Translation

The following article briefly describes 35 different technologies that China must import because it is unable to produce them domestically in sufficient quality or quantity. The article expresses concern that key Chinese industries would be severely hampered if China's supply of these technologies were to be cut off. This article is a PRC Ministry of Education summary of a series of 35 articles—each profiling a different "stranglehold technology"—that a Chinese government-run newspaper published in 2018.

Title
35 Key "Stranglehold" Technologies
“卡脖子”的35项关键技术

Source
PRC Ministry of Education (教育部) website, September 24, 2020. This article is a summary of a series of 35 separate articles that *Science and Technology Daily* (科技日报)—a weekday newspaper published under the auspices of (代管) the PRC Ministry of Science and Technology (MOST; 科技部)—published in 2018.

The Chinese source text is available online at:
https://www.edu.cn/rd/zui_jin_geng_xin/202009/t20200924_2016138.shtml
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Science and Technology Daily has put out a series of articles reporting on 35 “stranglehold” (“卡脖子”) technologies that are constraining China's industrial development, attracting widespread attention and discussion. The following are excerpts:

1. Photolithography machines

These “Details” Keep Top Photolithography Machines a Distant Prospect for China

For the photolithography machines that manufacture chips, it is their precision that determines the upper limits of chip performance. In an exhibition of technological accomplishments under the 12th Five-Year Plan [2011-2015], the best photolithography machines produced in China had a processing precision of 90 nanometers. This is equivalent to the level of the Pentium 4 CPU that hit the market in

2004. Overseas, meanwhile, levels of a dozen or so nanometers have already been achieved.

Photolithography machines have two synchronized workpiece tables, one carrying a negative plate, one carrying film. The two must always be in sync, with tolerances of under 2 nanometers. When the two tables go from static to dynamic states, the acceleration is like that in a missile launch. In operation, they are like two large airplanes moving in perfect tandem from takeoff to landing, with a knife on one plane stretching out and carving a grain of rice on the other, and no carving mistakes are allowed.

2. Chips

ZTE's Chip Problem, China's Worry

Domestic production of low-speed optical and electronic chips has been achieved, but for high-speed ones we are completely reliant on imports. The precision of most advanced mass-produced chips abroad is 10 nanometers, while in China it is only 28 nanometers, a two-generation difference. According to reports, in many fields, including computer systems, general electronic systems, communication devices, memory devices, and display and video systems, the share of chips produced domestically in China is zero.

3. Operating systems

Lost Opportunities: The Pains of a Great Power (大国) *Without a Domestically Developed Operating System*

When ordinary people look at China's flourishing IT industry, they think the technology gap is not great, but in truth it is. Three U.S. companies monopolize mobile phone and PC operating systems. Data indicate that the market share of Android systems reached 85.9% in 2017, and for Apple's IOS it was 14%. Other systems have only 0.1%. This 0.1% is basically also the United States—Microsoft Windows and Blackberry. Without Google having paved the way, smartphones would not be so popular, but the price for Chinese phone makers' free use of Android is that they may “have their food supply cut off” at any time.

4. Aircraft engine nacelles

No Homes of Their Own: The Nacelle Problem of Domestic Aircraft Engines

The compartment where an aircraft engine is housed is commonly called the “housing,” and it is one of the most important core components of aircraft propulsion

systems. Its cost represents around one-fourth of the entire cost of an engine. The nacelle needs to encase the engine so as to reduce drag. Its intake tract should also have the ability to de-ice and prevent ice, and it must protect the engine from interference with normal work while in flight. On the ground, it needs to permit convenient maintenance and repair of the engine. If the nacelle is damaged, it may result in serious engine accidents during flights. The larger the nacelle is, the more difficult the technology becomes. China still faces a yawning gap in this important field. According to publicly available information, China still has no specialized institution for independent development of nacelles, and it seems that relevant institutions have not set up any relevant academic programs.

