工業技術研究院
Industrial Technology Research Institute

智慧機電創未來
I2S一起發

Intelligent System Smart Sustainable Society

Intelligent MMSL
Enabling an Innovative Future
I2S ITRI GO

2024年報/簡介
2024 ANNUAL REPORT / MMSL OVERVIEW

機械與機電系統研究所
MECHANICAL AND MECHATRONICS SYSTEMS RESEARCH LABORATORIES, MMSL.

The Director's Words

Greetings to all distinguished leaders of industry and academia!

Welcome everyone to open this technical booklet, "2024: A Dragon's Leap into Promising Futures", to get to reveal the achievements of the MMSL, ITRI. As the general director of MMSL, I sincerely invite you to explore the fruitful demonstration of the past year and also kindly seek your encouragement and guidance!

MMSL has adopted a new slogan this year:

"Intelligent MMSL Enabling an Innovative Future I24S ITRI GO"

"I2" represents the two major areas of machinery: "Intelligent Manufacturing" and "Intelligent Mobility", and the "4S" echoes the technology strategy blueprint of ITRI in 2035.

- **System integration:** The term "machinery" now encompasses not only individual machine equipment, but also system integration, including concepts like smart factories with equipment integration for production lines.
- **Sustainable environment:** In recent decades, there has been a global wave of net-zero carbon reduction, where alongside our pursuit of technological advancements, we are also actively seeking harmony and coexistence with nature. The use of materials needs to align with the development of green technology.
- **Smart living:** With the increasing maturity of smart technology, AI, and robotics, it is essential to integrate technology into our daily lives, leveraging its capabilities to meet our needs more quickly, conveniently, and intelligently.
- **resilient Society:** We are committed to developing nationally-owned resilient technologies to address risks such as natural disasters and environmental impacts. The goal of our research and development is to assist the country in turning crises into opportunities.

Internally, we set the core philosophy outlined above as our research foundation; externally, we maintain ongoing collaboration and interaction with government, industry, and academia. By staying attuned to the trends of the times and embracing an innovative spirit, we aim to forge new horizons in the industry hand in hand with all research sectors.

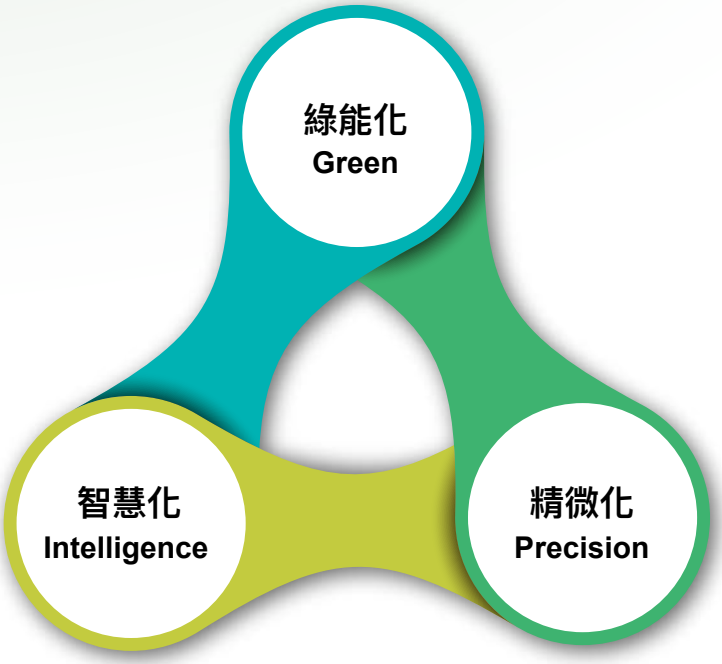
Semiconductors, AI machinery, smart vehicles, and sustainable zero-carbon initiatives are currently hot research topics. Over the past year, we have achieved remarkable results in these fields. For instance, our Institute's 2018 startup company, "Green Energy Mobility," collaborated with leading domestic enterprises such as Shihlin Electric, Hotai Motors, and Heraeus Corporation to establish a new subsidiary, "Gochabar," becoming the Institute's first exemplary company to succeed in creating a new startup. In the field of smart vehicles, we partnered with Taoyuan Airport in 2023 to introduce our self-driving technology for employee shuttle operations, making Taoyuan Airport one of the world's only airports with autonomous shuttle services. In the booming semiconductor industry, we launched the " Head-Matrix-ALD" to meet the demand for precision coating, integrating multiple front-end coating processes into one to reduce chip pollution caused by repeated conversions. These globally pioneering technologies have received international recognition and were honored with the 2023 R&D 100 Award in the United States, further demonstrating the leading position of MMSL in Taiwan's semiconductor industry.

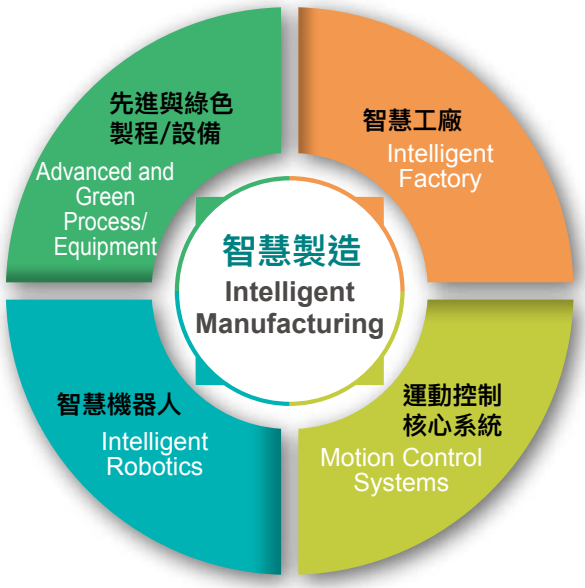
MMSL aspires to lead the forefront of the machinery industry. We hope this booklet serves as a valuable resource for you to promptly find solutions when facing research and development challenges. We look forward to more collaboration opportunities in the future and to advancing together with you side by side!

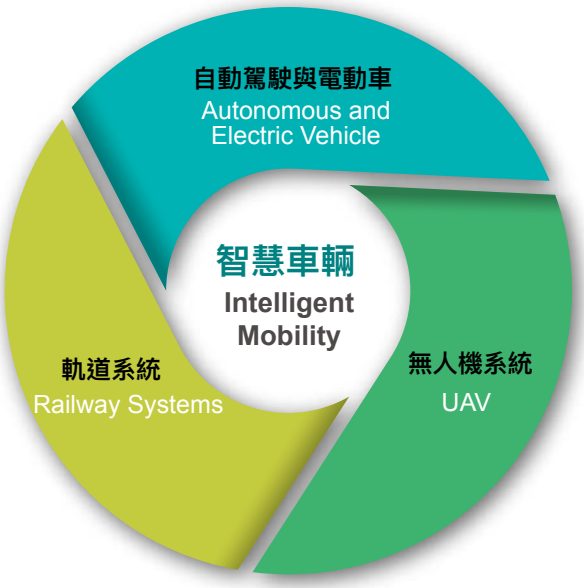
General Director, MMSL, ITRI

饒達仁 Da-Jeng Yao

Core Tech


綠能化
Green
智慧化
Intelligence
精微化
Precision


先進與綠色
製程/設備
Advanced and
Green
Process/
Equipment
智慧工廠
Intelligent
Factory
智慧製造
Intelligent
Manufacturing
智慧機器人
Intelligent
Robotics
運動控制
核心系統
Motion Control
Systems


自動駕駛與電動車
Autonomous and
Electric Vehicle
智慧車輛
Intelligent
Mobility
軌道系統
Railway Systems
無人機系統
UAV

International Awards

aePLASMA

2012

FluxMerge™ Motor

2013

Tactile-film System for Wearable Orthosis

2015

Exoskeleton Robot

2016

CyberEpi

2017

CINmat Microwave Annealing Technology

2019

UAV

2020

UAV

2021

Software-defined Augmented Robot Joint (SARJ)

Dual Arm Robot System (DARS)

2023

Head-Matrix-ALD

Spin off from MMSL

2015	創星淨聯科技 Purus tek. Co., Ltd.	PM2.5可攜式空氣清淨機 Portable Air Purifier	
2016	福寶科技 FREE BIONICS TAIWAN INC.	外骨骼行動輔助機器人 Wearable Walking Assistive Exoskeleton Robot	2016 R&D 100 Awards
2017	黑木 KUROKI INDUSTRIAL Co., Ltd	全加成印刷電子產品 Additive Process for Printing Circuit	
2017	起而行綠能 eTreego Co., Ltd	互動式充電管理系統 Interactive Charging Management System and Method Thereof	
2018	漢朋科技 HEN PENG TECHNOLOGY Co., Ltd.	流體機械能源服務 The Construction Technology of Fan Energy Test System	
2018	原見精機 Touché Solutions	安全觸覺機器人 Higher Sensitivity Tactile-film System for Wearable Orthosis	2015 R&D 100 Awards
2019	盟英科技 Main Drive Co., Ltd.	諧波減速機 Harmonic Reducer	
2021	智連工控 Adirtek Co., Ltd.	SECS/GEM 通訊協定/介面 SECS/GEM Solution	
2022	科飛數位 KopherBit Co., Ltd.	整車控制平台 Drive-by-Wire Vehicle Platform	

ADVANCED AND GREEN PROCESS/EQUIPMENT

Plasma Diagnostic Technology

Plasma processing is a technique that utilizes plasma for material processing and surface treatment. The main issue currently faced by plasma processing is the absence of real-time measurement technology, leading to inadequate process control. As a result, engineers are unable to quickly identify the factors affecting yield, which hinders process optimization and the development of new technologies.

Technical Advantages and Features

Langmuir Probe Measurement Module

- Multiple probes on the electronic test equipment fully measure important plasma parameters (plasma density, electron temperature, plasma potential, electron energy distribution function, etc.).
- Plasma density measurement range: 10^{9}~10^{12} cm^{-3}.

Non-Invasive RF Ion Diagnostic Module

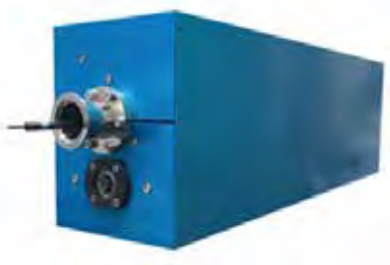
- The module analyzes the wafer surface's ion energy and flux in real time.
- Updated rate: 5 times per second.

End-Point Detection Module

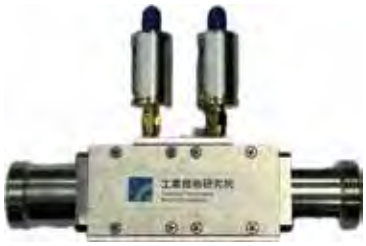
- Precision identifies etch endpoints, such as low etching exposure areas and complex operations, to achieve a recognition rate over 90% (typically, the recognition rate is less than 70%).

