



## COVID-19 Response: Building Safe Testing Booths for Medical Workers

In response to the escalating COVID-19 cases within Taiwan, ITRI rapidly deployed its positive pressure testing booths to hospitals and rapid testing stations, hoping to protect frontline health workers with a safe and clean working environment.

# ITRI TODAY 105 Summer Issue 2021

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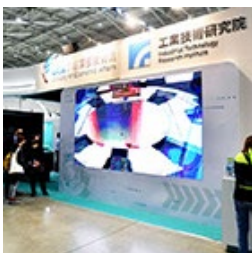


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## » Feature

# Positive Pressure Testing Booth Supports COVID-19 Efforts



***ITRI's Positive Pressure Testing Booth.***

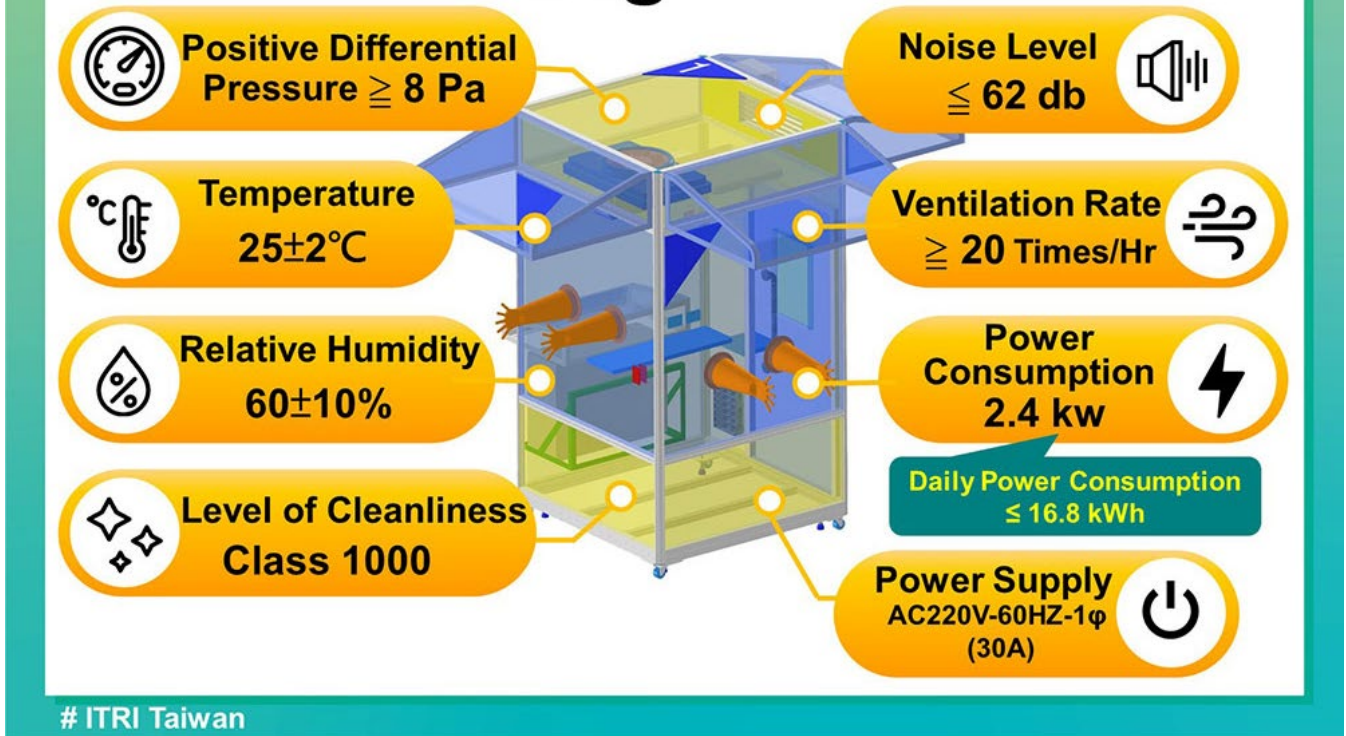
When Taiwan saw a sudden COVID-19 surge this May, the upgrade to a nationwide alert Level 3 (of a four-tier system) demanded a prompt scale-up of testing capacity. To support swab collection efforts, ITRI ramped up production on its positive pressure testing booths to assist health workers around the island. Several booths were built within 48 hours at key rapid testing stations, with the assistance of local component manufacturers and hospitals.



***When the local outbreak of COVID-19 began in mid-May 2021, ITRI staff rushed to build testing booths overnight.***

The testing booth was first developed in 2020 for alleviating the infection risks of medical workers when they collect nasal/throat swabs. This booth features safe design, high sample collection efficiency, energy-saving and comfort, ultra-cleanliness, and quick assembly. Working with the National Taiwan University Hospital Hsinchu Biomedical Park Branch and Mackay Memorial Hospital Hsinchu Branch during the designing phase, ITRI conducted field tests at these two hospitals. This year, the booth came into full play to help Taiwan overcome the pandemic crisis.

# Positive Pressure Testing Booth



## *ITRI's positive pressure testing booth features.*

Other than its quick assembly feature, the testing booth's two-sided design allows a high sample collection rate of at least 12 individuals per hour, and in urgent situations up to 240 samples per day. This suits the need for massive rapid testing, e.g. at the testing stations set up for science park employees or COVID-19 hotspots.

With the class 1000 level of cleanliness and airtight positive pressure technology of 10 Pascals (Pa), health workers inside the booth do not need to wear uncomfortable and cost-prohibitive PPE. Meanwhile, the booth is fitted with an air-conditioner, providing a safe and comfortable environment for medical workers. The built-in smart energy-saving technology also lowers daily power consumption to less than 16.8 kWh and daily electricity costs to below US\$2.

After fast deployment in the hardest-hit areas in Taipei, the testing booths soon attracted the attention of the public and received many inquiries for purchases or donation by businesses, charities, celebrities, and legislators. Hundreds of testing booths have been set up and launched in testing stations around the island since the May outbreak, showcasing the design's effectiveness in time-demanding situations.

ITRI's Positive Pressure Testing Booth was acclaimed for assisting in COVID-19 efforts amid the recent pandemic outbreak in Taiwan. The testing booth can also be integrated into a one-stop service that includes both sampling and testing in order to spot any cluster infection quickly.

Under the severe circumstances and challenges of the COVID-19 pandemic, ITRI put its technology solutions into practice during Taiwan's time of need. ITRI believes that this tech innovation can bring its benefits to other places when needed as it can boost the COVID-19 testing efficiency while ensuring the safety of health workers.



## » Spotlight



## Establishing Net Zero and Sustainability Strategy Office



***ITRI launched the Net Zero and Sustainability Strategy Office and announced its net zero by 2050 target.***

Many countries are heading towards net zero emissions by 2050 to curb global warming and meet their commitments under the Paris Climate Change Agreement. To align with the global trend of cutting carbon pollution, ITRI on March 22 launched its Net Zero and Sustainability Strategy Office and announced that it would achieve net zero emissions by 2050. The establishment of the Office will help promote and integrate technology R&D across industries and will assist Taiwan in drawing its strategic blueprint to meet the 2050 net zero target. This will also urge industries to shift their focus towards sustainable development and seize business opportunities brought about by net zero emission initiatives.

ITRI President Edwin Liu pointed out that 128 countries have pledged to go net zero by 2050, and that major enterprises such as Apple and Microsoft have announced plans for their supply chains and product life cycles to become carbon neutral or carbon negative by 2030. “These

trends will have major influence on Taiwan's export-oriented economy. First, carbon tariffs will impact Taiwan's indirect export trade and even the overall economy. Second, Taiwan's industries will lose their competitiveness if they fail to meet the global leading companies' carbon emissions reduction requirements for their suppliers," said Dr. Liu.

