NEW MATERIAL TECHNOLOGY

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Preface

New material technology is one of the main fields of scientific development in the 21st century. As a foundation and a forerunner to the development of high-tech industry, new material technology is widely used and serves various fields of social and industrial development. It also impacts on everyday life. New materials are a pillar of the technology revolution, and foster strategic emerging industries.

China has long been an advocate of innovation and development in material technology and industry, and is very active in science, technology and innovation (STI) in the field. The science papers and successful patent applications have been on a steady rise over the years. In the past decade, there have been 16,800 SCI papers on material in China, ranking first in the world. STI drives industrial development. China has succeeded in assembling the basic building blocks of a complete system of new material R&D and industrialization. It also hosts approximately 400 national key laboratories, national engineering centers and industrialized bases and holds a leading position worldwide in new technologies such as intraocular lens and all-solid-state lasers, optical fibers, superconducting materials, and nanometer materials and devices. Meanwhile, the industrialization of S&T advances in this field is achieved by way of piloting significant application and demonstration projects. A range of key new materials such as optical fibers, materials for integrated circuits, super steel, and magnesium alloys are now in scale production, laying a good foundation for strategic emerging industries and providing a steady stream of important materials to support economic and social development.

Improving the performance of existing materials, saving resources, reducing pollution and decreasing costs are a critical and leading element of the innovative development of material technology and the material industry in China.
**01. NEW FUNCTIONAL MATERIALS**

- Rare-earth functional materials
- High-performance membrane preparation and separation materials
- Advanced super conducting materials
- Lithium ion battery materials
- Biomedical materials
- Ecological environmental materials

**02. ADVANCED STRUCTURE AND COMPOSITE MATERIALS**

- Structural metallic materials
- Non-metallic structural materials
- Composite material
- Preparation and processing of material

**04. NANOMETER MATERIALS AND DEVICES**

- Leading-edge nanometer materials and devices
- Nanometer materials and devices in manufacturing industry

**03. NEW ELECTRONIC MATERIALS AND DEVICES**

- Solid state lighting
- Electronic information materials
- Optical communication, optical sensing materials and devices
- Intraocular lens and all-solid-state lasers
Functional materials perform specific functions in fields such as optics, electromagnetism, acoustics, chemicals and biology. They possess features such as separation, shape memory, and self-adaptation. They are widely used worldwide and have generated huge industries. Their recent development in China has been rapid, and China is now a world leader in terms of productivity and yield of the main types. They play a significant role in supporting high-tech development, promoting the structural adjustment of traditional industries, and driving energy saving and emission reductions.
RARE-EARTH FUNCTIONAL MATERIALS

Rare-earth functional materials are an important resource in the era of low carbon emissions, and boast significant strategic status and economic value. China possesses 30% of the world’s reserves of rare-earth resources, and takes up 95% of total world output. China has always attached great importance to research, development, and exploitation of rare-earth materials, giving priority to rare-earth permanent magnetic materials and comprehensively supporting new functional materials such as rare-earth catalysts, rare-earth luminescence, and rare-earth nanomaterials. In recent years, China has improved the rare-earth material’s industrial chain, increasing the supply and extending the application of abundant and surplus rare-earth elements. All this has promoted China’s competitive position in the international application of rare-earth functional materials.

CASE: Scale production of high-performance rare-earth permanent magnetic materials

After years of research and innovation, China has mastered a set of production processes in high-performance rare-earth permanent magnetic materials which represent a significant advance in this field and enable the large scale production of high-performance NdFeB permanent magnetic materials. These products have been successfully deployed in automotive, oil and wind power industries etc. In 2013, China’s output of sintering rare-earth permanent magnets stood at about 77,000 tons, representing 85% of world output and 75% of world value.
**CASE: R&D and industrial application of rare-earth luminescent materials**

The Youyan New Rare-earth Material Company develops its own independent intellectual property in continuous, energy-saving and low-cost scaled preparation technology and applications for high-end rare earth phosphor uses such as white light LED, CCFL, special phosphor for 3D display, high-efficient rare-earth up-conversion, and lateral heat (friction). Their first and second performance of phosphor has reached advanced world standards. The new phosphor improves the additional value of rare-earth oxides, provides technical support for developing more high-efficiency, advanced, new-type and high-end rare-earth luminescent materials, and promotes the value of rare-earth luminescent materials.
HIGH-PERFORMANCE MEMBRANE PREPARATION AND SEPARATION MATERIALS

With support from the Ministry of Science and Technology, Chinese researchers have developed a range of separation membrane materials with properties such as reverse osmosis, nano-filtration and ultra-filtration membrane with independent intellectual property. These play a significant technical role in comprehensive applications relating to water, energy development, environmental protection and transformation of traditional industries. The total value of China’s membrane industry has grown from 1% to 15% of the world output.

