

MEET TOMORROW

Charting the Future of Innovation

2019 ANNUAL REPORT

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Focusing on Industry's Needs and Creating New Markets

2019 was a challenging year, in which the US-China trade war impacted global industrial trends. Nevertheless, crisis more often than not presents opportunities, and this is a case in which every cloud has a silver lining. The struggle between these two economic powers underscores the importance of Taiwan's economic strategic position. Capital and talent are returning home, creating a rare opportunity for industrial transformation. Featuring a strong industrial supply chain, as well as outstanding software and hardware talent, the nation and its people work relentlessly to boost economic growth. At this critical juncture of resurgence, ITRI stands with industry, working to achieve new successes for Taiwan.

Facing up to new opportunities and challenges, in 2019, ITRI was dedicated to three areas of development. First, it focused on market-oriented R&D. By introducing its 2030 Technology Strategy and Roadmap, it developed various R&D plans to echo market demands and solve problems facing industry. In terms of serving as a bridge between industry and academia, and between Taiwan and the rest of the world, ITRI was actively expanding its cooperation with enterprises both domestically and globally, and using its impressive patent capacity to maximize the impact of R&D. As for assisting industry transformation and upgrade, ITRI launched new initiatives in AI, 5G communications, smart manufacturing, green energy technology, smart biomedicine, and circular economy, using its innovation prowess to support industries.

Propelling Taiwan's Innovation onto the Global Stage

In 2019, ITRI's innovative R&D achievements shone on the global stage, receiving a variety of awards. For instance, its RAIBA (Reconfigurable Array of Inexpensive Batteries Architecture) and iKNOBEADS won the 2019

R&D 100 Awards. Both innovations highlight ITRI's determination to develop technology that addresses the needs of industries and leads to greater human wellbeing. The former combines circular economy and energy technology, which can be applied in the area of renewable energy, while the latter constitutes an important breakthrough in cellular therapies to fight cancer.

ITRI's V2X safety solution iRoadSafe won an Edison Award, along with the ITS World Congress 2019 Industry Award. In addition, its Hybrid Power Drone with High Payload and Duration was named a CES 2019 Innovation Award Honoree in the Robotics and Drones category. Moreover, ITRI was recognized as a Derwent Top 100 Global Innovator for the third consecutive year in 2019 for its outstanding patent performance.

Industrializing R&D Successes to Meet Market Needs

In the marathon of taking R&D results from lab to market, ITRI serves as the runner for the last mile towards industrialization. This stage is extremely difficult and most prone to failure. ITRI shoulders this burden for the industry. It focuses on technology development trends and helps industries move a step ahead of counterparts overseas. The ITRI-organized Consortium for Intelligent Micro-assembly System (CIMS), for example, links firms in the fields of IC design, design, LEDs, packaging, PCBs, and systems integration, providing an interdisciplinary platform for interaction. The consortium made Taiwan take the lead in Micro LED technology deployment and application development. ITRI also founded a spinoff to which it transferred functional coating structures and equipment technology to meet the demand for the 10 nm process. This allows Taiwan companies to access



Edwin Liu
President

Chih-Kung Lee
Chairman

business opportunities in semiconductor materials, thereby overcoming the longstanding monopoly of heavyweight U.S. manufacturers. For localizing Taiwan's track industry, ITRI is cooperating with Taiwan High Speed Rail (THSR) on building Taiwan's first bogie running tester. Meanwhile, it has employed drone technology to assist THSR in inspecting 252 kilometers of bridges, thus improving the safety of the rail network.

Promoting the smart transformation of industry and providing related solutions is another key mission. In response to the needs of returning Taiwanese firms, ITRI is working with fitness equipment manufacturers in constructing smart digital factories. It is introducing smart pilot production line technology, enabling entire production lines to reach the goals of smart manufacturing. ITRI is cooperating with major textile manufacturers in installing automated garment-making

stations to enable rapid sampling, which greatly shortens the production timetable and saves on manpower.

Meanwhile, the Shalun Smart Green Energy Science City was formally opened in December 2019 to increase the awareness of sustainable environmental development. This science city provides a smart ecosystem that combines nature, humanities, and technology. ITRI assisted in the founding of the Green Energy Technology Demonstration Site, and has worked with the industry to establish a pilot production line and testing and verification platform, thereby forging a green energy innovation-oriented industrial ecosystem, a win-win outcome. In addition, since Taiwan has shifted to an aging society in 2018, ITRI is working to link the capacities of the industrial, public, and research sectors to build Taiwan's first senior citizen smart healthcare framework by introducing AI analytics along with remote and



diversified detection technologies. Such an integrated system will generate smart solutions in long-term and senior healthcare.

Connecting Funds, Technologies, and Industrial Markets

Taiwan is a powerhouse in the technology market, ranking among the top four most innovative nations in the world. However, it ranks only 25th in venture capital performance, a fact which points to a gap between the domestic technology market and capital market. As a promoter of industrial technology R&D, ITRI should play an important role as a matchmaker between the technology and capital markets at this critical juncture in the nation's industrial transformation.

We proposed three strategies. The first constitutes the valuation and financing of intangible assets, in line with the intangible economy. The second is boosting private equity and upgrading technology, which support enterprise transformation. The last is early-stage capital for startup simulation runs to strengthen ITRI's startup and entrepreneurship projects. With the joint support of the Industrial Development Bureau of the Ministry of Economic Affairs, the Taiwan Business Bank, and the Small and Medium Enterprise Credit Guarantee Fund, financing agreements for a first group of companies have been completed. Three startups and small and medium-sized enterprises (SMEs) have received NT\$25 million of preferential interest financing based on their patents. In addition, ITRI has launched a platform to invest in new ventures, assist in digital transformation, and cultivate talent, providing integrated services to help returning Taiwanese firms engage in smart manufacturing, transformation, and upgrading.

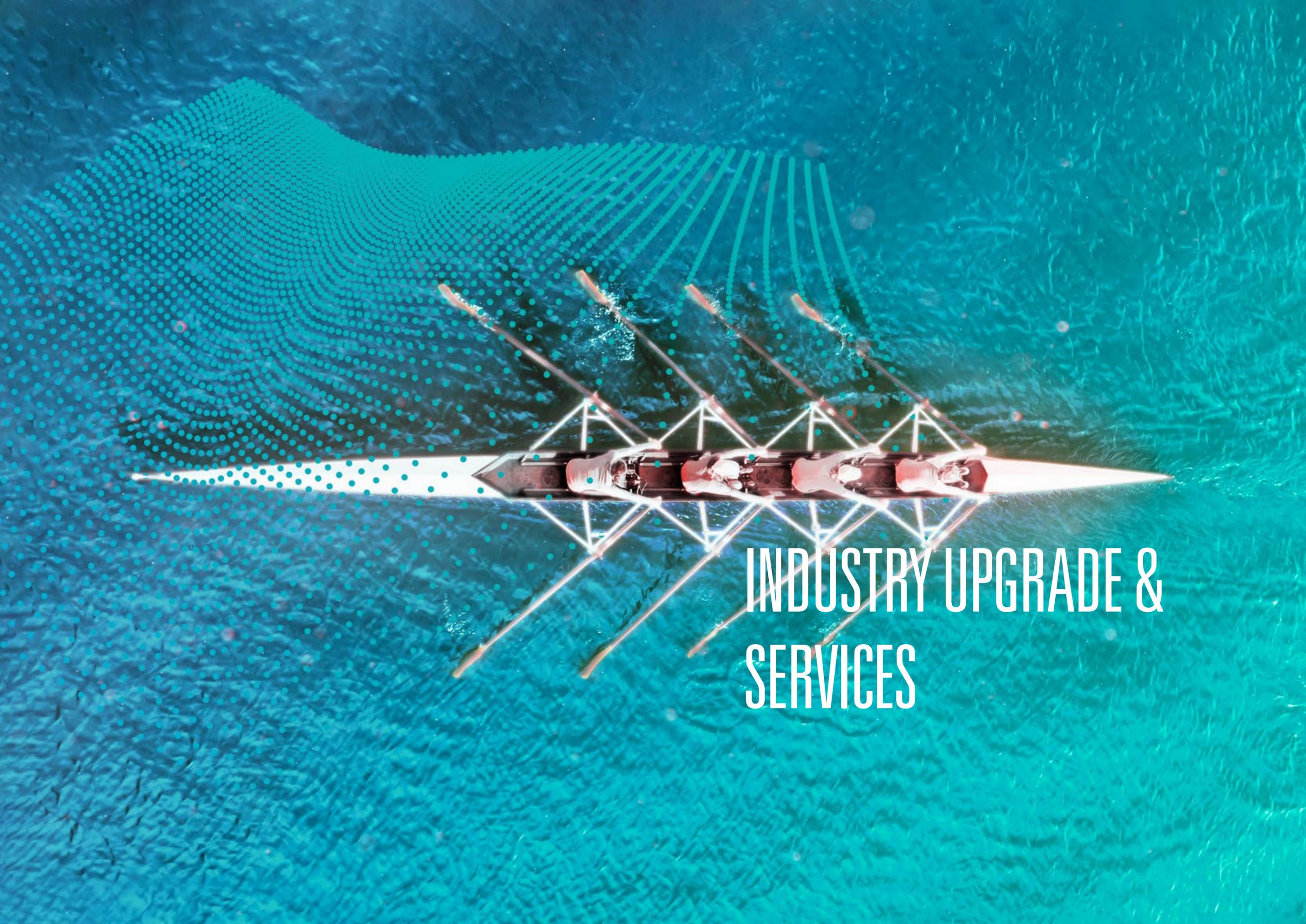
Reviving Remote Areas with Value-Added Technology

As the global industry rapidly changes, we face a situation in which traditional industries experience a talent gap. At the same time, aging of the rural population is leading to stagnation in industrial development.

ITRI has a deep understanding of local needs, and uses the power of science and technology to trigger innovative development among local industries, raising the willingness of young people from Hualien and Taitung to return to their hometowns to start businesses. For instance, rice husk carbonization technology provides opportunities to organic rice farmers in Hualien; this technology has turned waste rice husks into fertilizers and a rice vinegar that functions as an organic insecticide. Meanwhile, toxin-free seedling micro-propagation technology is used in helping residents of indigenous villages to grow Australian tea trees, enabling them to produce high-value essential oil products, and promoting the development of local industry. ITRI's Eastern Taiwan Industry Service Center Omega Zone has also carefully built an entrepreneurship platform for local youth.

Southern Taiwan, which is home largely to traditional industries, is also experiencing the challenges of transformation and upgrading. ITRI has instituted four main initiatives to ignite digitalization and fuel higher salaries: promoting industrial upgrading, maximizing local advantages, injecting innovation energy, and cultivating key talents. In one example, high value eco-material processing technology is assisting manufacturers to transform waste lemon peel into cattle silage; in another, Precision Dimension Laser Technology is supporting the transition of traditional industry through use of traditional screws in high-value tooth implants. Meanwhile, a micro sensors and AI-based water quality detection platform helps fish farmers use smart environmental monitoring systems for their grouper raising facilities.

This upgrading of local industry will further attract talents back to these areas. This will offer an arena for the younger generation to maximize their creativity, fulfill their entrepreneurship dreams, and inject new vitality into Taiwan's industry.



INDUSTRY UPGRADE & SERVICES

Supporting Innovative Startups with Industry-Related Services and Technologies

As the global map of industrial distribution rapidly changes, Taiwanese businesses are shifting away from the declining competitive advantages engendered by traditional process innovations and moving towards an Innovation Economy model. ITRI combines technology and innovation to provide services and support to new ventures during their startup process. The objective is to prompt a leap in the development of domestic industries and to stimulate structural transformation of the overall economy.

ITRI builds solid relationships with strategic key clients by launching cross-domain integrations and themed platforms. Starting from strategic joint R&D platforms, the collaboration model has gradually evolved to include joint R&D centers, strategic collaborations, strategic alliances, and eventually to setting up themed platforms. ITRI aims to establish strong long-term relationships with clients and expand technological values to further support the industry.

Major themed platforms established by ITRI in 2019 include the Discovering Technology Treasures project and various collaborations with different clients, such as public owned businesses, and industry partners from the petrochemical rail service, brand electronics, and Information and Communication Technology (ICT) fields. By forming a broader range of partnerships, we can combine R&D capabilities and the resources of cross-domain platforms to generate more business opportunities.

Promoting and Incubating Startups

Determined to build a comprehensive startup ecosystem, ITRI aims to provide one-stop services to new ventures; these services include assistance in early stage assessments and later stage marketing resources. ITRI continues to integrate and expand startup incubation service platforms and venues that connect a wide array of resources from different industries around the globe. In addition, ITRI transfers R&D results to industry via numerous startup projects launched by the government. The local young entrepreneur trend helped build a national brand for startups, Taiwan Tech Arena (TTA), and introduced Taiwan to the world at 2019 VivaTech.

Startup Incubation

Eight incubation projects were launched in 2019, among which two (01&02) developed into startups, and the others (03-08) in preparation.

01 Main Drive Corp.

The harmonic drive is a key indicator of the development of robotics technology, as it is crucial to the performance of high-precision industrial robots. The technology can be widely used in robotics, medical equipment, semiconductor and optical equipment, and in the national defense and aerospace domain. Main Drive Corp. sees automated equipment and robotics system factories as their target markets at the initial stage. Their products offer advantages such as high precision and long lifespan, and are expected to galvanize local technical development of key components related to autonomous robotics. This will help domestic businesses break through the limitations created by international manufacturers and increase the competitiveness of the Taiwanese robotics and automation industries.

02 Dye Sensitized Cell Project-Formosa Plastics Group Startup (Spin-in)

The dye sensitized cell (DSC) is a light-driven technology which can transform energy into electricity in low illumination environments and supply low current electricity. It is well suited to consumer applications such as remote controlled electric curtains, mesh window screens, and IoT sensors. For electric curtains and their sensors, the DSC technology perfectly integrates power generating, power saving, and energy storage functions and requires low levels of artificial light or window light

to fulfill power demand. This technology has already been transferred to Formosa Plastics Group and successfully gone into production. Moreover, it can be applied to various everyday equipment and wireless sensors, which will encourage more material and equipment suppliers to invest and create new market opportunities.

03 Functional Coating System Technologies Co.

This company has developed a complete suite of equipment and product applications with key modules, and provides precision Parylene coating services for the semiconductor, IC packaging and IC circuit industries. Before 2020, their business focused on (1) CMP membrane chemical resistance layer, (2) sensor conformal coatings, and (3) probe card pin insulation layers. With unique coating technology, they can provide customers with chemicals and moisture-resistant and insulation layers. The company can cooperate with customers and address their needs to conduct R&D and help them deploy new processes in current production lines.

04 DNN High Performance Deep Learning System Project

This system makes use of deep learning software developed by ITRI coupled with deep learning training hardware to create DNN appliance products. By offering deep learning models and highly-integrated soft/hardware for developers, and a high-efficiency development environment, the system is able to shorten model training time without compromising prediction accuracy, hyperparameters automated adjustment, and high-speed data transmission between data storage devices and memory.

05 Small Cell Project

The 5G NR L1 baseband software developed by ITRI is integrated with L2/L3 communication protocols on the SoC based platform to offer 5G base station software services and soft/hardware integration solutions. This technology can encourage Taiwanese netcom and equipment businesses to develop competitive 5G small cell products and overcome challenges such as high technical threshold, hefty licensing fees, expensive testing equipment, time-consuming and

complex telecom interconnection testing, and lack of vertical market integration. Furthermore, the Original Design Solution (ODS) business model can complement existing small cell companies and speed up 5G industry supply chain development.