Industrial Benefits and Business Opportunities

- **Industry Applications:**
  Plasma Processing Equipment Industry (e.g., plasma etching, coating, cleaning), Optoelectronic Semiconductor Manufacturing Industry (e.g., process monitoring and parameter optimization).
- **Application Examples:**
  Introduced to domestic optoelectronic semiconductor equipment manufacturers. In collaboration with these manufacturers, ITRI has jointly conducted verification of new product development. Additionally, the technology provides universities, such as National Tsing Hua University, with a fundamental research tool for plasma technology.



Langmuir Probe



Non-Invasive RF Ion Diagnostic

End-Point Detection

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Thin Film Process Optimization Simulator Technology

Thin film deposition is a process that applies a thin film to the surface of a material. The thin film coating process for complex nanodevices lacks simulation analysis tools for auxiliary processes, such as temperature, airflow, pressure, and electromagnetic fields. This deficiency results in the inability to effectively obtain optimal parameters, thereby affecting the product development timeline and increasing expenditures.

Technical Advantages and Features

Multiple Physics Coupling Technology

- The unique "Surface Chemical Reaction Pathway Decision-Making Technology" simplifies the chemical equation and obtains real data feedback for correction.
- Visual verification of flow field and AI quality calculation prediction tools for diagnostic parameters.

Shortening the Equipment Development Timeline

- A massive database obtains recommended optimal parameters (2 hours vs. 1 week).
- The accuracy of parameter prediction > 90%; shortened the time to market (1 month vs. 3 months).

Improving Productivity and Quality

- Enhancing machine capacity.
- Improving deposition uniformity.

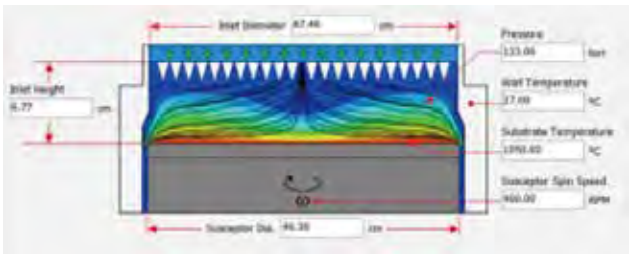
Industrial Benefits and Business Opportunities

- **Industry Applications:**

  Thin film equipment, such as MOCVD、PECVD、PVD, in the Optoelectronic Semiconductor Industry, such as LED, semiconductor, solar, and wireless communication.

- **Application Examples:**

  In collaboration with major domestic ODMs in semiconductor equipment, we aim to become a key component of the international supply chain by continually conducting technological R&D, thereby enhancing the quality of our deposition equipment.



The UI of Thin Film Deposition System

Key Modules of the Deposition Equipment

ITRI Outstanding Research Award in 2021

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High Aspect Ratio TGV Filling Technology

Advanced packaging substrates are transitioning to TGV glass substrates, replacing current polymer materials (e.g. ABF, BT), to align with the future trends of fine line spacing and high aspect ratios. TGV glass substrates offer excellent thermal conductivity, high stability, and corrosion resistance. However, when filling high aspect ratio holes in glass substrates, issues such as uneven porosity and coating layers can occur, affecting product quality.

Technical Advantages and Features

Adhesion Promoting Layer

- Synthesis of low-viscosity composite metal oxide solution.
- Formation of nano-micro porous structures.
- Adhesion ≥ 5 N/cm.

Copper Filling Within a High Aspect Ratio of Low void rate and H-Shaped

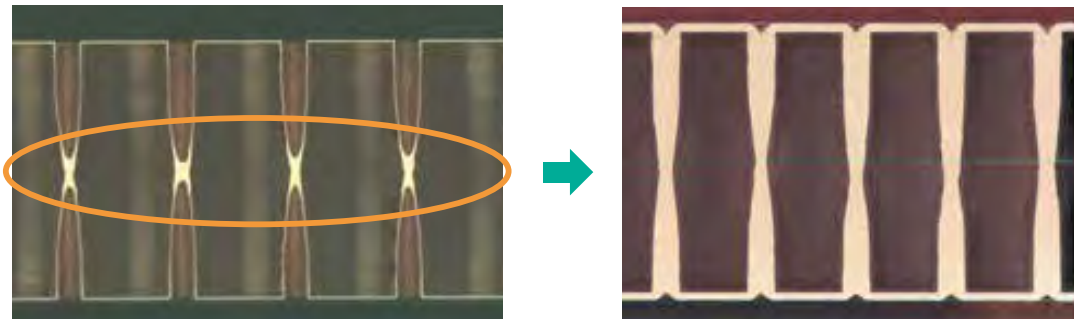
- Pioneering H-shaped electroplating for bridge hole filling.
- Filling in high aspect ratios >15.
- Plating defects < 5%.
- Applicable to different types of holes (e.g., straight hole, X hole, and funnel hole).

High Uniformity Low Plating Thickness

- Low face copper thickness (copper thickness <1/3 hole diameter).
- High uniformity (~ 90%).
- Applicable for 8”-12” TGV glass substrate.

Industrial Benefits and Business Opportunities

- **Industry Applications:**
  PCB, Advanced Semiconductor Packaging, Display Equipment.
- **Application Examples:**
  This technology, designated as a cooperating partner by domestic and foreign high-end carrier board manufacturers, reduces process time by 20% and completes products with aspect ratios exceeding 15. It has successfully entered the international supply chain.



H-Shaped Electroplating Bridge

Copper Filling by Electroplating for High Aspect Ratio

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Lapping and Polishing Technology for Hard & Brittle Materials

Processing hard and brittle materials, particularly silicon carbide (SiC), is crucial in the next-generation semiconductor industry. Due to the extreme hardness of SiC, the threshold for processing technology has increased. The processing time is now 10 times longer than before. Consequently, specialized processes and equipment have been developed to ensure production efficiency and quality.

Technical Advantages and Features

Ultrasonic-Assisted Roller Grinding

- Maintain sharpness by using the ultrasound induced vibration.
- With a special high-precision grinding wheel (#8000), the grinding speed of SiC is twice as fast as before.
- The surface roughness meets the industry demand of <5 nm.

Plasma Assisted Polishing

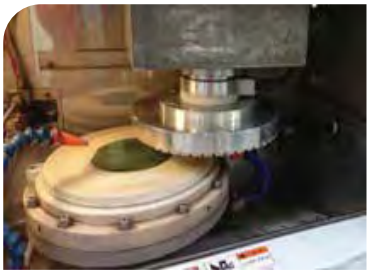
- Through plasma-assisted polishing, the surface of SiC is oxidized and softened.
- The polishing rate has increased by 5 times.
- Applicable for processing 4”- 8” wafers.

Hybrid Metrology High-Resolution

- A Single-machine of multi-parameter composite measurement, including SiC wafer's bending, warping, thickness, and roughness. (Typically requires 2 machines)
- The resolution of surface morphology/thickness meets the industry demand of 0.1 μm.
- The resolution of roughness measurement meets the industry demand of <10 nm.
- Applicable for processing 6”- 12” wafers.

Industrial Benefits and Business Opportunities

- **Industry Applications:**
  Semiconductor industry (Front-end, such as Sapphire, SiC, etc.).
- **Application Examples:**
  Applied to domestic machine tool factories and SiC processing industries, this assists enterprises in enhancing production efficiency and increasing industrial competitiveness.



Ultrasonic Assisted Grinding

Plasma Assisted Polishing

Hybrid Metrology Technology

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Energy Storage Graphene Supercapacitor

Supercapacitors, a type of energy storage component that is safer, more durable, and capable of faster charging and discharging than lithium batteries, typically have lower voltages (2.7V). Our institute's versions, made with 'plasma synthesized graphene' reach higher voltages (4V), increasing energy density and reducing the module size by over 50%.

Technical Advantages and Features

High-Voltage Supercapacitor

- Using plasma-synthesized graphene, which has stable internal chemical properties and no surface functional groups, we've developed a high-voltage (4V) supercapacitor module.

High Energy Density

- Plasma-synthesized graphene, paired with our proprietary lithium-ion electrolyte, offers excellent affinity, quick charge exchange, and faster reactions, enabling higher energy storage (high energy density) in the same volume.

Reduce Module Size

- High energy and power density halve module size and drastically shorten charging time (from 5C to 100C) while ensuring safety and boosting commercial value.

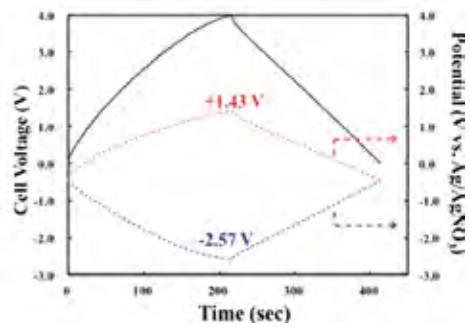
Industrial Benefits and Business Opportunities

- **Industry Applications:**

  Industry Applications: Storage Industry, Electric Vehicle Industry, Electronics Industry.

- **Application Examples:**

  Supercapacitor modules with plasma-synthesized graphene and self-developed lithium-ion electrolyte enable ultra-fast charging and discharging, making them ideal for high-torque and high-load electric vehicles. Demonstrated successfully in Xiluo transport vehicles and Kaohsiung light rail trams, these modules replace traditional lead-acid or lithium batteries, reduce charging time to 20 seconds, and mitigate air pollution and noise from conventional vehicles.



High-Voltage (4V) Graphene Supercapacitor

Xiluo Electric Fruit and Vegetable Transport Vehicles

Kaohsiung Light Rail Tram

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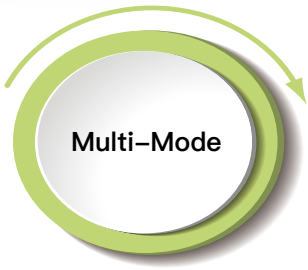
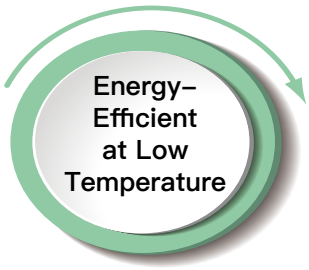
High Efficiency Microwave Heating Technology

For precision heating requiring strict temperature control, electric or combustion indirect heating is commonly used, resulting in higher pollution and prolonged heating cycles. Microwave heating technology allows the wavelength to directly penetrate and heat the material, leading to localized temperature increases, reduced annealing temperatures for semiconductors, and shorter times to reach target temperatures. Furthermore, advancements in process control are needed to ensure precise temperature uniformity.

Technical Advantages and Features



- By adjusting the spatial arrangement of microwave electric fields and signals, the number of modes increases fourfold, enhancing the objectivity of analysis results.



- Microwave annealing, a low-temperature process with workpiece temperatures half those of traditional RTA or laser methods, saves at least 50% in energy.

- Product uniformity exceeds 99%, meeting the semiconductor industry's standard (approximately 99%).

Industrial Benefits and Business Opportunities

- **Industry Applications:**

  Drying processes in the Food Industry, material heating in the Chemical Industry, and wafer annealing in the Semiconductor Industry.

