Research on 5G related technologies under the new generation of information technology

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Abstract. At present, 5G refers to a vital direction for evolving and upgrading new generations of information technology, and the Industrial Internet critically supports the fourth industrial revolution. 5G has acted as a novel driving force to lead the innovation and stimulate the novel types of information. From a technical perspective, in the 5G field, ultra-low-loss high-reliability copper-clad laminate materials employed in 5G high-speed communications (56Gbps, 112Gbps), 5G metamaterials and low-loss high-performance RF technology, and 5G low-loss magnetoelectric functions. For materials and devices, multi-module integrated printed circuits for 5G communication base stations, manufacturing of 5G communication optoelectronic integrated cables, and multi-channel high linearity and large dynamic range RF optical transceiver integrated modules in terms of 5G mobile communication will show critical significance, as well as in smart agriculture application and demonstration. From an application perspective, China has made it clear that it will start 5G commercial use in 2020, and has issued 5G licenses ahead of this year, which is also leading in the world. 5G fully complies with the future trends of human progress, social development and economic growth. Inevitably, its large-scale applications will be achieved and will expand to a wide range of industries and fields, extended to all aspects of the economy and society, alter human consumption patterns, and transform human production, which can provide a powerful means for the high-quality development and governance of society.

1. Introduction

2020 is recognized as the first year that 5G communication technology is officially put into commercial use. 5G, a vital project at the national strategic level of China, will be vigorously promoted and applied. As early as the 4G era [1], global mobile Internet traffic broke out. As suggested by the statistics from the Ministry of Industry and Information Technology, domestic mobile Internet traffic has doubled year after year, and the growth rate is significantly higher than the global average growth rate of 15%. High-definition video, Internet of Things (Internet of Vehicles), VR/AR and other application scenarios have progressively emerged, which has brought with it a strong demand for enhanced mobile broadband, massive connections, low latency, as well as highly reliable communication technologies [2-3]. 5G, a breakthrough mobile communication technology, will lead an emerging era of communication development under the two-wheel drive of user needs and
national investment [4]. Communication application transmission will be leading edge. Optical communication, the core of the wireless communication basic network, will be the first sub-sector to benefit in the construction of 5G communication infrastructure [5]. The 5G mobile communication network about to be commercialized should keep the overall energy consumption and overall cost of the network not to increase under 1000 times of traffic growth provided. Accordingly, the strict requirements of ultra-large capacity, high energy efficiency and low cost will give 5G mobile communication system design a severe challenge.

The base station refers to a signal exchange center for 5G communication. The base station equipment and components should be compatible or comply with the signal exchange center to exert high-quality communication effects. The multi-module integrated printed circuit board exhibits the advantages of high and low frequency hybrid transmission design, local high-efficiency heat control and high-density interconnection integration. It is an indispensable carrier component to ensure the reliable transmission of 5G base station signals [6]. High-performance, miniaturized and integrated radio frequency electronic components, electromagnetic metamaterials (metamaterials) are composite materials that have been processed or synthesized by manual methods, have periodic or quasi-periodic structures, and specific electromagnetic properties, and emerged in the early 21st century. The 5G base station radio frequency chip consists of power amplifier (PA), filter, duplexer, radio frequency switch (Switch), low noise amplifier (LNA), receiver/transmitter, etc. The performance of the 5G base station radio frequency chip is becoming more and more important in the RF receiver signal path, because it largely determines the strength of the 5G signal and the achievable low bit error rate [7]. If the performance of the 5G base station RF chip is insufficient, the remaining design work in circuit and receiving channel management will not be capable of satisfying the high-performance requirements of 5G. With the emergence of a new generation of semiconductor novel process technologies (e.g., silicon germanium SiGe, gallium arsenide GaAs and silicon-on-insulator SOI), the performance of 5G base station RF chips has been effectively enhanced to satisfy the needs of 5G development.