06 LiDAR Sensor IC Project

The CMOS single-photon avalanche diode (SPAD) developed by ITRI is a sensor element within the depth sensing SoC. The multi-channel LiDAR technical IC is completed with time-of-flight ranging and offers advantages such as low voltage, low power consumption and low cost. The technology aims at Automated Guided Vehicle (AGV) products as its initial market, and unmanned aerial vehicles along with autonomous vehicles as its mid-term target markets.

07 AI Clerk Service Project

The AI Clerk natural language analysis platform can automatically expand a tagged corpus. In other words, the platform only requires a small manually tagged corpus to process mass volumes of data related to product specs, discussion articles and literature. This can significantly reduce the time required to manually collect and tag a corpus. At the current stage the platform will assist e-businesses in setting up product databases and launching precision marketing operations.

08 Embedded Deep Learning Camera Project

With its core DNN algorithm technology, the embedded deep learning camera can complement existing baby or elder care solutions with detection, dynamic sensing, and big data analysis technologies. This camera can monitor and detect whether the infant is vomiting or if the mouth/nose is covered to prevent suffocation. This groundbreaking technology incorporates breathing and heartbeat monitoring functions with edge computing, high recognition rate and real-time reaction features to offer a new solution for baby safety. Future target markets include smart online cameras and other applications.

Providing Professional IP & Legal Support to Activate Taiwan Industries

As intangible assets are becoming an increasingly important contributor to economic development, ITRI is pioneering intangible asset financing to build an intellectual property protection network for industry by connecting the capital and technology markets through three major strategies. This will provide both a competitive advantage and a protection mechanism to enable Taiwan's industry to stay strong in global competition.

ITRI's outstanding performance in IP value creation is globally recognized and its strategy of balancing the quality and quantity of patents has shown good results in recent years. In 2019, it was named a Derwent Top 100 Global Innovator for the third time and won an Intellectual Asset Management (IAM) magazine Asia IP Elite Award for the seventh year in a row. It also ranked first in patent volume among six other renowned research institutes including SRI International and Fraunhofer Institute. ITRI's long-term efforts in IP deployment and application models have helped the government promote IP commercialization policies and made it a professional IP resource provider for industries.

ITRI has been working on facilitating the link between capital and technology markets via three major strategies: first, evaluating and financing intangible assets to serve the intangible economy; second, raising private funding and helping enterprises transform through the upgrading of their technology; and third, investing in the early stages of production simulation runs, thus strengthening ITRI's innovation and entrepreneurship operations.

Pioneering Intangible Asset Financing in Taiwan

In promoting intangible asset financing, ITRI collaborated with the Industrial Development Bureau of the Ministry of Economic Affairs, the Taiwan Business Bank, and the Small and Medium Enterprise Credit Guarantee Fund of Taiwan to provide Taiwan's first instance of intangible asset financing by connecting experts from multiple business sectors with counterparts in the technology service industry.



Three startups and SMEs have obtained NT\$25 million of preferential interest financing through their patents. In the era of global competition, ITRI assists domestic enterprises to boost their competitiveness and IP value, and creates an environment within which Taiwan's technology innovators can connect with the finance system.

Establishing an IPR Marketing and Trading Platform

The Taiwan Innotech Expo in 2018 gained wide attention and a positive response. In 2019, ITRI took the next step by establishing an exclusive and comprehensive intellectual property rights (IPR) marketing and trading platform linking the scientific and technological achievements of industry, academia and research institutes, as well as the seven main government ministries. During the exhibition, a total of 555 technologies from 205 exhibitors, including 76 institutes from 10 countries. The expo attracted a total of 45,000 visits, resulting in more than 1,600 business negotiations and transactions of more than NT\$60 million. In addition,

ITRI held the 2019 Global IP Strategy & Marketing Forum and a number of technology matching conferences, to offer manufacturers and business owners the information and knowledge they need to better grasp global IPR and the opportunities that technology transfer brings.

Comprehensive Patent Development, Analysis and Deployment Mechanism

While observing both the development of international emerging technologies and the patent strategies of large enterprises, ITRI continues to promote and implement a comprehensive patent analysis mechanism. In 2019, it focused on internationally competitive core technologies and proposed patent portfolios for 25 key government-sponsored programs by way of patent analysis. This comprehensive patent analysis and deployment mechanism encouraged Thailand's National Academy of Sciences (NSTDA) to assign senior patent researchers to come to Taiwan to gain expertise. Furthermore, this mechanism has been expanded to assist five nonprofit R&D organizations: Metal Industries Research & Development Centre, Development Center for Biotechnology, Taiwan Textile Research Institute, Food Industry Research and Development Institute and Automotive Research & Testing Center. Through case practice, this mechanism has helped these organizations focus on industrial needs, conduct comprehensive patent analyses, and gradually establish related processes internally. The patent analysis report format proposed by ITRI has also been adopted as an example for nonprofit R&D organizations, and functions as the foundation for the construction of key patent portfolios.

Taiwan's First Specialized Publication on Patents

To help enterprises use patents to grasp business opportunities, ITRI issued Taiwan's first patent-focused publication based on its innovative R&D capabilities and patents. Through cases of successful industry-research commercialization, the publication highlights five models of patent utilization and incorporates ITRI's 2030 Technology Strategy and Roadmap. It systematically organizes ITRI's abundant high-quality patents under three innovative application domains: smart living, quality health and sustainable environment; as well as within six research



areas: electronics and optoelectronics, information and communications, material and chemistry, mechanics and mechatronics, biomedical technology and devices, and green energy and environment technologies. Enterprises can efficiently search for and evaluate available patents according to their specific needs.

Promoting a Model of Industry-Academia Collaboration

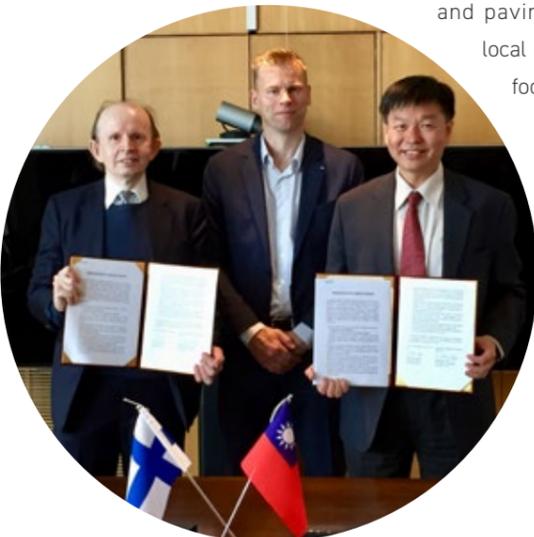
ITRI visits universities through the Industry-Academia Matching Service to conduct technical inventory and assessment of industrialization potential. By utilizing R&D resources and industrial experience, ITRI helps to focus the research achievements of universities toward industrialization and commercialization, facilitating technology transfer and strategic patent applications. Year on year, this increases industry-academia collaboration and startup funding. In 2019, ITRI's professional IP matching promoted 17 cases of academia-research collaboration covering the fields of information & communications, smart machinery, green energy, and biotechnology & medical care, which will enable Taiwan industries to apply academic/research innovations more effectively while reducing their R&D costs for industrial upgrading and transformation.

Connecting Globally and Seizing Opportunities

Taiwan has a world-renowned industrial supply chain and ranks 18th among the largest trading nations in the world. With resilience and perseverance, we have charted our own course towards the global markets. ITRI leverages its technology prowess to access global resources for Taiwan. By acting as a bridge between domestic and foreign industrial, academic, and research sectors, ITRI plays a pivotal role in accelerating and enhancing innovation-oriented R&D momentum, thereby solidifying Taiwan's position as a global hub of technology.

ITRI leverages its international connections to link with the global innovation and technology ecosystem network to remain relevant in technology R&D. This has led to the creation of a technological cooperation platform with selected countries or regions throughout the world. With long-term institution-to-institution partnerships, increasingly deep and broad international cooperation, and cutting-edge technology applications, ITRI has helped the industry in Taiwan to transform and upgrade. The institute continues to work with high-tech heavyweights such as DOCOMO Technology, NVIDIA, Corning, and Merck, as well as various economic and trade offices set up in Taiwan by European and North American countries and Japan. These efforts have resulted in a number of technology R&D cooperation projects, enabling ITRI to participate in the latest

international R&D innovations and paving the way for local industry to gain footholds in global markets.



Collaborating with EU Industrial and Research Sectors in Advanced Technology R&D

To keep pace with the accelerated advancement of emerging technologies and innovative applications, ITRI has been actively expanding its cooperation with European industries, government, academia, and research institutions. For example, ITRI and IDEA Consult, a major EU think tank, signed a memorandum of cooperation to cooperate on technology and industrial policy research, which is expected to improve research quality and yield policy recommendations with far-reaching impact. In addition, in view of the global circular economy trend and related business opportunities, ITRI worked with Finland's international consulting firm Pöyry on bio-material water treatment, CO₂ recycling applications, EU textile regulations, and packaging materials.

ITRI has also made considerable progress in cooperation with the UK. In 2018, it launched the UK-Taiwan Innovative Industries Programme with the British Department for Business, Energy and Industrial Strategy (BEIS) and the British Foreign and Commonwealth Office. This helped strengthen the bilateral relationship between Taiwan and the UK in selected innovation sectors, including biotechnology, AI, robotics, clean energy, and autonomous vehicles. The first phase of the cooperation (2018-2019) has successfully linked Taiwan with top UK R&D institutions and academia, such as the Advanced

Manufacturing Research Centre (AMRC), Imperial College London, and the University of Edinburgh. As a result, a total of 11 cooperation projects involving academia and research institutions were launched via the Programme.

Connecting the Industry to Global Innovation and Heading Towards Silicon Valley

ITRI has been working closely with major leading high-tech companies such as Microsoft and Applied Materials on AI applications and advanced semiconductors. It assisted Micron in establishing a "Global Center of Excellence" in Taiwan and joined hands with semiconductor makers in forming the "Packaging and Testing Alliance Smart Manufacturing and Application Technology Development Plan" to develop competitive DRAM packaging and testing processes. In addition, ITRI was instrumental in the signing of a memorandum of cooperation with Lightel in training laser source talent as well as technology development and transfer.

ITRI is active in working with startups.

It has partnered with AEye.ai to develop unmanned technology sub-systems and cooperated with Citrine Informatics on developing a material information platform and exploring the international market. Moreover, ITRI has been expanding its network with UCLA, the University of Washington, Stanford University, etc.



Enhancing Taiwan-Japan Industrial Cooperation and Sharing R&D Results

ITRI continues to promote cooperation with Japanese enterprises. It has successfully facilitated the signing of MoUs between Taiwan's Chunghwa Senior Care, the Ritek Group, and IdeaBus Technology and Japan's MWS-Hidaka Group, Tecnocare, and Sai, respectively. These

partnerships have targeted business opportunities in the health and wellness industry in both countries. ELECLEAN, an ITRI spinoff, has joined hands with Meri-tech to tackle the appliances market for disease prevention in public places in Japan. ITRI has also been engaged in technology collaboration with several world-class component manufacturers in Japan such as Taiyo Yuden, Tokuyama, and Fujitsu. Meanwhile, ITRI's partnerships with its Japanese institutional partners for technical exchanges and R&D cooperation have remained robust as ever. These partners include National Institute of Advanced Science and Technology (AIST), Asahi Kasei, and Mitsubishi Electric.

Embracing the New Southbound Policy to Enter Emerging Markets

In line with the government's New Southbound Policy, ITRI has been seeking opportunities for cooperation between Taiwan and 18 countries across Southeast Asia, South Asia, and Australasia. The institute is assisting Taiwan's industry and research institute to gradually expand their marketing plan in these areas as well as establishing local relationships to leverage regional advantages. In Thailand, ITRI worked with SCG Chemicals to develop energy storage components and with Panus to develop electric trucks. Such projects are expected to promote Taiwan's component manufacturers in entering the international markets. ITRI also teamed up with an electric bus alliance involving eEasy Technology Co. and Tong Ying Body Co. to partner with a Thai electric vehicle company, delivering batteries, drives, control systems and smart charging piles to Thailand. In Malaysia, ITRI licensed its Lignocellulose Fractionation Technology to All Cosmos Bio-Tech and built a ton-scale pilot plant in Malaysia, followed by a 10,000-ton quasi-commercial conversion plant. This project aims to utilize ITRI's technology in converting agricultural and forestry materials into sugar, promoting the renewability of biomass and energy.

Unlocking Local Opportunities with Technology

As more people move to cities, remote areas are faced with problems such as aging workforces, labor shortage, and loss of certain skills not passed down from previous generations. Therefore, the development gap between urban and rural areas becomes an important issue that needs to be addressed urgently. With its understanding of local situations, ITRI is able to provide targeted industries with crucial technologies and eco-friendly approaches to increase their value and help young entrepreneurs fulfill their dream. ITRI's collaboration projects contributed to the placemaking process and thus offered old industries a new chance.

The southern and eastern parts of Taiwan are known for their distinctive local features, diverse cultures, abundant natural resources and rich agricultural productivity. However, many young people choose to leave for bigger cities to start new lives. Still, there are some returning to work in their hometowns since memories of home are always in their hearts.

Another aspect is about the transformation of traditional industries. With the arrival of new technologies, how can these "invisible champions", who did very well in the earlier stages of Taiwan's economic development, connect with the world and present their outstanding performances?

Below are some examples of ITRI's efforts in creating additional value within industries and generating opportunities for young entrepreneurs who choose to return home. The institute's involvement provides a solid foundation for local startups and helps revive local industries.

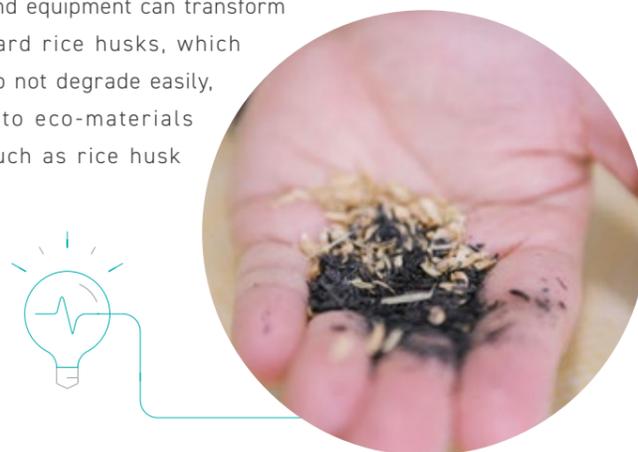
Biochar Technology to Support Young Startup

Fuli is Taiwan's main organic rice production area. For Yu-En Chung, who grew up in Taipei, it is a place full of childhood memories of his grandpa's home. Now Chung is the main operator of Manna Co., an organic rice brand from Fuli. Interestingly, he never planned to become a farmer. Chung came home to run his father's agriculture production and marketing group, co-op, and budding organic rice brand

when his father was ill and hospitalized, and thus began the younger man's experimental farming life.

With zero agriculture experience, Chung approached the subject as if it were an academic study and began to collect relevant data. He managed the marketing group, joined the traceability image platform, and recruited a group of local women to sew Hakka pattern cloth pouches for wedding rice packaging. Chung moved toward sustainable farming by implementing ITRI's rice husk carbonization technology and collaborated with the institute to cultivate health-promoting rice and develop technology to enable extraction of value-added by-products from what was previously production waste. These diverse operations add value to the farm and its rice products.

ITRI's energy-saving biochar technology and equipment can transform hard rice husks, which do not degrade easily, into eco-materials such as rice husk



charcoal. The charcoal can improve the soil and delay fertility level loss, while rice husk vinegar, a byproduct of the process, can be used as bug repellent. With ITRI's technical support, Manna Co. expanded its product line and saw a 150% increase in overall sales.