5. Touch sensors

An Oversight in Sensors, a "Domestic Touch" for Slow-Witted Robots

Touch sensors are core components of industrial robots. Exacting accuracy and stability requirements have stopped most enterprises in China from getting into touch sensors. At present, domestic sensor companies are mostly engaged in the production of gas sensors, temperature sensors, and other types. In an industry with over 100 enterprises, almost no sensor manufacturers produce touch sensors. Japanese array sensors priced at Chinese yuan Renminbi (RMB) 100,000 can distribute 100 sensitive elements in a 10 cm × 10 cm matrix, while domestic products are mostly one-point type (一点式), and generally cost RMB 100 each.

6. Vacuum evaporators

Vacuum Evaporator Shortage: A Shadow over High-End Displays

The "heart" of the organic light-emitting diode (OLED) panel manufacturing process. Japan's Canon Tokki monopolizes the high-end market, holding the industry by the throat. Industry forecasts of its annual output are usually between a handful to a dozen or so. You may have money, but they cannot be purchased and that's the end of it. In depositing organic light-emitting materials onto substrates, Canon Tokki can control errors to within 5 microns (1 micron is 1% of the diameter of a human hair), and no other company's evaporators can reach this level of precision. At present, China has no enterprises producing such evaporation machines, so we do not have much of a voice in this field.

7. Radio frequency (RF) components for mobile phones

RF Components: For Mobile Phones, an Embarrassing Reliance on Others

One-third of the space on a mobile phone motherboard is RF circuitry. The current trends in mobile phones—thinner, with lower power consumption, more frequency bands, greater bandwidth—pose challenges for RF chips. RF chips convert digital signals into electromagnetic waves. 4G phones must support a dozen or more frequency bands, with information bandwidth in the tens of megabytes. In 2018, the RF chip market was worth some U.S. $15 billion. The high-end market is essentially monopolized by three firms—Skyworks, Qorvo and Broadcom—although Qualcomm also has its foot in the door. Another key element in RF components is filters (滤波器), and the domestic-foreign gap is even greater. The market for the high-end filters used in mobile phones is several billion dollars, and belongs entirely to Qorvo and other foreign RF giants. China is the world's biggest producer of mobile phones, yet it is unable to make high-end RF components for mobile phones. That will require a solid accumulation of materials, processes, and design experience.

8. iCLIP technology

"Targets" Are Elusive, Leaving Domestic Production of Innovative Drugs in a Fog

Individual-nucleotide resolution Cross-Linking and ImmunoPrecipitation (iCLIP) is an emerging experimental technology, and is one of the most critical technologies for the development of innovative drugs. Its invention allows people to dispense with sophisticated observation instruments when determining where ribonucleic acid (RNA) and proteins "intersect," and it can even read the "code" of individual sites. iCLIP technology is difficult. Like looking for one person among a sea of tens of thousands of people, it must find one or a few definite binding sites among billions of base pairs, so one can imagine the accuracy involved. Foreign research teams have already launched a "technology race" in this field, with rounds of research papers coming out in cycles of a few months. Very few domestic labs have mature experience.

9. Heavy-duty gas turbines

"*Weakness Between the Kidneys*" (命门火衰)—*The Blade Wounds of Heavy-Duty Gas Turbines*

Gas turbines have broad applications in ships, trains, and large power stations. China has independent capability (自主化能力) in light gas turbines, but for heavy-duty gas turbines it essentially depends on imports. The main heavy-duty gas turbine makers internationally are GE in the United States, Japan's Mitsubishi, Siemens in Germany, and Italy's Ansaldo. Cooperation with China comes with harsh conditions: Design technology is not transferred, nor is the core hot-section (热端) component manufacturing technology, and only non-core components are licensed to be

manufactured in China. Not having independent capability means that an important link in China's energy security remains subject to control by others, and a risk of being “strangled” exists.