- **Application Examples:**

  In the food industry, this technology enhances baking processes by saving 30% on electricity and reducing heating times by over 50%. Additionally, it has been proven in semiconductor factories using low-temperature microwave annealing to improve uniformity and reduce annealing costs by approximately 50%.

2017 R&D 100 WINNER

Microwave Heating Machine

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Cloud Management System for Motors and Machinery Energy Efficiency

Existing factories have not fully optimized their capacity and power planning. During off-peak or low-load times, motors and power machinery such as pumps, fans, and compressors often run at full capacity, resulting in significant energy waste. These devices, the main power source of factory operations, present considerable potential for optimization and energy savings with prolonged use.

Technical Advantages and Features

Cloud-Based Mechanical Energy Management

- Using stand-alone external sensors for non-invasive measurement, this method assesses factory energy consumption without requiring downtime or disrupting production.
- An open cloud-based management system provides test results and updates monitoring every 5 seconds to ensure optimal performance.

Customized Service

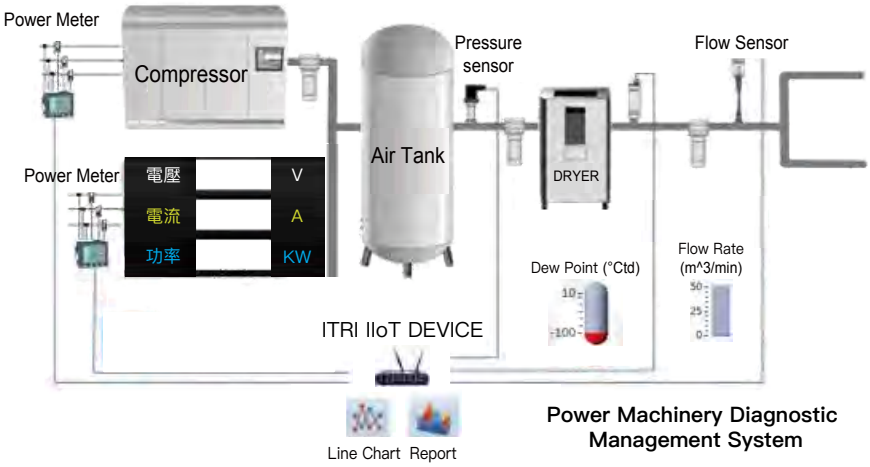
- Customize equipment specifications based on enterprise features.
- Supports common communication databases (ISO, IEC, NEMA, OPCUA, etc.), ensuring compatibility with existing customer systems.

High Energy-Saving Rate

- Providing precise energy-saving recommendations, with over 300 on-site diagnostic cases handled.
- Helping clients save energy, exceeding international standards by over 15%.

Industrial Benefits and Business Opportunities

- **Industry Applications:**
  The Steel, Food, Textile, and Electronics Industries utilize high-energy power equipment, such as motors, air compressors, and pumps.
- **Application Examples:**
  We have advised over 100 factories, including electronic, textile, and petrochemical plants, and established 106 high-efficiency motor technology demonstration sites, achieving energy savings of over 15%.



Power Machinery Diagnostic Management System

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Active Smart Battery Energy Storage Management System

Electricity generation from renewable energy, characterized by intermittency and decentralization, necessitates energy storage systems for optimal distribution and use. This technology utilizes active smart energy management, including intelligent battery capacity forecasting, proactive energy balancing across batteries, and demand–supply optimization, enhancing the overall efficiency of renewable power.

Technical Advantages and Features

Optimized Battery Management

- Stacked battery monitoring with ±1 mV accuracy (typically ±10 mV).
- Active battery balancing maintains consistent voltages across units, supporting currents up to 10 A (typically 100 mA).

Energy Management System Enhances Energy Storage Capacity

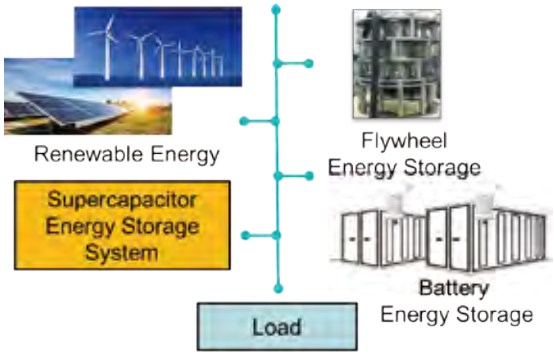
- Buffering power with a renewable energy storage system reduces grid impact.
- Increasing renewable energy storage capacity by over 17%.

Electrical Load Management

- Electricity is effectively stored and utilized during peak (daytime) and off–peak (nighttime) hours for peak shaving.
- Instant response to power demand and time distribution.
- Saving more than 10% on electricity bills.

Industrial Benefits and Business Opportunities

- **Industry Applications:**
  Energy Storage Industry and Green Energy Industry.
- **Application Examples:**
  Widely used in the energy storage and green energy industries, this technology collaborates with Taiwan's energy system integrators on various green power projects. It enables enterprises to save up to 20% on electricity, reduces energy costs by 10%, boosts renewable energy storage by over 17%, and is projected to yield billions in New Taiwan Dollars for the green energy industry.



Renewable Energy Storage Grid Diagram

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Precision Elastic Product Collaboration Design and Development Technology

Precision elastic materials, such as springs and seals, possess high precision and elasticity. Extensively used in the rubber, plastics, and textile industries, the elasticity complicates precise automated control, potentially affecting product quality. This technology enables the development of collaborative automated processes for elastic materials.

Technical Advantages and Features

Intelligent Clamping Fixture

- An intelligent clamping device automatically adapts to the workpiece shape, reducing positioning errors and maintaining stability at the target position and orientation.

Fully Automatic Integration

- Analyzing object motion trajectories based on different elastic materials and automatically managing movement, adhesion, and positioning within 7 seconds.

Intelligent Image Analysis

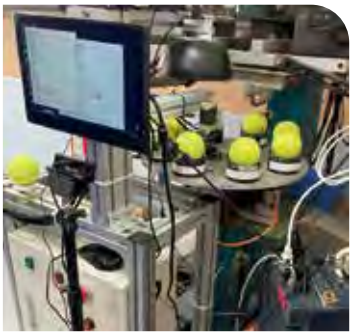
- Providing image analysis of posture to enhance alignment precision.
- Automatically aligns and identifies the best production design solution within 5 seconds.

Industrial Benefits and Business Opportunities

- **Industry Applications:**
  Rubber and Plastic Industry, Food Packaging Industry, Textile Industry, etc.
- **Application Examples:**
  This technology, adopted by leading domestic sports equipment manufacturers, has enhanced factory automation, boosted production efficiency by 50%, successfully facilitated entry into international markets, and established supply chains.

Precision Tracing Collaboration Equipment

Flexible Material Transfer, Adhesion/Positioning Fully Automatic Integrated Equipment



Precision Alignment Drive Module

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AUTONOMOUS AND ELECTRIC VEHICLE

RV Reducer

The component structure of RV reducers is extremely complex, requiring a complete integration of design, manufacturing, and assembly to ensure precision. Currently, domestic RV reducer manufacturers can only achieve accuracy and backlash, mostly within 2 to 4 arc. min.

Technical Advantages and Features

High Precision

- Transmission accuracy within 1 arc. min. (Industry average accuracy is 2 to 4 arc. min.

Design and Production Counselling

- Developed since 2015, this technology has yielded four cases of technology transfer and consulting, providing comprehensive industry solutions.

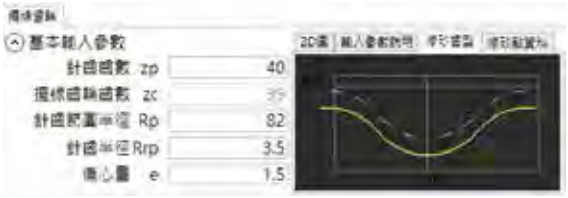
Performance Inspection of RV Reducers

- Establishing an RV Reducer Performance Testing Laboratory to offer testing services to the industry.

Industrial Benefits and Business Opportunities

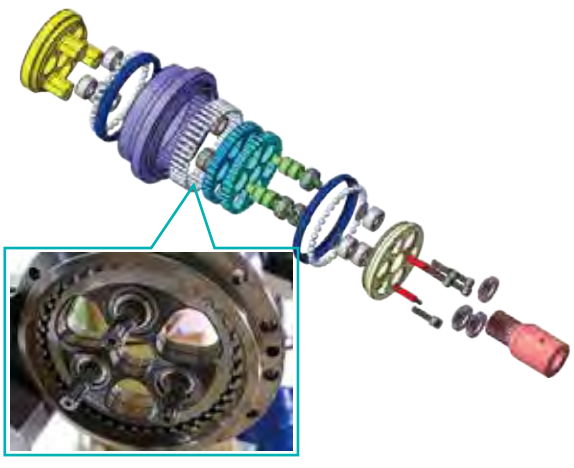
- **Industry Applications:**
  Ship Industry, Automated Robotics Industry (e.g. AGV), Wind Power Industry.

- **Application Examples:**
  - The technology was transferred to Luyang Technology Co., Saynen Industrial Co. and Yonford Gear Industry CO., assisting them in designing RV reducers and establishing manufacturing processes. Luyang Technology Co. applied the technology to AGV and has successfully entered the Central Taiwan Erlin Science Park.
  - In collaboration with Transcyko, we helped the company identify the best methods for producing RV reducers and provided product verification services, enabling their reducers to be successfully sold in international markets.



Key Component Design of RV Reducer

Performance Inspection of RV Reducer



Internal Structure of RV Reducer

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High Precision Profile Grinding Service

Recently, the precision machinery industry has demanded higher accuracy in part contours and shapes, often requiring varied and small quantities. This technology enables manufacturers to perform high-precision grinding of inner and outer diameters and to offer customized, flexible production.

Technical Advantages and Features

Special Hole/Shaft Grinding Services

- Capable of grinding eccentric shaft holes, non-circular spindles, and special bearing surfaces.

Grinding Capability

- Utilizing STUDER's multifunctional grinding machines from Switzerland, suitable for producing high-precision components.
- Processing capabilities include a minimum internal diameter of 30mm, external diameters from 3mm to 200mm, and lengths up to 800mm.
- Processing capability can reach 0.002 mm.

Customized Small Quantities Services

- Development of grinding processes for specialized shaft and hole components.
- Offering spindle repair services.
- Offering customized processes and small quantities services.

Industrial Benefits and Business Opportunities

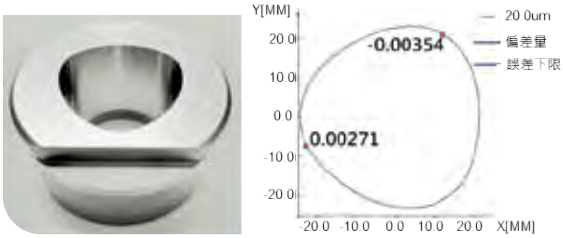
- **Industry Applications:**

  High-Precision Components for the Machinery Industry (e.g. Flexible bearings, eccentric shafts for RV reducers and harmonic drive reducers, high-precision multitasking spindles, camshafts, and high-performance positioning modules.