From Brick Kiln to Innovative B&B

Originally known as Funan Yaochang, Funan brick kiln was built in 1966. Operations here were later halted due to rising environmental awareness and overall industrial structure transformations. In 2000, the building was severely damaged in a storm. To save and preserve the kiln, the owner decided to transform it into an innovative themed B&B. After acquiring his bachelor degree in chemistry, second-generation owner Wei-Jie Xu did not enter the technology industry as most of his classmates did; instead he came home to help his parents run the business.

Through the Fuli placemaking program, Funan B&B received technical assistance from ITRI in extracting both essential oils from plants and rice bran liquid from the yellow outer layer byproduct of milling. The many flowers and herbs grown in Funan B&B's gardens were used to manufacture essential oils, rice bran soaps, face masks and other products, and guests were offered DIY activities. This diverse operation model has increased the average per customer spend by 10%.

A Fragrant Village: Tea Trees Nurture Hope in Tafalong

Situated on the rich black soil produced by the Matai'an and Hualien Rivers, Tafalong Village is the largest

Pangcah indigenous community in Taiwan. Village pastor Namoh Arang, who has long been dedicated to local community development, hoped to find a specialty produce to develop a community industry that would allow young folks to find employment at home.

Pastor Arang found his solution after seeing the tea trees at Omega Zone, ITRI's industry service center in Hualien. ITRI's non-toxic tree sapling micropropagation technology cultivates tea tree saplings which have a unique scent and can grow eight times faster than average tea trees. In addition, the production of essential oil can be increased by six times and delivers a quality that meets ISO and European pharmacopoeia standards. The soil properties and rainy climate of Tafalong Village make it the ideal environment for growing such trees.

Supported by ITRI, Tafalong Village planted 200 tea tree saplings by the end of 2017. In 2018, the village obtained organic certification for their tea trees. In addition to sharing plant health management and mass production technologies for high-value essential oil, ITRI customized extracting equipment so that the machinery is relatively easy to operate and very suitable for general micro farming and domestic use. The institute also helped the village promote and market their floral waters as well as their essential oil, sowing hope for local micro-industry development.



New Ways with Stone Scraps

ITRI's Omega Zone is a base from which young entrepreneurs in eastern Taiwan can start their businesses locally. It focuses on five major areas to stimulate local industry development: new technology agriculture, smart tourism, urban-rural digital development, health and sustainability, and rural education. With the help of Omega Zone, many young entrepreneurs in eastern Taiwan, like Lijuan Gaodeng and Jin Su, are able to gather resources for their startups and receive assistance in proposal writing, industry analysis, and resource matchmaking to help them successfully initiate their businesses.

Lijuan Gaodeng, from the second generation of a marble processing family, leveraged her skills in design to create new opportunities after the massive earthquake of February 6, 2018 hit the local marble industry hard. Gaodeng took marble scraps and defective marble for reuse, combining these waste materials with other media to create everyday items that reveal the warm and natural texture and the fun of mixing and matching. With ITRI's assistance, Gaodeng set up the Stone & Life brand, which invites artists from different fields to collaborate and create new artwork.

Another young entrepreneur who noticed the potential of marble scraps is Jin Su, a young man from Taipei interested in 3D printing technology. When Su learned that ITRI's Omega Zone has 3D printing resources, he made use of the quick mock-up platform at the service center to learn more about 3D printers and gain practical experience.

He later set up his own studio, began to work on various 3D printing projects, and developed an online platform for customers to create their own unique

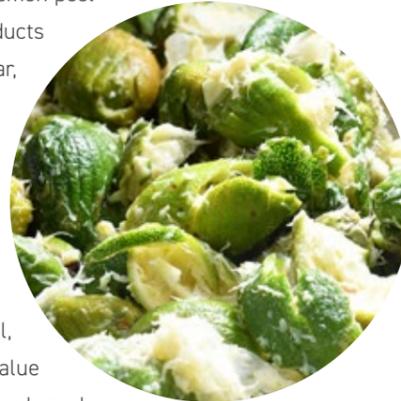


lamp designs. Marble scraps are the basic material for these products, which will be realized via 3D printing technology.

Yongda Food Technology Co. in Pingtung is Taiwan's largest lemon processing company. Its business scope stretches from contracting, procurement and processing to marketing; however, CEO Yao-Hui Tsai was deeply troubled by the massive amount of waste lemon peel left behind after juicing: every year the company was spending over NT\$4 million to clear out up to a thousand tons of it.

Turning Lemon Peel into Green Gold

Working with ITRI, Yongda Food Technology applies biochar technology to its lemon peel waste for bio-control products such as biochar and vinegar, both of which benefit eco-friendly farming. Technologies such as high-performance extraction and microbe transformation are used to extract lemon hydrosol, essential oils, and high-value pectin from the waste peel, and the company has even developed scalp conditioning and mosquito repellent products.



The biggest surprise was that silage for cattle could be derived from the peel. ITRI and Yongda Food Technology utilized high-value eco-material processing technology to manufacture a new type of silage that can stimulate lactation and improve meat quality. Sensing a potential market in the southern Taiwan dairy industry zone, Yongda has invested over NT\$10 million into silage fermentation, storage and packaging infrastructure. The ultimate objective is to increase lemon peel usage rate by 20%.

Transforming Screws into Artificial Tooth Roots

Taiwan is one of the top three screw exporting countries in the world, and Gangshan in Kaohsiung City is home to the "screw cave"—a major production zone for screws.

Taiwan Shan Yin International Co., a traditional screw manufacturer, set its sights on producing high-value artificial tooth roots but did not succeed until it met ITRI. Instead of using the traditional sandblasting and acid etching procedures for the tooth root implants, the company employed ITRI's Precision Dimension Laser technology, which uses lasers to accurately drill micrometer and nanometer holes that are specifically arranged so that bone cells in the mouth can grow tightly onto them, helping the wounds to heal faster.

Through trial and error, Taiwan Shan Yin and ITRI successfully developed a type of artificial tooth root manufactured with lasers, and obtained related medical material certifications. The product is now marketed as the Biomate Implant System in the EU, US, and Southeast Asia region, becoming a successful case of industrial upgrading.



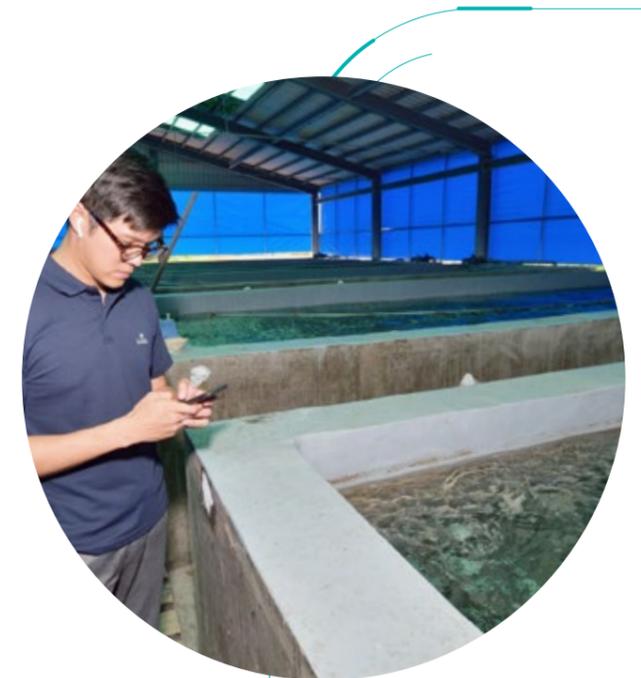
Big Data and Grouper Farming

Ten years ago typhoon Morakot caused great damage to fish farms in Pingtung, including Jian-Han Chen's family business. This tragedy made him think: is there a better way to rebuild and transform aquaculture industries to fit modern demands?

As a result, Chen and his family turned their fish farm into Lijia Green Biotechnology Co. This eco-friendly company adopts innovative R&D technologies to improve traditional aquaculture methods and is one of the few within the grouper industry which can offer a complete service including raising broodfish, spawning, fry and adult fish, as well as aquaculture product processing and marketing.

In 2017, Lijia Green Biotechnology started to work with ITRI and the Fisheries Research Institute to develop a high-density grouper pool decision support and smart aquaculture environmental monitoring system. The system can automatically monitor changes in the levels

of dissolved oxygen in fish pools. When there is a drop in oxygen, it can compute multi-parameter data and indicate the water change time, which best conserves energy, water and labor and reduces cultivation risks. With better water quality, farmers do not have to apply medicines to their fish pools, thus improving food safety and lowering costs. In the future, additional data will allow the system to further analyze feed conversion rate, growth rate and other factors for more efficient aquaculture management.





INNOVATIONS
& APPLICATIONS

Building a Better Future Through Market-Driven R&D

In light of the challenges posed by global trade restructuring, digital economy, aging societies, and megacities, ITRI is identifying emerging needs, presenting critical solutions, and exploring new markets. With its 2030 Technology Strategy and Roadmap, ITRI focuses its R&D efforts in three major application domains, namely Smart Living, Quality Health, and Sustainable Environment. It is charting a future where people can enjoy high-quality living and lifestyles, keep healthcare good and affordable, and create a low-carbon, energy-saving and circular community. To support multiple applications, ITRI has further advanced ICT enabling technologies. It has strived to cultivate a new generation of talent, work across industries, and forge cooperation.

Smart Living: Enjoying High-Quality Living & Lifestyles

In the area of Smart Living, we integrate software and hardware to develop novel technologies and services that satisfy individual and business needs. When developing Personalized Devices & Services, smart platforms are

built to achieve mutual communication among different terminal devices. In establishing Autonomous Mobility Systems, we adopt technologies such as high-precision imaging, enhanced perception systems, autonomous decision-making and control as well as high speed transmission. Moreover, the development of self-driving vehicles and drone applications make smart cities a reality. We are also deploying next-generation digital technology to boost Smart Industry & Services. This helps companies create a more efficient and effective business operating environment and provides new smart living solutions for the public.

Quality Health: Keeping Healthcare Good & Affordable

In response to aging population, in the Quality Health domain, we combine Taiwan's strengths in ICT and medical care systems. Based on new clinical technology and digital healthcare services, we focus on smart medical applications such as precision medicine, digital health and regenerative medicine to accelerate clinical trials and industrialization

impact. We also develop innovative cross-field medical solutions in Smart Healthcare to enable high-end medical treatment and high-quality healthcare services.

Sustainable Environment: Creating a Low-Carbon, Energy-Saving & Circular Community

As climate changes and the greenhouse effect becomes more severe, we have been dedicated to the transition towards a circular economy to realize the objective of a Sustainable Environment—achieving sustainable resource usage and economic development while minimizing environmental pollution. We are also working on edge computing and smart sensor control to build intelligent manufacturing systems, hoping to secure a foothold in the global digital supply chain. Moreover, we are active in promoting green industries and enabling society, industry and the environment to better co-exist by advancing Green Energy & Environment technologies in diverse energy generation, energy conservation, energy storage, and smart system integration.

ICT Enabling Technology: Boosting Multiple Applications

The flourishing of wireless communications, the Internet of Things, and big data technologies have brought a wide variety of application services and raised the demand for ICT enabling technologies. Therefore, ITRI spares no efforts to develop AI, semiconductor chips,

communications, data security, and cloud computing technologies to support high-efficiency AI capabilities, IoT communication capacities, and data safety needs required in diverse applications. ITRI hopes to highlight the value of innovative systems and application services and tap the potential of key technologies to accelerate industrial development.





SMART LIVING

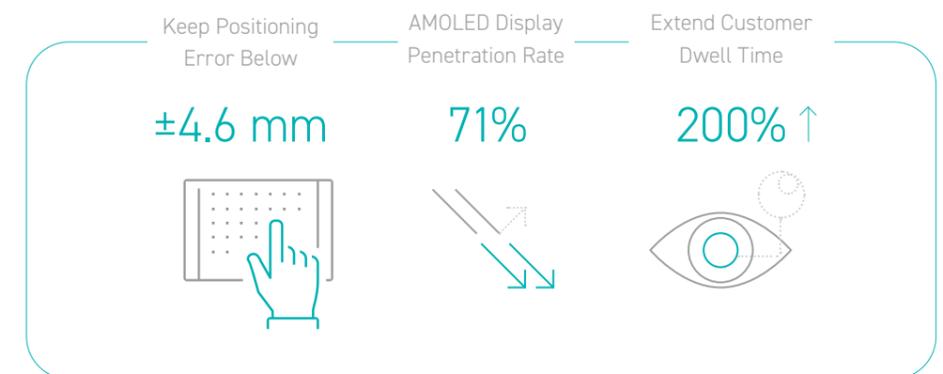
Enjoying High-Quality Living & Lifestyles

Personalized Devices & Services

Advanced Transparent Display Interactive System

The Advanced Transparent Display Interactive System has added value to key components for the automation of transparent displays. Users can select products of interest using an interactive interface, and relevant information about them will be shown. The smart interactive system allows real-time operation by two users, boasts accurate directivity, and keeps positioning error below ± 4.6 mm. The technology also enhances the development of innovative applications and services in the current display industry, facilitating the upgrading and transformation of Taiwan's industrial technologies.

The intuitive information display service included in the system has been tested in retail stores and is proven to extend customer dwell time from 20 seconds to 1 minute and thus increase their willingness to purchase. The transparent AMOLED display developed by ITRI boasts a penetration rate of 71%, attracting attention from many companies at the 2019 Touch Taiwan Exhibition.



Advanced Transparent Display Interactive System

R2R Optical Hybrid Film with Transparent and High Temperature Resistance

Rigid display panels are being developed into flexible ones, and various manufacturers are working towards flexible AMOLED technology. In addition to realizing bendable display panels, the industry will focus on large and roll-up displays. In 2019, the first smartphone with a folding screen was unveiled.

ITRI developed the new generation of high-temperature-resistance optical film by adding high nano-silica content into the PI substrate. Silica can improve the elastic modulus and heat resistance of PI, and increase flexibility. This material plays an important role in the OLED industry and will lead Taiwan's flexible electronics industry into a new era.



R2R Optical Hybrid Film with Transparent and High Temperature Resistance

Establishment of a Micro LED Inter-Industrial Platform

Indoor displays, mixed reality (MR), telematics, gaming, and many next-generation technologies require high-speed displays with high brightness, low electricity consumption and high resolution. ITRI developed a series of key technologies related to Micro LED displays for MR and advanced gaming monitors, such as the manufacturing of Micro LED dies, Micro LED mass transfer, and die repair.

Through the Consortium for Intelligent Micro-assembly Systems (CIMS), ITRI established an interdisciplinary exchange platform that helps to connect IC designers, display manufacturers, LED producers, package-testing providers, PCB suppliers, and system integration businesses around the globe. The objective is to build a foundation for the development and application of Micro LEDs in Taiwan. Through the platform, businesses across industries can work together on developing leading technologies for crucial products as well as on the standardization of development specifications. Trial production of relevant products can also be carried out via the platform.



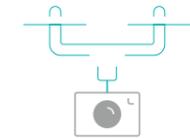
Establishment of a Micro LED Inter-Industrial Platform

Autonomous Mobility

Drone-Based Inspection Scheme

The Automatic Police UAV Patrol System (APUPS) adopts optimized dual communications of 4G and WiFi for remote control of drones with live streaming of less than one second delay.

With dual lens cameras, the drones are equipped to conduct large-scale observation and precise focusing. Bundled with the ground control station software, the solution offers a drone-charging system, allowing the drone to automatically return to the base station for recharging, and enabling simultaneous management and operation of multiple drones. Furthermore, through wireless communications and a ground management system, drone inspections support indoor positioning to overcome the limitations of drone flights. Besides conducting outdoor operations, the drones can also detect water leaks, deterioration, and other problems in tunnels, steel bridges, piers, offshore windmills, and



places where humans have difficulty accessing. It can also take photos using precise positioning technology without GPS. When receptors on the ground receive information sent by the drones, engineers can control drone flights and ascertain their precise status.

