem of key materials being controlled by others will be effectively alleviated.

By 2035, China will occupy a place in the ranks of the world's material powers. Centering on the major needs of ensuring national security, industrial security, and scientific and technological security, the problem of core systems and key devices being controlled by others will have been solved. China will build a systematic and all-round support capability for devices and materials related to the national economy and national security, comprehensively enhance the international competitiveness of the material industry, and build an independent innovation system for materials.

By 2050, China will be at the forefront of the world's material powers, with a fully built independent innovation system for materials, and its material R&D capability and industrial competitiveness will be at the leading edge globally. The development of materials will fully meet the needs of national economic construction and national defense security and support the economic and social development of the population.

4.3 Development focus and direction

4.3.1 Advanced basic materials

The development focus and direction for advanced basic materials mainly includes advanced steel materials, advanced non-ferrous materials, advanced petrochemical materials, advanced building materials, advanced light industrial materials, and advanced textile materials (Table 5).

4.3.2 Key strategic materials

The development focus and direction for key strategic materials mainly include special alloys for high-end equipment, high-performance fibers and their composites, new energy materials, advanced semiconductor materials,

chip manufacturing and packaging materials, rare earth functional materials, electronic ceramics and artificial crystals, advanced structural functional integrated ceramics and functionally graded materials, high-performance separation materials, membrane materials, new display materials, new-generation biomedical materials, and bio-based materials (Table 6).

Table 5. Development focus and direction for advanced basic materials.

Development focus	Development direction
Advanced steel materials	Steel for advanced manufacturing basic parts; high-performance marine steel; high-tech ship steel, new high-strength and toughness automobile steel; high-speed and heavy-duty rail transit steel; new generation fire-resistant, corrosion-resistant, and weather resistant construction steel and marine environment construction steel; super-large capacity oil and gas pipeline steel; deep-sea drilling, production, transportation, and storage steel; energy steel, etc.
Advanced non-ferrous metal materials	High-performance light alloy materials, key supporting materials of non-ferrous metals for functional components, rare and precious metal materials, etc.
Advanced petrochemical materials	Lubricating greases, high-performance polyolefin materials, polyurethane functional resins, fluorosilicone resins, special synthetic rubbers and elastomers, engineering plastics and special engineering plastics, catalysts and catalytic materials, new polymer materials, processing technologies and materials, high-end electronic chemicals, etc.
Advanced building materials	Cement-based materials for major engineering projects in extreme environments, functional and intelligent glass materials, industrial ceramic materials, high-performance fibers and their composites, environmentally friendly non-metallic mineral functional materials, etc.
Advanced light industrial materials	High performance paper-based materials, high-performance leather materials, etc.
Advanced textile materials	Differential functional fibers, bio-based fibers, nonwoven fiber materials, high-performance fibers and braided materials, textile composite materials, recycled fiber materials, etc.

Table 6. Development focus and direction for key strategic materials.

Development focus	Development direction
Special alloys for high-end equipment	Advanced wrought, powder, single-crystal superalloys; advanced black heat-resistant alloys; advanced black corrosion-resistant alloys; special Al, Mg, Ti alloys, etc.
High-performance fibers and composites	Carbon fiber and its composites, organic fiber and its composites, ceramic fiber and its composites, etc.
New energy materials	Si-based solar cell materials, GaAs-based solar cell materials, lithium-ion battery materials, all-solid-state battery materials, fuel cell materials, and other energy materials
Advanced semiconductor materials and chip manufacturing and packaging materials	Large-size silicon semiconductor materials, III-V semiconductor materials, third-generation semiconductor materials, ultra-wide band gap semiconductor materials, chip manufacturing and packaging materials, etc.
Rare earth functional materials	Rare earth magnetic materials, rare earth luminescent materials, rare earth catalytic materials, rare earth crystal materials, rare earth hydrogen storage materials, high-purity rare earth metals and compounds, etc.
Electronic ceramics and intraocular lens	Electronic ceramic materials, intraocular lens materials, etc.
Advanced structural functional integrated ceramics and functionally graded materials	Structural functional integrated ceramic materials, functional graded materials, etc.
High-performance separation membrane materials	Water treatment membrane materials, special separation membrane materials, gas separation membrane materials
New display materials	OLED/QLED display materials, micro/mini-LED display materials, laser display materials, display substrate materials, etc.
New generation biomedical materials	Regenerative medicine products, functional implant/interventional materials, medical grade raw materials, etc.
Bio-based materials	Natural polymer bio-based materials, bio-based synthetic materials, etc.

