Development Strategy of Key Materials for Novel Display in China

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Abstract: Novel displays are among the few electronic information industries valued hundred-billion US dollars. They are also regarded as a significant direction for China’s strategic emerging industries in the age of information and intelligence. Key materials and process technologies are critical for the development of novel display industry. In this study, the status quo, development trend, and problems of the key materials and their application to the novel display industry in China are systematically analyzed. In addition, the corresponding development goals and directions of the key materials are proposed herein. To seize opportunities created by technological upgrading and industrial transformation of the international display industry, China should establish a novel display innovation platform. An efficient technological innovation system should be built at the national level and from the perspectives of national economic development and the whole industrial chain. To this end, display applications should be promoted, and breakthroughs in key materials should be achieved. Moreover, the innovation ecology for industrial collaboration should be improved by integrating the advantages of interested parties to make breakthroughs in the common technologies of key display materials and processes. Furthermore, a feasibility analysis of the novel display innovation platform is conducted from the aspects of technology, market, funds, and policy, aiming to provide a reference for the transition of China from a follower to a leader in the novel display industry.

Keywords: novel display; organic light emitting diode (OLED); micro-LED; laser display; key materials

1 Introduction

Since the innovation of the first black and white television in 1939, display devices, as terminal display devices of human–machine interfaces, have been gradually applied in all fields of social life. Currently, novel displays have become one of the core technologies of the electronic information industry, which is the fundamental and the most dynamic industry in the strategic high-tech field. The application of novel displays is used in many aspects, such as industry, transportation, communication, education, aerospace, entertainment, and medicine, forming a market scale of hundreds of billions of dollars. This has greatly changed people’s life patterns [1]. There are multiple innovations in display technology, such as organic light-emitting diode (OLED) displays, quantum dot (QD) displays, micro-LED displays [2], and laser displays [3], which are making display technology high-definition, panchromatic, large-screen, flexible, and green. The integration of optics, semiconductors, materials, video, and information further enhances the competitiveness, innovation ability, and attractiveness to end consumers of display products.

After years of development, China’s display industry has become an important part of the world. In 2019, the comprehensive scale of the novel display industry in mainland China exceeded 3 trillion yuan, making it the world’s largest producer of display panels. It is in a period of development opportunities from big to strong. It is worth mentioning that, compared with developed countries, more than 60% of key materials and equipment in the upstream area of the display industry in China depend on imports. The key part of the display industry is still difficult to control independently, and potential development barriers are becoming increasingly apparent. These are the
bottleneck problems that restrict the development of the novel display industry in China.

Display materials play a key role in the development of display devices. The independent innovation of novel displays should be based on the innovation of related materials. In this paper, we discuss the development status and prospects of key novel display material systems and technologies at home and abroad, reveal the problems faced by China’s industrial development, and propose targeted measures for the independent and controllable development of China’s novel display industry. Through macroscopic research, we want to clarify the vantage point of technology in the future and promote the novel display industry in China to achieve high-quality development as soon as possible.

2 Development status of key materials for novel displays overseas

The display industry is a comprehensive industry involving optoelectronic materials and devices, optical engineering, microelectronics, electronics, and other fields. The new generation of technological changes is often driven by breakthroughs in materials and devices. Throughout the history of display technology and industry development, the second-generation digital flat panel display technology, represented by thin-film-transistor liquid crystal displays (TFT-LCD), has gradually become the mainstream since the beginning of the 21st century. In response to market demand, the size of display substrates is constantly expanding. At present, large-size production lines of the G8.5 generation (and above) have become the main force. The corresponding process technologies of semiconductors and vacuum are more difficult, and the demand and investment for resources are also greater.