ITRI has cooperated with Taiwan High Speed Rail and the Water Resources Agency in conducting bridge examinations and safety patrols using the APUPS. Meanwhile, ITRI is also exploring the system's business prospects in fields such as agriculture, police patrols, emergency rescue operations, and even territory monitoring and protection.



Drone-Based Inspection Scheme



iRoadSafe V2X Safety Solution

iRoadSafe V2X Safety Solution

iRoadSafe offers a smart V2X (Vehicle-to-Everything) road safety solution especially designed to handle the busy and complex traffic environments in the Asia-Pacific region. This solution integrates data from communications, sensors, traffic signals and other equipment to predict possible tracks through anti-collision algorithms on the distance between people, vehicles, and objects. The system then uses roadside units (RSUs) to broadcast alerts to all road users in a real-time manner.

iRoadSafe has been deployed in accident-prone sites in several cities in Taiwan, including a field trial with a bus service in Taipei and light rail transit system in Kaohsiung. It has also been industrialized and applied in New Taipei City, Taichung, Keelung, Hsinchu, Nantou and Tainan. This technology has been transferred to telematics companies and assisted in exporting the smart transportation system to Southeast Asia. iRoadSafe won Silver in the Transportation & Logistics category at the 2019 Edison Awards as well as the Industry Award at the ITS World Congress 2019. It was also the runner-up in the startup category of the



Harmonic Drives

Dubai World Congress and Challenge for Self-Driving Transport in 2018-2019.

Harmonic Drives

With the increasing demand for robotic arms, the harmonic drive has become one of the key components during the rapid development of industrial automation. ITRI remains committed to developing harmonic drive-based products such as joint modules and small rotary platforms. It has further integrated innovative gear tooth profile, rigidity control of flex spline, cyber-physical system (CPS) online tolerance distribution control, and micro-particle surface treatment technology in order to minimize errors in harmonic drives and maximize their product life cycle under high-intensity operations. All of this is done to enable Taiwan to bridge the gap in its industrial automation.

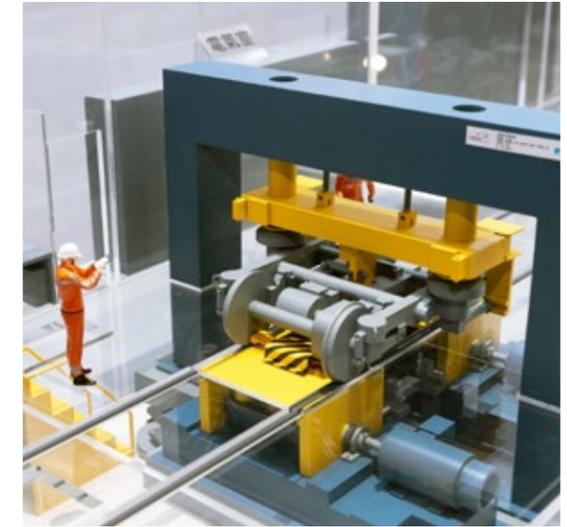
ITRI has built a testing platform where techniques can be tested under various scenarios, while helping shorten the time needed for certification. Other applications of harmonic drives have also proven to be feasible, such as six-axis robotic arms, wafer-handling robotic arms, and mobility aids. In 2019, ITRI founded a startup after transferring the technology for commercial uses.

Localization of Railway Construction Technology

Taiwan's railway systems have long relied on foreign suppliers. In order to effectively improve safety and reduce inspection time, a railway industry and local supply chain should be established. For railway industry localization, ITRI has been collaborating with railway companies including Taiwan High Speed Rail Corporation (THSR). There are more than 80 items for developing railway systems, such as the light electric railroad patrol system, underfloor lathes, the high-speed railroad switch testing system, the bearing vibration testing system for traction motors, drones for smart bridge inspection, the equipment system module, and the railway measurement instrument and calibration system. Furthermore, the two organizations are planning to further develop the nation's first bogie testing platform. To meet CENELEC standards, ITRI is also working with Kaohsiung Rapid Transit Corporation to develop a technology that allows platform gates to open and close in sync with the doors of MRT trains.

Autonomous Vehicle Test Driving at Hsinchu Open Field Facility

Autonomous vehicle test driving in Taiwan is limited to closed venues and low speeds. In order to enhance industrial competitiveness, ITRI has developed a dynamic, precise, and stable control mechanism by combining real-time positioning with mapping technology, deep machine learning, and a database of high definition 3D maps. In September 2019, a driverless car equipped with this control mechanism passed 64 tests in Taiwan's autonomous vehicle



Localization of Railway Construction Technology

testing facility and obtained the first testing vehicle plate in Taiwan. Through the cooperation with Hsinchu City Government, ITRI unveiled Taiwan No. 0001, Taiwan's first autonomous car that can be tested in open testing facilities.

ITRI also linked up with international carmakers by establishing a driverless car manufacturing supply chain that integrates key technologies from domestic institutes, such as sensing technology, AI, high-definition mapping data, and decision control. ITRI intends to extend the applications of driverless car technology to other service fields, including airport cargo collection, smart container transport systems at ports, and smart logistics systems.



Autonomous Vehicle Test Driving at Hsinchu Open Field Facility

Smart Industries & Services

AIoT Exhibition Service System—Smart Recommendation and Matchmaking Technology

In order to enhance the interactive experience and field application of AIoT-related technologies within the conference and exhibition industries, ITRI and industry partners have cooperated to develop relevant software and hardware integration display system application services. The front-end interface of the system uses instant LINE messaging system, which is very popular in Taiwan; meanwhile, the back-end system employs real-time business card recognition and business information database.

This system creates a customized interface for each activity on LINE and connects visitors through registration using their mobile phones. The interface is used for gathering real-time exhibition information, recommending related exhibits according to the visitor's

industry sector, promoting exhibition activities and related services to improve business matchmaking while using back-end database to perform precision marketing.

Smart Stores and Smart Shelves

Societal issues such as aging population and low birth rate have led to problems relating to lack of workforce and transitioning to retail automation. In order to establish a novel business model that reduces labor and improves customer services, ITRI combines various sensors to realize the "grab-and-go" unmanned stores concept. With an accuracy of up to 98%, the sensors can precisely identify and track activities in smart stores.

Through the combination of various sensing devices, such as cameras, load cells, and infrared light curtains, this technology helps to track in-store customers and overcome issues of blockages, overlapping images and shadows when an item is taken, returned, or misplaced. Sensors can operate independently or be used with other sensing devices for the management of smart shelves, smart stores, supply rooms or inventory. The combination of sensors can facilitate application of smart technologies and automation in the retail industry, leading transformation among retail equipment suppliers.



High-Density Smart Shuttle Rack System (SRS)

High-Density Smart Shuttle Rack System (SRS)

To facilitate the transformation and upgrading of the traditional logistics storage industry, ITRI developed crucial technologies including human-robot collaboration, order-based AI dynamic decisions and iAGV. It further created a control and smart scheduling system for the first Taiwan-made Shuttle Rack System (SRS). Incorporating current storage management and smart transportation modules used by logistics service providers and automated equipment suppliers, the SRS maximizes storage space and solves problems faced by e-commerce businesses such as excessive inventories, insufficient shipping time and limited manpower resources. The system is able to predict the number of orders, assign optimal storage locations, and plan the most effective order selection schedule. The SRS also attracted an e-commerce conglomerate to expand its investment in Taiwan, where it built the first AI-based high-density SRS logistics center in Asia. The SRS storage allows the number of stock items to be 2.5 times more, saving up to 60% of shipping time, and hopefully will decouple the production capacity during peak season.

Testing and Certification Technologies for Smart Lighting Systems

Driven by the trends of 5G and smart cities, the smart lighting market is growing. To meet the requirements of smart lighting systems, lighting components are required to be stable and highly compatible. With its experience of standardization work and its links with the International Commission on Illumination (CIE), ITRI has been providing lighting-related technical

services for years. It has been accredited as a DALI-2 Test House, meaning it can provide testing service for Digital Addressable Lighting Interface. ITRI has helped manufacturers in developing smart lighting control systems and entering the global supply chain. Furthermore, ITRI integrated the technologies of lighting, communication, electronics, artificial intelligence, and industrial design to develop intelligent dynamic road lighting and deploy the system at a fishing harbor in Taiwan in 2019. The system won the Golden Lighting Award presented by CIE-Taiwan in recognition of its outstanding contribution to energy efficiency.



Smart Stores and Smart Shelves



Testing and Certification Technologies for Smart Lighting Systems



QUALITY HEALTH

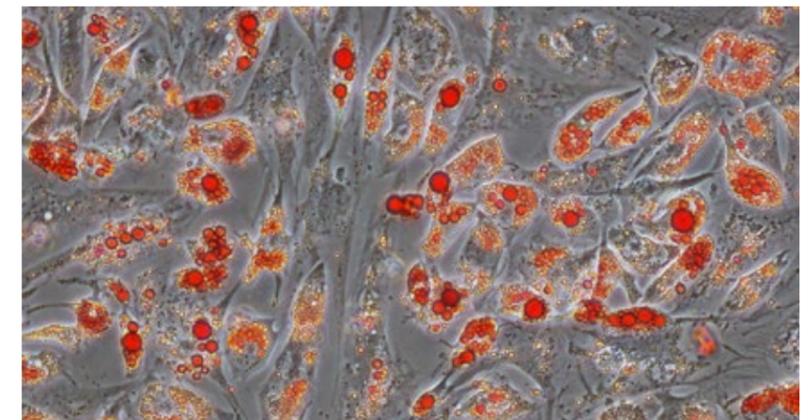
Keeping Healthcare Good & Affordable

Smart Medtech

Allogeneic Stem Cell Therapy

Cell therapy technology is a key indicator of a nation's biology achievement. With good cellular processes, it can help tissues self-heal, which neither medicine nor medical devices can accomplish as effectively. Since special regulations governing specific cellular therapeutic technology were enforced in Taiwan in 2018, more enterprises have started to invest in the cell therapy industry. ITRI, for its part, is devoted to the research and development of allogeneic stem cell core technology and to establishing a refined standard of procedure (SOP) that includes processes from purification to production, quality-control and pre-clinical verification. ITRI now runs a good tissue practice (GTP) stem cell production center offering customized mesenchymal stem cell (MSC) products and services along with essential documents for clients.

Global pharmaceutical and medical device companies have engaged in cell therapy technology in the hopes of getting a head start. The most difficult part is to maintain cell quality, high production efficiency and low cost. ITRI has integrated a supply chain including auto-machinery and the SOP of cells, assisting in the customization of a systematic standard process and providing clients with sufficient high-quality stem cell products.



Allogeneic Stem Cells



Liquid Biopsy

Liquid Biopsy

In response to the global trend of precision medicine, ITRI has designed a liquid biopsy for lung cancer based on only one syringe of blood. Standard procedures require blood centrifugation immediately after sampling the blood, and the sample must be preserved in the refrigerator. In contrast, ITRI's liquid biopsy can extract high-quality cell-free DNA and allow for two-week storage at room temperature after blood collection. The liquid biopsy system includes an IVD (*in vitro*

diagnostic device) kit and a machine which automatically diagnoses gene mutation of EGFR (epidermal growth factor receptor) indicating lung cancer. ITRI's liquid biopsy technology is comparable with similar world-class products but is less time-consuming and even more accurate because it adds testing for an eighth mutation. The introduction of this system has aligned manufacturers of components and modules, reagents, and machinery to form a supply chain for the precision diagnosis industry.



Intelligent Handheld Ultrasound Imaging System

ITRI has developed a handheld sonography system which weighs less than 400 g and is less than 16 cm in length. By using this wireless device along with a customized mobile application, doctors can diagnose patients in a variety of settings, including home care. The ultrasound imaging system features high-resolution imaging technology and is equipped with a series of ultrasound probes for different applications, such as internal medicine, gynecology, and rehabilitation. It is particularly suitable for emergency. This innovation was a winner of the 16th Taiwan National Innovation Awards.



Intelligent Handheld Ultrasound Imaging System

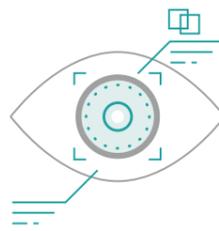
Drug SK0 for Multiple Sclerosis

ITRI found that SK0 drugs applied in the treatment of bronchial disorders can effectively alleviate symptoms caused by multiple sclerosis (MS). MS is an autoimmune disease caused by abnormalities in the central nervous system. Patients affected by MS can experience symptoms such as vision impairment, limb weakness, dizziness, pains, or urinary and defecatory dysfunction that would result in the inability for independent living or even paralysis. MS remains incurable today; only injections and oral medications can mitigate the symptoms.

With its drug research program, ITRI discovered in animal tests that not only can SK0 improve symptoms of spontaneous encephalomyelitis, but it also helps to reduce inflammation in the nervous system. This result suggests that the drug has similar effects to dimethyl fumarate, an oral medication for MS that is currently on the market. SK0 appears to be a stronger candidate in terms of medical treatments for MS due to innovative approaches, safe applications, reasonable production costs, and a large patient population. Currently, the Taiwan Food and Drug Administration (TFDA) has approved the Investigational New Drug (IND) clinical trial application and a global patent portfolio for SK0 has been completed.



Drug SK0 for Multiple Sclerosis



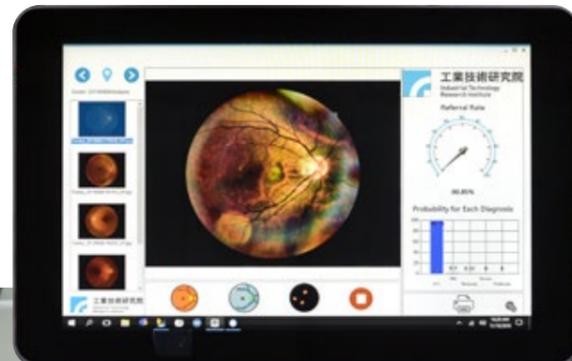
Accuracy Above
90%

Intelligent Medical Assistant Solution (iMAS)

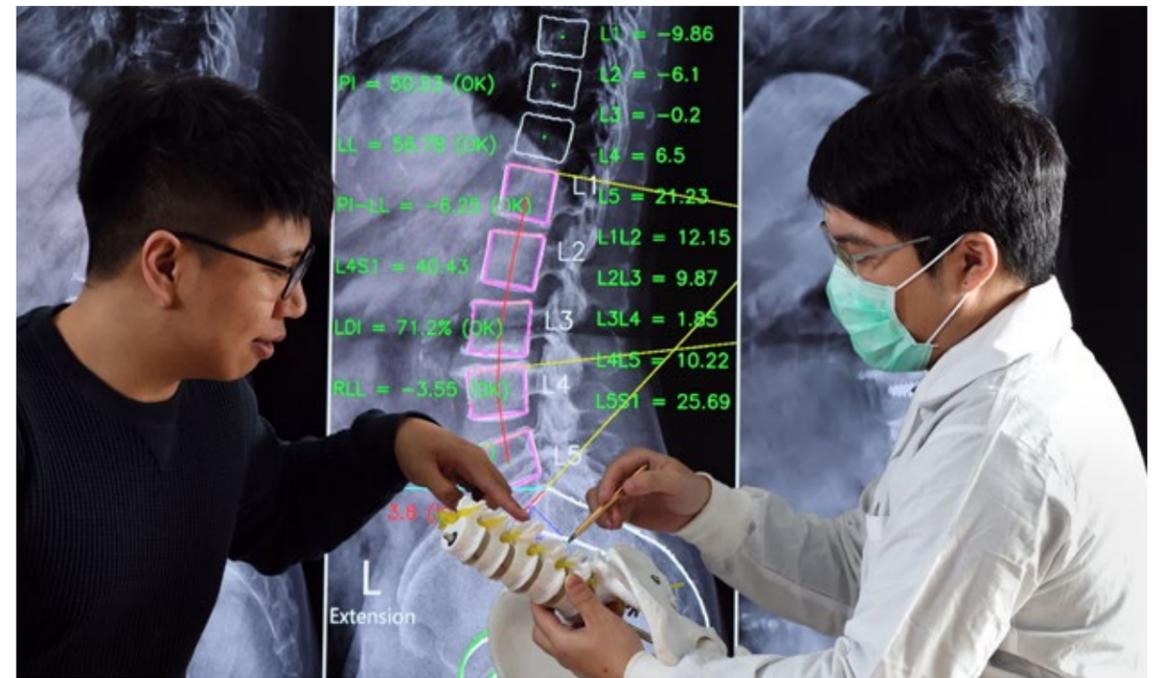
Although fundus examinations can help detect diabetes at an early stage, only a few people around the globe are screened. Many diabetics cannot even undergo regular examinations for pathological changes, or track the development of their disease. In Taiwan, the percentage of people receiving fundus examinations at ophthalmology clinics is still under 40%, making it the least effective measure under the national diabetic

care network. ITRI developed an intelligent gateway that compiles images through integrated soft and hardware to launch the Intelligent Medical Assistant Solution (iMAS), enabling patients to carry out one-click fundus self-examinations. With just a click of a button, users can take pictures of their retinas, which are then examined for any abnormalities by AI through an inserted intelligent gateway. It only takes five seconds to produce a diagnosis, with accuracy above 90%.