CASE: Ceramic membrane materials and reactor realize scaled production

Represented by Nanjing Tech University, the Chinese Ceramic Membrane Research Team develops scaled production technology for ceramic membranes with independent intellectual property, realizes the industrial application of coupling technology for membrane reactors, and establishes production lines for low-temperature sintering ceramic membranes with an annual output of 5000m³/year, as well as ceramic membrane reactors producing ten kilotons of caprolactam. Its production scale and product quality are of international standard, and its ceramic membrane product holds over two thirds of the domestic market.
**CASE:** *Perfluorosebacamidine ionic membrane preparation technology and industrial production*

Shandong Dongyue Federation has spent years mastering the preparation technology of perfluorosebacamidine ion-exchange resin, perfluorosebacamidine ion-exchange membranes, and chemical compound with perfluorosebacamidine, and is capable of industrialized production. Their 1.4m-wide perfluorosebacamidine ionic membrane for chlor-alkali is now in scale production and has been applied to the ten kiloton chlor-alkali devices, thus becoming a milestone in Chinese chlor-alkali industrial development and making China the third country mastering the core technology of chlor-alkali ionic membrane and production capacity.
**CASE:** High-performance membrane material preparation technology and application

In recent years, China has achieved important breakthroughs in high-performance membrane material preparation technology and water purification membranes such as low-pressure reverse osmosis membrane, nanofiltration membrane and hollow fiber ultrafiltration membrane. These are applicable to purification of household drinking water, centralized drinking water supplies for schools and communities and the transformation of urban tap water production, completes supportive use of membrane materials of millions of drinking water equipment, which effectively deal with the safety of drinking water caused by water pollution. Relevant products have passed the certification of American NSF and test of environmental and health products of CCDC. High-strength and anti-pollution plate-type, rolling-type and hollow fiber membrane materials have been developed, which satisfies the requirement of comprehensive treatment technology of urban sewage for membrane material of water treatment. Several demonstration projects of recycle of municipal sewage in small and medium-sized city have been built. At present, water purification membranes and integrated technology have been applied in Jiangsu, Tianjin, Anhui, Shanghai and Hainan. They are the first to realize the 106 indicator requirement of new water quality standard, and their main sanity indicators are superior to the European water quality standards in terms of turbidity and microorganisms etc.
ADVANCED SUPER CONDUCTING MATERIALS

Since the superconducting phenomenon was identified in 1911, superconducting phenomena, mechanisms, materials and their applications have been a hot research topic. Since reform and opening up, China has always regarded the superconducting field as a leading edge of high-technology. Thanks to the powerful support of the China’s S&T Programs, the country has made considerable progress in superconducting material’s research and application, especially in high-temperature superconducting filters in mobile communication and special communications, high-temperature superconducting current limiters for power systems, industrialization of low-temperature superconducting material for ITER plan, MgB$_2$ superconducting wire, and MgB$_2$ superconducting MRI design and manufacture. At present, China’s superconducting materials such as cables, current limiters, filters and energy storage have reached the stage of industrialization and are now widely used in industries such as electricity, communications and medical products.
CASE: R&D and application of Bi high-temperature superconducting wire R&D and application

Beijing InnoST produces Bi high-temperature superconducting wire in lengths of more than 1500m and whose critical current density is over 15000A/cm². The production line has an annual output of 300 kilometers. It supplies the high-temperature superconducting cable to Yunan Power Grid and the Korean LG Cable Company. Thus the manufactured DC transmission cable has realized the parallel operation. China’s superconducting cable technology leads the world.
**CASE: R&D and application of high-temperature superconducting filter**