Facing the carbon trade barriers that may occur in the future and the need for greener supply chains, ITRI established the Net Zero and Sustainability Strategy Office as a starting point to set Taiwan on the path of transitioning to net zero emissions. It will connect experts from different sectors and promote innovative interdisciplinary research to introduce net zero carbon emission approaches to industries. In addition, the Office will formulate 2050 net zero emission strategies for Taiwan, develop low-carbon tech solutions for industrial upgrade, and help build a zero-carbon industrial ecology.

Meanwhile, ITRI will also strengthen international cooperation and continue to explore opportunities from emerging industries in renewable energy, circular economy, and green transportation sectors. It is hoped that by joining the world to tackle carbon emissions, Taiwan will remain competitive in the global market and boost sustainable economic development.

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## » Spotlight

# How to Co-Invent with Taiwan to Achieve the 2050 Target

Dr. Alex Y.M. Peng

Executive Vice President

Achieving net zero emissions by 2050 is a global challenge. A study by Standard Chartered revealed that 55% of business leaders believe that their companies are not transitioning fast enough to reach net zero by 2050. It will truly take a concentrated effort from different sectors to co-invent with Taiwan in fulfilling this goal. So how can we take part to make the transition faster? Here's something ITRI can do and what it's been doing.

### Identifying Possible Pathways

2050 is still 30 years from now, and there will be many changes and variables for technological R&D and industrial development during this period of time. To respond against such uncertainty, ITRI will adopt scientific approaches and tools to explore possible pathways that Taiwan can take to achieve 2050 net zero emissions.

### Developing Low-Carbon or Carbon-Free Energy

The energy sector contributes to more than 90% of Taiwan's GHG emissions. Therefore, low-carbon or CO<sub>2</sub>-free power generation will play a crucial part in Taiwan's endeavor to achieve the 2050 target. ITRI will conduct scenario evaluations to determine the required energy supply and demand for achieving 2050 net zero emissions to assist the government in adopting low-carbon or carbon-free approaches, significantly increase energy efficiency, promote the use of renewable energy, and establish the [Loading Order](#).

### Working for Circular Economy

ITRI will continue to enhance its R&D capability and co-invent even more closely with industrial partners to accelerate the development of circular economy. It hopes that these efforts can replace existing production and consumption patterns, create innovative business models, and lead industries to transition to a green economy.



*ITRI is committed to helping Taiwan achieve the 2050 net zero target.*

## **ITRI's Commitment**

ITRI itself has also applied innovative technologies to its campus by focusing on four areas to show its determination toward net zero emissions by 2050.

First, it is working on **zero-carbon power generation**. It aims to deploy next-generation renewable energy and introduce a virtual power plant system to integrate all power sources for optimal regulation, providing a reliable overall power supply for ITRI's campus.

Second, for **low-carbon/zero-emission** manufacturing, ITRI will reduce CO<sub>2</sub> emissions from the lab manufacturing processes and reuse gases and materials. It will also enable low-carbon exhaust gas and wastewater treatments.

Third, **changing consumer and user behaviors**: ITRI will cut down building energy consumption and use electric cars and boilers to eliminate the use of fossil fuels. It will also promote a resource sharing platform to increase energy efficiency.

Lastly, **CO<sub>2</sub> capture and reuse**. By introducing advanced negative emission technologies, CO<sub>2</sub> in the air can be captured and converted into green hydrocarbons, helping ITRI achieve its 2050 commitment.

In addition to the applications on campus, ITRI has also been combining its multidisciplinary R&D prowess with the needs of industry partners to develop innovative tech solutions to achieve carbon reduction. (See the following article to learn more details.) Hopefully, these technological innovations can fuel the industries in becoming sustainable suppliers and transforming towards a net zero economy in order to protect the planet and stay ahead of the global market.



## About the Author



Dr. Alex Y.M. Peng is the Executive Vice President of ITRI. His research focus includes circular economy, energy & electronic materials, and strategy and R&D planning. He is the inventor of 26 patents and the winner of R&D 100 Award in 2009 and 2017 for high safety lithium-ion battery technology. Dr. Peng leads the Advanced R&D Programs and heads the Office of Net Zero and Sustainability Strategy at ITRI. He also actively promotes the Open Innovation System Platform (OISP) and global collaboration projects. Dr. Peng was the former President of Material Research

Society-Taiwan and used to be the President of both Taiwan Corrosion & Protection Association and Taiwan Battery Association.

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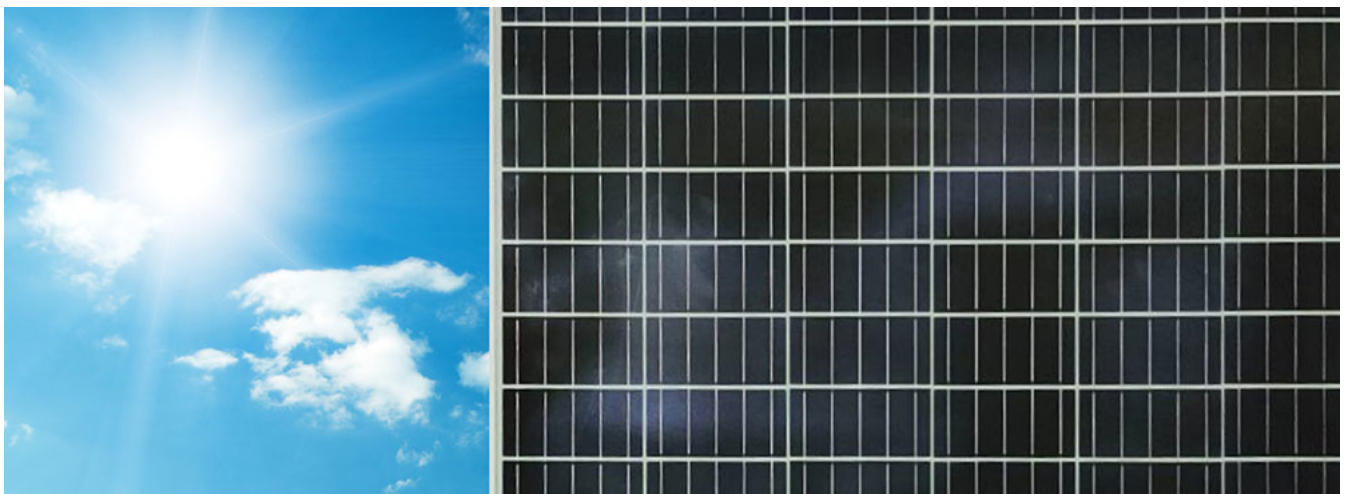
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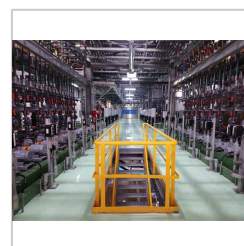
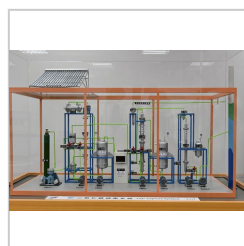
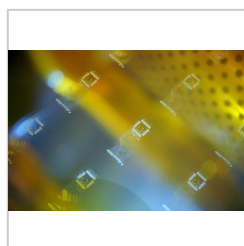
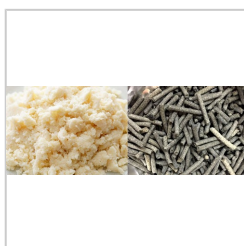
## » Spotlight

# Innovative Techs to Cut Carbon Emissions

ITRI has been developing multiple low carbon circular technologies based on four aspects: **Supply, Consumption, Manufacturing, and Environment**. These include using innovative technologies to recover waste and by-products to add new value or redesigning modular materials for ease of disassembly, incorporating the principles of circular economy into the production process. ITRI assists companies in integrated planning services to find their niche within the net zero economy, and actively deploys energy saving technologies on campus while changing its users' habits to maximize the use of resources through a sharing platform, bringing the benefits of energy saving, carbon reduction and sharing economy into play.