This one-click automated self-check model can be used in hospitals, clinics, health check centers, and related institutions. Meanwhile, it allows people to carry out examinations at home or in remote areas, thereby improving care for diabetics.



Intelligent Medical Assistant Solution (iMAS)



Spine X-Ray Image Measurement and Analysis Technologies

Spine X-Ray Image Measurement and Analysis Technologies

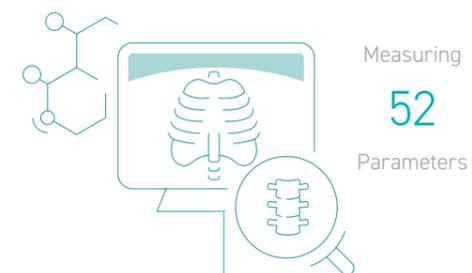
The preoperative evaluation for spinal surgery is based on the experience of physicians. However, due to individual differences and the lack of an objective tool to assist in clinical analysis, successful surgery and good postoperative results are hard to achieve. ITRI has applied an AI model and a deep learning and measurement algorithm to develop measurement and analysis tools for spine X-ray images. By training the AI model with preoperative and postoperative clinical images, the developed system can provide measurements of 52 parameters and the detection of abnormal spondylolisthesis. It can also simulate the effect of implants to aid physicians in evaluating spinal deformity. Physicians from several hospitals have joined the

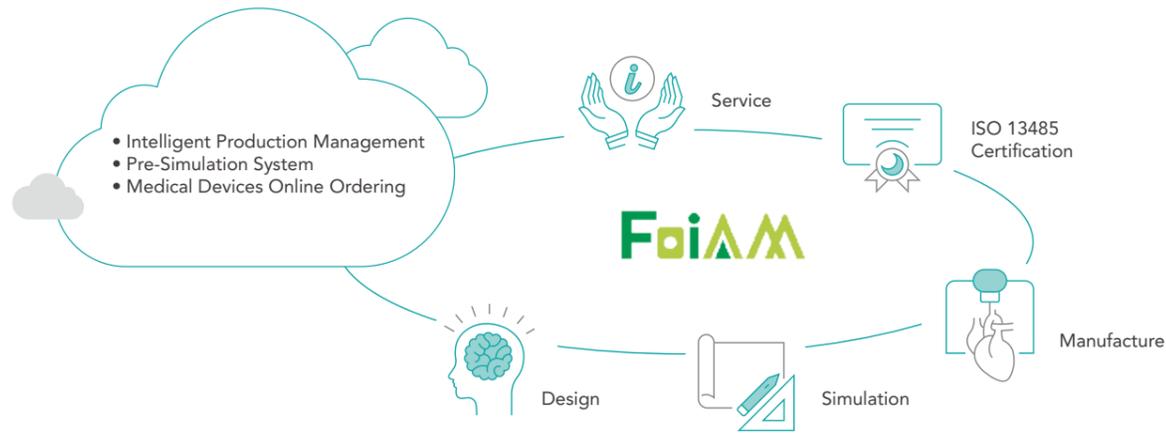
development trial using the system, and their comments have shown the improved efficiency of clinical diagnosis and treatment.

Integrated High-Efficiency Gene Editing-Based Cell Engineering Platform

By introducing a cutting-edge genome-editing technique, ITRI is able to alter cells using biological information to locate genetic targets that have higher potential. This technique can be applied to improve the functions of cell lines and facilitates the production of biologic agents and medications. Moreover, it can help doctors overcome serious medical obstacles, for example, in the curing of genetic disorders, improvement of immunotherapies, and treatment of cancers.

ITRI established a highly efficient cell line engineering platform by integrating the existing biological information analysis platform with cell line selection technology. It has now developed a variety of unique and patented cell strains used for the production of high-performance industrial cell lines. ITRI is also collaborating with U.S. companies in developing customized cell strains and intends to work on enhancing the clinical practice of cancer treatments in the future.





3D Printing Demonstration Project for Intelligent Manufacturing of Medical Devices

With the advantages of customized medical implant devices, ITRI established the Factory of Intelligent Additive Manufacturing Medical Devices (FoiAM) in Kaohsiung Science Park. FoiAM received ISO 13485 2016 certification, with approved factory registration and ASTM F3001 compliance for biomedical devices; it is ready to offer services in the design and manufacture of 3D printed medical devices with dedicated AM equipment.

The technology has completed 38 samples in 25 collaborative projects with the medical device industry, research institutes and hospitals. By cooperating with



Novel Targeted Drug for Glaucoma

Kaohsiung Veterans General Hospital (KVGH) and Alliance Global Technology, the first trial clinic using 3D printed medical devices has been set up at KVGH. The three organizations are also preparing to launch a human trial of additively manufactured mandibular prosthesis for oral cancer patients, which is the first of its kind in Taiwan to personalize medical treatments via smart innovative technologies.

Novel Targeted Drug for Glaucoma

The number of patients with glaucoma has been increasing substantially over the years. It is already the number two cause of blindness, which leads to a growing demand for glaucoma drugs worldwide. However, traditional glaucoma prescription drugs only provide patients with a limited selection which in repetitive use can easily lose drug efficacy or even result in side effects. ITRI has been dedicated to developing new small-molecular drugs for ophthalmology, introducing novel targeted drugs for glaucoma, organizing patent portfolios, applying for clinical trials, and promoting commercialization.

Adopting its unique targeted drug development technology, ITRI developed a new generation of ROCK (Rho-associated Kinase) inhibitors, which is better than other similar products in helping lower eye pressure without causing irritating side effects. This technology has attracted a drug manufacturer in France and spurred further collaboration between the two countries to facilitate the transformation of Taiwan's ophthalmologic drug industry.

Healthcare



Personal Companion Robot for Older People Living Alone (PECOLA)

Personal Companion Robot for Older People Living Alone (PECOLA)

An aging society such as Taiwan has an increasing demand for elderly care services. ITRI's PECOLA robot is able to identify and analyze the physical and mental states of seniors. The robot employs ambient intelligence technology in caring for its elderly companions, making sure they are in good health and spirits. It also compiles and sends information to the senior's family members to help spark topics for discussion and bolster communication between them. PECOLA uses image recognition to record changes in food portion and carry out diet analysis to understand the individual's food intake. PECOLA also uses WiFi signals in detecting one's breathing rate during sleep.

What's more, it utilizes deep learning technology to detect fall incidents. Once a fall is detected, the robot immediately calls the individual's family members to initiate a video session for home safety. PECOLA continues to integrate third-party services, such as entertainment and social activities for the elderly, as well as functions to foster convenience, smart living, and healthcare.

Miniature Multi-Pixel Gas Sensor

With air pollution becoming more severe, over 92% of the world's population is living under poor air quality conditions, driving demand for environmental monitoring devices. It is estimated that the annual production value of gas sensors will reach US\$3.1 billion in 2028.

The miniature multi-pixel gas sensor developed by ITRI combines a micro-machining multi-sensing unit and micro-heater and sensing materials, along with a patented programmable temperature control and sensing integrated circuit as well as patented dynamic self-compensation correction technology to realize composite gas sensing functions. All of this is offered in a tiny package which can detect carbon monoxide and volatile organic compound gases at concentrations of ppb level.

This technology establishes an AI inference model through machine learning and data tagging for intelligent system solutions. It has connected domestic and foreign system makers and platform application providers to introduce innovative applications of gas/odor analysis and develop smart sensors for real-time odor recognition, environmental and safety monitoring, medical treatment and healthcare.



Miniature Multi-Pixel Gas Sensor



SUSTAINABLE ENVIRONMENT

Creating a Low-Carbon, Energy-Saving & Circular Community

Circular Economy

Energy-Saving Fast Biochar Expert System

Taiwan annually produces more than ten million tons of agricultural waste with lignocellulose. If zero-waste recycling can be used to generate high-value-added biomass and energy recycling can be applied, it will increase the value of agricultural circular economy and reduce agricultural waste treatment costs. However, since incineration or external heating carbonization generally produces biochar and consumes large amounts of energy, ITRI's Energy-saving Fast Biochar Expert System uses a direct-thermal anoxic combustion system with an intelligent control interface.

The system can set up parameters for different materials and apply carbonization heat without requiring additional fuel. It will simultaneously produce biochar and natural vinegar, and recycle heating energy. This system can be custom-designed for various carbonized materials. With different moisture content of raw materials, the carbon yield is 25-30% and vinegar yield is 30-35%. The outcome can enhance soil optimization, pest control, and crop growth promotion to reduce use of agricultural fertilizers; thermal energy can provide hot water or be used to dry crops.



Energy-Saving Fast Biochar Technology

Green Technology for Electronic Grade Solvent Recycling

The demand for top quality wet chemicals such as etching or cleaning solvents for high-end processing is very high within the semiconductor and optoelectronics industries. ITRI has developed Dividing-Wall Column (DWC) green distillation technology for electronic grade solvent purification and recycling based on typical chemical separation techniques. It features reliable output purity and quality, a high recovery rate and low energy consumption. This pioneering technology for the electronic-material factory production line can solve the dilemma of high-value solvent loss and poor quality from off-site recycling.

ITRI's solution is suitable for exhaust solvent from lithium batteries or thin-film material factories and cyclic purification of the stripper or thinner used in wafer or LCD panel plants. The technology has been verified through factory application. Besides improving sewage discharge, the system operating cost is less than 50% of the price of solvents, with return on investment under two years regardless of the system capacity. There

are currently seven successful commercial cases with potential benefit of US\$40 million annually.

Ultimate Hydrogen Purifier (UHP)

Taiwan's semiconductor and electronics industries produce more than 140 million cubic meters of unrecyclable hydrogen waste per year. Due to the high price of hydrogen purifiers, these wastes are usually incinerated or released into the atmosphere. ITRI thus developed Ultimate Hydrogen Purifier (UHP), a low-cost membrane solution for hydrogen separation. Unlike traditional hydrogen separation membranes which are made of pure palladium, ITRI's UHP has an extra layer of porous ceramic added to the palladium surface. With its pores slightly larger than hydrogen molecules and smaller than mixed gas molecules, the ceramic layer allows hydrogen molecules to pass through while blocking mixed gases to efficiently produce highly-purified hydrogen. The production cost of the UHP membrane is 50% lower than that of pure palladium membranes. This technology is now being adopted by chemical engineering and semiconductor equipment suppliers.



Ultimate Hydrogen Purifier (UHP)

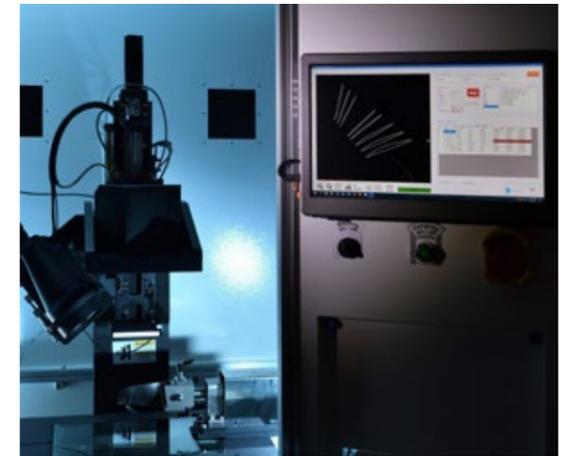
Smart Manufacturing

Intelligent Vision 2D+3D High Accuracy High Precision Measurement Technology

ITRI's Intelligent Vision 2D+3D High Accuracy High Precision Measurement Technology combines analysis methodologies for both 2D images and 3D models to acquire highly accurate and precise object measurements in edge and surface curvature. The system can be adopted in production lines for measurement, inspection, identification, and automated positioning. In comparison to mainstream measurement systems such as the coordinate measuring machine (CMM), the speed of ITRI's technology is three times faster under the same accuracy and precision conditions. Numerical values comparable to those from hard gauge inspections can be obtained, eliminating significant expenses for hard gauge fabrication, calibration, and maintenance. The system enhances production and quality efficiency significantly while promoting the transition towards automated and intelligent manufacturing.

The Industrialization of 3D Electric Circuits for High-Frequency Telecommunications

While telecommunication equipment manufacturers rush to produce products with smaller sizes, narrow bezels and multifunctional antennas, surface adhesion problems in 3D electric circuit production remain unsolved.

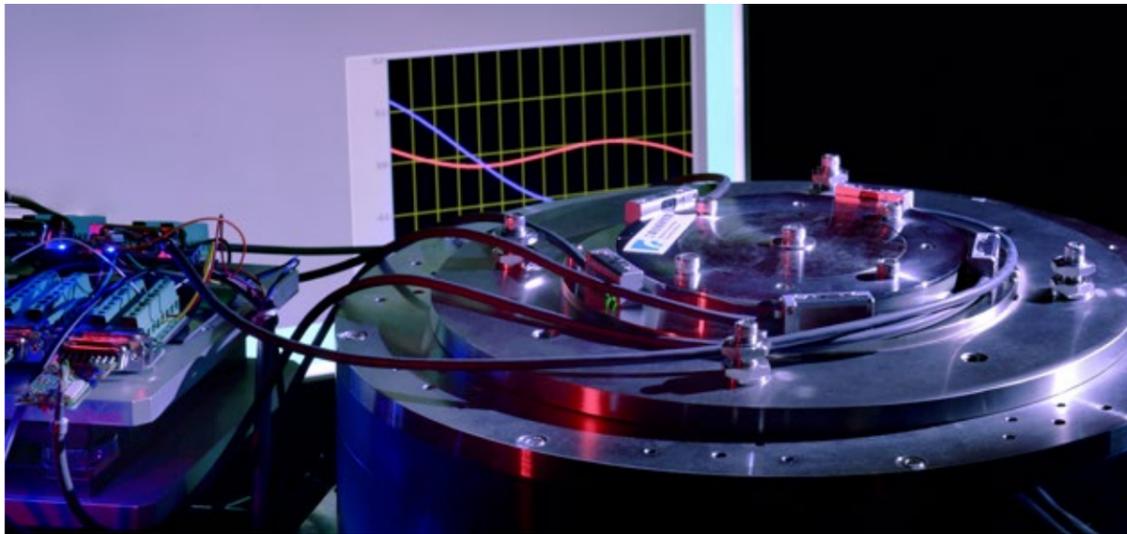


Intelligent Vision 2D+3D High Accuracy High Precision Measurement Technology

ITRI has developed multi-antenna 3D multi-input multi-output (MIMO) technology for the manufacture of 5G products with a high screen ratio, assisting businesses in applying this technology in their production of laptop frames. The screen ratio of laptops has increased from 82% to 95%, while notebooks are becoming capable of transferring data at a speed up to gigabits per second. Meanwhile, ITRI has been working with major international manufacturers to develop 3D wall-embedded PTFE cables for high-frequency 5G telecommunications, which helps increase data transfer efficiency by 20% and reduce device thickness by 50% (< 0.4 mm). ITRI is also cooperating with prominent international glass manufacturers to create a 28 GHz MIMO antenna module for 5G networks. This technology received the 2019 National Industrial Innovation Award, the Technical Achievement Award, and the Technology Management Award.