- **Application Examples:**
  - Collaborated with Swiss bicycle manufacturer BMC to grind hollow, oval aluminum seat posts with a 1 mm thickness and 400 mm length, achieving a grinding precision of 0.03 mm and an average surface roughness of 0.15.
  - Developed a special-shaped inner diameter grinding process for bearing components in military drones, achieving geometric accuracy within 0.01 mm and average surface roughness below 0.1.
  - Developed grinding processes for RV and HD reducer components and CAPTO spindles, achieving precision up to 0.004 mm.

Grinding of Aluminum Oval Seat posts

Grinding of Non-Standard RV & HD Transmission Components



CAPTO Spindle Inner Hole Grinding Techniques & Measurement Results

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High-Precision Embedded Intelligent Gearbox

A reducer, a mechanical device, converts high-speed rotational power into low-speed, high-torque output. Maintenance is typically manual and scheduled, using external sensors to assess health and collect data. However, this method requires extensive transmission wiring, which interferes with signal collection if space around the machine is limited.

Technical Advantages and Features

High Precision and Efficiency

- When operating, a reducer's gear gap decreases precision. This technology reduces gear backlash from 8 to 4 arc. min, boosting precision by 50%.
- An autonomously designed high-efficiency gearbox operates at 3100 rpm and 81 Nm torque, achieving 98.4% efficiency, surpassing the industry standard of 97%.

Embedded Sensors

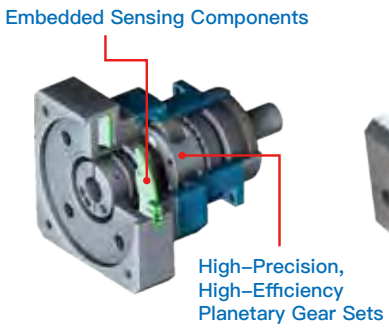
- Embedding sensing components, such as 3-axis accelerometers, temperature sensors, and WiFi transmission, in the reducer decreases its volume by approximately 40%.

High Precision Verification Platform

- Using a high-precision verification platform, we test for efficiency, gear backlash, torsional rigidity, and transmission accuracy, achieving errors under 5 arc seconds.

Industrial Benefits and Business Opportunities

- **Industry Applications:**
  Gearbox Industry, Panel industry (e.g., transportation panel equipment).
- **Application Examples:**
  Verified by the top three domestic panel manufacturers, this solution addresses excessive equipment wiring and limited space, reduces manual inspection time, and enhances labor efficiency by over 20%, advancing smart manufacturing.



Intelligent Reducer
Internal Structure

Intelligent Reducer with
Embedded Sensing Components

High Precision
Verification Platform

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Transmission System Design and Analysis for EV

Designing electric vehicle transmission systems is complex, tailored to the specific vehicle model, chassis, and usage scenarios. It entails customizing component layouts and mechanisms, including the number of gear teeth, gear profile, and gear requirements, to meet product longevity, dimensions, and NVH (noise, vibration, and harshness) standards. This meticulous process is time-intensive and costly.

Technical Advantages and Features

Accurate Calculation of Gearbox Lifetime

- Products are designed with a multibody dynamics model and a design database to achieve mileage lifespans typically between 200,000 and 400,000 kilometers.

Patented Two-Speed Gearbox

- Patented two-speed gearbox design, superior to typical single-speed electric vehicle gearboxes, meets real-world road requirements (low/high speed) with gear shifts under 0.4 seconds.
- Custom gear ratios and mechanism solutions are tailored to client specifications for vehicle model and performance.

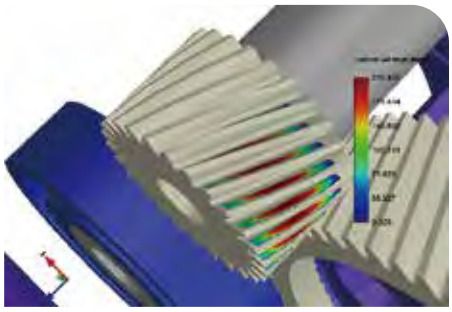
Optimized Gear Design

- Gear contact surfaces reduce pressure by up to 20%, extending gear life.
- Transmission error is reduced by up to 30%.
- Gearbox noise is reduced by 10 decibels, typically from 50 to 90 decibels with increasing speed.

Industrial Benefits and Business Opportunities

- **Industry Applications:**
  Electric Vehicle and Vehicle Industry.
- **Application Examples:**
  This technology has been transferred to BATOM and CHENTA, and has also assisted ZEPT, GOGORO, and TDCM in becoming suppliers of power modules and components for electric vehicles, electric motorcycles, and electric-assist bicycles, both domestically and internationally (e.g., TESLA, CMC, GOGORO, BROMPTON).

Two-Speed Transmission Module Prototype



Gear Tooth Modification Simulation Analysis Diagram

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Electric Vehicle Digital Communication Conformance Testing Technology

During the charging process of electric vehicles, continuous message exchanges between the vehicle and the DC power supply equipment are necessary to ensure safety. However, due to the presence of various electric vehicle and DC power supply equipment manufacturers in the market, this technology is essential for digital integration to guarantee a safe charging process.

Technical Advantages and Features

Capable of Measuring High-Power DC

- Capable of providing high-power/voltage/current DC testing services up to 500 kW/1000 VDC/1200 A (typically 400 kW/1000 VDC/500 A), suitable for testing large electric buses.

Support Common Communication Standards

- Support commonly used communication protocols, charging methods, and charging interfaces.

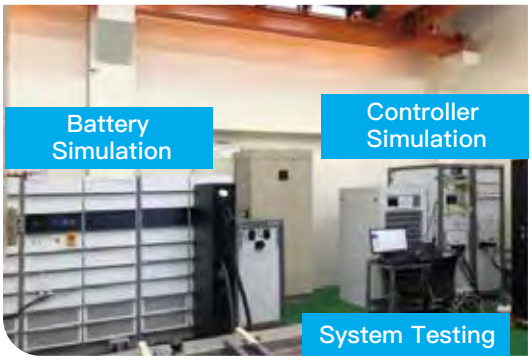
Approved by the Bureau of Standards, Metrology and Inspection

- Approved by the Bureau of Standards, Metrology and Inspection, it is the most comprehensive laboratory in the nation for testing equipment and specifications.
- According to international testing standards, the laboratory can test 100% of the vehicle classifications on the market.

Industrial Benefits and Business Opportunities

- **Industry Applications:**
  EV Industry, EVSE Industry.
- **Application Examples:**
  This technology has been transferred to numerous domestic manufacturers, assisting them in acquiring capabilities for "new product development verification" and "certification testing services", including EVSE suppliers: eTreego Co., Ltd, Delta Electronics, Allis Electric Co., Ltd, Mobiletron Co., Ltd., Aiox Innovation Company; and electric bus manufacturers: DE FINE BUS AND TRUCK CO., LTD, Master Transportation Bus Manufacturing Ltd., Tron Energy, TONG YING MOTOR CO., LTD.

E-Bus



Automated Testing System for Digita Communication Conformance

DC Charging Equipment

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Autonomous Driving

The transportation industry has faced challenges such as a shortage of professional drivers, long working hours, and risks of night operations in recent years. Therefore, autonomous driving systems assist the industry in automating and transforming to meet the rising demand while improving road safety.

Technical Advantages and Features

Autonomous Full-Speed Range Suitable for Multiple Vehicle Classifications

- Full-speed range suits various vehicles (sedans, trucks, buses, tractor-trailers, etc.).
- Applicable to vehicles with different power sources (diesel, electric, hybrid).
- Suitable for urban areas and highways.

Large-Scale HD Mapping

- Equipment installation and removal are straightforward and suitable for various vehicle classifications.
- Only 10% of the industry's hardware cost is needed to produce maps that meet the Ministry of the Interior's accuracy specifications.
- Centimeter-level positioning, unaffected by tunnel/bridge obstructions.

Implementation of International Standards for Verifying Cyber-Physical Systems

- Implementing International Safety Standards (IEEE 2846, ISO 21448) to ensure the safety of autonomous driving decisions.
- Customized high-fidelity traffic scenarios integrated with real traffic data.
- Verifying Cyber-Physical Systems to ensure the safety of real-vehicle testing in open fields.

Industrial Benefits and Business Opportunities

- **Industry Applications:**
  Logistics Industry, Intercity Bus Industry.
- **Application Examples:**
  - In cooperation with Transurban, Australia's leading road operating company, the autonomous tractor-trailer was conducted at night on Melbourne's M1 freeway. It was Australia's first highway autonomous driving test case and Taiwan's first international export of open-road for autonomous driving.
  - In collaboration with Taoyuan International Airport, autonomous vehicles have provided shuttle services between Terminals 1 and 2, establishing Taiwan's fastest operational autonomous vehicle service. This initiative, alongside Waymo's service at Phoenix Sky Harbor Airport, represents the second global case where autonomous vehicles operate on the airport's open roads.
  - In partnership with HCT Logistics Company, the autonomous logistics service was implemented between fixed business locations and customer sites in Hsinchu City, marking it Taiwan's first self-driving logistics application.

Australia Transurban
35-ton Container Tractor Trailer Truck

Taoyuan International Airport
Autonomous Shuttle Service

HCT Logistics 5-ton
Autonomous Logistics Vehicle

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Digital Twin Technology and High-Fidelity Vehicle Model

For vehicle manufacturers, accurately predicting performance and handling during the early stages of vehicle development is a challenging task. Previously, validating with actual vehicles required significant testing resources and was time-consuming, leading to excessively long product development cycles.

Technical Advantages and Features

High-Fidelity Vehicle Model

- Using multibody dynamics to construct models, the accuracy of control simulations exceeds 90%.
- The battery's SOC (State of Charge) estimation accuracy is up to 97%.

Full Vehicle System Simulation

- Based on model development and employing Functional Mock-up Units (FMU), this approach ensures model sharing and interoperability.
- Reducing models from 3D to 1D retains 80% accuracy and achieves real-time simulation calculations.

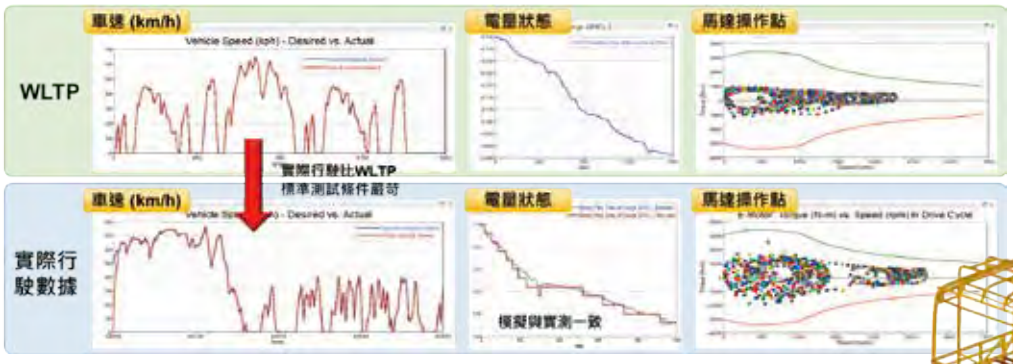
Electric Vehicles Database

- Suitable for electric vehicles. Customized vehicle/power system modeling.
- 7~12 meter buses.
- 3.5~26 tons trucks.