In recent years, with the emergence of new-generation information technologies, such as fifth-generation mobile communications, big data, and artificial intelligence, novel displays have been cross-integrated with technologies such as ultrahigh-definition video, flexible display, sensing technology, and printed electronics, enriching the terminal product system of novel displays. For example, novel display technologies and products such as printed displays, mini/micro-LED displays, laser displays, and electronic paper displays, have the conditions for industrialization, leading to a comprehensive technological innovation of the entire display industry chain, including display materials, devices, equipment, and manufacturing technologies.

2.1 Printed display and key materials

Printed display technology sprays ink prepared from OLEDs or quantum dot LED (QLED) materials on the required pixel positions by inkjet printing, which is the technology of manufacturing display devices. Its corresponding key materials are printing luminescent materials, inks, etc. [4]. Foreign companies have an earlier layout in the printed display industry and its key materials, and have a solid material technology and equipment foundation. This has been commercialized.

Advanced countries have invested a lot of resources in basic and applied research on key materials, devices, processes, and system prototypes. For example, DuPont, Polyera, and Plextronics in the United States and Merck Group, FlexInk, and Plastic Logic in Europe have technical advantages in in the manufacturing process and printing of small-molecule OLED materials, organic semiconductor materials, OLED light-emitting materials, QD materials, and organic TFT (OTFT) backplane integrated materials. In view of the future development trend of printed display, some relevant research institutions have implemented the advanced layout in materials and processes, such as Stanford University, Northwestern University, University of California, Berkeley in the United States, Cambridge University in Europe, Imperial College London, the British Printed Electronics Center, the National Technical Research Center of Finland, and the Heidelberg Innovation Laboratory in Germany.

In Japan, JOLED Inc. completed the 20 in/230PPI prototype development, and constructed the G5.5 production line in 2018. Sumitomo Chemical Tokyo Electron Co.; Seiko Epson Co.; Toppan Printing Co., Ltd.; and Dai Nippon Printing Co., Ltd. focus on prototype and mass production research. In South Korea, LG Electronics has completed the development of a 55 in printed OLED prototype, and Samsung Electronics conducts research and development on printed OLED/QLED materials and technologies.

2.2 Evaporated OLED display materials

The key materials of OLED display technology, which is based on the evaporation process, include red, green, and blue light-emitting materials; hole/electron transport materials; and electrode materials. Related luminescent materials can be divided into fluorescent and phosphorescent materials. They can also be divided into small-molecule luminescent materials and polymer luminescent materials based on their molecular weight [5]. These key materials account for about 30% of the OLED display material costs.

Japan, the United States, and South Korea have advantages in the supply of OLED display materials. Sumitomo
Chemical Co., Ltd. and Showa Denko Co., Ltd. of Japan mainly supply OLED polymer light-emitting materials. Idemitsu Kosan Co., Ltd. and Mitsui Chemicals Co., Ltd. of Japan are leading companies in the supply of small-molecule light-emitting materials. Idemitsu Kosan Co., Ltd. and LG Chem. of South Korea have become advantageous suppliers of OLED electronic transmission materials. Tokuyama Co., Ltd. of Japan; Merck Group of Germany; and Idemitsu Kosan Co., Ltd. are the main suppliers of hole-transport materials. Samsung SDI Co., Ltd. of South Korea; Universal Display Technology Co., Ltd. of the United States; Nippon Steel Chemical Co., Ltd. of Japan; and Merck Group of Germany mainly supply green phosphorescent materials. The Dow Chemical Company of the United States and Tokuyama Co., Ltd. of Japan are the main suppliers of red phosphorescent materials.

2.3 Laser displays and their key materials

Laser displays are a new type of display technology with three primary colors: red, green, and blue (or multiprimary colors), as the light source. Laser displays have the advantages of large size, large color gamut, ultrahigh definition, and high viewing comfort [6,7]. Their key materials include three-primary-color laser materials and ultrahigh-definition imaging materials.