Many of China's universities, research institutes and companies, including Tsinghua University and Hi-tech Superconducting Electronic Technology Corporation Ltd., have cooperated for the design and manufacturing of various standards of superconducting filter systems (GSM, CDMA and WCDMA etc) in the field of mobile communications. Their superconducting filter has been applied successfully in the CDMA mobile communication station of Tangshan Branch of China Unicom and has increased its communication distance by 1.7 times. China has thereby become the second country after the US to acquire this practical core technology.
CASE: 10.5kV/1.5kA high-temperature superconducting current limiter and the world-first superconducting transformer substation

The Institute of Electrical Engineering of the Chinese Academy of Sciences is cooperating with multiple institutions and enterprises in the development of the 10.5kV/1.5kA three-phase high-temperature superconducting current limiter. This is China's first and world's fourth high-temperature superconducting current limiter with grid-connected operation. Moreover, it has several innovative features. Having been successfully applied to the world's first superconducting transformer substation located in Baiyin City of Gansu Province, it is also the only distribution-level full superconducting substation. It integrates the latest research and development advances in superconducting power technology in China, and holds approximately 70 patents in core and critical technologies. It has also create other firsts in China and in the world.
LITHIUM ION BATTERY MATERIALS

The lithium ion battery is a new kind of energy storage system and is widely used in fields such as the information industry, new energy automobiles, and the smart grid. It has good commercial prospects and the potential to generate huge revenues, and has thus become a key item for research and development in many countries. The performance of the lithium ion battery mainly depends on the structure and performance of the materials inside the battery. China attaches great importance to research into the lithium ion battery and has made breakthroughs in key technologies such as new cathode materials, anode materials, electrolyte salt, and diaphragm. In this field China has reached the level of the developed countries.

CASE: Widespread application of primary materials in small lithium ion battery

In terms of the main raw materials of small lithium ion battery, China has the capacity for independent R&D and production, and its product performs to international standards. China holds 1/3 of the international market and the battery has been successfully used in such devices as cell phones, laptops and cameras etc. It plays an active role in promoting the development of the information industry in China.
**CASE: Demonstration application of LFP cathode materials**

In scale of industrialization and technical level of LFP cathode materials, China is an international leader. This industry provides key materials for large-scale demonstration and application of large-volume cathode batteries and for the development of the new-energy automobile industry.

![Large-volume lithium ion battery](image1)

LFP cathode materials are applied to the production of lithium ion battery on large scale
**CASE:** High-performance LFP nano cathode materials are applied to manufacture of cylindrical battery

Ningbo Materials Institute of the Chinese Academy of Sciences is working on a new generation of anode materials for a high-energy density power lithium ion battery-LFP, and has established a production line with an output capacity of kilograms. The materials have been successfully applied in the manufacture of cylindrical batteries. The working voltage of the battery is 3.9 V, and the energy density is 20% higher than an LFP battery, which improves the cycle life, discharge performance, high and low temperature performance, and safety performance of the lithium battery.

![Coating process in the production of LFP nano anode materials](image1)

![Slicing process in the production of cylindrical lithium battery](image2)
Battery classification system in the production process of cylindrical lithium battery
**BIOMEDICAL MATERIALS**

Biomedical materials are high-tech special functional materials used to diagnose, treat, repair or replace human tissue and organs, or strengthen their functions. With constant government support, China has achieved outstanding research results in biomedical materials, and leads the world in the number of published theses and patent applications. Achievements such as the successful R&D of repair materials of nanocrystalline calcium phosphate collagen basal bone, and optimized titanium alloy materials mark breakthroughs in high-end biomedical materials in China. The development of Chinese biomedical materials generates a steady stream of new technologies and beneficial products.

**CASE: Development of artificial bone product with totally new material technology**

Tsinghua University has developed repair materials in nanocrystalline calcium phosphate collagen basal bone which are close to the composition and hierarchy structure of natural bone. Their products have achieved certification by the SFDA (State Food and Drug Administration) and been employed successfully in more than 20,000 medical cases. Ti2448 new medical titanium alloys researched and developed by the Institute of Metal Research of Chinese Academy of Sciences possess the characteristics of high strength and low modulus; products such as bone plate, bone peg, vertebral column and artificial joint manufactured from this alloy have entered the stage of scaled application.