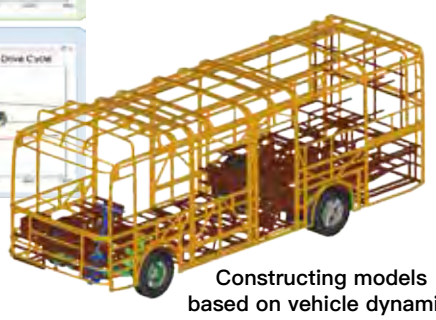
Industrial Benefits and Business Opportunities

- **Industry Applications:**
  Electric/Fuel cell commercial vehicles (buses/trucks).

- **Application Examples:**
  - This technology has been transferred to the electric bus manufacturer Tron-e, which has obtained Lane Keeping Assist CSF/ACSF certification, enhancing safety.
  - For electric buses operating on specific routes, whole-vehicle simulations were conducted; the battery status simulations correlate with actual test results.



Energy Consumption Simulation



Constructing models based on vehicle dynamics

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Motor Controller Technology

Most electric vehicles use AC motors as their driving core, but the batteries supply DC power. Therefore, it is necessary to use a motor controller to convert DC into AC. The conversion process incurs power losses, which increase proportionally with the rise in driving power.

Technical Advantages and Features

Taiwan's First SiC Motor Controller

- Characterized by low switching losses, it is capable of reducing power consumption by 50%.
- Featuring variable frequency with a small size and high efficiency, achieving a power density of 60 kW/L (compared to the current domestic industry standard of 26 kW/L).

Integrated Cooling System

- Cooling of key components such as power modules and capacitors is conducted simultaneously, increasing the motor's rated power (continuous output) by 10%.
- Integrated design reduces the volume of water channels and lowers the cost of the cooling system by 50%.

Multi-Core High-Efficiency Processor

- Established a multi-core high-efficiency processor platform capable of handling high-frequency, high-speed application scenarios.
- In response to market demand, an all-in-one power system has been assembled, integrating components such as the motor, gearbox, and drive controller.

Industrial Benefits and Business Opportunities

- **Industry Applications:**
  Electric Mobile Vehicle Industry (e.g. Electric Vehicles, Boats, Drones).
- **Application Examples:**
  This technology has been transferred to major Taiwanese power motor manufacturers, including Shihlin Electric & Engineering Corp, Tatung, TECO, and Actron Technology Corporation, successfully accelerating the domestic self-sufficiency of critical modules. The CMC Veryca E300 utilizes this core technology. Additionally, the technology has been transferred to the top five Taiwanese ICT electronics manufacturers, aiding the domestic ICT industry in entering the electric vehicle supply chain.

Transferred to TECO, Tatung, Shihlin Electric & Engineering Corp
IGBT Motor Drive Controller Technology

Derivative Technology Facilitated by CMC
Launch the newly redesigned e-VERYCA E300

Transferred to Major ICT Companies ≥200 kW SiC Motor Drive Controller Technology

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機械與機電系統研究所

MECHANICAL AND MECHATRONICS SYSTEMS RESEARCH LABORATORIES, MMSL.

INTELLIGENT FACTORY

AI Identification and Feedback Module for Appearance Quality of Metal Products

Traditional visual inspection are easily affected by metal surface reflections and uneven light source. It leads to misjudgment issues, especially inspects on irregularly shaped 3D metal parts. Factors like low detection rate, unstable effects, and limited applications cause difficulty to achieve the goals of intelligent inspection. Using AI for detection helps overcome problems related to metal surface reflections and uneven lighting, and interference from the shadowing.

Technical Advantages and Features

AI Image Recognition Technology

- AI deep learning module trains on complex defect features, such as random wood grains and helical gear teeth. The AI module adapts to various environments and production lines.
- The scope is to broaden to varies industries, such as food and textile inspection.

Dynamic Optimal Lighting Layout Imaging

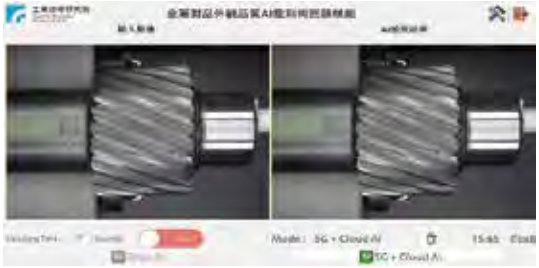
- Combining image filtering transformations with blur analysis enables light and shadow detection, overcoming issues like reflections and uneven illumination in dynamic imaging.
- Based on light and shadow detection, dynamic adjustment reduces reflections in multi-angle imaging by light source placement and detection angles.

3D Helical Gear Inspection

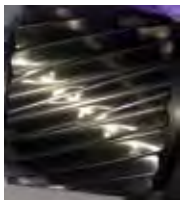
- A specialized detection model for 3D helical gears achieves a defect detection rate of 98% (industry average 80%).
- Breaking through technological bottlenecks by automatically detects challenging defects such as tooth surface black spots, tip collisions, and broken teeth, identifying flaws as small as ≥ 0.1 mm.

Industrial Benefits and Business Opportunities

- **Industry Applications:**
  Metal Product Processing Industry (e.g., Plumbing Supplies, Gear Manufacturing, Powder Metallurgy).
- **Application Examples:**
  The technology, integrated into specialized gear inspection equipment, has been successfully implemented by electric vehicle gear production line. It reduces inspection time by 50%, tripling daily production capacity, and cutting annual quality control costs by about 50%.



AI Deep Learning Image Recognition



A Conventional Imaging Setup Often Leads to Reflection

Optimal Light Source Arrangement for Imaging Reflective Surfaces

3D Helical Gear Inspection Mode

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Injection Molding Full Inspection and Process Parameter Optimization Technology

Traditional injection molding industries rely on manual quality assessments, which results in unstable quality and decreased the production efficiency. The parameter adjustment is based on production experience. It leads to challenges in knowledge management and production parameters optimization. Intelligent quality control can be achieved by using AI could establish relationships between process parameters and defects in injection products, such as short shots and deformations.

Technical Advantages and Features

Big Data and AI Deep Learning Analysis and Feedback

- Big data collects from product design parameters, process parameters, and quality control inspection.
- AI deep learning models provides real-time feedback and predicts upcoming manufacturing issues.
- Saving the manual inspection labor cost in 90% potentially.

Visualization of Key Feature Information

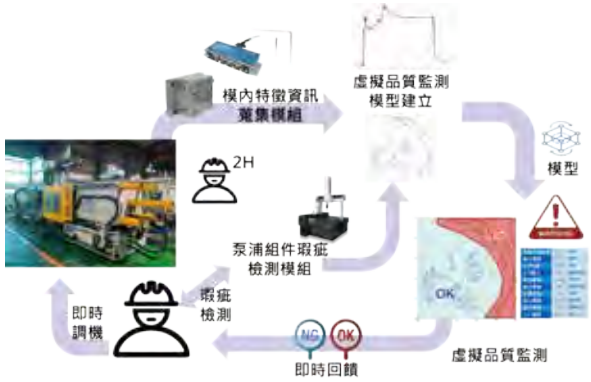
- The visualization interface displays key features of the machinery and molds, including mold internal pressure, integral pressure, and the slope of the pressure curve.
- Real-time monitoring and control enable the setting of machinery standards to ensure the quality.

Quality Prediction through Monitoring & Simulation

- Analysis and detect the planar geometric features of the finished product by monitoring machine status.
- Workpiece quality can be predicted with 96% accuracy (industry standard often involves manual spot checks) by simulating machine status and parameters.

Industrial Benefits and Business Opportunities

- **Industry Applications:**
  Electronics component industry (plastic casings), transportation tools (car bumpers, interior trim panels), and other plastic products.
- **Application Examples:**
  The software module, implemented at pump manufacturer, enhances intelligent injection molding of plastic casings and sets up a quality monitoring system. This has increased the yield by 12% (from 84% to 96%) and reduced annual carbon emissions by 25.33 tons.



Process Parameter Collection and Feedback System

Information Visualization of In-Mold Features and Full Inspection of Injection Molding Quality

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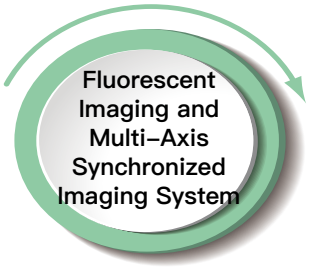
AI Smart Magnetic Particle Inspection Module for Magnetically Conductive Materials

Surface and subsurface cracks inspection is crucial in steel manufacturing. Fluorescent magnetic particle inspection (MT) techniques are typically the method for inspection. Uneven powder residue can lead to misinterpretations and result in error rates exceeding 20%. Additionally, exposure to black light (UV) poses risks to human eyes and skin, potentially causing conditions such as cataracts. AI is necessary to accurately identify defects, given the challenge of defining uneven residues in images.

Technical Advantages and Features

- AI deep learning–based defect detection technology distinguish true and false defects with over 90% accuracy, compared to 80% with manual detection.
- Reducing reliance on personnel and increasing equipment competitiveness.



- Fluorescent imaging highlights the features of shallow subsurface crack defects.
- Multiple synchronized mobile imaging modules expand the imaging range from 0.2 to 12 meters at the same resolution.
- Reducing the time required for manual inspection by 55%.

- Defect distribution is presented through a visual interface that includes information on defect size and location.
- Based on defect distribution, the system provides immediate feedback to the grinding process.

Industrial Benefits and Business Opportunities

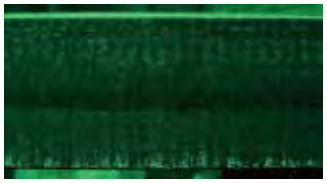
- **Industry Applications:**

  Metal Processing (Casting, Forging, Steel Bars), and Steel (Steel Billets, H–beam Steel) Industries.

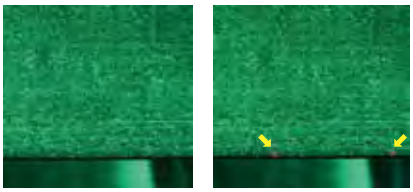
- **Application Examples:**

  The module, implemented in steel industry, established the first domestic AI inspection process for surface defect detection and removal, reducing inspection times by 50% and boosting accuracy from 80% to 90%.