4.3.3 Cutting-edge new materials

The development focus and direction for cutting-edge new materials mainly include 3D printing materials, superconducting materials, intelligent bionic materials, and graphene materials (Table 7).

Table 7. Development focus and direction for cutting-edge new materials.

Development focus	Development direction
Materials for 3D printing	3D printing metal materials, 3D printing organic polymer materials, 3D printing biological materials, 3D printing inorganic non-metallic materials, 3D printing composite materials, etc.
Superconducting materials	High-performance superconducting wire and magnet equipment for high magnetic field, low-cost kilometer-grade Bi2223 and YBCO coated conductors, etc.
Intelligent bionic materials	Intelligent bionic materials for resource utilization, intelligent bionic materials for environmental protection, intelligent bionic materials for energy utilization, intelligent bionic materials for life and health, bionic materials and intelligent integration, etc.
Graphene materials	High-efficiency graphene electrode materials, graphene collectors and other materials used in the field of new energy; graphene rubber, graphene aramid and other polymer composites, graphene carbon fiber, graphene glass fiber and other composites, and graphene metal composite reinforcement materials used to promote the aerospace field; breakthrough graphene heat conduction and heat dissipation materials for electronic information applications, etc.

4.3.4 New material evaluation, characterization, and standard platform construction

The aims of material evaluation, characterization, and standard platform construction mainly include the construction and improvement of basic platform elements, mechanism construction and improvement, key tasks for platform operation, and other key development directions (Table 8).

Table 8. Development focus and direction for new material evaluation, characterization, and standard platform construction.

Development focus	Development direction
Construction and improvement of basic platform elements	Optimize the new material industry standard system and new material standard supply structure; establish and improve the new material quality evaluation system; accelerate the cultivation and establishment of professional third-party certification and evaluation institutions for new materials; cultivate group standardization organizations to support the development of the new material industry; build professional quality certification and evaluation abilities for new materials; integrate new material testing resources to improve the comprehensive quality of new materials; strengthen the construction of a standardization ability of social groups, build an international standardization brand, and focus on improving the R&D level of detection and analysis instrument technology to support the inspection and detection ability of new materials
Mechanism construction and improvement	Establish a coordination mechanism for the establishment of new material standards, promote technological innovation and industrial development, establish a coordination and interaction mechanism for quality technology infrastructure, and explore the innovation of mechanisms for establishing standards for new materials
Key tasks for platform operation	Use big data technology to lead new material research and promote the transformation of new material research results; organize the revision of new material standards; carry out comprehensive evaluations of new materials; ensure the sustainable development of the platform, provide services and safe operation conditions

5 Policies and measures

5.1 Building an independent innovation system for new materials

An independent innovation system with enterprises as the main body will be built to promote the resource integration and planning layout of national key laboratories in the field of materials. A national manufacturing innovation center focused on graphene, lightweight materials, rare earth new materials, advanced composite materials, and other key materials will be established. New industrial technology research institutes in the field of

materials will be established. It is essential to coordinate the construction of collaborative research institutions focused on new materials; strengthen the organization and coordination of the Ministry of Science and Technology, Ministry of Industry and Information Technology, and National Development and Reform Commission; form joint efforts; reasonably allocate innovation resources, and avoid the dispersion of innovation resources and the repeated construction of innovation carriers in the field of new materials.

5.2 Strengthening the construction of digital R&D platforms, production application platforms, and resource-sharing platforms for new materials

We will vigorously promote material genetic engineering; build a digital R&D platform for materials; accelerate the integration of material genetic engineering into the entire lifecycle of R&D, design, manufacturing, and application of new materials; shorten the R&D cycle of new materials; and reduce R&D costs. In addition, it is essential to improve the national production application demonstration platform, solve the problems of core material production application technology development, evaluate the application technology service environment, construct production application demonstration lines, improve resource database sharing, and promote the application technology innovation and development level of new materials. Further, it is important to strengthen the construction of new material resource-sharing platforms; gather and process massive data resources such as new material products, enterprises, gathering areas, capital projects, achievement awards, academic literature, standards, patents, and experts; build a knowledge service system for the new material industry; and build a new material instrument facility sharing system to realize online interconnection and service-sharing of key instruments and facilities.