Artificial bone product manufactured by the repair materials of nanocrystalline calcium phosphate collagen basal bone

Artificial joint of optimized titanium alloy
Using an artificial joint in a hip replacement operation
ECOLOGICAL ENVIRONMENTAL MATERIALS

Faced with huge pressure on resource, environment and population, every country is increasing research into the coordination between economic development and ecological environment and resources, and thus ecological environmental materials and relevant fields are being given particular attention. China has established the analysis methodology and developed environmental load evaluation technique and relevant database for material and product design, production, recycling and reuse. And they have been applied in many newly-built and renovation projects, with the resultant economic and social benefits.

CASE: Production and application of mulching film materials that can be completely degraded

The mulching film materials produced by Kingfa Company have staged stable performance in use and they can be completely degraded to carbon dioxide and water by microorganisms or enzymes in the bodies of animals and plants. Their products have passed the strictest current CEN13432 standard biodegradation tests. With the volume of carbon dioxide released as the test standard, the product can be degraded by 90% in 180 days and the degradation products do not have any negative impact on the growth of plants. This kind of mulching material has been widely used in the Xinjiang Production and Construction Corps demonstration base of modern agriculture.
A widely used agricultural mulching film that can be degraded completely
Advanced structure and composite materials play an important role in the national economy. Targeting the goals of high-efficiency, energy-saving, and environmentally friendly social development, the National Scientific Plan promotes steel, nonferrous metals, ceramic materials, project plastics, and composite materials as advanced structural materials with high performance and high added-value. The advanced structure and composite materials industry in China is currently developing rapidly and output is increasing steadily.
STRUCTURAL METALLIC MATERIALS

Advanced metallic materials are important to the national economy and play a key role in major national projects, improving the level of equipment manufacture and promoting energy saving, emission reduction and lower consumption, as well as modernizing relevant fields of application. The type and quality of steel materials in China is constantly advancing, along with the process technology. The 7000 series aluminum alloy is in wide use, and it performs to a level comparable with foreign materials of the same type. The light alloy that has been developed for modern automobile engines and drive mechanisms and its development technology have been successfully applied to the production of other automobile parts, resulting in lighter automobiles. Also under development is a high-performance and low-cost magnesium alloy with high-temperature and creep resistance, high strength and toughness, and high resistance to deformation.

CASE: Technology and production of ultrafine crystalline carbon steel

A research team from Northeastern University has developed a range of super steel products and designed the complete technology for super steel production with more than 50 core patents, which improves the steel's yield strength to 400–500MPa level while ensuring good plasticity and process performance. Since 2007, the annual output of super steel in China has exceeded ten million tons, promoting the quality increase and the updating of straight carbon steel products as well as enabling the extensive use of super steel in the fields of automobiles, buildings and machinery etc.

Production workshop for continuous rolling of super steel
Beam in super steel
Wheel in super steel
Long components in super steel were used in the construction of China’s National Grand Theater.
**CASE: Upgrading and efficiency of new steel material in power industry**

China has recently mastered the technology and the scale production of high-end oriented high-grade silicon steel. The high magnetic strength oriented steel manufactured by Wuhan Iron and Steel (Group) Corp has been used in the 500KV ultra high voltage transformer in the Three Gorges, and China has become one of the few countries that can produce this grade of product. Anshan Iron and Steel Group Corporation has developed a steel for the volute of hydropower generating units. The comprehensive performance of this product fully meets the required technical standards and the quality is as advanced as the same type of international products, ensuring the smooth completion of the right-bank project of the Three Gorges. In terms of steel for nuclear power, Baoshan Iron and Steel Plant has developed the steels used in the 690 U-type pipe for the nuclear power steam generator, in reactor containment, and in the main equipment of the nuclear power conventional island.
**CASE:** Research and application of new-type aluminum electrolysis with low energy consumption, low temperature and low pressure

The new-type aluminum electrolysis with low energy consumption, low temperature and low pressure under research by the China Nonferrous Metals Industry Association can reduce the DC consumption of each ton of aluminum by 1,200 kWh to below 11,900 kWh. Two demonstration enterprises are saving 420 million kWh of power annually, reducing the discharge of fluorocarbons by more than 50%.