*The TOPCon Solar Cell saves space and has improved efficiency.*



For the goal of achieving net zero and a sustainable environment, join us in looking at some of the achievements from ITRI's current research.

## **Supply**

### **TOPCon Solar Cell**

ITRI's TOPCon Solar Cell features high optoelectronic conversion efficiency, high ROI, and short energy payback time (EPBT), and has successfully concluded pilot production. With a 23.5% battery conversion efficiency and a module power up to 360W through 120 half-cut G1 cells, this world-leading technology has completed verification at the Shalun Green Energy Technology Demonstration Site. This is an effective renewable energy solution for cutting down carbon emissions, as it does not require intricate and complex manufacturing processes, saves over 10% of building land required for the solar power plant, and increases the ROI by 3%.

### **Integrating Virtual Power Plant Technology with Multiple Resources**

ITRI has been developing virtual power plant (VPP) technology, which integrates distributed resources to facilitate the power grid's balance between supply and demand. With the monitoring, forecasting, modelling, and decision making of facility operations, the VPP platform can agilely regulate a customer's overall power demand or generation to meet market needs of a certain time. Currently, ITRI has set up a VPP demonstration platform, with the dispatching center located at ITRI headquarters. The platform links multiple resources including air conditioning of buildings, solar PV systems, and energy storage systems at various ITRI campuses to demonstrate dispatchable customer resources on a MW scale, which will benefit the integration of renewable energy.

## **Consumption**

### **Fermentation and Strain Taming Technology for Lemon Peel Reuse**

Leveraging an innovative silage processing technology, ITRI has explored the new use of eco-materials and turned lemon peels to a low-cost feed for ruminants. This feed increases the intake of cows and improves their health. It is estimated that with this technology, ITRI has helped manufacturers recycle and process over 6,000 tons of waste lemon peels a year. Since the silage feed can be stored at room temperature, the manufacturing process requires less energy and reduces transportation costs, consequently cutting down on greenhouse gas emissions in livestock farming.

### **Turning Bean Dregs to Cat Litter**

Taiwan produces approximately 400,000 tons of bean dregs every year. To deal with this sizable problem, ITRI has assisted tofu manufacturers in developing technologies to reuse bean dregs, effectively processing them into cat litter. Through integrated planning involving careful formula design and performance testing, bean dregs can be transformed into value-added products, which also saves the significant cost originally needed for waste disposal.

## **Manufacturing**

### **Easy-Dismantled PV Module**

ITRI's easy-dismantled PV module utilizes a patented encapsulation film ingeniously composed of the innovative thermoset and thermoplastic bi-layered material. Using the combination of EVA (ethylene-vinyl acetate) with high adhesion strength and TPE (thermoplastic elastomer) with excellent PID resistance and easy dismantling, the PV module has the dual characteristics of operational durability and recycling efficiency. Compared with existing PV modules, which can only be recycled into broken glass granules and low purity silicon scrap, a retired easy-dismantled module can separate and restore entire glass sheets and all cells for further reuse and regeneration. Moreover, the environmental impact due to waste from the original mining production process will decrease by 50-60%, in addition to the carbon reduction for glass and silver metal exploitation.

### **Green Additive Process for Microelectronic Circuits**

ITRI has integrated transfer printing equipment and machine tooling with ultrafast laser and metallization equipment to develop electrical circuits with 3  $\mu\text{m}$ -wide wires. This green manufacturing process saves 87.7% of energy and 92.2% of water as well as reduces 87.2% waste, which allows manufacturers to reach a new level in refining circuits and achieving green manufacturing. With ITRI's assistance, PCB manufacturers have completed the world's first roll-to-roll SAP microelectronic FPC softboard production line.

## **Environment**

### **CO<sub>2</sub> Capture & Utilization Technologies**

ITRI has been developing CO<sub>2</sub> capture technology which uses high performance absorbent, with a capture system for field verification currently established in a power plant and chemical plant. ITRI has optimized operation parameters through field verification: The purity of the captured CO<sub>2</sub> can reach 99.9%, and the absorbent regeneration heat can be less than 3 GJ/tCO<sub>2</sub> during the process. The purified CO<sub>2</sub> can be converted into valuable hydrocarbons, such as natural gas, methanol, and a variety of petrochemicals, which can later be used to produce clothing, shoes, and camping sleeping pads. This technology can be applied to the petrochemical, steel, electricity, and other industries to reduce carbon emissions, and will help facilitate a circular economy and environmental sustainability.

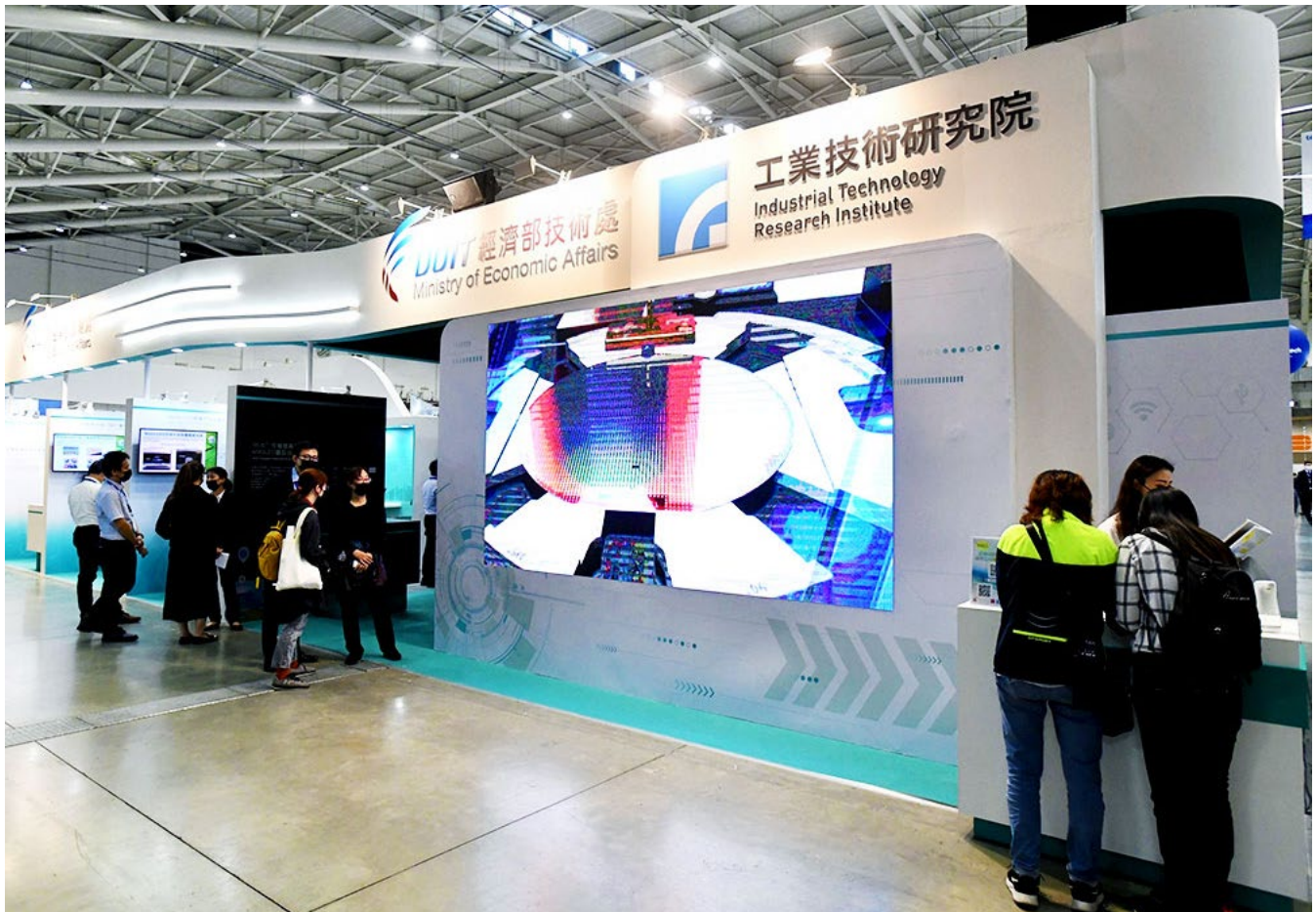
### **High-Performance Water Processing and Recycling Technology**

ITRI has developed optimized processing units and procedures for wastewater reclamation. Key technologies include porous bio-carrier BioNET, fluidized bed crystallization (FBC), anaerobic fluidized bed (AFB), and electro dialysis (ED) to meet the water demands of traditional industries and high-tech factories. The service has been adopted by hundreds of businesses in Taiwan to handle both domestic and industrial wastewater processing to produce high-quality reclaimed water resources.