In the 1990s, Japan, South Korea, and the United States established a layout of laser display technology research through the US Department of Energy program, Japan Science and Technology Basic Plan, and other national projects to guide and support related businesses in solving technical problems. For example, Japan’s Nichia Chemical Co., Ltd. and Mitsubishi Electric Co. have invested about 3.2 billion US dollars in the research and development of three-primary-color (semiconductor laser) laser displays. The key indicators of gallium indium phosphorus (GaInP) red and gallium nitride (GaN) blue/green laser displays, such as power and service life, are currently in an internationally advanced position. Texas Instruments in the United States and Sony Co. in Japan have monopolized the supply of ultrahigh-definition image processing chips such as 2K/4K resolution reflective digital micro-mirrors devices and reflective liquid crystals on silicon.

2.4 Mini/Micro-LED displays and their key materials

Mini/micro-LED displays are a novel display technology composed of micron-level semiconductor light-emitting pixel arrays. It is a comprehensive technology that combines display and LED technologies [8]. GaN luminescent materials, high-mobility semiconductor materials, drive technology, and mass transfer technology are the key materials and technologies for mini/micro-LED displays.

More than 10 years ago, mini/micro-LED displays have attracted the attention of researchers. CEA-Leti of France launched full-color display devices for virtual reality/augmented reality display applications with a pixel size of only 10 μm. The 55 in “Crystal LED Display” released by Sony Co. in 2012 has a contrast ratio of up to one million to one, and a color saturation of up to 140% NTSC (the color television broadcasting standard established by the National Television Standards Committee of the United States), with fast response speed and long service life. In 2016, Sony Co. introduced the “modular splicing” process, which splices multiple modules into a larger-size display screen. In 2018, Samsung released a large-size mini-LED display wall prototypes and products, the LED size being about 60–100 μm.

2.5 QD displays and their key materials

QD displays are display technologies that use light-emitting QD materials [9], which can be divided into photoluminescent and electroluminescent based on the luminescence form. The corresponding key material is a nanosized QD material.

At present, the upstream companies that produce QD materials and QD backlight devices mainly include QD Vision, Nanosys in the United States, and Nanoco Group PLC in the United Kingdom. QD Vision mainly uses cadmium selenide (CdSe) QDs, and Nanosys and NANOCO Group PLC use indium phosphide (InP) QDs. Because of the EU’s ban on the sale of electronic products containing cadmium (toxic), CdSe disappeared from commercial applications. South Korea’s technology research and development is carried out with Samsung Electronics as the core unit, in collaboration with Seoul National University, Korea Institute of Science and Technology and other scientific research institutions. Samsung Electronics acquired QD Vision in 2016. Other QD materials, such as perovskite QDs and carbon dots, are emerging research directions for QD materials. Related research has gradually deepened.

2.6 Reflective displays and their key materials
Reflective displays usually refer to a paper-like display technology realized by ambient light reflection. At present, mainstream technologies are divided into electrophoretic electronic paper, electrowetting electronic paper, and cholesteric liquid crystal electronic paper. The corresponding application terminals include e-books, mobile terminal displays, auxiliary displays, and smart electronic tags. Related key materials include color display materials (including particle systems and solution systems), dielectric wetting materials, high-transmittance/high-reflection TFT backplane materials, and pixel structure materials [10].

US Amazon.com, Inc., the German ADT Group, and Dutch Eutipal of the Netherlands are the dominant companies in reflective display technology. In 2017, the US company CLEARink Displays also released a full-color video display electronic paper prototype that can play full-color videos at a frame rate of 30 fps. In 2018, Plastic Logic made a breakthrough in increasing the pixel density of electronic paper. The released 10.8 in display screen achieved a resolution of 500PPI.