Production line for Low-temperature low-voltage aluminum electrolysis with new technology

300KA production line of aluminum electrolysis
**NON-METALLIC STRUCTURAL MATERIALS**

Inorganic non-metallic materials include ceramics, glass, cement, refractory materials, enamels, and abrasives. New inorganic non-metallic materials do not contain harmful elements and possess specific performance characteristics achieved through microstructure design, precise chemometry and advanced preparation processes. China has recently made breakthroughs in this area, and produces half of the world's zirconia fiber connectors and alumina substrate. Production of carborundum ceramic rollers and sealed rings has reached industrialized scale. The performance index of large-dimension thin-wall carborundum ceramic heat exchanger tubes meets the highest international standards. Large-dimension complex shape carborundum ceramic optical components have been employed in important national projects, and silicon nitride bearing balls are now in scale production.

**CASE: Industrial scale production of mass molding of high-reliability ceramic components**

After years of research, China has mastered various key technologies in the mass preparation of high-reliability ceramic components. It has also established a production line for ceramic microbead with annual output of 50 million, completed the manufacturing of more than 60 industrial devices of eight types, and established large-scale production capability. These products have been applied in more than 60 manufacturing enterprises and been exported to other countries and regions such as Japan, Korea, and Taiwan. Relying on technical advances, Handan of China has established the largest and strongest production base for ceramic microbeads and upstream and downstream products.
**COMPOSITE MATERIAL**

High-performance fiber and composite materials are a strategic emerging structural material that combines polymer science, textile science and carbon material science. These are key materials in the energy-efficient and low carbon economy, and for driving the upgrading of traditional industry. They are therefore of strategic importance in national development. With the strong support of the national science and technology plan, researching and applying high-performance fiber and composite materials is developing fast in China.

**CASE: Preparation technique and application of p-aramid fiber industrialization**

The China Shenma Group has mastered three key production technologies for producing p-aramid fiber: solvent recovery, continuous polycondensation in low-temperature-solution, and dry wet spinning process. The Group has the capacity to produce a steady supply of 1,500 tons/year p-aramid fiber. The material's comprehensive performance has reached the level of comparable basic products elsewhere in the world. The Group's products have reached volume production and are now being applied in protective devices, high-temperature-resistant rubber hose for automobiles, and fuel hoses.

![Aramid fiber featured gloves](image1)

![P-aramid fiber protective clothes](image2)

![Thousand-ton P-aramid fiber production line](image3)
PREPARATION AND PROCESSING OF MATERIAL

China is now a major producer of advanced structure and composite materials. Steel production has reached 70 million tons, making up 45.5% of global output. It leads the world in the production of main metals such as aluminum, magnesium, copper and alloys. Output of engineering plastics has surpassed 10 million tons, which indicates that China has become the global production for structural materials. In the field of material preparation and processing, China has achieved high efficiency, high performance, high precision, low cost and low load, and has made a number of world-leading technological breakthroughs with proprietary intellectual property rights.

CASE: Energy saving and emission reduction technology and the industrialization of polycrystalline silicon

China has made remarkable progress in energy saving and emission reduction technology and in the industrialization of polycrystalline silicon. An energy-saving reduction furnace of 24 bars with high yield and low power consumption developed by the China Silicon Corporation in Luoyang, Henan Province is the leading reduction furnace in the world. After optimization, a single cycle of the reduction furnace can yield more than 6,000 kg of product. The direct power consumption of the reduction process can be lower than 80 kWh/kg respectively, and 100 kWh can be saved on every kilogram of polycrystalline silicon.
**CASE**: New dry process production technique and low environmental load cement production