## » R&D Focus

# Novel Display Applications at Touch Taiwan 2021



***ITRI Pavilion at Touch Taiwan 2021.***

ITRI has been working closely with industrial and research partners to develop advanced, high-value display technological applications and upgrade associated production processes. The latest R&D achievements and novel applications were showcased at Touch Taiwan in Taipei in late April. Highlights this year include a floating stereoscopic interactive system for a touchless elevator panel, a smart transparent car window that merges physical and virtual reality to display dynamic tourism information, a redistribution layer (RDL) integrated thin-film 5G filter and many more.

Dr. Chih-I Wu, ITRI's Vice President and General Director of the Electronic and Optoelectronic System Research Laboratories, stressed that ITRI has been dedicated to key enabling technologies for display manufacturing, which echoes the Ministry of Economic

Affairs' development strategies. For instance, ITRI has developed Low Diffraction AM Micro LED Display Technology to improve the background visibility of transparent panels, with a diffraction intensity of less than 1% -- much lower than the current 30%-40% of most transparent displays. This offers advantages to the application of transparent displays such as in AR surgical information systems and smart windows of vehicles.

The other focus, according to Dr. Wu, is on the panel-level RDL technology. Compared to RDL lines on wafer substrates or PCB carriers, ITRI's panel-level RDL can control panel warpage during processing to 1%, and the line width and line spacing of thick copper conductors can reach 2  $\mu\text{m}$ . This helps the integration of functional components. For example, RDL integrated communication filters can be applied to the packaging of 5G communication chips to meet the demand of thin and light circuit surface area. The panel-level RDL technology can also be applied to the driver circuit of micro LED display panels to increase panel design flexibility.

## ITRI's Tech Highlights at Touch Taiwan 2021

### Anti-Epidemic Floating Stereoscopic Interactive System



***ITRI developed the Anti-Epidemic Floating Stereoscopic Interactive System to enable touchless control of elevator panels.***

In response to the needs of the post-pandemic era, ITRI has developed the Anti-Epidemic Floating Stereoscopic Interactive System based on the full-view light field stereoscopic technology. This system has the characteristics of low cost, small size, low power consumption and high customization. It can be applied to various smart living applications such as elevator



panels, game consoles, retail displays and industrial machine tools, creating a human-machine interface for contactless operation and control.

**Comparison of ITRI’s floating touch technology with a commercial counterpart.**

<b>Item</b>	<b>ITRI</b>	<b>Others</b>
<b>Image Source</b>	~1,500 ppi	154*118 (~38 ppi)
<b>Interactive Interface</b>	<b>Full-View Floating Stereoscopic Technology / Floating Touch</b>	<b>Floating 2D Image / Floating Touch</b>
<b>Bulky Size</b>	79 mm x 79 mm x 61mm	237 mm x 157 mm x 97 mm
<b>Image Size (L x W x H)</b>	35 mm x 35 mm x 35 mm	5” (2D)
<b>FOV</b>	60 degrees	45 degrees
<b>Power Consumption</b>	< 1 W	~60 W

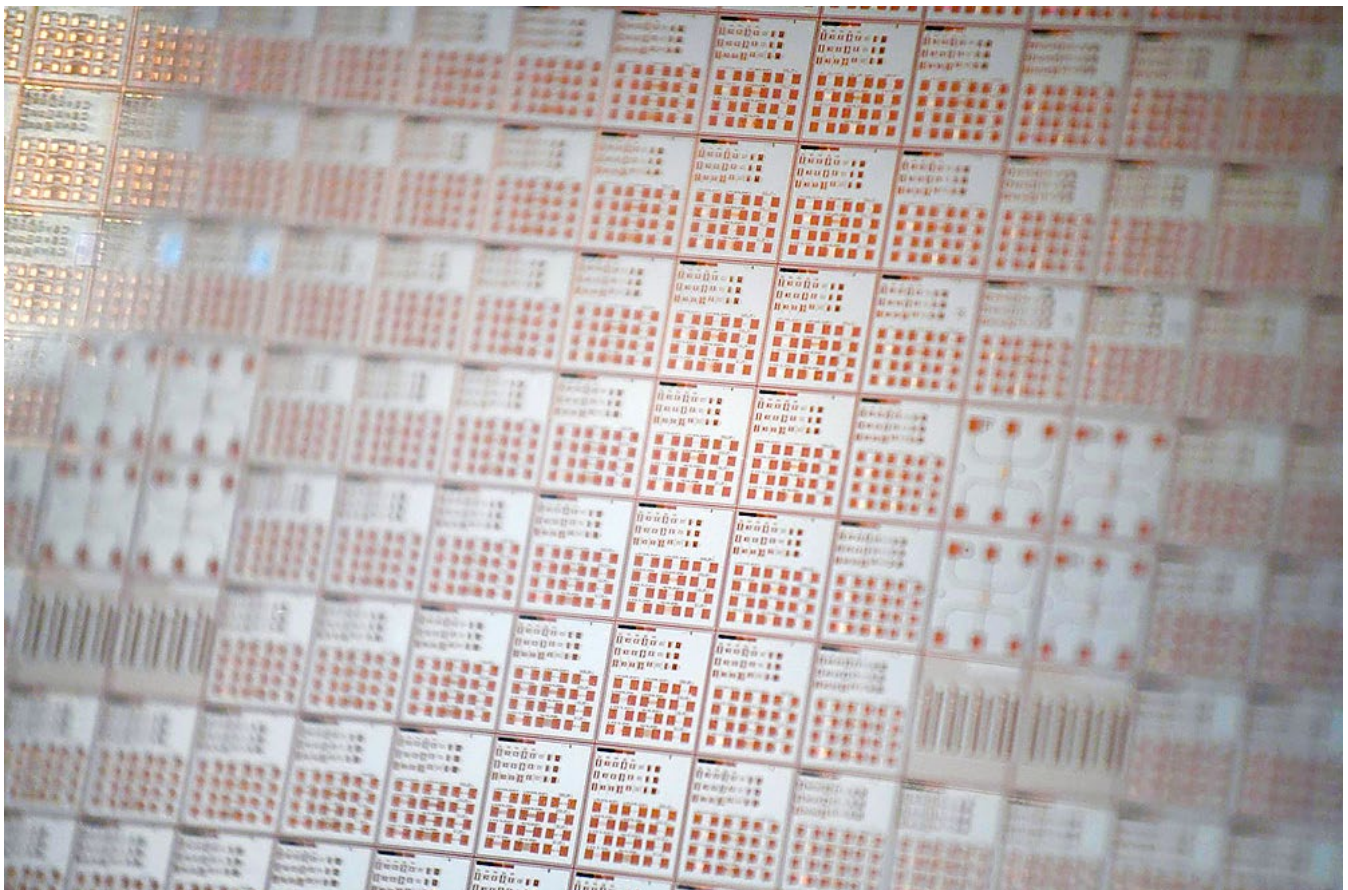
**In-Vehicle Transparent Display of Virtual-Real Fusion Smart Window**

To enable smart cities and Mobility as a Service (MaaS), ITRI has developed the world’s first transparent display of virtual-real fusion smart car windows. This smart window provides passengers with real-time and intuitive scene-fusion information, which enhances the user’s experience in smart car cabins. The information fusion accuracy can reach 80%, with a fusion frequency of 30 FPS. This technology can be applied to the fields of smart mobility and smart edutainment.