2.7 Other displays and their key materials

As the current mainstream display products, liquid crystal displays involve three basic materials: liquid crystals, glass substrates, and optical films [11]. In the high-end liquid crystal material market, Germany’s Merck Group, Japan’s Chisso Co., Ltd.; DIC Co., Ltd.; and ADK have advantages. In terms of glass substrate materials, Corning Co. of the United States and Asahi Glass Co., Ltd. of Japan have a leading position in the market. In terms of optical films, the mid-to-high-end optical film products mainly originate from Toray Co. of Japan; 3M Co. of the United States; and SKC Co., Ltd. of South Korea. Most key raw materials have high technical thresholds.

Flexible displays are display devices that can be rolled, deformed, and assembled by flexible electronic components. They have broad prospects in the fields of mobile devices and wearable devices [12]. The key material is a flexible substrate material. A polyimide (PI) substrate, which is currently the only material capable of flexible OLED substrates, has excellent heat resistance and dimensional stability. It has become a key core material for flexible OLED displays. At present, US and Japanese companies, such as DuPont; Ube Kosan Co., Ltd.; Zhongyuan Chemical Industry Co., Ltd.; and Toray Co., Ltd., have a monopoly in the supply of high-temperature electronic grade PI (yellow) and optical grade PT (colorless and transparent), sales of which are accounted for more than 70% of the global PI market. Folding-screen mobile phone products were successfully commercialized in 2019. With the expanded application of flexible-display technology, the demand for PI will grow steadily in the future.

3 Development status of key materials for novel displays in China

3.1 Policy environment for the novel display industry is continuously optimized, and the industrial scale is in the leading position

As the development of the novel display industry is emphasized, policy documents, such as Long-term Scientific and Technological Development Plan (2006–2020) and a key area technology road map for China Manufacturing 2025, are published. With the continuous support of the National Science and Technology Major Projects, Chinese National Programs for High Technology Research and Development (863 Program), the National Basic Research Program of China (973 Program), the National Science and Technology Support Program, the National Key R&D Program, and other national science and technology and industrial plans, China has a high self-sufficiency rate of display screens, as compared to relying solely on imports. Subdivision fields, such as OLEDs, QD displays, micro-OLED displays, laser displays, electronic paper displays, and 3D displays, have also made considerable technological progress, ensuring the sustainable development of novel display technologies and industries.

As of 2019, about 45 production lines have been put into operation in China. In the future, 19 G8.5 Gen (or more advanced) production lines and 20 AMOLED mass production lines will be put into use. The total investment is about 1.3 trillion yuan, and the industry size is more than 3 trillion yuan. China’s related industries have become the most competitive, owning the largest scale and the largest market in the world. The global display industry is accelerating its transfer to China. For example, domestic display panels account for 50% of the world’s total output, TV screens account for 70%, and the output of computers and mobile phones exceeds 90%.

Correspondingly, the rapid development of China’s display market has promoted further expansion of the demand for key display materials. For example, the demand for OLED light-emitting materials is expected to exceed 159 t by 2021, with an average annual growth rate of 30%. The demand for three-primary-color semiconductor lasers for laser displays is expected to exceed 5 × 10^6 by 2022. In 2021, the demand for substrate glass for liquid crystal displays above G8.5 will increase to 3.6 × 10^8 m². Simultaneously, the demand for glass back covers, 3D covers,
and flexible covers continues to rise.

3.2 Technological innovation capabilities continue to increase, and novel display materials obtain innovative applications

Scientific research institutes, universities, and enterprises have carried out a lot of work in basic research and application of key materials, devices, and process technologies related to novel displays, and have accumulated a good foundation. (1) Regarding liquid crystal displays, domestic institutions began to attach importance to independent technological innovation, mastered the mass production technology of LCD display devices, possessed the mass production capacity of display panels, and cultivated one batch of backbones in technology and production. A group of companies, represented by BOE Technology Group Co., Ltd. and Shijiazhuang Chengzhonghonghua display materials Co., Ltd., carried out research and made breakthroughs in glass substrates, polarizers, liquid crystal materials, film material, and other upstream industries, achieving steady improvement in the localization rate. (2) Regarding OLED display materials, Guangzhou Huarui Optoelectronic Materials Co., Ltd.; Beijing Dingcai Technology Co., Ltd.; Jilin Aolaide Optoelectronic Materials Co., Ltd.; Xi’an Ruilian New Materials Co., Ltd.; and other companies are focusing on research and development of OLED materials. (3) The printing and display technology with the characteristics of light and thin, flexible, large-area, and green manufacturing has developed rapidly in recent years. Guangdong Juhua Printing and Display Technology Co., Ltd.; Najing Technology Co., Ltd.; South China University of Technology; Fuzhou University; Zhejiang University; Changchun Institute of Applied Chemistry, Chinese Academy of Sciences; and other institutions have deployed research and realized theoretical verification.