Scientific development in China’s cement industry is focused on a new dry process production process. In the pre-decomposition kiln energy conservation calcination process, large raw material homogenization, energy-saving grinding technology, automatic control technology and environmental protection areas, China is a world leader in all processes from design to manufacturing. Currently, China's cement industry is active in many parts of the world, and has successfully contracted many projects in Europe, America, the Middle-East and the Commonwealth of Independent States. With the considerable reduction in cost per unit of the new dry process production line, this process is developing very fast, increasing from 109 production lines in 2000 to 1173 in 2010. Among these, four 10,000 tons/day production lines represent the most advanced and largest production lines in the world. More than 95% of production lines in the 4,000-6,000 tons/day range are built by China. The Pre-dissociation system, large grate cooler, and energy-saving grinding machine are all world-leading technologies.
Cement production plant employing new dry production process with cyclone pre-decomposition kiln.
New electronic materials and devices are an important part of the electronic information industry. They lead the electronic information industry chain, serve as a base for systems and terminal product development in fields such as communications, computers and networks, and digital audio and video, and play an important supportive role for innovation and growth in the electronic information industry. China is currently developing rapidly in the field of new electronic materials and devices, and has achieved several technological breakthroughs in the fields of semiconductor lighting, display mechanisms, photo-communication, optical sensing and solid state laser technology. The industry focuses on developing products of smaller volume, lower cost, higher precision, and higher level integration.
SOLID STATE LIGHTING

Solid state lighting represents a revolutionary advance in lighting technology comparable to the development of the filament light and the fluorescent lamp. As a strategic emerging industry of the 21st century, it has unmatched potential. Guided by the national S&T programs and driven by market demand, solid state lighting technology has made huge strides forward in China, and the gap between China’s technology and the most advanced international level is steadily narrowing. It is anticipated that innovations in technology will lead to significant progress in system integration. China has established a complete industrial chain and is a major exporter. By 2015, the industry is expected to achieve revenue of 500 billion yuan.

CASE: Pilot project on solid state lighting

In 2009, to break through the key technology bottlenecks that limit industrial transformation and upgrading, to promote energy conservation and emission reduction, to drive consumption demand, to promote innovation and technological development, and to effectively guide the healthy and rapid development of the semiconductor lighting industry, China launched the pilot project on solid state lighting in 37 cities. By integrating technologies such as optical design, heat dissipation, and drive system, key problems have been solved and lighting products have been deployed for both external and internal use. Lighting of tunnels, roads, and subways has surpassed 130 lm/W, which saved considerable energy. Compared with traditional lighting, LED lights can provide energy savings of more than 70% in landscape lighting, more than 30% in road lighting, and more than 50% in interior lighting. Currently, more than 3,500 demonstration projects have been implemented in the 37 pilot cities, and more than 11.5 million LED lights have been installed, saving 2.4 billion kWh in power per year.

1.08 billion LED chips were used on the Shanghai Expo site
**ELECTRONIC INFORMATION MATERIALS**

Electronic information materials are used in microelectronics, photo-electronics, and new-tech devices. They are an important part of the modern information industry. Currently, the gap between China and the developed countries in this field is narrowing rapidly.

**CASE: Base metal electrode key material drives the industrialization of chip electronic devices**

Chinese researchers have mastered base metal electrode key material and thickness-reducing technology and successfully developed a series of chip inductance products with proprietary intellectual property rights, reaching international advanced level generally with some taking the lead. With dozens of new-generation high performance chip device material production lines, China's industry scale of chip electronic devices has ranked among the top in the world. The total scale can be 50 billion devices per year with 50% exported, and the annual output can reach as high as 0.5 billion yuan.
**CASE: R&D and application of new high frequency surface acoustic wave devices**

Tsinghua University and China Electronics Technology Group Corporation have jointly developed a range of inter-digital transducer materials of high electro-migration resistance and power resistance, and set up a high-frequency surface acoustic wave devices production line. This development improves the frequency of China's surface acoustic wave filters from 100 MHz to one GHz. The new high-frequency surface acoustic wave devices have been applied in 3G communication, RFID, GPS, and Beidou Navigation Satellite System.
OPTICAL COMMUNICATION
OPTICAL SENSING MATERIALS AND DEVICES

Optical fibers are the most important physical carrier of communication transmissions. They are critical in communications development, and the development of high-speed backbone network, MAN, fiber access network, and broadband radio access network represent major challenges in information technology. The optical fiber industry of China has developed rapidly in recent years, with great improvements in the structure and variety which increase preform productivity and lower optical fiber cost.