*ITRI developed the world's first transparent display for virtual-real fusion smart car windows.*

## Functional RDL Integrated Thin Film Passive Device for 5G Filter Applications



***ITRI's RDL technology enables the development of film-type filters for 5G applications.***

As the 5G era arrives, ITRI has developed a 3rd-order bandpass filter embedded in redistribution layers (RDLs) by use of panel level manufacturing. A thinner stacked circuit with size shrinkage can reduce the dimensions of the resulting 5G system module.

**Comparison between ITRI's film-type filter and an LTCC filter.**

<b>Item</b>	<b>ITRI's Film-Type Filter</b>	<b>LTCC Filter</b>
<b>Band</b>	N77 (3.3 -4.2 GHz)	N77 (3.3 -4.2 GHz)
<b>Dimensions</b>	0.6 × 0.5 mm <sup>2</sup>	2.0 × 1.25 mm <sup>2</sup>
<b>Thickness</b>	< 50 μm	650 μm
<b>Insertion Loss</b>	<3 dB	<3 dB





## » R&D Focus

# Addressing Sensor Reliability Through Environment-Based Multi-Sensor Fusion

By Peter Chondro

With the advent of semiconductor integrated circuits (ICs), the annual sales of silicon-based circuits have skyrocketed to approximately US\$439 billion in 2020 [1]. This growth has led to the widespread application of more powerful yet compact circuits in fields such as advanced robotics and notably autonomous vehicles (AVs). The deployment of machine learning in AVs is accommodated by current-generation computing platforms such as NVidia DRIVE or Qualcomm Snapdragon Ride. This emerging technology is expected to generate additional revenue of up to US\$1.5 trillion for the automotive industry by 2030 [2]

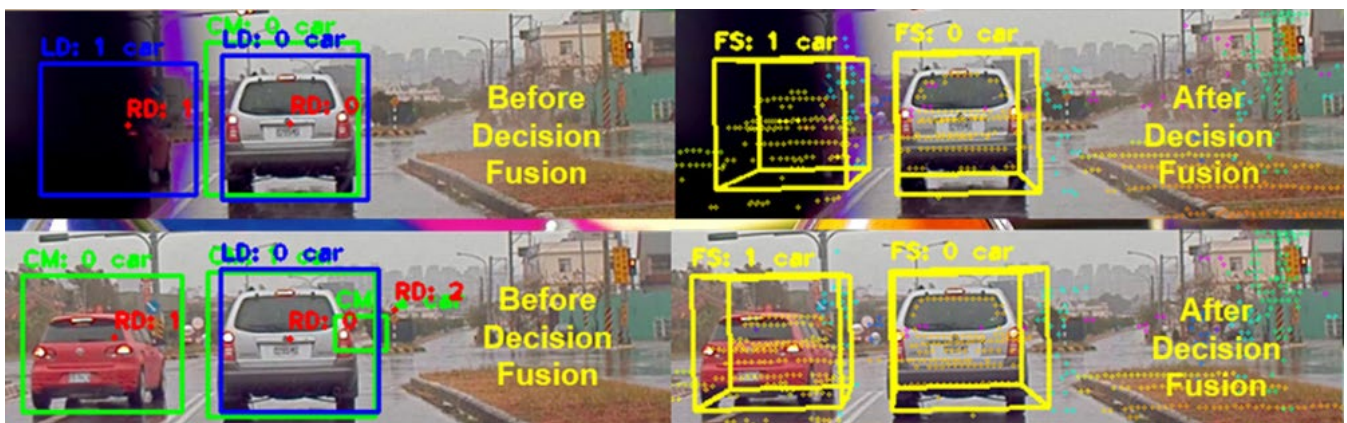
However, the general public and investors still cast doubt on the prospect of AV technology [3]. One of the concerns is sensor reliability. Recently, an incident occurred when an autonomous vehicle plowed into an overturned truck on the highway; investigation later revealed that environment-induced failures in both the camera-based classifier and RaDAR-based system resulted in false negative detection of the overturned truck [4]. Without a reliable sensing module, any robotic system including AVs cannot function properly due to limited surrounding awareness.

In an attempt to solve this issue, ITRI has proposed a framework that uses an environment-based fusion technology to set up multi-modal sensors for AVs. The framework is comprised of multiple sensor types including (but not limited to) RGB camera(s), LiDAR(s), and RaDAR(s). Each type has specific characteristics and is sensitive to the surrounding environment in ways that can affect sensor performance (see Table 1). As a result, sensor reliability is dependent upon environmental conditions. For instance, LiDAR may provide more reliable data for its corresponding classifier compared to an RGB camera working in the night-time environment.

**Table 1. Comparison of Common Sensor Characteristics in Different Environments**

Constraints	RGB Camera	LiDAR	RaDAR
Sensor Type	Passive	Active	Active
Lux Interference	Highly Sensitive	Not Sensitive	Not Sensitive
Sun-Exposure Interference	Highly Sensitive	Slightly Sensitive	Not Sensitive
Weather Interference	Mildly Sensitive	Highly Sensitive	Slightly Sensitive
Sensing Range	50 Meters	100 Meters	150 Meters
Field of View	60°	360°	30°
Resolution	Dense	Sparse	Highly Sparse

ITRI’s method known as Decision Fusion can be applied to the embodiment of a vehicle or robots with multiple on-board sensors (e.g. RGB Camera, RaDAR, and LiDAR) [5]. The technology provides overlapping field of view based on different sensor types and the surround-view of multiple sensors from each sensor type. The method begins with a data preprocessing technique. This synchronizes and rectifies the coordinate system of RGB camera(s), RaDAR(s) and LiDAR(s) into a unified center of coordinate. Once rectified, the sensor data are processed accordingly by the corresponding classifier of each sensor type to produce a set of meter-based 3D object detection boxes. Since there may be multiple sensors for each sensor type, a meter-based 3D intersection-over-union technique is used to combine the overlapping field of view from each type via bounding boxes. See Figure 1 below for the demo of Decision Fusion.



**Figure 1. Demo of Decision Fusion (CM: Camera, LD: LiDAR, RD: RaDAR, FS: Decision Fusion)**

Then, the bounding boxes used between different sensor types are compared in pairs. For instance, in the first stage, all LiDAR-based classifier detections are compared with those from the camera-based classifier. To perform this comparison, any LiDAR detection that overlaps with camera detection will be scored against one another based on seven criteria: 1) Time of day; 2) Local intensity; 3) Weather condition; 4) Light exposures; 5) Object distance; 6) Angular position; 7) Classifier confidence.

Those detected with the highest scores based on these criteria are chosen as the result of this first comparison. On the other hand, LiDAR or camera detections without any pair are analyzed based on these seven criteria to determine whether or not it is a false positive. This comparison is later repeated between the results and RaDAR-based classifier. Table 2 shows the comparison of each sensor type's classifier performance against the use of Decision Fusion. Note that the proposed Decision Fusion could improve RGB camera-, LiDAR- and RaDAR-based detection with accuracies of 9%, 6% and 11% respectively.

**Table 2. Evaluation of Object Detection Before and After Decision Fusion**

<b>Evaluation</b>	<b>Camera</b>	<b>LiDAR</b>	<b>RaDAR</b>	<b>Proposed</b>
ACC	87.0%	90.1%	84.8%	<b>96.0%</b>
FNR	5.6%	4.5%	7.1%	<b>2.0%</b>

Highlighted scores represent best results.