In addition, China’s technology in laser displays and micro-LED displays has developed rapidly. (1) Regarding laser displays, China’s technology level is in line with the international level, and the industrial scale is in the leading position of the world. Key core laser display materials, such as three-color laser displays, ultrahigh-definition imaging chips, optical lenses, and high-gain screens, are focused. Institutes and companies, such as China Institute of Physics and Chemistry; Institute of Semiconductor Technology; Suzhou Institute of Nanotechnology and Nano-Bionics; University of Science and Technology of China; Qingdao Hisense Laser Display Co., Ltd.; Changhong Laser Display Technology Co., Ltd.; Shenzhen Guangfeng Technology Co., Ltd.; and Chengdu FSSCREEN Science and Technology Co., Ltd. rapidly shorten the gap with foreign countries, and some products have realized domestic production. (2) Mini/micro-LED displays, GaN epitaxial material, active substrate materials, special display materials for massive transfer, and color displays are the main focus. Relevant units include Shenzhen City Star Power Technology Co.; Tianma Micro Electronics Co., Ltd.; Southern University of Science and Technology; Institute of Microelectronics; Chinese Academy of Sciences; and Panda Electronics Group Co., Ltd..

4 Problems of key-material development for novel displays in China

Although China’s novel display industry has advantages in scale, the development of the entire industry chain is uneven. Key materials and equipment are highly dependent on foreign sources, and the profit rate is low. There are hidden dangers to the development of the industry. There is still a big gap in industrial technology accumulation between Chinese and foreign companies, and the production of raw key materials is challenging. There are a large number of domestic companies, scientific research institutes, and universities involved in display materials. They also made a certain overall progress. However, in the context of the gap between China’s novel display materials and the advanced international level, the industrial application of key materials has always been weak.

4.1 High dependence on key materials

China’s display industry is still in a “big but not strong” situation. The advantage of the domestic flat-panel display industry lies in system integration and manufacturing. However, it still has a high degree of external dependence in terms of key materials and processes, components and preparation technologies, auxiliary materials, and high-end equipment. For example, more than 70% of related materials rely on imports. Mainly engaged in processing and manufacturing in China, these parts are at the bottom end of the entire display industry chain, with low technical content and meagre profits.

The core basic patented technologies related to key materials for novel displays are concentrated in European and US companies, and the core patented technologies in products and processes are mainly mastered by Japanese and South Korean companies. The high-end liquid crystal materials for TFT-LCD displays have been monopolized by
German and Japanese companies for a long time. The exposure machine was monopolized by Japanese companies. Most glass substrates for TFT-LCD rely on imports from US and Japanese manufacturers. OLED display light-emitting materials rely on imports from companies in the United States, Japan, and South Korea. The core materials for the commercialization of laser displays, including three-primary-color luminescent materials and imaging materials, also rely on imports. For printing display, the mainstream technology for large-size/flexible OLED displays in the future, material inks are mainly dominated by Japanese, German, and US companies.