**CASE: Research and application of TS-SEED optical fiber technology**

In line with the ‘broadband China’ strategy, FiberHome Technologies Group has set up the ‘TS-SEED optical fiber technology system’ and mastered five key technologies involved. Their high-speed wiredrawing process can run as fast as 2,400m/minute. It has achieved capacity for self-development and scale production of ‘optical fiber preform, optical fiber, and optical cable.’ Its products are exported to Europe, America, and the Middle-East, and have been successfully applied in the projects of China Mobile, China Telecom, China Unicom, State Grid Corporation of China, and CNPC.

This domestic large-scale high-speed wiredrawing tower production workshop has been developed independently

TS-SEED optical fiber and cable products
**CASE:** Development and application of heavy-gauge optical fiber preform and its manufacturing equipment

The Yangtze Optical Fibre and Cable Company in Wuhan has successfully developed a process for preforming heavy gauge RIC (Rod In Cylinder) and the associated technology focusing on high-speed continuous wiredrawing. They are capable of producing optical fiber preform with a diameter of φ200mm. A single wiredrawing preform can reach a length of 7,500 kilometers, and the wiredrawing speed exceeds 2,400m/min. Optical fiber manufacturing equipment producing heavy-gauge optical fiber preform through high-speed wiredrawing is now in extensive use; the annual output of optical fiber preform can thus reach 1,900 tons.

Manufacturing heavy-gauge optical cable preform   Optical cable produced by high-speed continuous wiredrawing

Optical cable production department of Yangtze Optical Fiber and Cable Company Ltd
**INTROOCULAR LENS AND ALL-SOLID-STATE LASERS**

With the maturing of LD (semiconductor laser diode) technology, all-solid-state lasers are developing rapidly and are in widespread use. This will be the main field of future development in the laser industry. In the past decade, the all-solid-state laser with proprietary intellectual property rights and technological advantages from optical to laser system integration has become one of China’s new high-tech disciplines.

**CASE: R&D and industrialization of high-tech crystal products in China**

Chinese introcular lenses dominate the international market, and manufacturing technology for three Chinese brands of nonlinear optical crystal – BBO, LBO, and KBBF - is progressing continuously. A series of international best performances have been set:

- efficient power output of 177.3nm and 3.5mW
- laser output of 193nm Watt and quadruplicated laser output of tisapphire laser (175~232.5nm)
- the first vacuum ultraviolet laser angle resolution electronic EDS of ultra-high energy resolution using 177.3nm laser output by KBBF crystal as light source
- large-size LBO crystal produced weighing more than 2kg
- caliber of second harmonic frequency device reaches 50mm×50mm and third harmonic generation device reaches 100mm×100mm. Quality of industrialized Nd:YVO4 laser crystal product has been further improved and now holds more than 75% of the market share
- 6 production bases in China of Nd: YVO4, LBO, BiBO, BBO, bond device of blue and green, and nonlinear crystal deposition, which are all the largest in the world.
**CASE:** High-efficiency all-solid-state continuous wave laser technology and manufacturing

The Institute of Semiconductors, Chinese Academy of Sciences has made a series of important breakthroughs in high efficiency all-solid-state lasers and mastered a series of important technologies in 1-10kW high-efficiency all-solid-state laser, such as quality of high beam, control of high stability, engineering design, and optical fiber coupling. It has developed a range of high-efficiency all-solid-state laser at 3kW, 4kW, 6kW and 8kW, and some indicators have reached leading international level. These achievements drive China’s development in the field of high-efficiency all-solid-state continuous wave laser, and are of great significance in engineering advanced laser manufacturing equipment and improving processing and equipment.

Research test of 6kW high-efficiency all-solid-state laser

Engineering prototype of 6kW high-efficiency all-solid-state laser
**CASE: R&D and manufacturing of kilowatt all fiber laser**

Shanghai Institute of Optics and Fine Mechanics, the Chinese Academy of Science and Huazhong University of Science and Technology have jointly developed a kilowatt all fiber laser prototype, increasing scale production of single mode all fiber laser from hundred watt to kilowatt. This laser has important applications in cutting sheet metal and welding. With the combination of a high-efficiency all fiber laser and an intelligent machine arm, the goal of flexibility and intelligence of high-efficiency all fiber laser processing (such as welding, cutting, covering, and 3D printing) becomes achievable.
Nanometer materials and devices are involved relevant to many disciplines, and this research field covers a vast area of modern science and industry. China is one of the countries taking the lead in developing nanometer scientific research; currently, it is a world leader in general research, and also among the leading countries in terms of the number of published scientific research papers on nanometers, the frequency of references, and the number of patent applications filed and approved. The total number of SCI thesis ranks No.1 in the world.
LEADING-EDGE NANOMETER MATERIALS AND DEVICES