Through its environment-based multi-sensor fusion technology, ITRI aims to enhance the perception capability of AVs for more precise and reliable detection of road hazards regardless of the environmental conditions, thereby improving safety of self-driving.

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## About the Author



Peter Chondro is a senior engineer working for the Information and Communications Research Laboratories at ITRI. He received his B.Eng. degree in electrical engineering from Institut

Teknologi Sepuluh Nopember (ITS), Indonesia in 2014 and his M.Sc. and PhD degrees in electronics and computer engineering from National Taiwan University of Science and Technology (NTUST), Taiwan in 2016 and 2018, respectively. His current research focuses on computer vision and machine learning for autonomous vehicles.

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» Honor



## ITRI Wins One Gold and One Silver at Edison Awards 2021



***ITRI received two Edison Awards in 2021, marking the fifth consecutive year that it has won this honor.***

ITRI earned new accolades this April when it took home two medals at the [Edison Awards](#), known as the Oscars for Innovation. It is the fifth consecutive year that ITRI has received this honor. This time it bagged a gold with its AI-Based High-Density Shuttle Rack Service System in the Innovative Service: AI Application category, and a silver with its eco-friendly microbial dye technology MetabColor in the Engineering & Materials Science: Primers, Coatings & Dyes category.

The Edison Awards are among the most prestigious accolades honoring excellence in new product and service development, marketing, human-centered design and innovation. Besides



ITRI, other winners this year include Abbott, Corning, Dow, GoPro, Merck, and many more global innovators.

Frank Bonafilia, Executive Director of Edison Awards, stressed that the awards symbolize the persistence and excellence personified by Thomas Edison. “We are looking for game-changing new products and services. And ITRI has delivered again with MetabColor as well as the AI-Based High-Density Shuttle Rack Service System,” he said.

ITRI President Edwin Liu also pointed out that the Edison Awards focus on the “real-world applications” of innovative R&D results. “Winning two awards is a big applause for our R&D teams and meanwhile demonstrates that our market-oriented research and the 2030 Technology Strategy & Roadmap align with the global trends,” said Dr. Liu.

Dr. Liu further commented that the AI-Based High-Density Shuttle Rack Service System optimizes logistics efficiency to meet the increasing needs for e-commerce and respond to the rise of “stay-at-home economy” in the post-pandemic era. MetabColor, on the other hand, features a non-toxic dye production process that eliminates health hazards and aligns with the global target of zero net carbon emissions. It is thrilling that both technologies have been introduced to industries.

Click below to learn more about these innovations.

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[AI-Based High-Density Shuttle Rack Service System](#)



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[MetabColor: The Eco-Friendly Microbial Dye Technology](#)

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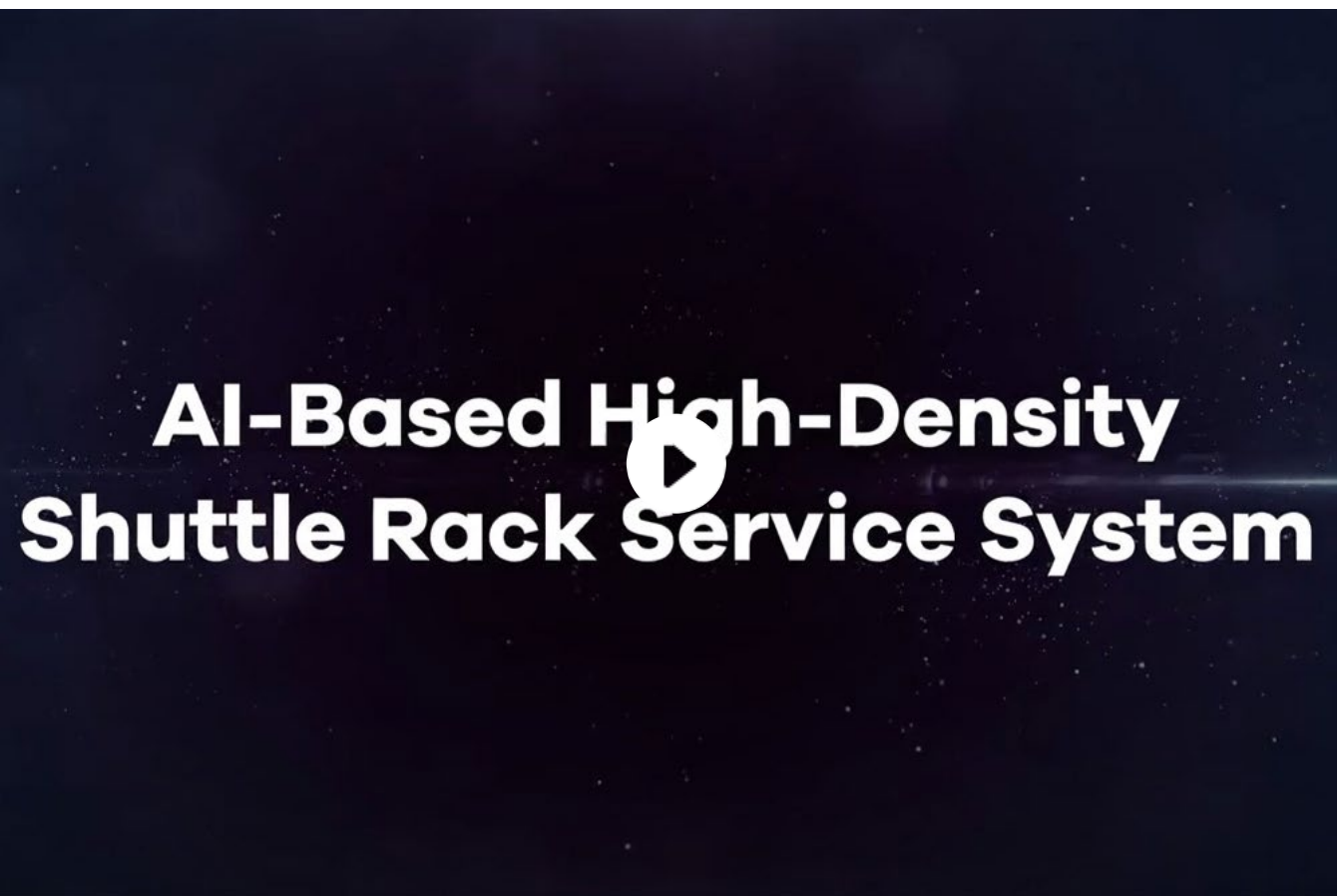


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## AI-Based High-Density Shuttle Rack Service System



***ITRI's AI-Based High-Density Shuttle Rack Service System won gold at Edison Awards 2021.***

With the ongoing COVID-19 pandemic, logistic services have hit a new level of importance to meet the increasing demands of e-commerce, so an automated high-performance service system for the logistics chain is desirable to enhance warehousing and delivery efficacy. ITRI's AI-Based High-Density Shuttle Rack Service System is the first of its kind in Asia with high transport efficiency, low environmental impact, and low labor intensity.

The smart urban logistic service system features automated processes and optimal resource distribution. It brings end-to-end visibility and improves the way companies transport goods, control inventory and mobile assets, replenish stock and manage the retail experience. This

leads to efficient transportation and thus minimizes carbon footprints to strengthen environmental protection.



***General Director of ITRI's Service Systems Technology Center Roger Cheng (second right in front row) led his team to develop the AI-Based High-Density Shuttle Rack Service System.***

To transform the traditional logistics storage industry, ITRI developed crucial technologies including Human-Robot Hybrid Technology, Order-Based AI Dynamic Decision Technology, and Smart Scheduling Systems to build the AI-Based High-Density Shuttle Rack Service System.