With the arrival of the 5G market, the single-channel transmission rate of PCB links has been gradually elevated from the original 10Gbps to 25Gbps. To achieve faster transmission rates and greater data capacity, the single-channel rate will be further elevated to a single channel 56Gbps, even at 112Gbps, thereby causing the basic frequency of signal transmission to increase from the current 5GHz, 12.5GHz to 14GHz or even 28GHz [8]. With the increase in the frequency, the transmission loss of the link will become more significant, so PCB substrates essential for signal transmission are required to have extremely low losses. The PCB substrate material for high-speed transmission refers to a key basic material for 5G applications in the future. At present, nations are competing for the standard-setting power of 5G communication. As impacted by the high cost of network deployment and the continuous evolution of technology, 5G networks cannot achieve full coverage in a short period. Thus, they should draw upon the existing 4G LTE network for deployment [9]. Non-independent networking (NSA) has become a vital scenario for 5G NR deployment. In the non-independent networking mode, the mobile terminal will work in both the LTE network and the NR network. Under the network spectrum planning, there are scenarios with the NR network frequency band nearly twice that of the LTE network frequency band. The harmonics of the LTE uplink signal will trigger serious interference to the reception of the NR downlink received signal. As a result, the terminal's business cannot proceed normally, and the 5G service experience has dropped dramatically. Great challenges are imposed on 5G antenna design. First, the complex boundary conditions caused by the mobile terminal installation environment limit the performance of the antenna; second, the contradiction between limited antenna space and multi-band/wide-band coverage, and the terminal MIMO multi-antenna The problem of strong electromagnetic coupling caused by short-distance layout. 5G, the fifth-generation mobile communication network, has become a part of China's national strategy [10]. The development of high-speed access networks has promoted the rapid development of optical communication backbone networks, FTTX, triple play, data centers, 5G and other industries. The opportunities it brings are undoubtedly huge, and the scale of China's base stations will reach the 100 billion market by 2020.
2. Explore the challenges of 5G core material devices and key technologies

Though the 5G specification standard has been completed, it is still being continuously improved and developing. Of course, 5G core material devices and key technologies are the same.

2.1. Ultra-low-loss high-reliability copper-clad laminate for 5G high-speed communication (56Gbps, 112Gbps)

Dielectric properties, glass transition temperature, thermal decomposition temperature of functionalized polyphenylene ether resin and special crosslinking curing agent. The key technologies used are free radical curing technology, glass fiber cloth selection, development of new filler types and content selection, flame retardant selection, etc. [33-36]. By regulating the proportion of formula resin, the prepared prepreg exhibits high manufacturability and low volatility, which achieves the balance of dielectric properties and heat resistance of high-speed substrates; besides, it shows good processability in the PCB processing stage, which is suitable for meeting 5G high-speed Ultra low loss electronic circuit substrate for communication.

2.2. 5G metamaterials and low-loss high-performance RF technology

It primarily works in the high-frequency band 3.3-5.0 GHz. For the 5G antenna array, the loss of the existing 141 coaxial cable is excessively large, about 1dB/m, and it cannot provide a more stable phase. The wireless less antenna array uses waveguide feed technology to reduce losses and provide consistent phase. Based on three-dimensional photonic crystal metamaterials, most known metamaterials are composed of randomly oriented conductive elements mixed with non-conductive elements [11]. It is difficult to produce a uniform material with ideal dielectric properties by randomly mixing the conductive part and the non-conductive part. The process is complex, unsuitable for mass production, and heavy; the density of the new metamaterial should be less than 65kg/m3. Compared with similar materials known, this material is suitable for automated manufacturing and is suitable for the production of focused multi-beam antenna lenses. New metamaterials should reliably isolate conductive particles and eliminate passive intermodulation that may result from metal-to-metal contact. The structure of the new metamaterial provides ideal dielectric properties. This material has the characteristics of an anisotropic dielectric material or an isotropic dielectric material. Accordingly, this material applies to the manufacture of various focusing lenses. New metamaterials can provide uniform and variable dielectric constants along the layer. The new metamaterial has heat dissipation channels to focus high-power electromagnetic waves. The new metamaterial has low loss, and its insertion loss is in the order of 10-4.