Fluorescent Magnetic Inspection Imaging Module



Residual Fluorescent Magnetic Particles



Original Images AI Detection Results

Fluorescent Magnetic Particle AI Detection that Overcomes Misjudgment due to Residual Particles

Real–Time Feedback on Visualized Defect Status

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Non-Symmetrical 3D Composite Braiding System

In response to the demand for energy conservation and carbon reduction, components must maintain structural strength while reducing weight. Traditional composite braiding and stacking methods require customized molds and depend on manual lamination for forming, which is particularly challenging for tubular structures and irregular shapes, material utilization rate achieves only 60% 70%. This technology introduces a 160-spindle radial composite braiding device that tightly fits outer fibers to core surfaces via weaving and axial expansion; dual-arm propulsion aids in swiftly producing complex three-dimensional parts, thereby improving material utilization.

Technical Advantages and Features

Radial Composite Braiding Equipment

- The first domestic radial composite braiding equipment, featuring 160 circular motion of the spools.
- Fiber utilization has increased to 80%, up from 60-70% with traditional equipment."

Dual-Arm Propulsion Control

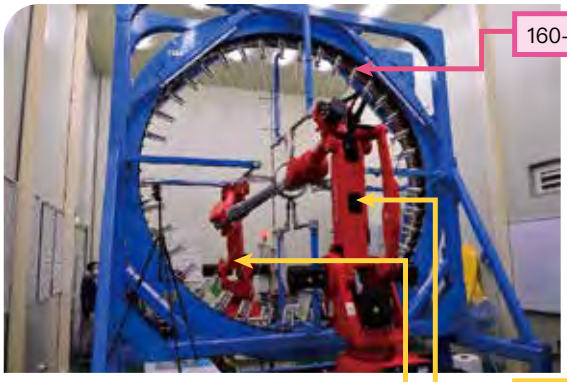
- Combines dual-arm synchronized control for high stability.
- Suitable for manufacturing slender workpieces up to 3 meters in length.

Optional Expandable Axial Fiber

- The expandable 40-strand axis enhances the product's tensile and bending strength, broadening its application range.

Industrial Benefits and Business Opportunities

- **Industry Applications:**
  Aerospace Industry, Transportation Industry, Green Energy Industry.
- **Application Examples:**
  - Established the first domestic 'Composite Component Verification and Trial Production Laboratory,' which develops lightweight composite components and leads Taiwanese manufacturers into the international composite component market.
  - In the aerospace industry, the development of carbon fiber engine blade weaving technology is currently in the phase of small-scale production testing.
  - In the defense industry, lightweight personal protective equipment is being developed to provide the national military with high-strength protective gear.



Radial Composite Braiding Equipment


Irregular Structures and
Slender Composite Braided Products

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Prognosis Monitoring System, PMS

Traditional manufacturing often faces interruptions in operations due to equipment inspection and maintenance cycles. These gaps can result in issues or shutdowns, requiring expert intervention and impacting production capacity. Moreover, inefficient maintenance scheduling can lead to higher costs. AI-based prognosis monitoring systems, learning from expert analysis techniques, streamline complex sensor data to provide intuitive equipment status information. This system acts as a 24-hour monitoring AI engineer, accurately predicting machine conditions, diagnosing anomalies, and offering immediate feedback.

Technical Advantages and Features

Customizable Equipment Health Monitoring

- Monitor the health of equipment according to ISO vibration standards, such as air compressors and mechanical vibrations.
- Customize specific health indicators to accurately predict equipment lifespan.

Equipment Health Trend Forecasting & Optimal Maintenance Scheduling

- Capable of predicting the deterioration of health status or even the Remaining Useful Life (RUL), with an error rate of less than 10%.
- Providing recommendations for optimized maintenance scheduling, with proven cases that have increased equipment lifespan by at least 50%.

Automatic Fault Diagnosis for Rotary Machine

- Capable of automatically diagnosing 17 common faults in rotary machines, including bearing and gear damage.
- The accuracy of fault diagnosis exceeds 85%.
- Proven cases have reduced maintenance operation time by up to 30%.

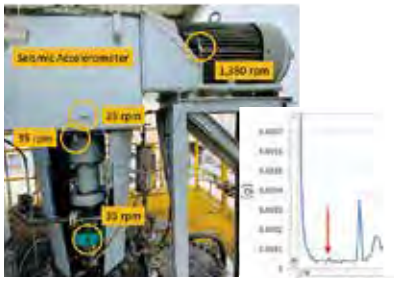
Industrial Benefits and Business Opportunities

- **Industry Applications:**

  Electronics, semiconductors, metals, petrochemicals, automation, and information services industries, among others, are all applicable as long as they can utilize vibration signal collection and AI analysis.

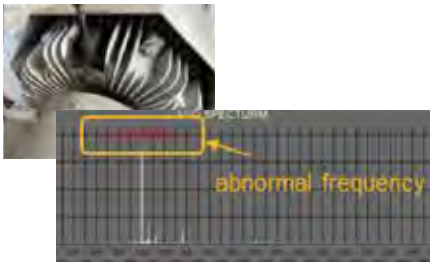
- **Application Examples:**

  This technology has been applied to over 500 pieces of machinery. Partnering with leading manufacturers, such as a domestic semiconductor vacuum equipment producer, has led to a 50% increase in equipment lifespans. Similarly, collaboration with a top domestic machining factory has improved tool lifespans by 10% through optimized drilling processes. In the green energy sector, we worked with a state-owned enterprise to diagnose gearbox anomalies in wind turbines a month in advance, effectively leveraging the benefits of predictive maintenance.



Continuous and High-Quality Signal Monitoring

Fast and Accurate Fault Diagnosis



Effective Forecasting of Trend States

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Flexi-Modeler for OPC UA

Industry 4.0 adopts OPC UA as the communication standard to help integrate Taiwan's industries with international norms. By establishing OPC UA servers, data is captured from various devices and systems and provided to clients in a unified format. However, building device information models is complex, involving software installation, data definition, and security configurations, which adds to development costs and time. This technology assists users in quickly completing OPC UA modeling and facilitates the transfer of data to cloud or on-site systems for display, analysis, or decision-making.

Technical Advantages and Features

Easily Modeling

- Support various OPC UA Companion Specifications.
- Automate hierarchies and inheritance for easy, fast programming.
- Reducing user development time by more than 80%.

HMI with Industry Knowledge

- HMI with Industry Knowledge, users can get started quickly.
- With three major industrial automation communication setting interfaces: Method, Event, and PubSub.

Cross-Platform Control Module

- Seamless International Communication (IEC 62541).
- Simplified Setup, Rapid OPC UA Server Control Module Deployment.
- Cross-platform: Windows, Linux Ubuntu and ARM.

Industrial Benefits and Business Opportunities

- **Industry Applications:**
  Plastics and Rubber, Machine Tool Industry, and Automation.

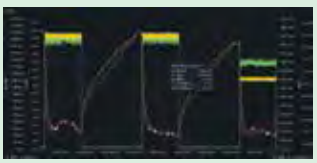
- **Application Examples:**
  This technology has been implemented in nationally renowned injection machine controllers and intelligent pumps, aiding manufacturers in rapidly establishing information models with companion specifications and constructing OPC UA servers, which has doubled production reporting efficiency and reduced development time by 30%.

Flexi-Modeler
Easily Modeling

Import

Cross-Platform
Control Module

Apply



Pump Test Facility

Pump Test Facility

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SECS/GEM Communication Technology

Electronic device controllers handle data collection, equipment monitoring, and production control in factories. However, diverse brands and models lead to non-standardized communication technologies, complicating integration and requiring extra manpower and time. The SECS/GEM standard can be quickly implemented through simple, automated settings, solving issues with complex processes, multiple devices, and challenging information integration.

Technical Advantages and Features

International Communication Standards

- SECS/GEM is the official communication standard in semiconductor industry.
- Equipment uses the standard (SECS/GEM) to communicate and process and data.

Efficient Core Driving to Fully Interconnect the Entire Factory's Information

- Efficient driving structure technology offers application on a broad product range, equipment and factories.
- Improving factory connection, increasing automation efficiency, and reducing labor costs.

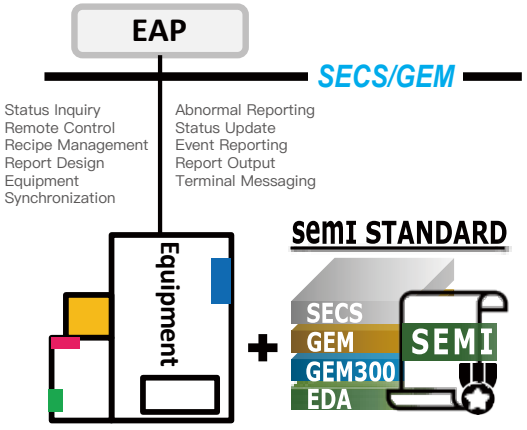
One-Stop Professional Consulting Services

- With over 20 years experience in industry counseling, thousands cases service has facilitated collaboration users and makers.
- One-stop services including factory visits, specification negotiations, and validation.

Industrial Benefits and Business Opportunities

- **Industry Applications:**
  Semiconductors (including Wafer Foundries and Packaging/Testing Facilities), PCB Printed Circuit Boards, Panel Manufacturers, and Solar Energy.

- **Application Examples:**
  - Assisted the largest domestic photomask manufacturing company in SECS/GEM communication standard implement while facilitating the sale of their photomask cleaning equipment to major semiconductor companies in the United States, generating additional output value exceeding 30 million NT Dollars.
  - Guided a top domestic die-sorting equipment manufacturer to integrate advanced semiconductor communication systems into the LED machines and the solution was successfully sold to Toshiba Corporation and OSRAM GmbH , receiving high customer praise.



ITRI

6 Major Industries
50 types of equipment

Comprehensive Professional Technical Services

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智慧機器人

Detachable Joint Robot System

For various and small-scale automated production lines, diverse types of robotic arms are required. However, the robotic arms available on the market come in fixed configurations, making customization impossible for customers. When maintenance is needed, the entire arm must be sent back to the manufacturer for repairs. The process not only involves laborious tasks but also halts production lines, leading to delays in delivery schedules.

Technical Advantages and Features

Flexible Modular Design

- Quickly replace faulty joints, reducing factory downtime from 2 days to 0.2 days.
- Easily adjust the robotic arm's degrees of freedom and arm length without being constrained by the fixed configurations.

Quick Replacement

- Similar to LEGO bricks, customized robotic arms are based on cost and requirements.
- Completing assembly within 5 minutes; setting up operation within 10 minutes.

High Performance

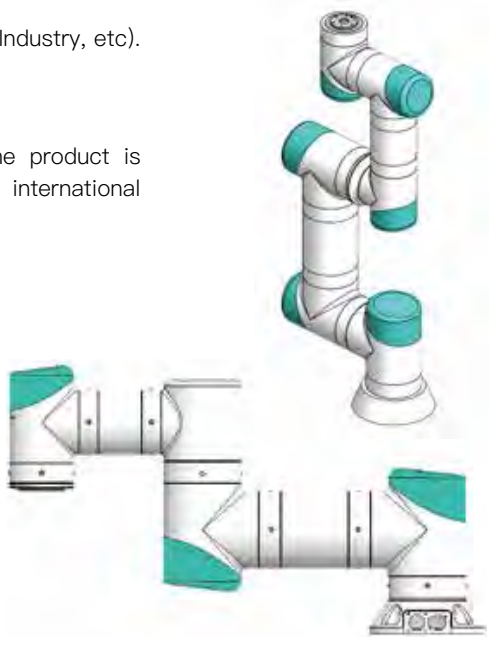
- Modules integrate intelligent components, such as motors, gearboxes, encoders, and drivers, for plug-and-play functionality without requiring additional configuration.
- Volume has been reduced by 15%, the high torque-to-weight ratio has been increased by 30%.