The Industrialization of 3D Electric Circuits for High-Frequency Telecommunications



Portable Continuous Angle Standards (PoCAS)

Portable Continuous Angle Standards (PoCAS)

The five-axis machine tool is of crucial importance in smart manufacturing. Its positioning accuracy is significantly affected by the geometric error of the rotary table. Based on current measurement capability, the accuracy (specification) of the rotary table made by domestic manufacturers is around $\pm 10''$ for positioning error (angle) and $\pm 10 \mu\text{m}$ for linear error. This accuracy level lags behind those attained by competitors.

ITRI has developed Portable Continuous Angle Standards (PoCAS) based on the concept of encoder calibration technology. The measurement error caused by manual installation can be minimized by the proprietary mechanism design and analysis algorithm. PoCAS can be used to measure angular positioning error and linear installation error simultaneously. Its positioning and linear uncertainty are less than $0.8''$ and $3 \mu\text{m}$ respectively. By applying PoCAS, the installation and measurement process can be completed within 30 minutes. During the production process, PoCAS can help the industry to meet the measurement requirements for assembly and quality control, while improving the accuracy of the rotary table for the five-axis machine tool.

High-End Intelligent Five-Axis Controller Technology

Five-axis machines are capable of making complex surfaces for high-end parts in automobiles, aerospace

and precision machinery. However, since advanced multi-axis control technology in Taiwan is not yet maturely developed and imported multi-axis controllers are all closed systems, it is difficult for machine tool manufacturers to develop their own customized value-added applications.

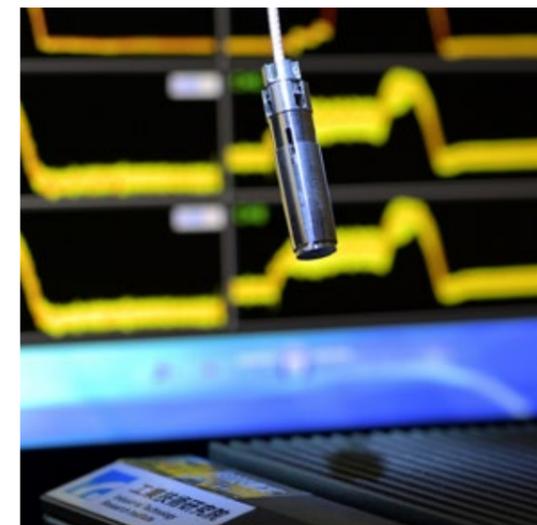
ITRI has developed a high-end five-axis controller that supports EtherCAT protocol with open Windows-based platform. The controller features simultaneous five-axis control functions, including tool center point control and a guidance function for tilted-plane machining. With the integration of spindles and servo drives via EtherCAT fieldbus, total solutions for digital control systems are included.

The controller can demonstrate rapid machining results and prevent machines from colliding via a built-in three-dimensional cutting simulation and anti-collision module. IoT devices can be connected by IO-Link together with EtherCAT fieldbuses to the controller. Since value-added software applications can be developed on an open Windows platform, it is easy to build super intelligent machines and automated production lines.

ITRI has helped several machine tool manufacturers succeed in developing high-end intelligent five-axis machining and increasing the unit price of their CNC machines to NT\$5 million. ITRI has also assisted manufacturers to build I4.0 (Industry 4.0) smart production lines via an open controller platform.

Dynamic Force Sensor Module

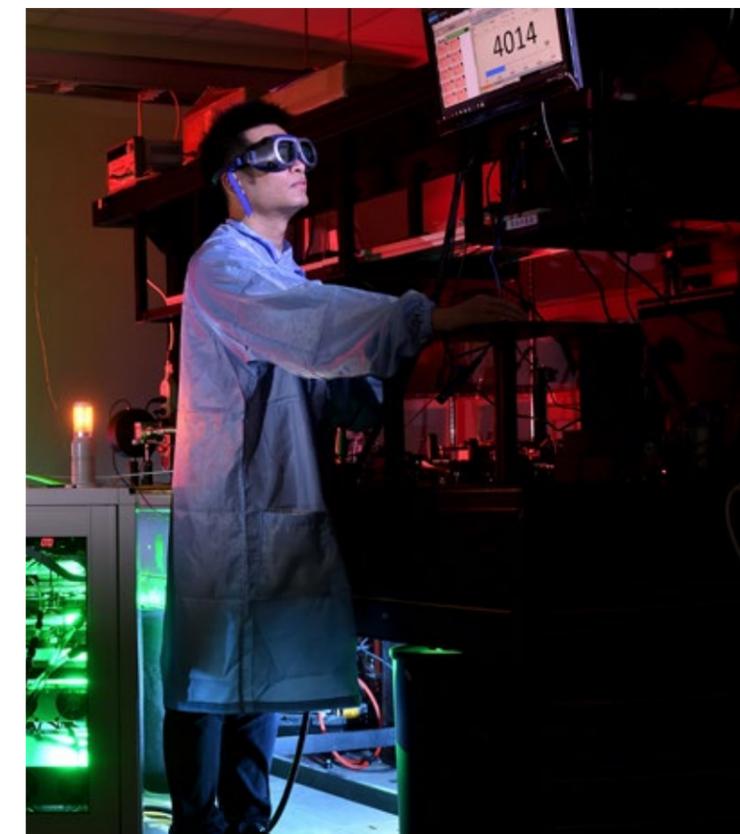
Taiwan's aerospace component and fastener suppliers rely on high-cost imported dynamic force sensors for press-forming processes. Moreover, the domestic forging and press-forming industry can neither monitor the quality of processing nor analyze the causes of malfunction due to lack of real-time pressing force monitoring techniques. To address these demands, ITRI offers a complete software and hardware integration scheme through its dynamic force sensor module. This scheme prevents signals from weakening over time through shock-resistant sensors and electrical circuits that can eliminate ambient interference. Also, it reflects the pressing force characteristics in real-time and monitors the forging force distribution curve, helping fastener manufacturers to control production yield and energy consumption, reduce inspection costs, enhance product quality, and increase the added value of products. This scheme has been adopted by major fastener manufacturers in Taiwan for full product inspections to enhance product quality and stability. The defect rate is lowered to 0 ppm. The objective is to assist domestic forging and press-forming businesses in incorporating AI into manufacturing and improving their production techniques.



Dynamic Force Sensor Module

4 kW High-Power Direct Diode Laser (DDL)

Laser sources, the most critical component in laser-based processing equipment, account for 30% of the NT\$20 billion worth of annually imported laser equipment. ITRI's 4 kW high-power direct diode laser (DDL) is a success featuring arrayed laser diode technology with high-efficiency fiber combiners, heat dissipation design as well as driver and control power electronics. The high-power DDL also features domestic laser diodes (LDs) and a smart power management function that provides real-time power monitoring and control. When laser output drops 10%, the high-power laser source self-compensates to maintain a stable output. The 4 kW DDL is suitable for metal welding and surface heat treatment, which can facilitate the development of high-power laser-based processing equipment in Taiwan.



4 kW High-Power Direct Diode Laser (DDL)

Green Energy & Environment Technology

Smart Environmental IoT Governance Model

Traditional air quality monitoring instruments are not widely distributed due to their high cost and massive size. As a result, government and factories face difficulties in identifying sources of pollution from insufficient air quality data. ITRI adopted the microsensor technology to collect high-resolution data and analyze them through big data to identify pollution hotspots and peak times in achieving smart environmental management.

Apart from developing air quality sensors, ITRI has established an innovative management model based on the environmental Internet of Things and set up a mechanism to ensure the quality of data collected by microsensors. ITRI has installed 8,300 air quality sensors nationwide, assisting environmental protection agencies in holding violators responsible via smart inspection technology to protect public health.

Celluad™

ITRI has developed Celluad™, a cellulose-based adhesive that is free of formaldehyde but exhibits great adhesion and water-resistance. It is an affordable alternative to toxic formaldehyde-based plywood products and features high process compatibility. There is no need to purchase additional equipment to produce plywood with Celluad™ in wood panel factories.

Cellulose, which is most abundant in nature, is the ideal material to solve the issues of resource scarcity and high costs in the development of formaldehyde-free adhesives. After thermal curing, this material shows excellent adhesion capability which derives from the curing resin cross-link reaction, allowing the adhesive to resist boiling water for 4 hours, successfully meeting the boiling water test requirements of CNS1349 type I (100°C).

Celluad™ is applicable to plywood, flooring, and lumber core board and can help manufacturers develop eco-friendly products and grasp new business opportunities. Celluad™ has obtained patents in Taiwan, the U.S. and Japan and has passed product certification among European and Japanese furniture retail chains. Researchers are now working to extend its use to particle board. The continuous development of this novel material will enable wider applications and help create a healthier environment.



Plywood Products Using Celluad™



Reconfigurable Array of Inexpensive Batteries Architecture (RAIBA)

Reconfigurable Array of Inexpensive Batteries Architecture (RAIBA)

As the automotive industry faces a transition from fossil fuel-based to electric vehicles, rechargeable batteries are playing a more important role in energy storage and utilization. The new challenge is to develop batteries that not only provide stable and sufficient power but also function safely and efficiently. RAIBA is a world-leading technology using AI to control electric discharge load of battery modules and integrate the storage system of new and old modules. This allows different battery modules to complement each other in the most efficient way, reduce energy waste, and extend system cycle life. The technology has already been adopted by electronic and electromechanical companies and businesses that have transformed gas stations into recharging stations. The objective is to facilitate the sustainable development of energy storage infrastructure and electric vehicles, and create new business opportunities for renewable energy. This technology won an R&D 100 Award in 2019.

Phthalate-Free Safe & Eco-Friendly Plasticizer Technology

Plasticizer is a vital industrial raw material in our daily necessities, and the most widely used type today is Phthalate Esters, a group of environmental hormones that has been phased out in many countries. Given that the use of phthalate-free safe and eco-friendly plasticizer has become a trend for the petrochemical industry, ITRI has developed a hydrogenation process using a patented highly active and selective catalyst, and multi-hydrogenation with packed-bed reactors in series. The new process can directly hydrogenate Phthalate Esters (e.g. DOP/DINP) into a phthalate-free, safe and eco-friendly plasticizer under relatively low pressure, temperature and hydrogen-oil ratio, thereby reducing the process cost and safety risk. This multi-step connected reaction manufacturing process uses a low-cost single-tube fixed-bed reactor instead of costly multi-tube units to reduce facility construction and operating costs. This technology has been transferred to Taiwan's manufacturers.



Nanofiltration

Nanofiltration

Taiwan relies on imports for more than 90% of its water treatment membranes. In response to the government's reclamation policy, the water treatment industry urgently needs to independently develop competitive membrane materials. ITRI's Nanofiltration (NF) technology has the characteristics of low operation pressure, high permeability and anti-fouling ability. Through membrane product development and field system verification, NF membrane material and a module system featuring high efficiency and long-term stability were developed. Field tests have shown that 100 CMD domestic wastewater can be reclaimed with a recovery rate of 75%. Operating costs can be reduced to less than NT\$16/ton, which is more optimal than the reverse osmosis (RO) solution used currently.

Inverter Air-Conditioning for Mass Transit Industry

Public transport vehicles travel through areas with different climate conditions, but they usually adopt non-inverter air conditioners that are power-

consuming and fail to control temperature efficiently. Besides, crucial components such as compressors, fans, and controllers are mostly imported from manufacturers abroad, who control prices and after-sales services. Therefore, the Taiwanese transportation industry is in desperate need of a total solution for Taiwan-made public transport AC systems.

ITRI has cooperated with industry alliances to develop a three-in-one variable speed scroll compressor that is 30% smaller than the original design. Other inventions include variable speed axial fans, centrifugal fans, and VRV (variable refrigerant volume) and VAV (variable air volume) air conditioning systems. In addition to functioning as a cooler, a heater and a dehumidifier, each system can modify temperature, humidity, and CO₂ concentration according to weather conditions and the number of passengers on board, using an AI-computing control system. This technology is currently being tested on Taoyuan City's MRT system. The objective is to realize a public transportation system with a smart inverter AC system that conserves energy and provides excellent user experience.

Energy-Saving Improvement Technology for Refrigeration System

Nationwide supermarkets consume over one billion KWh of electricity annually, of which 70% are from freezers and refrigerators. Most of these systems are using non-inverter, large horsepower motors that are unable to adjust capacity with the fluctuating loads, causing waste of power.