2.3. R&D and industrialization of 5G low-loss magnetoelectric functional materials and devices

With the rapid development of 5G communication technology and the blowout requirements for various high-performance, miniaturized and integrated RF electronic components, by exploiting the advantages of China's rich rare earth resources, independent research and development consists of serial low-temperature co-fired RF ferrite ceramics, microwave media. The core magnetoelectric functional materials urgently required by the 5G industry (e.g., electroceramics and microwave ferrite ceramics) realize LTCC (low temperature co-fired ceramics) high-frequency inductors, resistors, filters, antennas, circulators/isolators, etc. Mass production of small-scale integrated RF electronic components enables R&D and production technologies in the relevant field to fully achieve independent domestic substitution. It is and is applied in 5G typical scenarios (mainly 5G base stations, 5G mobile phones and Internet of Things). The importance is presented below: it can fundamentally address the contradictory root problem between low-temperature co-firing of the full-band LTCC material and good electromagnetic, force heat, and integration performance, which will show a greater application for passive/active system integration materials and devices in the future, enhance the role, invent the LTCC gyromagnetic (30-100GHz) and millimeter-wave low-loss microwave ceramic material system to underpin the application of the material in future communications, realize composite multi-performance LTCC materials in the radio frequency band,
microwave, as well as millimeter wave band. In the future, the LTCC process will exhibit simpler structures, better integration and lower cost for filters and combination modules. Moreover, passive and silicon-based active integrated systems or components can be assembled on multiple chips to truly achieve microwave communication and radar. SIP miniaturization of components and mobile communication systems.

2.4. Key technology and industrialization of multi-module integrated printed circuit for 5G communication base station

The 5G industry chain ecosystem can provide supporting core components for 5G communications. It should break through the technical bottlenecks of multi-module integrated printed circuit printed circuit boards and realize independent research and development of multi-module integrated printed circuit boards for 5G communication base stations. Specific to industrialization, there are the problem of reliable signal transmission, the problem of efficient heat release, as well as high-density interconnection integration and industrial manufacturing.

2.5. R&D and industrialization of key technologies for the manufacture of photoelectric integrated cables for 5G communications

The first problem to be addressed in 5G communication is that the long distance and long-distance connection between the signal and the power supply requires large bandwidth and high power. Thus, the photoelectric integrated cable is the optimal choice for 5G wireless coverage. However, as impacted by the more complex application scenarios of 5G, the cables supporting them also have a series of new requirements, making development extremely difficult. Though the 5G communication standards are unified globally, the specific solutions of various communication equipment manufacturers are different. At the early stage, the relevant Chinese manufacturers have conducted considerable matching tests with the communication equipment of Huawei and ZTE to form industry standards. Together with Huawei, this solution is recommended to IEC to form an international standard. The butterfly optical cable has the characteristics of miniaturization and easy construction. Strictly symmetrical and tight cable forming technology is adopted to make the product structure stable, tensile, compressive, not easy to bend, not easy to twist and other performance advantages, which can meet various construction conditions. Moreover, strict symmetrical and tight cable formation technology is adopted to make the product structure stable, tensile, compressive, not easy to bend, not easy to twist and other performance advantages, which can meet various construction conditions. In the complex application scenarios, fiber fusion splicing technology cannot be used, so one of the vital technologies for the success of on-site quick splices. By employing precise size control and multi-layer tight cladding technology, the optical unit and the quick connector are perfectly matched. Thus, the joint is convenient, and the reliability turns out to be high. The miniaturization and high power of 5G equipment have caused large heat generation. Accordingly, high-temperature resistant materials are used to make them easy to process. Moreover, they are resistant to high temperature and high flexibility, and can be used under high temperature conditions for a long time.

2.6. Research on Multi-channel High Linearity and Large Dynamic Range RF Optical Transceiver Integrated Module for 5G Mobile Communication

To comply with the major requirements of ultra-broadband dynamic analog transmission and low-power wireless access in 5G mobile communications, centering on the new requirements and challenges of the microwave and light wave fusion access system by exploiting the changeable and diversified services, the support in the 20GHz frequency band exceeds 4 Multi-band, multi-standard wireless signal multi-channel (≥4) integrated optical transceiver module to achieve multiple services, large dynamic, long-distance fiber distribution and multi-domain resource centralized management and control of a new generation of microwave optical wave fusion access and ubiquitous spectrum sensing system. The optical fiber transmission distance exceeds 20km, the system SFDR reaches over 95dBHz2/3, and a verification platform is built. The key chips and devices of high-performance RF
optical modules achieve the overall improvement and practicability of optical link performance indexes, realize the broadband, high linear, high power, multi-channel analog direct modulation laser technology, and realize the broadband, high linear, low insertion loss modulation. Its array technology, high-power broadband photoelectric detection array receiving technology, low noise analog optical amplifier technology and multi-mode integrated RF optical module are also realized.