Industrial Benefits and Business Opportunities

- **Industry Applications:**
  Multi-industrial applications (Light Industry, Semiconductor Industry, Medical Industry, etc). Applied to parts assembly, material inspection, surgical assistance.
- **Application Examples:**
  In co-production with the largest domestic joint module manufacturer, the product is exported to Europe, America, India, and Southeast Asia markets through international distributors to meet the demands of collaborative and DIY requirements.

Pick-and-place

All-In-One Module



Adaptable Robot Assembly

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AMR and Intelligent Fleet Management System

Autonomous Mobile Robots (AMRs) alleviate labor shortages and enhance factory efficiency by performing tasks such as goods delivery and environmental cleaning independently. However, inconsistent communication systems across factories hinder AMRs from communicating during routine tasks, complicating the coordination and integration with equipment such as elevators and shelves, thereby limiting the use and expansion.

Technical Advantages and Features

Seamlessly Communicate Across Different Areas

- Satisfying the communication standards of the Autonomous Mobile Robot Alliance (AMRA).
- Integrating with various domestic brands of AMRs.
- Compatible with different types of mobile vehicles, such as Automated Guided Vehicles (AGVs), Autonomous Mobile Robots (AMRs), and Overhead Hoist Transporters (OHTs).

Smart Traffic Management & Dual-Module Scheduling

- Intelligent traffic management and multi-path planning algorithms with flexibly arranged tasks.
- Dual modular (simultaneously running direct routes and detour tasks)
- Smart charging and parking management for continuous 24/7 operation.

Support the Factory Communication Protocols

- Communication among the factory's peripheral equipment, including warehouses, electronic shelves, elevators, and automatic doors.
- Supports Universal Communication Protocols, including Modbus, AMQP, REST API, and SECS, ensuring high compatibility with enterprises.

Industrial Benefits and Business Opportunities

- **Industry Applications:**
  Semiconductor Industry, Manufacturing Industry, Medical and Service Industry.
- **Application Examples:**
  - Applied at the semiconductor packaging and testing plant, Siliconware Precision Industries, the Intelligent Fleet Management System commands and dispatches multiple autonomous mobile robots to transport wafer carriers (FOUPs and Magazines) in the cleanroom, achieving flexible scheduling. This technology has successfully reduced manpower by 15%, increased production capacity by 50%, and achieved a production line utilization rate of 95%.
  - Applied at the screw mold factory, San Shing Fastech Corp, the "Intelligent Task Scheduling" achieves dual-module operation of detour and direct transport between workstations. The "Fleet Management System" communicates with peripheral automatic, enabling AMRs to have the capability of transporting goods across floors and buildings. After implementation, it saved 3 manpower in each area.

For Different Guiding Type Magnetic Guidance & SLAM

SANSHING

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RoboTwin Integrated Virtual-Real Robot Control Unit

Virtual-real integration is not commonly implemented in all factory lines due to a lack of big data and reliable verification platforms. This increases the risk of failure in the actual implementation of products and requires more time to be spent on the production line.

Technical Advantages and Features

Advanced Factory Deployment

- Rendering a 3D scene from 2D static images without Computer-Aided Design (CAD) models.
- Simultaneous remote immersive interaction with three units helps overcome cross-factory limitations.
- Completed advanced simulation and dynamic verification within a week to enhance implementation confidence.

Robots Equipped with Smart Vision

- Fully automated database generation by using AI-powered vision database automation tools.
- Completed the visual recognition system within 3 days, with general machine adjustment taking about 10 days.
- Visual-guided robot for loading, unloading, and processing operations.

Digital Twin Fast-Learner

- Generative AI robots equipped with learning and decision-making capabilities.
- Non-engineers can easily get started.
- Optimize configurations and adjust paths within one day.

Industrial Benefits and Business Opportunities

- **Industry Applications:**

  Manufacturing Industry, such as electrical machinery factories, steel industry, powder metallurgy, metal processing industry, and other Processing Industries.

- **Application Examples:**
  - Successfully entered the Horizon Europe research project, collaborating with European partners such as Fundacion TEKNIKER in Spain, DFKI in Germany, and Philips Consumer Lifestyle in the Netherlands.
  - Introduced to the top 10 hand tool factories in Taiwan, the system is used for high-difficulty assembly (e.g., ratchet wrenches), resolving high-contact-rich issues and increasing productivity by 30%.

Horizon Europe

Practical Applications in Electrical Manufacture — Virtual War Situation Room / Virtual-Reality Integration / Remote Maintenance and Operation — Human-Machine Collaboration / Robot Automation / AI Intelligence

High-Fidelity Bidirectional Connectivity

Production Line AI Database

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RobotSmith: Robot Metal Processing Technology

Metal component manufacturing traditionally relied on manual labor, making tasks such as grinding, quality inspection, defect assessment, and regrinding prone to quality variability. Additionally, the factory environment contributes to labor shortages due to noise, odors, and the risk of occupational injuries associated with the inspection process.

Technical Advantages and Features

First Set of Domestic Virtual and Augmented Reality Software

- Own brand "RobotSmith"
- Compatible with 10+ global robot brands, such as ABB, KUKA, FANUC, YASKAWA.
- Introducing ChatGPT to the production line to offer troubleshooting guidance through an AI assistant.

No Programming Required & High Processing Accuracy

- No programming needed; the production line be deployed within 5 seconds through natural language.
- Automatically generate machining programs, reducing operation time by 95%.
- Supports multiple sensors (temperature, pressure, position, etc.) for instant detection of process variations, achieving machining accuracy within 0.1 mm—three times better than the industry standard.

Real-Time Presentation with Predictive Capabilities

- The simulation and actual error are within 0.5mm, with no time discrepancy.
- Predicting the time of abrasive belt wear with an accuracy of over 95%.
- Defect recognition rate exceeds 95%.

Industrial Benefits and Business Opportunities

- **Industry Applications:**

  Metal Processing Industry (such as plumbing fixtures, kitchenware, fine cutlery, bicycles, and artificial joint medical materials) performs grinding, polishing, deburring, sawing, welding, and spraying, among other tasks.

- **Application Examples:**
  - Successfully implemented at HCG, a leading sanitary ware manufacturer, Robotsmith has decreased faucet grinding time from 6 to 3.5 minutes, increasing efficiency by 41%. It also reduced product costs by 20%, generated over 50 million NTD in benefits, and enhanced Taiwan's sanitary ware
  - production lines for greater international competitiveness.

  Robotsmith, the first nationwide grinding and polishing robot, partners with top domestic medical material manufacturers to precisely grind complex, custom titanium artificial joints. It enhances surface smoothness and biocompatibility, extending the implant lifespan to 30 years.

Artificial Joint Grinding

Polishing and Grinding Production Line

Simulation Software Interface

Metal Processing Robot Machine

ROBOTSMITH + ChatGPT

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機械與機電系統研究所
MECHANICAL AND MECHATRONICS SYSTEMS RESEARCH LABORATORIES, MMSL.

UNMANNED AERIAL VEHICLE(UAV)

Redundant Flight Control System Technology

The majority of drones currently employ a single-controller flight control hardware architecture, which poses a significant threat to flight safety in the event of a flight control system malfunction. To address this issue, MMSL has developed a redundant flight controller to enhance mission reliability.

Technical Advantages and Features

Real-time Redundancy Control Switching

- Equipped with a redundancy mechanism, the parallel flight controllers can switch to the backup module in real-time.
- A built-in triple redundancy sensor system, which uses data from three or more sensors to compute and feedback to the core flight control, enhancing the reliability of the aircraft's attitude and positional status.

Highly Compatible and Easily Development

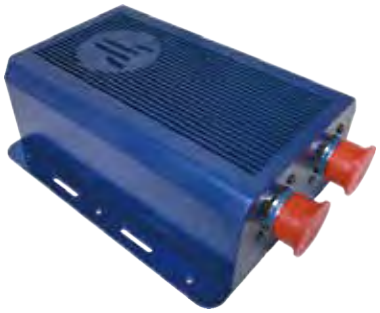
- Based on the open-source Pixhawk system, this platform is optimized for cybersecurity and compatible with commonly used flight controller software like PX4 and Ardupilot.
- Supporting the Robot Operating System (ROS/ROS2) for developing intelligent payloads and integrated applications.

Easy to assemble, Waterproof and Dustproof

- An all-in-one military-grade connector that can be quickly assembled in 5 minutes and effectively prevents cable disconnection.
- Enclosed case design with a waterproof and dustproof rating of IP65 or higher.

Industrial Benefits and Business Opportunities

- **Industry Applications:**
  Unmanned Vehicles Industry, such as UAVs, USVs, UGVs.
- **Application Examples:**
  This technology's flight control module has been integrated into ITRI's large 8-axis drone, designed for cleaning systems such as insulators, electric towers, and building facade cleaning. It is currently undergoing field validation in Taiwan.



Redundant Flight Controller

Redundant Flight Controller Applied to Insulator Cleaning

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Insulator Cleaning Drone

In the electric power transmission system, the insulators on high-voltage electric towers require cleaning and maintenance to reduce the risk of arcing or erosion, thereby ensuring the stability of the power supply. Whether performed through manual climbing or by using helicopters equipped with water guns, cleaning remains a high-risk and costly operation. The insulator cleaning drone significantly reduces the risk exposure to personnel and offers a more competitive model for maintaining the transmission network.

Technical Advantages and Features

Complete System Development

- Capable of autonomous flight operations.
- Single-trip payload capacity can reach up to 38 liters of water.
- Featuring frontal autonomous obstacle avoidance.
- Stable hovering cleaning mode near electric tower proximity points.

Water Nozzle Functional Payload

- Water pressure of 20 MPa, effective cleaning distance of 3 meters.
- The gimbal's servo controls the water nozzle, complying with the standard operating procedures for cleaning insulators along multi-segment paths.
- Remote real-time monitoring of the cleaning process.

Tracking Control

- The onboard AI automatically recognizes the type and distance of the insulator strings and calculates the necessary adjustments for water nozzle gimbal control.
- An algorithm for image processing that resists mist interference.

Industrial Benefits and Business Opportunities

- **Industry Applications:**
  Operation and Maintenance of Electric Power Infrastructure and Industries Requiring High-Altitude Cleaning Services (such as Insulator Cleaning and Building Cleaning).

- **Application Examples:**
  Obtained the first-phase test flight certificate for high-voltage electric tower sites and is currently verifying cleaning performance in the field. Derivative applications include horizontal spraying on large fruit trees, demonstrating effective penetration through large tree canopies.