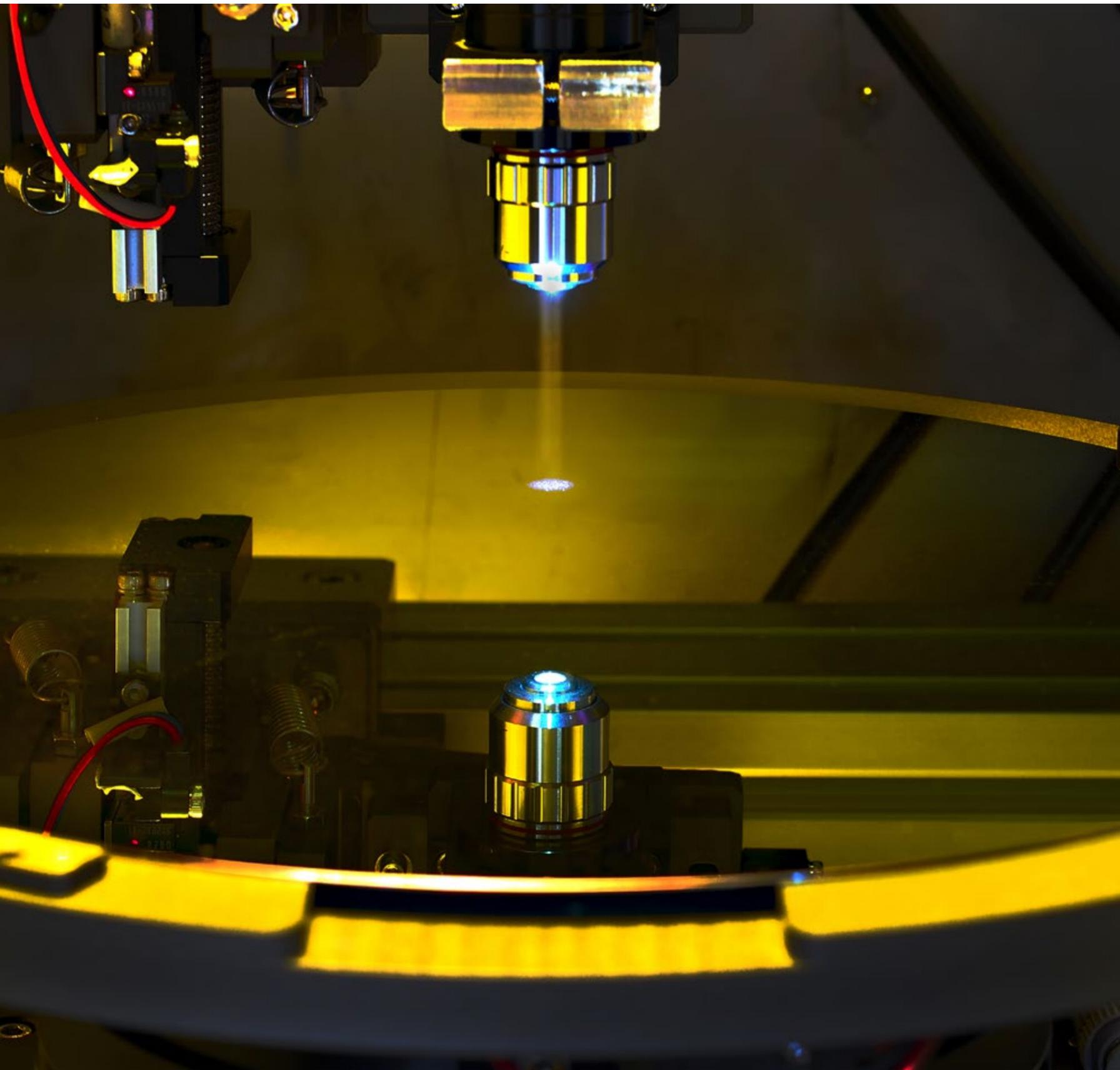
ITRI has developed a smart inverter control module that avoids energy wasting by using floating pressure control to change low-pressure setting according to load fluctuations. This innovation can improve the efficiency of the compressor operating in optimum state with a general-purpose inverter. Field test results have shown a 20% improvement of energy efficiency. With an estimate of around 2,200 supermarkets and with a 30% penetration rate of this application, this technology can save NT\$90 million in electricity costs and contribute to approximately NT\$120 million in business revenue.

Testing and Certification Technologies for Photovoltaic Products

Photovoltaic (PV) technology is a key application in the field of green energy. PV products must meet the requirements of international standards. ITRI has been focusing on PV standardization work and providing testing services for years. In 2019, the Non-uniform Dynamic Mechanical Load System was established to serve as the test platform for wind resistance of PV modules. It can provide customized configuration of mechanical forces according to the intended environment. Based on technical capacity, ITRI has been active in Photovoltaics Quality Assurance Task Force (PVQAT) TG7 (wind load) and IEC TC82 for the development of international standards for wind resistance. This standardization work can enhance the reliability and safety of PV products and connect manufacturers to the global market. In 2019, ITRI provided 86 cases (32 vendors) of technical services and 25 cases (12 vendors) of industrial cooperation in helping manufacturers to obtain international business orders.



Testing and Certification Technologies for Photovoltaic Products



ICT ENABLING TECHNOLOGY

Boosting Multiple Applications

Advanced Inspection and Metrology Technologies for Semiconductor Manufacturing

With the miniaturization of electronic devices, the manufacturing process of semiconductor products requires advanced equipment to meet measurement challenges. ITRI has developed a series of advanced inspection and measurement technologies to provide metrology solutions for industry. The mono-droplet generator (MDG) and element reference standard were established to generate a particle standard for particle size calibration of Single Particle Inductively Coupled Plasma Mass Spectrometry (spICP-MS). The metrology solutions meet the calibration requirements of particle sizes and number concentrations for related raw materials used in semiconductors. For Die Attach Film (DAF), ITRI has developed a film thickness and wafer thickness measurement technology. It breaks the limitation of DAF thickness measurement and offers good accuracy regardless of DAF thickness. The three-dimension profile measurement technology is capable of alignment inspection for the stacking modules of integrated circuits with heterogeneous integration. The accuracy has been improved from 100 nm to 10 nm, greatly enhancing the competitiveness of manufacturers of automated wafer size measurement equipment.



Advanced Inspection and Metrology Technologies for Semiconductor Manufacturing

Robot Self-Learning Technology

In order to assist the industry to improve production efficiency, ITRI has developed self-learning technology for robots. The robotic arms adopt AI technology that enables quick learning and can complete different workpiece grasping tasks for small industries and diverse production needs. At present, the workpiece loading and unloading mode using visual analysis technology needs to be adjusted by an engineer with image processing expertise. Depending on the complexity of the workpiece type, it takes one to seven days to complete successfully. In addition, the installation of special machines or visual parameter adjustment is time-consuming and costly and may lead to idled machines due to lack of flexibility. ITRI uses robot simulation software to teach self-learning robotic arms to grasp workpieces. It only takes about 12 hours to complete the training and the robotic arm can work for actual workpieces the next day with slight adjustment, which greatly shortens the replacement time for new workpieces.



Robot Self-Learning Technology

PCB Equipment: M2M Communications Technology

Taiwan is the world's largest printed circuit board (PCB) provider with a complete supply chain. However, system integration between new and old machines remains a complex task due to a lack of standard machine interfaces for communication. To solve this issue, ITRI initiated the Printed Circuit Board Equipment Communication Interfaces (PCBECI), a proposal for PCB standards, which was adopted as the formal standard for communications equipment by Semiconductor Equipment and Materials International (SEMI) in September 2019.

The PCBECI provides communication standards such as time setting, incident reporting, abnormality alerts, machine constants, remote control demands, data transfer between terminals, management of prescription transfer and machine status reporting. The communication protocol of PCBECI and other relevant technologies have now been adopted by over 20 major PCB manufacturers, with around a hundred machines already connected to the Internet.



Panel-Level Fan-Out Module Integration Technology

Panel-Level Fan-Out Module Integration Technology

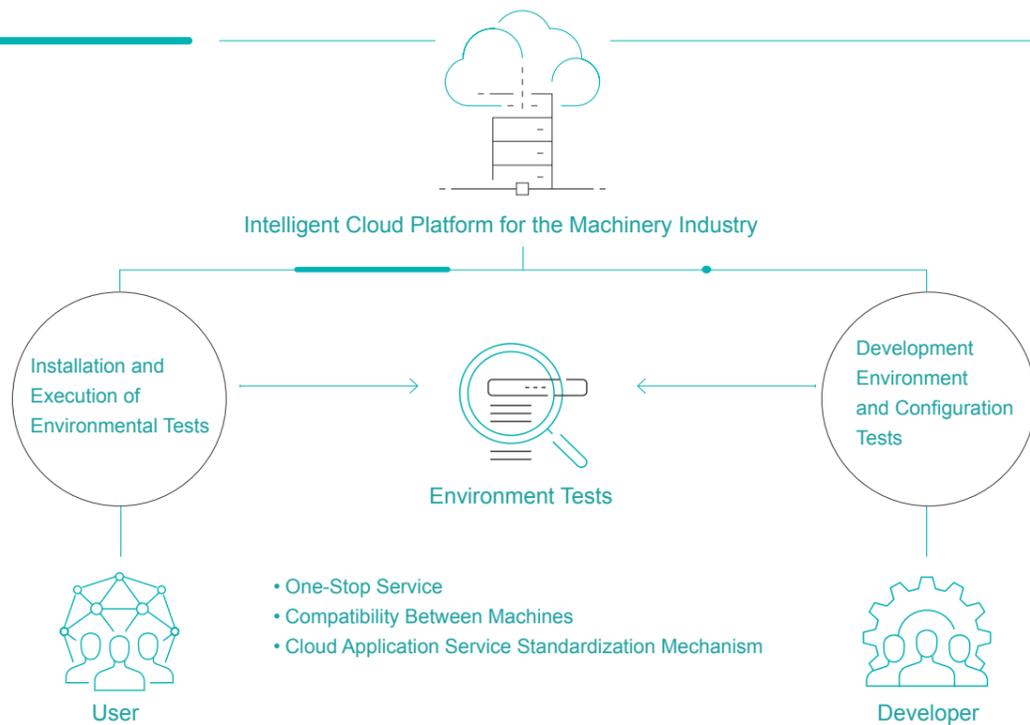
Based on the size and process framework of current IC carriers, ITRI's Panel-level Fan-out Module Integration Technology features cross-field integration of the panel-level fan-out packaging design and process. Besides upgrading the IC carrier industry, the technology makes it possible to embed 2 μm fine conduction lines in IC carriers for the PCB industry. Furthermore, a testing platform for materials and processing is established using ITRI's fan-out packaging design and process technology. Currently adopted by manufacturers at home and abroad, this platform prepares IC carrier factories for offering packaging services to clients and allows material manufacturers to carry out packaging testing on fan-out packaging materials.

Innovative Memory Solution: Next-Generation FRAM and MRAM

In the era of 5G and AI, semiconductors are geared towards heterogeneous integration as combinations

of various technologies and next-generation memory can overcome current computing limitations. ITRI was the most prolific contributor in the field of innovative memory at the International Electron Devices Meeting (IEDM) held by the Institute of Electrical and Electronics Engineers (IEEE), where it presented three critical papers on ferroelectric RAM (FRAM), and another three on magnetoresistive RAM (MRAM), providing a new direction for the research and development of the industry.

The high-speed, high-endurance spin-orbit torque (SOT) MRAM developed by ITRI diverts electric current away from components to prevent damage when data are being loaded from, or written into MRAM. SOT MRAM is also more stable and can load and save data faster than other existing MRAM options. Relevant technologies have been introduced to ITRI's pilot wafer manufacturing plant.



Intelligent Cloud Platform for the Machinery Industry

The Taiwan Association of Machinery Industry (TAMI) White Paper proposed to build a cloud platform that would fulfill the vision of a NT\$2 trillion machinery industry by 2025. However, there are still a number of problems that make the transformation difficult: (1) Smart machine box (SMB) incompatibility and duplication of software development by different institutes and companies. (2) Lack of a software marketplace for the machinery industry. (3) Lack of a standardized SaaS/Apps development process. In order to resolve these problems, ITRI proposed to integrate IoT solutions, cloud computing, virtualization and containerization techniques to build a common cloud platform for the machinery industry which includes standardized SMB runtime and information model, standardized development process and standardized marketing and operation platform. This would be the world's first cloud service platform for the machinery industry, through which service developers could benefit from reducing development and maintenance costs. Meanwhile, products can be provided globally via e-commerce platforms and protected by world-leading cyber security teams. The end-user would thus benefit from services and applications on the cloud with lower costs and better delivery, reliability and quality management.

Smart Management Platform and Software Solutions

Many factories struggle to acquire comprehensive production information and have difficulty in factory automation, which consequently limits their improvement in product quality and energy efficiency. To solve this problem, ITRI adopted industrial IoT technology to create a smart analysis and management system that leverages industrial big data for energy management, process monitoring, preemptive maintenance, and other functional schemes. The system allows managers to improve information transparency and utilize smart tools to enhance production through cloud computing. The system also provides an advanced industrial software control system to improve equipment control and the manufacturing process.

Many manufacturing factories are using this management platform. Together with effective administrative management strategies, it can save up to 3% of energy consumption. The platform also helps the public sector understand the energy demands of industries. ITRI is now promoting the installation of this technology across 117 car manufacturers nationwide and has integrated its autonomous control software into the distributed control system (DCS) adopted by Taiwanese equipment suppliers. The software solution has also been applied to 35 chemical engineering factories and marketed to China and the United States.

5G Small Cell

As 5G networks are integrated with cloud and virtualized solutions, service providers are promoting Open virtual-Radio Access Network (Open vRAN). This opens up and standardizes base station interfaces so that telecommunications companies can establish flexible and cost-effective 5G networks with third-party equipment providers. By directly purchasing equipment from manufacturers, telecom operators can break through the oligopoly of major international brands, potentially resulting in drastic cuts to installation costs and large-scale reshuffling of orders.

With years of R&D results in key technologies, ITRI has led local businesses in exploring the global 5G market by proposing a solution that involves 5G base station software technology and software/hardware integration. ITRI established a 5G base station network with 18 Taiwanese companies, devising 5G small cell products and facilitating the development of crucial products, modules, and components related to small base stations, mobile edge computing (MEC), and network function virtualization infrastructure (NFVI).