Leading-edge nanometer materials and devices are applied in areas such as nanometer information material, nanometer biomedical material, serious disease detection and treatment technology, new energy nanometer materials, and environmental friendly nanometer materials. Focusing on cultivating new economic growth areas and promoting a strategic emerging industry, China has developed a series of nanometer materials and devices and established application pilots.

CASE: Industrialization of amorphous, nano-crystalline material and their products

Amorphous alloy (or metallic glass) is a green energy-saving material. A transformer using amorphous alloy as the core material can save 60%-80% of energy compared with a traditional silicon steel transformer, which results in nano-crystalline material and strip with obvious advantage in high-frequency applications. After decades of research, China has mastered key technologies in amorphous nano-crystalline materials and their products, and became the second country to establish amorphous strip production with a capacity of ten thousand tons. A second generation production line has now been put into production, making China's nano-crystalline industry No.1 in the world in output, and establishing China in the world's top three in terms of technology.

Amorphous alloy distribution transformer  Direct injection iron-based nano-crystalline alloy strip  Amorphous alloy strip production line
CASE: Key technology of fluorescent quantum dot nanometer material in the field of rapid disease detection

By adopting an innovative ‘green’ synthesis method without organophosphorous, ‘layer-by-layer growth’ technology, and a controllable new manufacturing process, and by mastering some key technologies such as fluorescent quantum dot nanometer material manufacturing, cladding, surface group decoration, directional coupling with biomolecule, and scale production, a group of researchers from Jilin University and Yunnan University have developed a rapid test process for AIDS marked by fluorescent quantum dot. The lowest detectable amount is 0.1NCU, the accuracy is 99%, and the test time is 10 minutes. It is capable of diagnosing the disease much faster than much more complex equipment, and can be used in situations requiring rapid and accurate test. It boasts promising application prospects.

Test paper of hepatitis B immune marked by modified Au nano-crystalline

Immunochromatography results of immune test paper marked by magnetic nano-crystalline
NANOMETER MATERIALS AND DEVICES IN MANUFACTURING INDUSTRY

Nanometer materials and devices in manufacturing industry include nanometer material green graphic arts technology, nanometer film lubrication technology, and nanometer composite textile materials for transmission and upgrading of traditional manufacturing industries, such as light industry, chemical industry, metallurgy, textile, and building material. China's S&T programs focus on high efficiency energy-saving processes and nanometer material and technology for cleaner production, and supports technological development in traditional industries to improve product quality, lower costs, and achieve energy conservation and emission reduction.

**CASE: Application and industrial development of nanometer material green graphic arts technology**

The Institute of Chemistry of the Chinese Academy of Sciences strongly promotes digitalization and greening process of the printing industry by making the following efforts:

- Taking the lead research and apply special invasion principle of amphiphilic and amphiphobic nanometer surface material to propose initiative nanometer material green graphic arts technology
- Setting up systematic demonstration line, including 300 thousand upgrading nanometer compound transfer material, million square meter super-hydrophilicity panel, ink box production and printing
- Forming sets of system technology with independent intellectual property rights from material, equipment to software.

Sketch map of hydrophilic character of nanometer panel  
Nanometer ink used in nanometer material green printing  
Nanometer green printing plate making machine
**CASE: High polymer matrix nanometer special functional fiber and its industrialization development**

Donghua University is making use of nanometer technology to improve traditional textile chemical fiber industry processes. It has set up a 3,000 ton/year process production line of functional nanometer composite resin, and an R&D and production base for functional nanometer special fiber with a capacity of 10,000 tons per year. Conducting moisture PP fiber and its product, antibacterial polypropylene, and polyester fiber are all in the process of industrialization.

![Complete spinning production line for special high-strength PE fiber](image-url)