“

Janet Chen, Chief Operating Officer of ITRI's Service Systems Technology Center, stated that the innovative system incorporates the “goods-to-person” method that increases the number of stock items by 2.5 times, saves up to 60% of shipping time, and helps improve the logistics performance during peak periods by ten times.

”

In space design, the automated vertical warehousing system allows storage racks up to 14 stories high. This makes it particularly suitable for use in space-starved cities. What's more, with the AI capability, the inbound/outbound precision rate rises from 75% to 90%. Such a highly efficient, reliable and convenient logistic service is expected to offer better online shopping experiences for consumers.



***ITRI's smart logistic system was introduced to Yahoo Taiwan's AI automated logistics center to enable high storage capacity and order processing efficiency. (photo credit: Yahoo Taiwan)***

Seeing the industry's need for technological upgrade, ITRI has worked with Yahoo Taiwan, HCT Logistics and iAmech to apply the AI-Based High-Density Shuttle Rack Service System to Yahoo Taiwan's first AI automated logistics center in Taiwan. The collaboration creates a success model for how innovative logistic services lead to high storage capacity and order processing efficiency. The joint efforts have also earned ITRI a gold medal in the Innovative Service: AI Application category at the Edison Awards 2021.

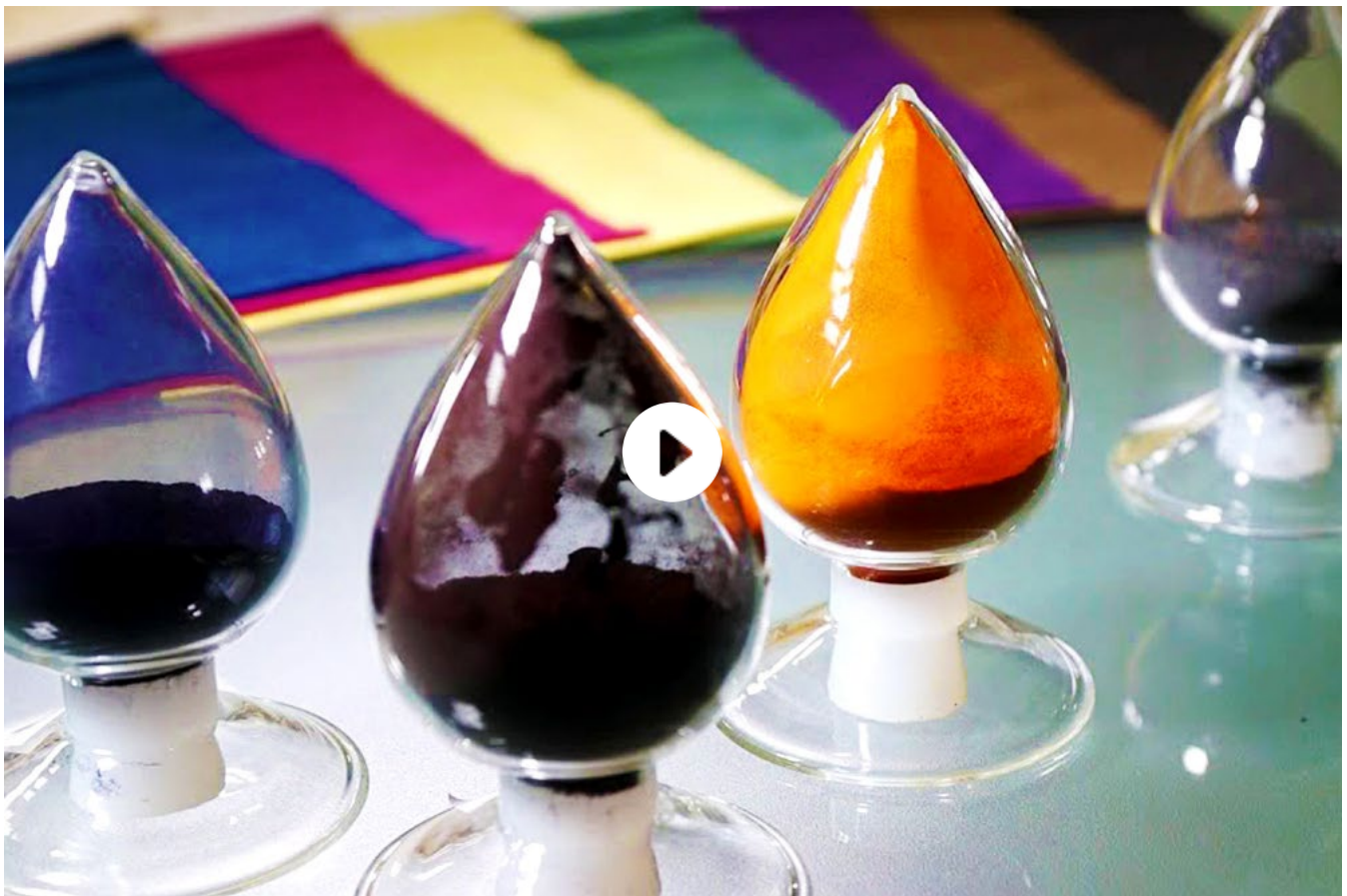
ITRI has collaborated with system integrators and allied with various industrial partners in logistics sectors. The system has been extended to Taiwan's Free Trade Zone and Post Logistic Park. These practical applications will be beneficial for the validation of the system and the exploration for new opportunities in urban economies.

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## MetabColor: The Eco-Friendly Microbial Dye Technology



***ITRI's MetabColor, a pioneering solution that offers an eco-friendly microbial dye manufacturing process, won silver at Edison Awards 2021.***

ITRI's innovative microbial dye manufacturing process, MetabColor, won a silver medal at this year's Edison Awards in the Engineering & Materials Science: Primers, Coatings & Dyes category. Unlike synthetic chemical dyes that contain carcinogens and may cause environmental and health hazards, MetabColor's microbial-based dyes adopt non-toxic material and an eco-friendly production process aiming to counter the drawbacks of traditional chemical and plant dyes.

Researchers of MetabColor modified microbes and developed unique fermentation, separation, and purification processes to create natural dyes. The bio-based dyes are available

in five colors (blue, red, yellow, brown, and black), with the proprietary MetabColor Black being the world's first black dye that eliminates the process of mixing concentrated color dyes.



***The MetabColor dyes come in five colors, including the world's first black dye that does not require color mixing.***

While other microbial dyes currently in the market are limited to the color blue, ITRI has engineered unique metabolic pathways for MetabColor, enabling the bacteria to produce red, yellow and blue dyes, which are then mixed to create dyes of various colors. This sustainable microbial dye production technology provides the textile industry with an alternative to the polluting chemical dyes or scarce/expensive plant dyes. Moreover, it exhibits brilliant color strength and fastness on fabrics, making it a high-value and cost-effective system for textile manufacturers.

“

Our technology features microbial carbon source utilization and modifies microbial strains to produce natural dyes,” said Jing-Wen Tang, Division Director of ITRI’s Material and Chemical Research Laboratories. “As the dye production process is non-toxic, there are no health hazards. Moreover, the process has higher efficiency and significantly reduces wastewater discharge, homing in on the global trend of achieving net zero carbon emissions.

”



***Dr. Tzong-Ming Lee (front center), Vice President and General Director of ITRI's Material and Chemical Research Laboratories posed with the R&D team of MetabColor.***

Patents have already been filed for the dye producing strain design, dye formulas, and related eco-friendly textile dyeing methods, enhancing the overall value of the technology. More importantly, MetabColor dyes and its manufacturing process comply with international legislation requirements such as ZDHC and REACH, which helps manufacturers enter the global market with a cutting-edge advantage as a green supplier.

ITRI is already working with Eclat Textile Company and JINTEX Corporation, OEM of global leading apparel brands, on empirical testing and verification of MetabColor products. This collaboration has entered the trial production stage, which will strengthen textile applications and accelerate the time-to-market of these microbial dyes.