2.7. 5G communication and all-optical network super large core number optical fiber cable and industrialization

As impacted by the advantages of high-density, easy installation and installation of optical fiber ribbons, convenient off-line or branching, and fully dry water-blocking and moisture-proof structure, the skeleton optical cable simplifies the conventional structure of optical fiber extraction, fiber drop, and connection work to the greatest extent. The pain points and difficulties of the application link are favored by operators and integrators. Given the characteristics of 5G technology's own communication architecture and large data transmission capacity, and the optical fiber expansion problem of the last 1 km of the FTTH entrance of the all-optical network. The large core number expansion of the skeleton optical cable turns out to be the most urgent product problem to be solved in the construction application of the skeleton optical cable. Technical breakthroughs have been made from fiber coloring technology, skeleton tension control technology, optical fiber in-groove technology, water blocking tape wrapping technology, and optical fiber and tape technology, which has tackled down the production bottleneck and flatness quality problems of coloring process and skeleton cable forming process, as well the cost of auxiliary materials (e.g., resin). Through optimization and experimental calculation and with the optimization parameters of curing power and coating pressure, the tile-like problem attributed to excessive curing of the optical fiber ribbon is addressed. Moreover, the problem of excessive flatness of the optical fiber ribbon resulting from uneven coating pressure is tackled down. By optimizing the guide rail and position of the optical fiber mold, the frictional force between the mold and the guide plate and the squeezing force between the optical fibers are reduced.

Notably, key science and key technology applied in digital twins are shown in Fig. 2. When the full-factor model of the intelligent production process is constructed for the automatic production line, it needs to realize the rapid learning and design of industrial equipment, as well as the accurate mapping of virtual and real design, resulting in a variety of the production line data and their complex sources[6]. It is difficult to monitor data equipment, product quality, energy consumption and other production line processes. Hence, the relationship between the original design and transfer learning is researched, and the simulation solution methods are integrated to build a simulation solution interface for modelling and data fusion. This will help to develop high-confidence and effective simulation solutions for production line design.

3. Objectives and expected

The formation of objectives and expected for the main content and innovation of these challenges.

3.1. Ultra-low-loss high-reliability copper-clad laminate for 5G high-speed communication (56Gbps, 112Gbps)

The PCB substrate material for high-speed transmission is a vital material for 5G applications in the future. At present, nations are competing for the standard-setting power of 5G communication. It is therefore suggested that 5G communication has risen to the level of national information security and strategy, especially for China’s “2025 intelligence”. The realization of "manufacturing” is a critical foundation.

Main technical indicators reached:

1.    Glass transition temperature Tg (DSC) $\geqslant 180^\circ$C
2.    Dielectric performance $Dk/Df$ (RC56%, 10GH) $\leqslant 3.50/0.0025$
3.    Copper foil peel strength (1OZ HVLP3)$>0.7N/mm$
4. Z-axis expansion coefficient $Z\text{-CTE}<2.5\%$

This pertains to the field of high-speed circuit industry for 5G that China strongly encourages and supports the development. Through the research on this key basic material, the localization of high-performance high-speed substrates is achieved, the core technology of the industry, and the initiative of industrial development are mastered, so that China’s printed circuits The industry continues to develop safely. Moreover, the product performance has surpassed that of Japanese and American counterparts, breaking the technological blockade of advanced countries against China.