10. LiDAR

LiDAR Dimness Leaves Autonomous Driving in a Tangle

Light Detection and Ranging (LiDAR) is a sensor that comes with its own light source. It actively emits laser beams to sense its surroundings, like a bat using echolocation. It is a necessary component of self-driving cars, and it determines the level of evolution of the autonomous driving industry. In this field, however, Chinese products have almost no influence. Among self-driving cars with LiDAR currently on the road, almost all use products from Velodyne in the United States. Their LiDAR products are the industry standard, and account for over 80 percent of market share.

11. Airworthiness standards

Airworthiness Standards: Another Difficult Hurdle for Domestic Aircraft Engines

For an aircraft engine to obtain a flight release certification, it must go through a rigorous set of verifications for the “airworthiness” standards system, including for design, manufacturing, verification and management. But at present, airworthiness verifications by the Federal Aviation Administration (FAA) and European Union Aviation Safety Agency (EASA) have the greatest influence and the highest levels of recognition internationally. Even though China has basically the same rules and requirements as the FAA, China's airworthiness regulations lack corresponding technical support due to the paucity of domestic aircraft engine models, as well as the lack of practical engineering experience. Airworthiness verification of actual models has become a barrier that leaves them stuck outside the airspace of other countries.

12. High-end capacitors and resistors

Without This Know-How, High-End Capacitors and Resistors Will Remain Beyond Our Reach

Capacitors and resistors play major supporting roles in the electronics industry. China is the largest market for electronic components, consuming trillions of resistors and capacitors every year. But the best consumer-grade capacitors and resistors come from Japan. The market for capacitors is over U.S. $20 billion annually, and for resistors it's also in the tens of billions of dollars. For so-called high-end capacitors and resistors, the most important thing is that [components in] the same batch should be as identical

as possible. Japan does the best in this respect, and the gap for domestic enterprises is large. The products of domestic enterprises mostly belong to the low end, and are comparatively weak in terms of processes, materials, and quality control.

13. Core industrial software

Core Industrial Software: China's "Uncharted Territory" in Smart Manufacturing

China's core industrial software sector basically remains an "uncharted territory." This industrial software vacancy creates headaches for smart manufacturing. When the complexity of industrial systems reaches a certain level, it is necessary to replace human brain calculation with computer-assisted industrial software. For example, for electronic design automation (EDA) industrial software, an "essential tool" in chip design and production, there is in principle no difference between domestically produced EDA and mainstream EDA from the United States, but the difference in software performance is not a small one, mainly reflected in a lack of support for advanced technologies and processes, and there is a "generation gap" compared with advanced EDA tools from abroad. Three overseas EDA giants—Cadence, Synopsys, and Mentor—account for 70% of total revenue in the industry globally. Development of an independent industrial operating system + independent industrial software system (自主工业操作系统+自主工业软件体系) must not be delayed.

14. ITO target materials

Unable to Sinter Large-Size Targets, Panel Display Manufacturing Depends on Others for Survival

Indium tin oxide (ITO) sputtering target materials (靶材) have a wide-ranging market worldwide. They are not only used for making liquid crystal displays (LCDs), flat panel displays, plasma displays, touch screens, electronic paper, and OLEDs, but also for solar cells and anti-static coatings, transparent conductive films for electromagnetic interference (EMI) shielding, etc. The thickness of ITO films varies depending on functional requirements, but generally ranges from 30 nm to 200 nm. In terms of this size issue, there have been few breakthroughs among domestic ITO target material companies, and instead, back-end flat panel display makers must turn to others to survive. To sinter large ITO sputtering target materials, you need to have a large sintering furnace. Abroad, it is possible to do single target materials that are 1200 mm wide and nearly 3000 mm long, while domestically only those with widths under 800 mm can be manufactured. In terms of output efficiency, the monthly output of Japanese-style equipment is 30 tons to 50 tons, while our output is only 30 tons

annually. And importing a piece of equipment costs RMB 10 million, an astronomical sum for small domestic enterprises.

Our annual ITO target material consumption is more than 1,000 tons, about half of which is imported to produce high-end products.