5.3 Building a policy system to promote the development of new materials

We will improve fiscal, taxation, and financial policies; increase fiscal, taxation, and financial support; and improve investment and financing mechanisms. We will vigorously implement the intellectual property strategy, establish a national intellectual property fund, focus on key technologies in the industry, transform core technological achievements into intellectual property, strengthen the protection of intellectual property rights, and enhance the efficiency of intellectual property operations. We will actively play a guiding role through government procurement policies and encourage the first batch of new materials to be used as demonstration catalogue products in important industries such as major infrastructure, major construction projects, and other fields related to the lifeline of the national economy. In addition, it is essential to improve the import and export policy system; maintain a fair-trade environment; support new material enterprises through trade relief, anti-monopoly policies, and other methods to maintain fair competition; and guide and support new material enterprises in dealing with trade friction. We should establish a fault tolerance and incentive mechanism for the application of the first batches of new materials, study and establish a fault tolerance mechanism for government investment funds, increase support for the field of new materials, and accelerate investment decision-making to ensure the safety and stability of funds.

5.4 Improving the standards, testing, characterization, and evaluation system for new materials

It is essential to establish a standards system to support the high-quality development of the new material industry; carry out pilot actions for new material standards; increase the effective supply of advanced basic materials, key strategic materials, and cutting-edge new material standards; and fully realize the leading role of standardization in the development and quality of the new material industry [11]. In addition, it is necessary to improve the new material testing, characterization, and evaluation system; establish a national new material testing and evaluation platform; build a new material testing and evaluation system; and solve the bottleneck of new material testing and evaluation. Finally, a focus should be placed on vigorously cultivating and developing independent certification and testing brands to enhance international competitiveness.

5.5 Cultivating a talent team suitable for development of the new material industry

While attracting innovative foreign talent in the field of new materials, we should also strengthen the cultivation of domestic talent to create a sustainable talent supply. In the field of basic research on new materials and research on major global issues, we should actively launch major international scientific

programs and projects and build world-class new materials research platforms/projects, which can attract the participation of top foreign scientists and teams, overcome scientific research difficulties, and provide career platforms for scientists to exert their strength. For major scientific and technological projects on new materials that do not involve state secrets, foreign talent can be attracted to participate in the research. We should constantly improve the mechanism for evaluating talent in the field of new materials in China; overcome the tendency of focusing solely on papers, titles, academic qualifications, or awards; and pay attention to the quality, contribution, and influence of landmark achievements. It is suggested that the mechanism of scientific and technological evaluation of talent should be adjusted, and the value of scientific and technological personnel should be reflected in the transformation of achievements through relevant incentive methods.

References

- [1] Gan Y. Advanced material technology is a chassis technology [N/OL]. China discipline inspection and supervision newspaper, (2020-08-17) (6) [2020-09-01]. http://www.jjjcb.cn/content/2020-08/17/content_94016.htm. Chinese.
- [2] Gan Y. Innovation driven needs strong new material technology support [R]. Ulanqab: The Opening Meeting of the 4th China Entrepreneurship and Innovation Expo, 2019. Chinese.
- [3] National Advanced Material Industry Development Expert Advisory Committee. Annual report on the development of China's new material industry (2018) [M]. Beijing: Metallurgical Industry Press, 2019. Chinese.
- [4] Third Generation Semiconductor Industry Innovation Strategic Alliance. Third generation semiconductor industry development report [R]. Beijing: Third Generation Semiconductor Industry Innovation Strategic Alliance, 2018. Chinese.
- [5] Gan Y. Enhance the basic ability of new material industry and promote the high quality development of new material industry [R]. Beijing: China Iron & Steel Research Institute, 2020. Chinese.
- [6] Yao Y. Implementing industry-university-research institute Combination, promoting industry technology progress [J]. Science & Technology Industry of China, 2011 (1): 18–19. Chinese.
- [7] Wei F L, Hu C M. Research on the spatial distribution of China's strategic emerging industries [J]. Inquiry Into Economic Issues, 2012 (9): 112–115, 176. Chinese.
- [8] Cao G Y. Several reflections on advanced materials technology under the new situation [R]. Nanjing: China New Material Industry Development Conference, 2019. Chinese.
- [9] Gan Y. Advanced material development strategy of manufacturing powerful nation [R]. Harbin: International Forum on New Material Science and Technology Development, 2019. Chinese.
- [10] Gan Y. Development and innovation of technology foundation of three basic industries [J]. China Computer Users, 2017 (1): 30–35. Chinese.
- [11] Xu F. Nine ministries and commissions jointly promote the pilot action of new material standards, and propose to promote the establishment of a unified market system conducive to promoting high-quality development through standard upgrading [N/OL]. China Quality News, (2018-03-30) (A01) [2020-09-01]. <http://epaper.cqn.com.cn/article/462512.html>. Chinese.