3.2. 5G metamaterials and low-loss high-performance RF technology

Electromagnetic metamaterial (metamaterial) refers to a composite material that has been processed or synthesized artificially. It exhibits a periodic or quasi-periodic structure and special electromagnetic properties. Metamaterials emerged in the early 21st century. They have three important characteristics, i.e., a special artificial structure, the physical properties of supernormality, as well as the electromagnetic properties of supernormality. Metamaterials are listed by the US Department of Defense as one of the six major disruptive basic research technologies, and they have been taken as one of the "10 major achievements in 50 years" in the field of materials science and one of the 10 major breakthroughs in the first 10 years of the 21st century. The extraordinary physical properties make the application prospects of metamaterials very wide, and the application scope covers all aspects of industry, military, life, etc. To be specific, electromagnetic metamaterials employed in metamaterial radar antennas, absorbing materials, electronic countermeasure radars, and metamaterial communication antennas will have far-reaching effects. Metamaterial communication antennas have unparalleled advantages over conventional antennas in 5G and large-scale satellite communications (6G) in the future. Thus, the development of metamaterials that can be mass-produced at low cost is strategically significant to China's 5G and future 6G. Based on metamaterial technology, the product's working frequency band is 10MHz-6GHz. As compared with known similar materials, it is light in weight, raw materials are easily available, and the process is relatively simple and suitable for automated production.

Main technical indicators reached:

1. The yield rate reaches 95%,
2. The volume is less than 10%
3. The density reaches 45kg/m$^3$,
4. The dielectric constant is 1.04-1.85

The 4G and 4.5G stock markets are expanded to make money. At present, the traffic is the main contradiction facing operators. If the lens antenna solution is used to split the previous single sector into multiple sectors to increase the network capacity, China’s three major Nearly 4 million base station antennas of operators' base station expansion products need to be replaced by $400*3*5000=60$ billion. To achieve coverage in the identical area for 5G, the number of 5G base stations is at least 3 times that of 4G. Accordingly, the power consumption of 5G will be 12 times that of 4G. China Mobile's electricity bill reached 24.5 billion RMB in 2018. After all upgrades to 5G, China Mobile will pay 294 billion in electricity bills, while China Mobile's profit in 2018 is 117.781 billion RMB. If 5G uses a lens metamaterial antenna, the power of the main equipment of the base station can be reduced by up to 50%. In addition, the device selection of the main equipment of the base station will be wider, the chips and devices will be cheaper, the source channels will be more, they will not be stuck, and the operators will save tens of billions every year.

3.3. R&D and industrialization of 5G low-loss magnetoelectric functional materials and devices

The low-loss problem of broadband LTCC materials is solved, and the large-scale application of novel magnetoelectric materials is realized in 5G communication components. To be specific, it is based on the building of a theoretical model of "atomic cluster" materials, based on the electric domain-
magnetic domain coupling theory to design and optimize broadband low-loss LTCC materials, and find ways to improve its electromagnetic performance, force thermal performance and integrated performance. To yield the optimal formula for broadband low-loss LTCC materials; the "seawater lava method model" is proposed to optimize the simulation of its doping, nanocrystal implantation, domain-domain transfer pinning and other processes to achieve the low temperature of broadband low-loss LTCC materials (900°C) Co-firing. The loss model of LTCC materials is built, i.e., the grain boundary resistance widening band model and the electric domain pinning model. Thus, the material frequency band is widened to the microwave/millimeter wave range. Novel effects of multiphase recombination and co-doping are reported to form glass-dielectric recombination, i.e., magnetic-dielectric composite material system, to achieve multi-performance low-loss LTCC material technology breakthroughs in multiple frequency bands. Moreover, based on the breakthrough of common basic technology of LTCC materials, the original ceramic strip and integration module for RF and microwave devices are designed. Combined with the original ceramic strip technology innovation, the development of RF microwave filters, antennas, circulators, switches, waveguides, etc. The design theory of LTCC integrated device is verified, and LTCC material is developed to realize batch application.

3.4. Key technology and industrialization of multi-module integrated printed circuit for 5G communication base station

The low-frequency medium mixed voltage method is adopted to achieve low-cost multi-band transmission design; the development of low-profile copper processing technology to enhance the integrity of high-frequency signal transmission; the optimization of line etching technology to control single-line impedance errors.