15. Core algorithms

With Inept Algorithms, Domestically Produced Robots Are a Bit "Slow"

China has already been the world's largest robotics application market for five years running, yet reliance on imports for high-end robots persists. Due to a lack of core algorithms, domestic industrial robots are far inferior to the products of the "big four" in industrial robots—FANUC (Japan), ABB (Switzerland), Yaskawa (Japan) and KUKA (Germany)—when it comes to stability, failure rate, ease of use, and other key indicators. The gap in core algorithms is excessive, resulting in poor stability and high failure rates among domestic robots. The algorithm gap is not only reflected in core controllers, but also slows down servo system response speeds.

Every action a robot completes requires the coordinated operation of the core controller, servo drivers, and servo motors. For a single servo system, domestic robots have high dynamic and static accuracy, but high-end robots generally have six or more servo systems at the same time, and it is difficult to achieve good control results with traditional control methods.

16. Aviation-grade steel

Weak in Aviation-Grade Steel, Large Domestic Aircraft Lack Support for Takeoff and Landing

The landing gear is the only component that supports the aircraft, whether it's taking off or landing. During the landing phase in particular, it carries the load not only from the weight of the fuselage, but also from the huge impulse of the aircraft in the vertical direction. As a result, the material strength of the landing gear must be exceptionally good, and one must rely on special-purpose steel. The most widely used type currently is 300M steel from the United States. To improve the surface quality, the material uses vacuum heat treatment technology, avoiding defects such as hydrogen permeation, component surface brightness, no oxidative decarburization, carbonation, and intergranular oxidation. The domestic super-strength steel used in China to make landing gear sometimes has point defects, sulfide inclusions, coarse crystals, internal cracks, heat treatment hydrogen permeation and other problems. These problems are related to insufficient purity in the smelting process. So, there is a big gap between

China and the United States in high-purity smelting technology, and there is much room for improvement.

17. Milling cutters

For High-Speed Railway Track "Facelifts," Domestic Milling Cutters Are Not Up to the Task

With China's rapid construction of high-speed rail in recent years, track maintenance problems are making domestic experts increasingly concerned. If maintenance is not done properly, it will not only cut life cycles short, but will also lead to high risk of hidden dangers. China's independently innovated (自主创新) and developed robotic equipment for dual-power electric drive milling and grinding maintenance—a milling and grinding car known as the rail "ambulance"—can be a "bodyguard" for railway tracks. But the core milling cutter components of the milling and grinding cars still have to be imported from abroad. The material in milling cutters is a kind of super-hard alloy material. We already know the metallic ingredients, but not how they are proportioned and synthesized, much like figuring out the ancestral recipe of a certain Chinese medicine, where it is not all that clear what the ratios of various herbs were.

18. Steel for high-end bearings

High-End Bearing Steel, a Difficult Shortcoming for Chinese Manufacturing to Overcome

An indispensable core component in machinery and equipment, bearings support rotating mechanical bodies, reducing their coefficient of friction and ensuring their rotary accuracy. Whether it is aircraft, automobiles, high-speed rail, high-precision machine tools, or meters and instruments, they all need bearings. This places high demands on their precision, performance, service life, and reliability. And China's axle-making technology is close to the world's top level, but almost all the material, that is, high-end bearing steel, relies on imports.

The R&D, manufacturing, and sale of high-end bearing steel are basically monopolized by the world's bearing giants, Timken in the United States and SKF in Sweden. In previous years, they established bases in Yantai and Jinan, procuring low-end materials in China, using their core technology to make high-end bearings, and selling to the Chinese market at ten times the cost. Adding rare earths in the steelmaking process can make the original high-quality steel become even "stronger." But how are they added? That is the core secret of the world's bearing giants.