Drone-Based Insulator Cleaning Operation

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Customized Technology for High-Efficiency Drone Motors and Smart Electronic Speed Controller

For military or commercial drones, the motors and electronic speed controllers directly affect the dynamic performance of the flight. These components need to be developed based on the overall takeoff weight and power configuration of the drone and must be matched with the propeller output settings to optimize the drone's durability and controllability. This technology addresses the domestic shortage of high-thrust electric propulsion modules for medium to large drones, thereby accelerating the development of the entire power system and enhancing flight reliability.

Technical Advantages and Features

Autonomous High-Efficiency Motor

- Equipped with development examples and trial production capabilities for series items under 5 kW.
- Customized design and the local supply chain.
- The housing's optimized air-cooled flow channel design ensures sustained high output.

Autonomous Electronic Speed Controller

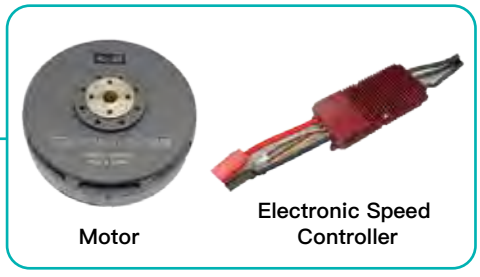
- Optimized sensorless control technology enhances performance for medium to high thrust output.
- Capable of receiving dual input commands via CAN/PWM.
- Real-time monitoring and recording of motor operational status.
- Optimized housing design for heat dissipation supports sustained high current output.

Safety Certification

- Obtained TAF, IP55, and IECQ certifications (dustproof, waterproof, low temperature, vibration).
- Assisting in obtaining EMI/EMC certifications.
- Assisting in obtaining MIL-STD-related certifications.

Industrial Benefits and Business Opportunities

- **Industry Applications:**
  Related to Unmanned Vehicles, Including Drones, Unmanned Boats, and Autonomous Vehicles.
- **Application Examples:**
  The drone motors and electronic speed controllers developed through this technology are suitable for medium to large multi-rotor drones. Specifications have been adjusted according to manufacturer demands. The technology has been transferred to two domestic manufacturers, who will establish production lines and become parts of the drone supply chain.



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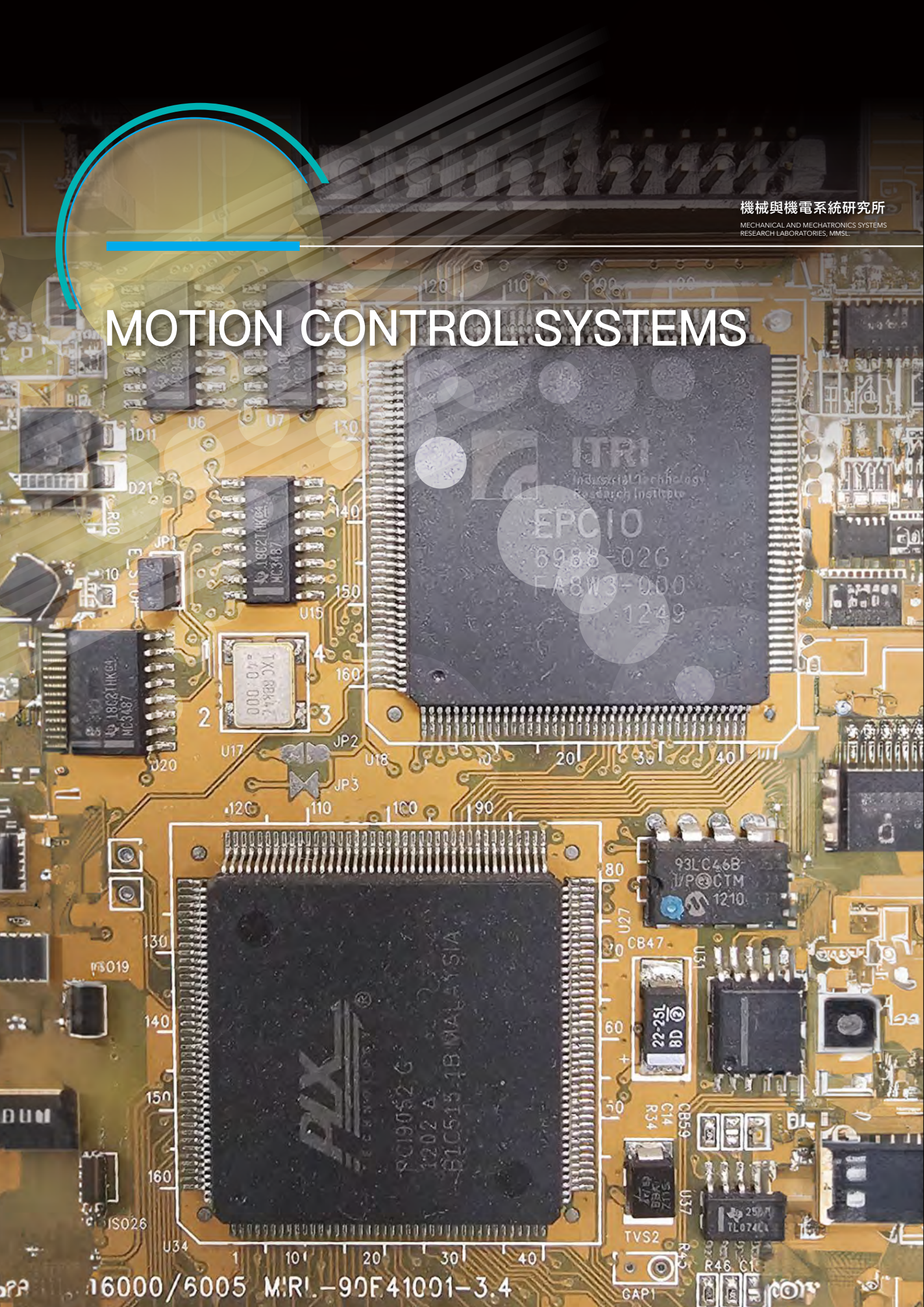
MOTION CONTROL SYSTEMS



EtherCAT Motion Control Platform

The evolution of robots, machine tools, and semiconductor equipment is marked by the integration of sophisticated mechatronics systems, necessitating increased axis capabilities, heightened precision, and seamless multi-axis synchronization. Crafting these advanced mechatronics systems relies heavily on the expertise of skilled professionals adept at navigating complex wiring intricacies and crafting bespoke designs tailored to precise applications. Domestic operators are actively addressing these challenges.

Technical Advantages and Features

Cross-Platform Library

- Offers a diverse range of motion control function libraries, encompassing linear, arc, circular, and point-to-point movements
- Supports common network communication protocols (EtherCAT) and input/ output modules (I/O).

Customized Multi-Axis Synchronous Control

- Supports Multi-axis control up to 128 axes (typically limited to 32 axes).
- Provides Customized motion trajectory planning.

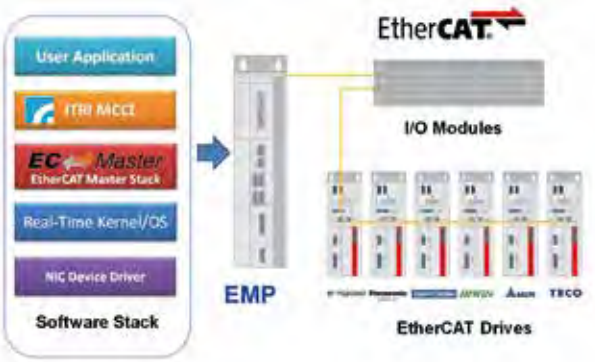
High-Speed Synchronized and Real-time Updates

- Real-time precision motion control, with update cycles as fast as 250 μs (typically 1,000 μs).

Industrial Benefits and Business Opportunities

- **Industry Applications:**
  Industrial Robotics, CNC Machine Tools, Semiconductor Equipment.

- **Application Examples:**
  Assisted Company F, the world's largest EMS manufacturer, in transitioning to a fully digital multi-axis motion control platform. Designed and developed a range of robots for diverse tasks such as polishing, grinding, pick-and-place, welding, assembly, and painting. Successfully integrated over 1,000 digital motion control platforms into their 24-hour production lines, resulting in a remarkable productivity increase of approximately 20%. This initiative also led to the achievement of domestic controller self-sufficiency.



EtherCAT Motion control Platform (EMP)

Motion Control Command Library (MCCL)

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Reduced Rare Earth Magnet Motor Technology

High-performance industrial control motors and automotive permanent magnet motors are highly dependent on foreign rare earth magnets, especially heavy rare earth (such as dysprosium and terbium), which are essential for motor temperature resistance and high magnetic energy. Consequently, motor design that reduces the use of rare earth magnets has become a key technology.

Technical Advantages and Features

Advanced Materials

- Selecting high saturation magnetic flux materials (>1.8T) and high-performance silicon steel (characterized by low iron loss, self adhesion, and high strength), combined with composite magnets, to reduce motor iron loss by more than 10% and simultaneously decrease magnet costs by 5%.

Innovative Design to Enhance Performance

- By implementing low rare-earth electromagnet and high-voltage designs, the motor speed is increased to over 20,000 revolutions per minute. Utilizing a multi-layer magnetoresistive reluctance structure enhances motor output torque by 5% and ensures the rotor's mechanical strength and rigidity.

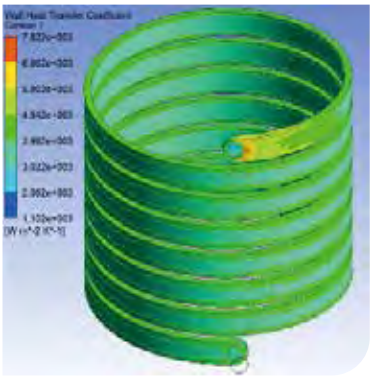
Heat Dissipation

- Utilizing external circulation active cooling, such as liquid cooling channels inside or outside the stator, ensures that the motor operates within the appropriate temperature range, maintaining efficiency, safety, and stability.
- Optimizing the flow field of the working fluid reduces the energy consumption of fluid circulation and enhances the cooling effect.

Industrial Benefits and Business Opportunities

- **Industry Applications:**
  Mobile Vehicle Equipment Industry, Automotive Motor Manufacturing Industry.
- **Application Examples:**
  Currently collaborating with leading domestic electric vehicle manufacturers, we are jointly applying low-rare-earth motor development technology to smart mobile vehicles and electric vehicles, and partnering with the industry to enter international electric vehicle-related markets.

Using Advanced Materials to Build Lightweight, High-Efficiency Motors



Optimized Cooling Design with a Water Jacket Flow Field

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Location

- 58 Bldg. 自動駕駛與電動車
- 22 Bldg. 先進與綠能製程設備 / 智慧機器人
- 53 Bldg. 軌道系統
- 11 Bldg. 智慧工廠 / 運動控制核心系統 / 無人機系統

MMSL Youtube

MMSL Web

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