Main technical indicators reached:

1. Number of layers 8~18, thickness 1.2~4.0mm
2. Board warpage ≦ 0.8%; through-hole thickness-diameter ratio ≥ 10:1
3. Single wire impedance deviation ±10%; back drill depth error ≤ 5%
4. Flatness of copper block and board surface ±75μm, copper block thrust ≥ 300N
5. Signal transmission insertion loss ≥ -45dB/m@20GHz
6. 288 degrees 10s/3 times thermal shock or lead-free reflow soldering 3 times, the product will not delaminate and change color

By locally embedding copper blocks and high thermal conductivity composite materials, to achieve efficient thermal control in the board, develop electrodeposition formulations, improve the uniformity of high thickness-to-diameter ratio through-hole plating; develop in-board resistance, improve system integration of functions, and build product systems, performance testing methods as well as evaluation mechanisms.

3.5. R&D and industrialization of key technologies for the manufacture of photoelectric integrated cables for 5G communications

United Huawei, combined with global practical application scenarios, creates a low-cost wiring solution for 5G coverage. It has a range of industry-leading advantages (e.g., high bandwidth, small outer diameter, low weight, high flexibility, high temperature resistance, as well as easy construction). A vital condition for the popularization of 5G communications. 5G communication should be popularized, high-efficiency laying, and low cost are necessary conditions. This product integrates optical units and electrical units, reducing the amount of construction work by half. Moreover, the cost of the product itself is also lower than that of conventional optical cables and cable separation solutions.

Main technical indicators reached:
1. Solve the problem of matching with the interface of 5G communication equipment, the use of 1.6mm × 2.1mm butterfly optical cable is characterized by miniaturization and easy construction.

2. Solve the industry's difficult problems in the construction of optical fiber

3. Solve the problem of quick coupling on site

4. Solve the temperature resistance problem caused by high power and high heat dissipation of 5G equipment

5. Solve the universal compatibility and scalability problems with the device

At present, it is predicted that the demand for Huawei alone is nearly 60,000 kilometers a year, and the sales amount is approximately 600 million; the demand for ZTE is about half of Huawei. Furthermore, the direct purchase volume of the three major domestic operators in China is about 5 times that of equipment manufacturers. This project is the first in the industry. After the success, the total product demand is about 5 billion RMB per year, thereby creating novel opportunity for the entire cable industry and benefiting from upstream raw materials, equipment manufacturers, testing institutions and other links.

3.6. Research on Multi-channel High Linearity and Large Dynamic Range RF Optical Transceiver Integrated Module for 5G Mobile Communication

High linearity and large dynamic range RF optical transceiver integrated chips and modules, based on MZI-PLC silicon-based integrated coupling structure, 42-degree inclined array waveguide coupling method, 3D integrated microwave package design method for electrical design, thermal management and reliability analysis. The 1310nm band multi-channel (≥4) integrated RF optical transceiver module was developed by exploiting the prepared multi-channel (≥4) laser array chip and high-saturation power photodetector array chip. The 3dB bandwidth of each channel is greater than 20GHz, SFDR is greater than 95dBHZ2/3, effectively increasing the number of indoor coverage users. A multi-band, multi-standard wireless signal multi-channel (≥4) integrated optical transceiver module has been realized, supporting more than 4 services in the 20 GHz frequency band. The new generation of microwave optical wave fusion with large dynamic, long distance fiber distribution and centrally controlled multi-domain resources into ubiquitous spectral sensing systems. The optical fiber transmission distance is greater than 20km, and the system SFDR is greater than 95dBHZ2/3. A verification platform was established.

3.7. 5G communication and all-optical network super large core number optical fiber cable and industrialization

The mold was redesigned to solve the problem of high precision mold size, especially to realize the high precision molding technology from 330μm to 295μm thickness. The tension control method was converted from the traditional spring control to the fully automatic cylinder control system to keep the tension constant in the acceleration and deceleration stages. A novel electrical control system was designed, which greatly reduced the difficulty of operation and maintenance. After improvement, the control of the skeleton tension achieved digital precise control, the production and quality level of the overall equipment was greatly improved, the stability of the production process and product consistency have been ensured, and the production problem of skeleton deformation was completely solved. Product quality and production speed have been comprehensively improved. By improving the feeding structure of the water blocking tape wrapping machine, the time for replacing the water blocking tape was shortened by 50%, the weight of the wheel of the wrapping tape machine decreases by 30%, the lateral force on the skeleton during the winding process was reduced, and the long disk water blocking was developed. The belt technology and supporting equipment were capable of reducing the number of times to change the water blocking belt, completely improving the conventional water blocking belt wrapping technology and process flow, and solving the bottleneck problem in the high-speed production of this process.
Main technical indicators reached:

1. Through structural optimization and corresponding process development, the outer diameter of the 144-core skeleton type optical fiber ribbon cable has been reduced from 14.6mm to 14.1mm.
2. Reduced the outer diameter of the 288-core skeleton type optical fiber ribbon cable from 17.9mm to 17.4mm
3. Reduced the outer diameter of the 144-core skeleton type optical fiber ribbon cable from 14.1mm to 13.1mm
4. Reduced the outer diameter of the 288-core skeleton-type optical fiber ribbon cable from 17.4mm to 16.4mm

After the further optimization of the fiber optic cable structure, the cost of the skeleton fiber ribbon cable is better. In the increasingly fierce market competition, the market competitiveness of the products has been guaranteed, especially with the beginning of the first year of 5G in 2020, the arrival of the super high data volume in the real 5G era, which puts forward higher requirements for the high density and more efficient fiber optic cable products. Multi-core high-density banded fiber optic cable will become the core product of 5G commercial carrying optical network. China's potential domestic market is expected to reach billions of dollars.

4. Case of Smart Agriculture

In the 5G era, considerable IoT devices and agricultural machinery have become new networking terminals, bringing three aspects of improvement to smart agriculture: high speed, large capacity, and low latency. The lack of various production technologies and management information in conventional agriculture restricts the development of agricultural production, becoming a bottleneck in structural adjustment and a bottleneck in structural adjustment. 5G+ smart agriculture is the fundamental way out for agriculture. In recent years, smart agriculture has also developed rapidly. With the wide application of Internet of Things technology in many fields of agriculture (e.g., agricultural environmental monitoring, greenhouse production control and water-saving irrigation). Smart agriculture adopts advanced technologies and solutions based on 5G+ the Internet of Things. Through real-time collection and analysis of field data and deployment of command mechanism, it is necessary to build an intelligent farm based on the Internet of Things for the purpose of improving operation efficiency, expanding income and reducing loss, so as to achieve double harvest of crop quality and yield. On the other hand, by advancing agricultural informatization, using high-tech information technology and modern communication methods, considerable agricultural scientific and technological information, production information and market information are delivered to farmers, striking their thinking, inspiring their creativity, and quickly realizing rural. The optimization of industrial structure is of far-reaching significance for boosting the rapid development of modern agriculture.

This case refers to the specific application of 5G strategic cooperation between the Agricultural Science Research Center of Dongguan, China and the Dongguan branch of China Unicom Network Communication Co., Ltd., Dongguan Unicom provides 5G network support for smart greenhouses, and implements considerable 5G technologies in smart greenhouses. Good infrastructure construction will increase the efficiency of the entire agricultural industry chain. Moreover, the two parties will continue to explore several fields (e.g., communication technology, cloud computing, big data, as well as the Internet of Things) to support the Dongguan Rural Rejuvenation Action Plan. "Dongguan Modern Agriculture Science and Technology Park Photovoltaic Agricultural Greenhouse" takes up a total area of 7000 square meters, a smart greenhouse covering an area of 3120 square meters, a use area of 3360 square meters, as well as a distributed photovoltaic installed capacity of 200kW in total. Over the past few years, the project unit has been committed to researching and applying modern agricultural technologies. It has continuously attempted to introduce automation, informatization and Internet of Things technologies, and the application is introduced into agriculture, which continuously
improves the development level of smart agriculture. It has several patent achievements regarding the project.