19. High-pressure piston pumps

High-Pressure Piston Pumps: A Thorn in the Side of China's Equipment Manufacturing Industry

Hydraulic systems are one of the key components of the equipment manufacturing industry. They are indispensable in all areas of engineering that involve mechanical equipment scenarios. High-pressure piston pumps are core components of high-end hydraulic equipment, and have been called the “heart” of hydraulic systems. China's hydraulic industry became the world's second largest in 2017, but the industry is large without being strong, especially in high-pressure piston pumps with rated pressures of more than 35MPa, for which China depends on imports for 90% or more. Domestically produced hydraulic piston pumps have large gaps compared with foreign brands in terms of technical advancement, reliability, service life, variable mechanism control functionality, and dynamic and static performance indicators, which are basically equivalent to the level overseas in the early 1990s.

20. Aviation design software

Aviation Software Plight Has Domestic Aircraft Design under a “Paralysis Curse”

After the 1980s, the world's aviation industry entered a new digitalized design phase. Now, the reliance on software has reached a level at which design is impossible without it. Designing an aircraft requires at least several dozen different kinds of software, and they are all products from countries in Europe and North America. Domestic design organizations not only have to invest huge amounts of money to buy software, but also have a paralysis curse hanging over their heads: If ever the curse is invoked, a “tight band” will paralyze the entire aviation industry. According to media reports, when designing the J-10 (歼-10) aircraft, all of the metal parts of the main landing gear's principal bearing structure were commissioned to be manufactured abroad. After it was built, there was a problem with the retraction of landing gear: There was a 5mm error, so it had to be reordered and manufactured again. This one little error delayed the first flight of the J-10 by eight or nine months. Without the support of fully digital software, any small error may become a nightmare for the manufacturing industry.

21. Photoresists

China's Semiconductor Industry Losing Its Luster Due to Photoresists

Although China has become the world's largest producer of semiconductors, the panel industry production chain as a whole is still relatively backward. At present,

imports are relied on for almost all photoresists used in LCDs. This core technology has so far been monopolized by TOK, JSR, Sumitomo Chemical, Shin-Etsu Chemical, and other Japanese enterprises. Consider [Chinese tech company] BOE Technology, which has a certain competitive strength internationally. It has established 17 panel display production bases, 16 of which have been put into operation. But the photoresists BOE uses for high-end panels is still provided by foreign enterprises. The main components of photoresists are polymer resins, color pastes, monomers, photoinitiators, solvents, and additives. Their development involves numerous technical challenges, which require making adjustments across various aspects such as oligomer structure design and screening, synthesis process determination and optimization, active monomer screening and control, color paste fineness control and stability, product formula design and optimization, product production process optimization and stability, final use condition matching, and tolerance adjustment. Therefore, a very high level of technical difficulty is involved if you want to develop and produce it independently.

22. Common rail systems

When Common Rail Is No Good, Domestic Diesel Engine Production Suffers

Electronically controlled diesel common rail systems are like the “hearts” and “brains” of diesel engines, and how good or bad their quality is seriously affects the use of such engines. The diesel engine industry is an important equipment foundation for promoting a country's economic growth and social functioning. Globally, China is the main market for, and producer of, diesel engines. However, enterprises in Germany, the United States, and Japan have the lion's share of the domestic market for electronically controlled common rail systems in diesel engines. Domestic common rail systems still have certain gaps compared with the products of leading foreign companies in terms of performance, functionality, quality, and consistency, yet they do not have a clear cost advantage.

23. Transmission electron microscopes (TEMs)

High-Definition 3D Photographs of Our Proteins Dependent on Foreign TEMs

Electron cryomicroscopy, which can take high-definition 3D “color photos” of microstructures, is a powerful tool for life science research. TEM production capability is one of the foundations of electron cryomicroscope manufacturing capability. At present, there are only three firms in the world producing TEMs: JEOL, Hitachi, and FEI in Japan. No domestic enterprises produce TEMs. The tools used in conjunction with electron cryomicroscopy need to be produced in the country of origin. When parts break, no one can be found to repair them, and you have to wait for the parts to arrive in the mail

before they can be replaced. For Chinese electron cryomicroscope users, this kind of experience may well continue for a long time.