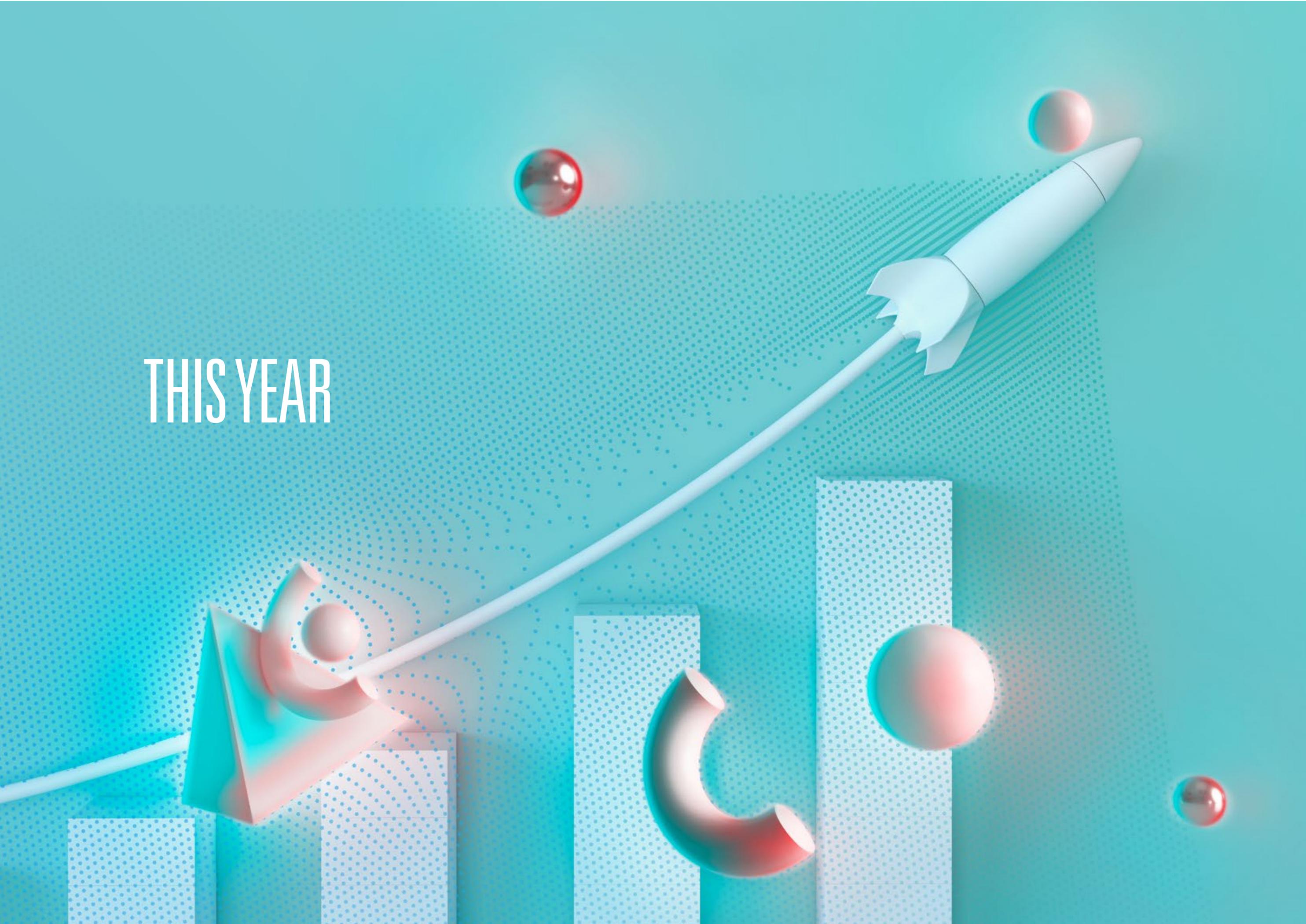


Millimeter Wave Phased Array Antenna

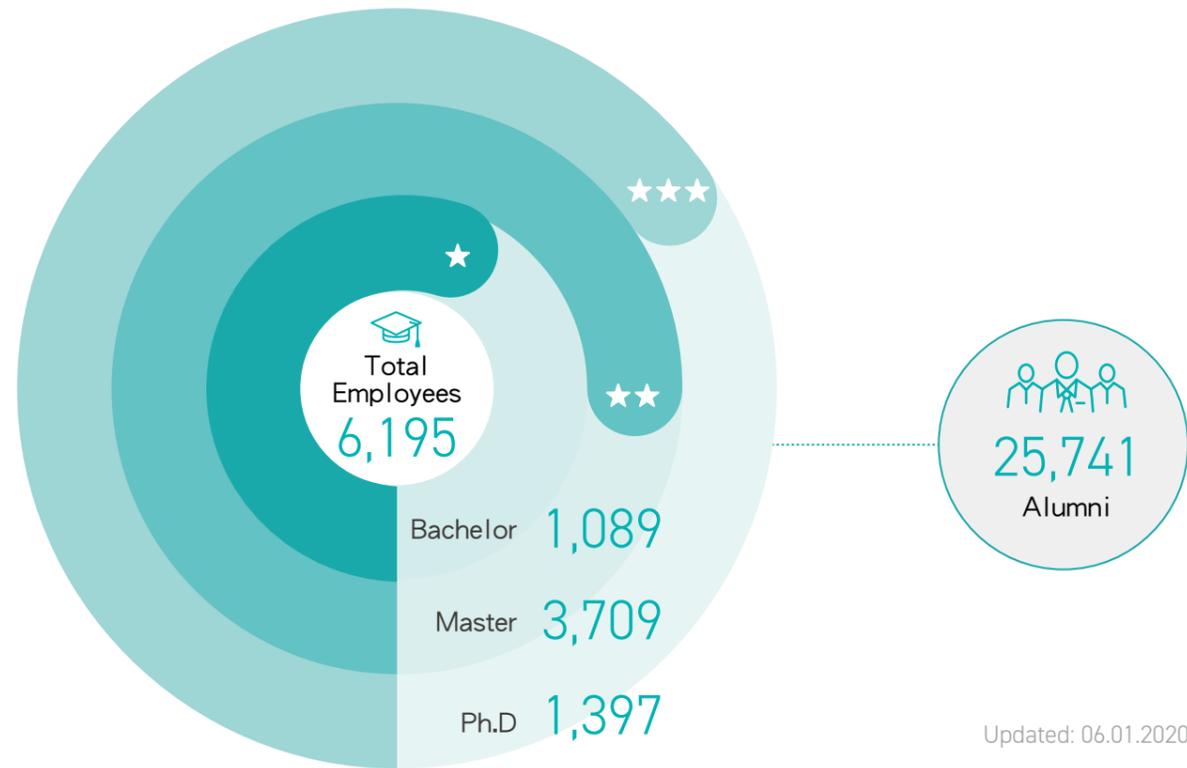


5G Small Cell

THIS YEAR



Organization & Human Resources



Management Units

Chairman, Board of Directors

Chih-Kung Lee

Managing Director

Chih-Kung Lee
Tsung-Tsong Wu
Jong-Chin Shen
Sin-Horng Chen
Chao-Tung Wong

Director

Ming-Hsin Kung
Wen-Lon Cheng
Kai-Hung Hu
Chi-Mau Sheih
Chao-Yih Chen
Zhang-Hua Fong

Executive Supervisor

Hung-Kun Tsai

Supervisor

Ching-Jong Liao
Fuh-Sheng Shieu

President

Edwin Liu

Executive Vice President

Pei-Zen Chang
Alex Y.M. Peng

Executive Operating Officer

Shiaw-Shian Yu

Senior Vice President

Jia-Ruey Duann
Cheng-Wen Wu

Chairman of Industrial Technology Investment Corporation

Edwin Liu

R&D and Business Units

ITRI Southern Region Campus

Cheng-Wen Wu

ITRI Central Region Campus

Stanley H. Huang

Biomedical Technology and Device Research Laboratories

Chii-Wann Lin

Green Energy and Environment Research Laboratories

Ren-Chain (Joseph) Wang

Material and Chemical Research Laboratories

Tzong-Ming Lee

Mechanical and Mechatronics Systems Research Laboratories

Jwu-Sheng Hu

Information and Communications Research Laboratories

Tzi-Cker Chiueh

Electronic and Optoelectronic System Research Laboratories

Chih-I Wu

Industry, Science and Technology International Strategy Center

Stephen Su

Laser & Additive Manufacturing Technology Center

Fang-Hei Tsau

Smart Microsystems Technology Center

Chun-Hsun Chu

Intelligent Machinery Technology Center

Lai-Sheng Chen

Computational Intelligence Technology Center

Vincent Feng

Service Systems Technology Center

Jen-Chieh Cheng

Center for Measurement Standards

Tzeng-Yow Lin

Commercialization and Industry Service Center

Jia-Ming Liu

ITRI College

Yi-Chun Chou

Service Units

Technology Transfer and Law Center

Peng-Yu Wang

Office of Strategy and R&D Planning

James Wang

Business Development Center

Shiaw-Shian Yu

Office of Marketing Communications

June Lin

Administrative Service Center

Chi-Liang Lee

IT Service Center

Yi-Jen Chen

Finance and Accounting Center

Hui-Jen Fan

Office of Human Resources

Ta-An Ho

Financial Report



Statement of Comprehensive Income

Unit: Million NTD

Accounting Item	2019	2018
Total Revenues	24,512	23,841
Revenues from Contracted Projects	8,191	9,092
Revenues from Technological Service	14,793	13,194
Derivative Revenues from Contracted Projects	1,355	1,390
Non-Operating Revenues	173	165
Total Expenses	24,305	23,787
Contracted Projects Expenses	8,183	9,074
Technical Service Expenses	14,094	12,605
Derivative Contracted Projects Expenses	1,313	1,313
Applied Research Expenses	680	758
Non-Operating Expenses	35	37
Net Income	207	54

Balance Sheet

Unit: Million NTD

Assets	2019	2018	Liabilities and Funds and Surplus	2019	2018
Current Assets	9,749	9,016	Current Liabilities	7,744	7,299
Cash	5,373	5,458	Accounts Payable, Accrued Expenses, Receipts under Custody and Other Payables	6,593	6,389
Accounts Receivables, Accrued Incomes and Other Receivables	4,192	3,381	Advance Receipts	1,151	910
Prepaid Expenses	118	176	Other Liabilities	3,554	3,522
Inventories	66	1	Total Liabilities	11,298	10,821
Other Financial Assets-Non Current	6,789	7,181	Funds and Surplus	10,393	10,889
Property, Plant and Equipment	8,044	7,941	Initial and Donated Funds	468	468
Other Assets	461	473	Donated Surplus	636	636
			Assets Improvement and Expansion Reserve	6,214	6,479
			Investment Surplus	3,046	3,246
			Adjustment to Shares of Changes in Equities of Investments	29	60
			Accumulated Surplus	1,520	848
			Others	1,832	2,053
			Total Funds and Surplus	13,745	13,790
Total Assets	25,043	24,611	Total Liabilities and Total Funds and Surplus	25,043	24,611

Snapshot of 2019



JAN

1/7

The Hybrid Power Drone with High Payload and Duration was named a CES 2019 Innovation Award Honoree.

1/15

ITRI signed an MoU with IDEA Consult to facilitate the cooperative exchange of industrial and technology policies between Taiwan and Europe.

1/29

ITRI signed a cooperation agreement on Research of Next Generation Energy Metering System with TEPCO Power Grid and Tokyo Gas, establishing a demo field at the Shalun Smart Green Energy Science City.

FEB

2/12

ITRI cooperated with the Yunlin Branch of National Taiwan University Hospital to create a from-hospital-to-home safety net and demo field for the elderly by devising a digital platform that integrates medical services and healthcare.

2/26

ITRI brought together 25 leading companies and schools in the fields of electricity, power grid, and renewable energy to establish the Power Grid Alliance & Academy to promote energy transformation.

MAR

3/25

ITRI and the British Office Taipei unveiled the achievements of the UK-TW Innovative Industries Researcher Placement Programme.

3/26

By launching a prosthetic reconstruction clinical trial project with Allianz Global and Kaohsiung Veterans General Hospital, ITRI provided patients with personalized smart medical treatments based on innovative technologies. The project was the first to use 3D printers to produce fillers specifically designed for oral cavity cancer.

APR

4/3

The V2X road safety system iRoadSafe received a 2019 Edison Award.

4/10

ITRI received the National Industrial Innovation Award from the Ministry of Economic Affairs for seven major achievements: a Distinguished Academic and Research Institution Innovation Award, two Innovative Trailblazer of the Year Awards (Team Category), a Model of Local Industry Innovation Award, an Industry Innovation Alliance Award, and two Innovation Elite Awards.

4/12

ITRI was listed among the Derwent Top 100 Global Innovators for the third time, becoming the most award-winning research institution in Asia.

4/22

Ms. Yi-Chun Chou was named the General Director of ITRI College.

MAY

5/7

ITRI established the Taiwan Ophthalmology and Optics Industry Platform, aiming to enter the global market by compiling resources and momentum from related industries.

5/22

ITRI licensed its Lignocellulose Fractionation Technology to All Cosmos Bio-Tech and assisted the company to build a ton-scale pilot plant in Malaysia and tap into the Southeast Asia market.

JUN

6/3

ITRI initiated multiple transnational green energy technology projects by signing an MoU with Pöyry, a renowned consulting and engineering firm headquartered in Finland.

6/12

ITRI signed an MoU with the Thai logistics company Panus on the development of electric trucks and further formed an electric bus alliance with eEasy Technology and Tong Ying Body to help Taiwan's suppliers enter the ASEAN market.

JUL

7/3

ITRI collaborated with the Taiwan High Speed Rail Corporation in reinforcing railway system safety and announced the application of the first bogie running tester in Taiwan.



**7/15**

ITRI signed a contract with Tonic Fitness Technology Inc. on an experimental initiative, which helped the company build smart factories by adopting smart manufacturing technologies that integrate both software and hardware.

AUG

8/12

ITRI coordinated with significant manufacturers to form an alliance to invest in high-capacity battery systems for high-performance laser welding equipment, in the hope of increasing the production capacity and quality of Taiwan-made batteries.

8/13

ITRI and UCLA Samueli School of Engineering established an industry-academia network for AI and robotics to cultivate top interdisciplinary talents through a bridge program.

8/27

ITRI collaborated with the Taiwan Business Bank and the Small & Medium Enterprise Credit Guarantee Fund of Taiwan to connect technology and capital markets to make possible preferential interest financing through intangible asset valuation. This trilateral cooperation is the first of its kind in Taiwan.

SEP

9/5

ITRI cooperated with Microsoft to develop AI chip technologies, facilitating cooperation in AI chip design and protection of chip card terminals, while developing relevant applications.

9/18

ITRI developed a technology for low-warpage panel-level fan-out packaging integration and worked with Innolux Corporation to explore various applications and business prospects for next-generation chip packaging.

9/23

ITRI's Hybrid Power Drone with High Payload and Duration was shortlisted for the Drone X Challenge 2020 in Dubai, making ITRI the only R&D institution from Asia to achieve this qualification.

OCT

10/15

ITRI held the 2019 ITRI Laureates Award Ceremony, at which President Tsai Ing-Wen presented medals and certificates to the five laureates: AbGenomics Chairman Patrick Y. Yang, Taiwan Cement CEO Nelson Chang, Winbond Electronics Chairman Arthur Yu-Cheng Chiao, Allis Electric Group President Chen-Tung Yang, and Formosa Plastics Chairman Jason Lin.

10/22

With the help of Hsinchu City Government, the first road trip was taken by Taiwan No.0001 at Nantiao Fishing Harbor in Hsinchu, making it Taiwan's first autonomous car to be tested in an open field.

10/23

iRoadSafe received the Industry Award at the 26th ITS World Congress.

10/24

ITRI's ICT Innovation for Self-Service Ophthalmoscope won the merit award in the Innovative eHealth Solutions category at the 23rd World Congress on Information Technology (WCIT).

10/30

ITRI's Optical and Electrical Testing Laboratory was recognized by the Digital Illumination Interface Alliance (DiiA), making it the only testing laboratory in Taiwan to receive a Digital Addressable Lighting Interface (DALI) certificate.

NOV

11/1

ITRI received two 2019 R&D 100 Awards with its bionic knobby magnetic beads manufacturing technology (iKNOBEADS) and Reconfigurable Array of Inexpensive Batteries Architecture (RAIBA).

11/11

The Consumer Technology Association (CTA) announced ITRI's PECOLA (Personal Companion for Older People Living Alone) and iStimUwear as CES 2020 Innovation Awards Honorees.

DEC

12/10

ITRI established manufacturing bases for laser system technology and equipment and expanded applications of domestic laser technologies by forming the Laser Source Industry Alliance with 13 Taiwanese laser technology companies.

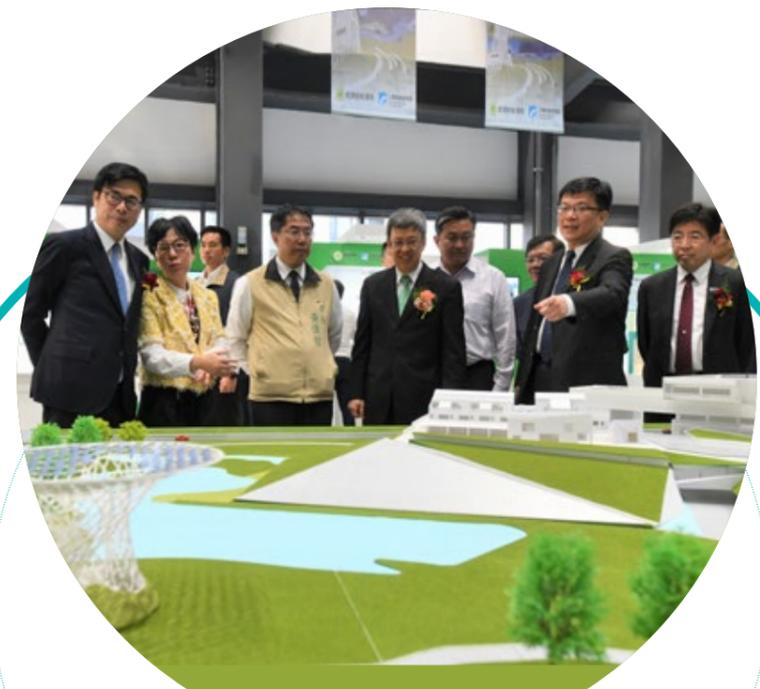
12/12

Dr. Shiao-Shian Yu was named the Executive Operating Officer of ITRI.

Dr. Stanley H. Huang was appointed as the General Director of ITRI Central Region Campus.

12/16

Shalun Smart Green Energy Science City, the first science park integrating nature, culture, and technologies in Taiwan officially opened. The science park enables businesses to develop and test green technologies for industrial use, creating a hub for the green energy economy.



Domestic & International Offices



Overseas Offices

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