By improving the modernization level of modern agricultural science and technology park facilities agriculture, the transformation of traditional agricultural production mode. Using comprehensive sensing, reliable transmission, advanced processing, intelligent control and other technologies, to achieve accurate, intensive, sustainable production, and improve the quality and efficiency. Therefore, a modern intelligent greenhouse is constructed, which integrates science, industrialization, mechanization, informationization and service facility agriculture. Thus, it can radiate the surrounding agricultural science and technology park, comprehensively enhance the level of modernization of facility agriculture, reduce the use of chemical fertilizers and pesticides in greenhouse agricultural production, science and technology and protect the park soil and water quality to improve the ecological benefits. At present, agricultural big data is shifting from technological innovation to application innovation, and 5G will also bring massive raw data to agriculture, which boosts the continuous advancement of smart agriculture. In the future, big data technology is capable of continuously and deeply integrating the rich data types of agriculture with application scenarios to achieve a big explosion at the level of application innovation. 5G will bring the prosperity of the big data industry and the rapid growth of smart agriculture. Moreover, 5G will be more real-time and accurate than 4G. Besides, it will rapidly send image data in real time. There are four major application scenarios in the agricultural field in the 5G era, i.e., intelligent planting technology, intelligent agricultural management, open planting process, as well as intelligent labor management.

A set of standardized and modular intelligent greenhouse management solutions has been formed. Through effective data analysis and meteorological environment monitoring, automatic management of greenhouse crop growth can be realized. Through the application of 5G intelligent greenhouse management system, can save more than 50% of labor, more than 30% of fertilizer, and more than 20% of pesticides. Core technologies represented by 5G communications, the Internet of Things, and artificial intelligence will integrate government agricultural departments, agricultural production and distribution enterprises, agricultural technology extension departments, agricultural practitioners, and agricultural research institutions to integrate information providers and information demanders. 3. The information transmission channels are organized into a tight information chain to offer one-stop integrated information services for all aspects of agricultural production-supply-sales-processing and storage. In addition, consumers are able to trace the entire product operation chain based on traceability. In China, it is the first to use 5G technology in agricultural production management, to achieve intelligent planting technology, intelligent agricultural management, open planting process, and intelligent labor management. After completion, it will act as the domestic leader in the application of 5G technology in agricultural management.

5. Discussion
At present, the global 6G technology research remains preliminary, the technical route is still unclear, the key indicators and application scenarios have not yet been uniformly defined. In addition, the understanding and definition of 6G in academia and industry remain in a relatively vague stage of incubation. In November 2019, the Ministry of Science and Technology of China held the "National 6th Generation Mobile Communication (6G) Technology R&D Work Startup Meeting", which marked the official start of China’s 6G technology R&D work. 6G technology critically impacts national strategy, small enterprise development and personal quality of life improvement. The three major 6G scenarios for the consensus reached by the International Telecommunication Union at the "Network 2030" seminar consist of (1) very large capacity (VLC) and very small distance communication (TIC), (2) more than "best effort" (BBE) and high Precision Communication (HPC), as well as (3) convergence of multiple types of networks. Moreover, when 5G and the existing demand are highlighted, it can be suggested that 5G and even the current Internet architecture still have some fundamental problems that have not been solved, which primarily cover the following five aspects (i.e., security, availability, mobility, economy and scalability Sex).
6. Conclusions

5G refers to a vital direction for the evolution and upgrading of new generation information technology, and the Industrial Internet is the key support for the fourth industrial revolution. 5G has become a novel driving force for leading innovation and stimulating new types of information consumption, as well as an emerging engine for promoting industrial upgrading and driving sustained economic growth. Through the construction of 5G network systems and the popularization of 5G terminals, components such as base station antennas, filters and communication PCB boards are increasingly demanded.

From a technical perspective, in the field of 5G, the number of international standard texts proposed by China accounts for about one-third of the world. The number of patents owned by China is also the world’s first, and Huawei is the world’s largest enterprise with 5G patents. From an industrial perspective, China had an early start in the development of 5G chips, mobile phones, base stations and other key links of the industrial chain, and put them into production and use. From the perspective of application, China has made it clear that it will initiate the commercialization of 5G in 2020 and promote the issuance of 5G licenses this year, which is also relatively advanced in the world. The impact of 5G technology on the industrial chain is shown in Figure 1.

![Fig.1 5G technology on the industrial chain](image)

5G is fully in line with the future trends of human progress, social development, and economic growth, and its large-scale applications will inevitably be achieved. In the 5G era, the door of the Internet of Things will be opened and expanded to all industries and fields, as well as to all aspects of the economy and society. This will change the way people consume, transform the way they produce, and provide a powerful tool for high-quality development and governance of society.

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