24. Main bearings of tunnel boring machines

Chinese-Made Tunnel Boring Machines Have to Use Main Bearings from Others

Called the “heart” of a full-section tunnel boring machine, the main bearing bears the main load of the machine during operation. It is a key component of the cutter head drive system, working under very adverse conditions. Compared with traditional rolling bearings with diameters of only a few hundred millimeters, the main bearing of a tunnel boring machine is generally several meters in diameter, and is the most complex of bearings structurally, requiring hundreds of manufacturing processes. In terms of tunnel boring machine manufacturing capability, domestic tunnel boring machines are close to the world's most advanced level, but they all depend on imports for the most critical main bearings. The market is dominated by Germany's Rothe Erde, IMO, and FAG, and Sweden's SKF.

25. Microspheres

Microspheres: The unbearable lightness of national industry

Microspheres (微球) have diameters one-thirtieth the width of a human hair. In mobile phone screens, each square millimeter requires a hundred microspheres. Two glass panels are held up, equivalent to a skeleton, and liquid crystal is then poured into the gap between the two glass panels. Without microspheres, the LCD screen you are looking at could not have been produced. Without them, chip production, food safety testing, disease diagnosis, biopharmaceutical manufacturing, environmental monitoring...many industries would be in dire straits. In the field of microelectronics alone, China imports tens of billions of RMB worth of microspheres annually. With an industry scale of about U.S. $100 billion, mainland China's LCD panel shipments reached 33% of the world total in 2017, making it the world leader. But only one or two companies in the world can provide the key materials in these panels—spacer microspheres, as well as conductive gold microspheres. These materials, like chips, have people in a stranglehold.

26. Underwater connectors

With No Domestic Producers of Underwater Connectors, Seafloor Observation Network Depends on Others

Along with ships and remote sensing satellites, seafloor observation networks have become a third kind of ocean observation platform. Through them, humankind can delve deep into underwater observation and understanding of the ocean. If the different kinds of moored observation platforms are likened to arms and legs, underwater connectors are like joints. They play irreplaceable roles in the construction, operation and maintenance of subsea observation network systems. At present, China's underwater connector market is basically monopolized by foreign countries. If such connectors were to be embargoed, construction and operation of the entire submarine observation network would be brought to a halt.

27. Key fuel cell materials

Without Three Key Materials, Fuel Cell Commercialization Will Be Hard to Achieve

Foreign fuel cell vehicles have achieved mass production, but China's automotive fuel cells are still in the technology validation phase. The current state of China's automotive fuel cells is: almost no component manufacturers, no vehicle stack (车用电堆) production companies, and only a very small number of fuel cell vehicles in commercial operation. There are a number of key materials that determine the service life and performance of fuel cells. China is not completely without these materials, and some lab results have even reached international standards. There are no batch production lines, however, and the fuel cell production chain is still obstructed. China has long been dependent on foreign countries for the key materials, and if they were to be embargoed, China's fuel cell industry would be without a basic supporting component.

28. High-end welding power sources

Domestic Production of Welding Power Sources "Misfires," Frustrating Underwater Robot Operations

With a sea area of more than three million square kilometers, China is a maritime power (海洋大国), and is vigorously developing high-end marine resources and equipment to defend its maritime rights. When ocean equipment develops cracks and other failures, they need to be repaired using welding equipment, sometimes called the "sewing machines" of industrial manufacturing. Underwater robots are relied on to achieve deep-sea welding. Although China has the world's largest welding power source manufacturing base, with an annual production capacity of more than 10 million units, high-end welding power sources are still basically monopolized overseas. Improving China's underwater robot welding technology has long proven difficult. The reason is that high-end welding power source technology is controlled by others (受制

干人). Overseas, fully digital control technology for welding power sources is already relatively mature, while domestically, analog control is still the dominant technology.