What impact can MetabColor bring about ultimately? MetabColor has the potential to facilitate a comprehensive eco-friendly dye supply chain. By applying this technology, it is believed that we can resolve the challenges of textile dye pollution caused by the fast fashion industry and thus enhance environmental sustainability.

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## » Honor



## ITRI and Four Other Recipients from Taiwan Honored as Top 100 Global Innovators



***MOEA Minister Mei-Hua Wang (center) attended the award ceremony to congratulate the five Top 100 Global Innovators from Taiwan.***

On April 20, Clarivate held an award ceremony to honor its Top 100 Global Innovators 2021 from Taiwan, including the several-time winners ITRI, Foxconn, Quanta Computer, and the first-time winners ASUS and Kinpo Electronics. The number of the Top 100 Global Innovators from Taiwan hit a new high, ranking third in the world.

With the support of the Ministry of Economic Affairs (MOEA), ITRI stood out among 14,000 institutions worldwide, gaining a place on the list that only 0.7% of these institutions achieved. ITRI has made the Top 100 list for the fifth time, making it the most awarded among Taiwan innovators and Asian research institutions. Over the past five years, ITRI has licensed its



patents to over 915 companies/times. Its almost 5,000 patents have assisted Taiwan industry in protecting their R&D innovations, securing business opportunities, and obtaining access to the global market.



***Rob Davey, VP Strategy, Intellectual Property Group of Clarivate, congratulated five Top 100 Global Innovators from Taiwan on their excellence in innovation.***

Clarivate Vice President Rob Davey in a recorded video remarked that since 2012, the Top 100 Global Innovator report has identified organizations at the very pinnacle of the global innovation landscape. “2020 was an unprecedented year and one full of unexpected events. We’re very pleased to see an increase in the number of Taiwan-based organizations that have made it on to this year’s Top 100 Global Innovators list. It highlighted the way that organizations such as those in the Top 100 Global Innovators can succeed and lead the way even in the most difficult times, with a steadfast and resilient focus on innovation,” he said.

The Top 100 Global Innovators 2021 report showed that ITRI has excellent R&D quality and strong influence on industrial innovation. In recent years, ITRI’s efforts to strengthen patent globalization have begun to bear fruit. Its patents feature three main characteristics: 1) High Innovation: 98% of its patents are invention patents; 2) International Deployment: The number of foreign patent applications is nearly double that of domestic applications; 3) High Patent Quality: ITRI has received a large number of citations in its US patents, suggesting its strong patent influence.



***ITRI President Edwin Liu (right) accepted the Top 100 Global Innovator 2021 trophy from Nathan Fan (left), General Manager of Clarivate in Taiwan.***

ITRI President Edwin Liu remarked that intellectual property rights are an important link in national competitiveness, and how to best utilize patents to enhance enterprise value is a pressing issue. ITRI, he said, engages in a two-pronged strategy to assist Taiwan industry to gain advantages and seize business opportunities. First, it activates patents, and to date ITRI has a total of over 17,000 valid patents. In order to allow these patents to be effectively used by industry, ITRI actively promotes links between the capital market and the technology market. The Small & Medium Enterprise Credit Guarantee Fund of Taiwan and 26 banks are promoting the valuation of intangible assets and technology value-added financing so that startups can use patents to obtain financing and develop new businesses, consequently boosting the value of innovation. Secondly, ITRI strengthens R&D, deploys key preliminary patents, and assists industry in advancing the use of these patents. “ITRI, as a pioneer in industrial technology, will keep innovating and engaging in early key patent deployment for potential and trending technologies to stay competitive in the forefront,” said Dr. Liu.

This year is the 10th edition of the Top 100 Global Innovators, which honors companies and institutions at the top of the global innovation landscape for their efforts in contributing new ideas, solving problems and creating new economic value. The Top 100 Global Innovators are recognized for their excellent patent performance across four criteria: volume, success, globalization and influence. Winning this award represents outstanding effort not only in the quantity of filed patents, but also success in obtaining granted patents, breadth of filing of inventions, and external citations.



## » Activity

# Self-Driving Bus Route Provides Shuttle Service to High Speed Rail Station

ITRI joined the efforts of the Hsinchu County Government, Yosemite Bus, Mobiletron Electronics Co., Ltd., and Maxwin Technology in the launch of a self-driving electric bus providing shuttle service between Hsinchu High-Speed Rail Station and the nearby downtown area. This autonomous vehicle operation supported by the Ministry of Economic Affairs (MOEA) constitutes the first commercial route for a self-driving bus in Taiwan and marks an important milestone in the development of smart public transport here.



***ITRI has joined hands with industrial partners to provide the first commercial operation for a self-driving electric bus in Taiwan.***

The newly-launched shuttle bus has three features.

- 1. Taiwan’s First Self-Driving Commercial Operation on Crowded Roads:** This is the first example in Taiwan of the commercial operation of a self-driving vehicle on a road with a mixture of vehicles. Tests were carried out on roads used jointly by automobiles and

motorcycles in urban areas. These experiments improved the functionality of the computing system that processes people, vehicle, and road data. This better reflects the unique complexities of Taiwan's road system and marks an enormous breakthrough, as previous operations of self-driving vehicles were limited to suburban areas or on urban roads with dedicated bus lanes.

- 2. Smart Collision Avoidance:** The bus operates using ITRI-developed iRoadsafe V2X (Vehicle-to-Everything) technology, integrating data from communications, sensors, traffic signals and other sources. This solution is tantamount to having an eye in the sky that boosts operational safety. The technology won Silver at the 2019 Edison Awards and the Industry Award at the ITS World Congress.
- 3. Links with Smart Bus Shelters:** Passengers are able to easily access bus schedules, and the shelters offer two-way communication. The traffic control center can detect the flow of people waiting via a camera installed in the shelter, enabling real-time adjustment of bus frequency and monitoring the path of the self-driving bus.

As Taiwan's traffic environment is more complex than that of Europe and North America due to its high traffic flow and vehicle density, the local ICT industries, automotive electronics suppliers and transport operators have a competitive strength in developing related technology and services. The launch of the self-driving shuttle bus furthermore integrates automakers and automotive electronics manufacturers including RAC Electric Vehicles Inc., ADLink Technology Inc., Unex Technology Corp., and Neusys Technology, and it aims to provide seamless transfer services to enable Mobility as a Service (MaaS).



*A launch ceremony was held on April 12 to announce the self-driving shuttle service for the Hsinchu High Speed Rail Station.*



## » About Us



Industrial Technology Research Institute (ITRI) is one of the world's leading technology R&D institutions aiming to innovate a better future for society. Founded in 1973, ITRI has played a vital role in transforming Taiwan's industries from labor-intensive into innovation-driven. To address market needs and global trends, it has launched its 2030 Technology Strategy & Roadmap and focuses on innovation development in Smart Living, Quality Health, and Sustainable Environment. It also strives to strengthen Intelligentization Enabling Technology to support diversified applications.

Over the years, ITRI has been dedicated to incubating startups and spinoffs, including well-known names such as UMC and TSMC. In addition to its headquarters in Taiwan, ITRI has branch offices in the U.S., Europe, and Japan in an effort to extend its R&D scope and promote international cooperation across the globe. For more information, please visit

<https://www.itsri.org/eng>.

**Publisher:** Edwin Liu

**Editors-in-Chief:** June Lin, Jenny Chao

**Deputy Editor-in-Chief:** Irene Shih

**Executive Editor:** Alex Chang

**Contributing Editors:** Dan King, Vivian Chen, Larry Hsu

**Video Photographer:** Michael Hsu

**Graphic Designer:** Luc Tsui

**Marketing & Services:** Larry Hsu

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<https://www.itri.org/itritoday/subscription>

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**ITRI TODAY Website:**

<https://www.itri.org/english/itritoday>

**Published by:**

Industrial Technology Research Institute

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