4.2 Problems of “small, messy, and disorganized” in some industries are prominent, and the market competitiveness is low

The development of novel display materials requires a long development cycle and a large investment, and has a slow growth. Domestic companies are under greater pressure for business development, and the prices of their main products are still relatively low. For these companies, early technology accumulation, research, and development consume a lot of resources and funds, and continuous high investment poses a great challenge. Taking the OLED display field as an example, Chinese panel manufacturers are actively expanding panel production capacity for the mobile market. There are more than 20 newly established OLED material manufacturers. Related companies have weak research and development capabilities. They lack unified deployment and long-term planning, and they put small and disorganized investments. Their technical applications are mainly applied for low investment, short cycles, quick results, and high efficiency. They mainly produce and provide intermediate products of OLED materials, becoming suppliers of raw materials for foreign dominant OLED material companies, resulting in a lower proportion of high-end products and a low product added value.

4.3 Self-sufficiency rate of high-end products is low, and the independent guarantee ability of high-end applications is insufficient

China has made great progress in the field of key materials for novel displays, and their material properties have been significantly improved. However, there is still a big gap compared to foreign superior enterprises, which is prominently manifested in the stability and service life of materials. Taking the laser display field as an example, China’s related industries have developed rapidly, which is reflected in the continuous increase in product types, gradual improvement in market recognition, continuous expansion of market scale, and overall industry level close to internationally advanced countries. Domestic enterprises have the ability to develop mid-to-high-end laser display products, but there are obvious shortcomings in laser display core materials such as red, green, and blue laser display material devices, ultrahigh-definition video image modulation devices, ultrashort focal lenses, and screen diaphragms. Related materials are monopolized by foreign companies. As a result, the production cost of domestic high-end laser display products has increased significantly, restricting the development of the industry.

5 Thoughts on the development of key materials for novel displays in China

5.1 Industrial development goals

The display industry plays a pivotal role in China’s economic development, and the next five to ten years will be a critical period for the initiative in the industrial development. At an important node in the transformation and development of the display industry, the strategic formulation, planning, and deployment of new key display materials should be demonstrated. Moreover, China should commit to moving from long-term follow-up development to leading the future technological and industrial innovation and development.

In 2025, the technology and application of novel display materials will be synchronized with the advanced international level, and key high-end materials will achieve independent controllable guarantees. An innovation platform around novel display materials, technologies, and applications will be developed to effectively solve the shortage of materials for industrial development.

In 2030, public service platforms such as the upstream and downstream collaborative innovation system and evaluation and standards will be fully completed and used to create an industry chain ecology covering materials, devices, and complete machines. The maturity of key material technologies will be improved. Continuous innovation capabilities and product market competitiveness will be achieved, and the localization rate of key materials will be further improved.

In 2035, a new key display material system with independent intellectual property rights will be formed to achieve comprehensive independent protection in major areas of the national economy, supporting the cluster of novel
display industries. Technology, industry, and talent levels will reach the world’s leading level. China will rank among the world’s display material powerhouses.

5.2 General development ideas

The novel display key material has the characteristics of large research and development investment, long technical process, and high investment risk, and belongs to a talent/input/resource-intensive industry. At present, under the situation that the development speed of the international flat panel display industry is slowing down, China’s related industries show a good momentum of bucking the trend, but most of the upstream key materials rely on imports, and the huge industrial scale and risks coexist.

To ensure the independent, controllable, and safe development of China’s display industry, a top-level design led by material breakthroughs should be urgently developed. A full-chain deployment around the application of novel display materials, devices, and systems needs to be carried out. China should open up all technical links in the industry chain and make breakthroughs with overall breakthroughs of core materials; solve the real problems of novel display technology bottlenecks and missing technologies in the industry; promote the localization of materials, technologies, and equipment; and enhance the core competitiveness of the novel display industry.

5.3 Key development directions

The display industry has entered a new stage of renewal, the so-called big reshuffle. For a long period of time in the future, various display technologies will coexist and make a diversified development in their respective advantageous application fields. Overall, the display industry is expected to show the characteristics of comprehensive development. Key technology research actions for novel display key materials need to be implemented, and the maturity of key materials, continuous innovation capabilities, and market competitiveness of products should be improved. The key development directions are as follows.