29. Lithium battery separators

Single-Layer Separators, Two Very Different Environments: Domestic Lithium Battery Production Still Waiting for the Clouds to Part

As the “heart” of new energy vehicles, domestic lithium-ion batteries (“lithium batteries”) are still not stable enough. Of the four core battery materials, we have achieved domestic production of (国产化) positive and negative electrode materials and electrolytes. Only separators continue to be a weakness. High-end separator technology has fairly high barriers. Not only must huge amounts of money be invested, but it also requires strong R&D and production teams, sophisticated process technology and high-level production lines. For high-end separators, there is still heavy reliance on imports.

30. Components for medical imaging equipment

Dull Detectors Blur Medical Imaging

Most domestically produced medical imaging equipment currently relies on imports for components, and at least ten to twenty years will be needed to reach the existing levels of others. In traditional medical imaging (computerized tomography [CT] and magnetic resonance imaging [MRI]), China's earliest patents came twenty years after those of the United States. In terms of patent numbers, the United States has ten times as many as China. This means that the entire industry is already in the hands of foreign enterprises. All the intellectual property rights, original achievements, and accumulated scientific research are in foreign countries, and China accounts for only a small portion.

31. Ultra-precision polishing techniques

In Ultra-Precision Polishing Techniques, the Road to the Top is Long and Rocky

How important is ultra-precision polishing in modern manufacturing? Its application areas can shed light on this question directly: integrated circuit manufacturing, medical devices, automotive parts, digital parts, precision molding, and aerospace. “It's the soul of technology.” The United States and Japan have firmly seized the initiative in the global market, and the composition of their materials and their manufacturing processes have always been mysteries. In other words, buying and using their products does not mean you can imitate or even copy their products.

32. Epoxy

Insufficient Resiliency in Epoxy Means Domestic Carbon Fiber Lacks Strength

The quality of carbon fiber can be compared to metals—lighter than aluminum, but stronger than steel—and it is also characterized by high temperature resistance, corrosion resistance, fatigue resistance, and creep resistance. One of its key composite materials is epoxy (环氧树脂). However, the epoxy resins currently used in the domestic production of high-end carbon fiber are all imported. At present, China has been able to produce T800 and other types of high-end carbon fiber, but then Japan's Toray Industries mastered this technology in the 1990s. Compared with carbon fiber, China's high-end epoxy industry lags gravely behind the international situation.

33. High-strength stainless steel

The Intractable "Rust Disease" of Rocket Engines

The steel used for rocket engines needs to have a number of characteristics, among which high strength is an important target that must be met. However, in the strength and rust resistance of stainless steel, there are trade-offs that are very difficult to get right. If rocket engine material rusts badly, the impact will be great. Relying completely on the material itself to achieve both high strength and rust resistance performance—this is a worldwide challenge. Most of the materials now used in China's aerospace industry are materials that were used abroad in the 1960s and 1970s. Developed countries strictly control the content of impurities in the production process. If the purity is substandard, it's back to the furnace, but domestic manufacturers often lack this kind of rigorous attitude.

34. Database management systems

Database Management Systems: China still Looking for the "Right Way to Open"

The two most popular database management systems in the world today are Oracle and MySQL, both of which are Oracle Corporation products. Competitors include products from IBM and Microsoft, among others. A handful of U.S. companies—Oracle, IBM, Microsoft, and Teradata—account for most of the market share. Chinese database management system products also have some market share, but only a fraction, and their stability and performance have not convinced the market. Banks, telecommunications, electricity, and other enterprises with extreme stability requirements will not consider Chinese products.

35. Scanning electron microscopes (SEMs)

SEM "Visual Impairment" Makes Penetrating Observation Difficult for Industrial Manufacturing

SEMs, known as "microscopic cameras," are high-end electron optics instruments widely used in materials science, biology, medicine, metallurgy, chemistry, semiconductors, and other research fields and industrial sectors. China relies heavily on imports for the SEMs used in research and industrial sectors. Each year China spends more than U.S. $100 million on the hundreds of SEMS we purchase, mainly from the United States, Japan, Germany, and the Czech Republic, among other countries. Domestically produced SEMs only account for 5% to 10%.