Vapor-deposited OLED materials and printed OLED materials with independent intellectual property rights should be developed, and the performance of vapor-deposited materials and printing inks should be improved for completing the global patent layout.

Environmentally friendly QD luminescent materials with narrow spectrum width, high efficiency and long service life and mass production processes for manufacturing of 100 kg-level materials should be developed to enhance product innovation capabilities.

Large-area, low-cost GaN epitaxial materials and high-mobility, high-stability active substrate materials for micro/mini-LED applications should be developed, and key technical problems such as massive transfer and bonding, color conversion, and light extraction should be solved.

With the application of the whole machine as traction, short-wavelength aluminum–gallium–indium–phosphorus red light, long-wavelength indium–gallium–nitrogen blue–green light, and other laser display luminescent material technologies, 4K/8 K ultrahigh-resolution, fast-response imaging chips should be developed. This is required to compensate for the shortcomings and to improve the continuous supply of new materials.

New-generation reflective display materials such as color display materials, dielectric wetting materials, and pixel structure materials should be developed to support applications in the directions of low power consumption, visual health, low light and heat radiation, flexible display devices, etc.

Display substrate materials and technologies, such as substrate, high-aluminum cover, and high-resolution glass materials, and mass production processes should be developed to achieve domestic substitution for high-generation applications.

6 Development suggestions—A novel display innovation platform

6.1 Platform construction and operation

As a complete system covering materials, equipment, panels, and terminal products, novel displays need to take advantage of the guiding function of national industrial policies, gather high-quality domestic innovation resources, and implement collaborative innovation of “politics, industry, learning, and research.” Creating a novel display innovation platform is an important measure that fits the future development trend of the display industry and builds an ecological chain for the display industry. It is also a strong support for seizing the opportunity of new-generation display technology and industrial transformation and leading the industry’s international technological innovation cooperation and competition.
Regarding platform construction ideas, it should be guided by the government to gather superior institutions in the display industry in terms of materials, processes, and devices to jointly conduct research on key novel display technologies. As a public platform, it should focus on research and development of printed displays, OLED displays, laser displays, micro/mini-LED displays, and other novel display key materials.

The platform operation is technology-oriented and market-driven, which is based on market principles, providing upstream and downstream companies with open and shared research and development, pilot trials, and services. It should gradually realize self-hematopoiesis through mechanisms such as technology transfer, industry incubation, platform technology services, and intellectual property rights. It is supposed to form the source of supply of core display technologies in China, an innovative高地 for the development of regional industrial clusters, and a place for training and exporting novel display talents.

### 6.2 Platform risk analysis

For the novel display technology and its key materials, the world’s display powers have carried out adequate development strategy discussions and basic research layouts. The accumulation of technology is relatively rich. There is little risk in the selection of technological paths when China conducts platform construction and selects technological paths.

As for market risk, novel displays fit the technology and product trends of large-screen, flexible, high-definition, transparent, three-dimensional, intelligent, and low-cost devices, which is the inevitable direction of future industrial development. The development of novel display materials focuses on the above-mentioned application directions and scene characteristics to a greater extent, which can provide basic judgments with clear technical directions and controllable market risks.

Considering capital risk, the platform is supported by leading national resources, with companies with financial strength as the main body, taking advantage of the combination of public and market resources to reduce investment and financing risks. The technological achievements of the platform can implement rapid market transformation and maximize investment value. At the same time, it drives the rapid development and structural upgrading of the novel display industry. Therefore, capital risk can be controlled.

Regarding market competitiveness, the platform can gather domestic superior resources and establish a complete ecosystem covering basic research, common key technology research and development, testing and verification, and industrial applications. Supporting patent pool construction and talent training will comprehensively improve the international competitiveness of China’s novel display industry.

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