

Advanced And Green Process/Equip

先進與綠色製程 / 設備

產品及產業化 Product And Industrialization

高精度研磨加工技術

High Recision Grinding Technology

簡介 Introductions

高精度與高效率傳動模組，為滿足精密零件加工需求，引進美國 MOORE TOOLS 的工模磨床 (JG)、瑞士 HAUSER 的座標鏜床和 STUDER 的萬能內外圓磨床設備，進而追求更高品質的精密加工精度。

High-precision and high-efficiency transmission modules. In order to meet the high accuracy and high quality in processing, the MOORE TOOLS jig grinder from United States, HAUSER jig boring machine and STUDER universal cylindrical grinder from Switzerland were introduced and utilized.

特色與創新 Features and Innovations

- 非圓輪廓、曲軸 / 凸輪軸研磨、小型零件平面研磨、精密定位孔加工、異型孔加工等。
- Polygonal taper grinding, cam/crankshaft grinding, planar grinding, precision holes by drilling, boring, and reaming, etc.

應用與效益 Applications and Benefits

- 工具機、航空零件、高精度主軸、刀桿、各式精密零件、精密導螺桿、螺帽、各式非圓形研磨、精密模具、精密泵浦輪軸等。
- For machine tools, aviation parts, high-precision spindles, tool holders, various precision parts, precision lead screws, nuts, various non-circular grinding, precision molds and precision pump axles.



STUDER S31 萬能內外圓磨床
STUDER S31 Cylindrical Grinder



研磨實例
Grinding applications



高速錐形主軸
High speed capto shaft

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電漿精準離子能量分佈控制技術

Precise Ion Energy Distribution Control Technology

簡介 Introductions

整合多重物理耦合模擬分析，包含熱傳 / 氣流 / 電磁場 / 電漿 / 化學反應等，建立電漿製程反應數據資料庫且建構電漿診斷技術，包含蘭牟爾探針、GEA 離子能量分析模組及非侵入式射頻離子診斷等，以精準控制離子能量分佈，並優化加速電漿源開發時程。

Integrates multi-physics modeling techniques such as thermal, flow, E/M, chemical reaction to create plasma database, and to develop plasma diagnostic technology such as Langmuir probe, GEA ion energy analyzer and non-invasive rf ion measurement technologies, to control precise ion energy distribution and to optimize plasma source module design.

特色與創新 Features and Innovations

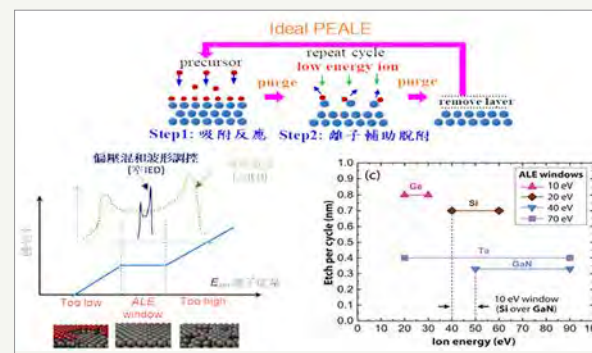
- 傳統電漿模組單頻偏壓所產生離子能量分佈過寬 (IED > 45 eV)，無法滿足原子層級製程 (ALE or ALD) 所需。本創新技術建構偏壓混合波形調控模組，抑制電漿鞘層電位離散分佈，進而達到精準窄離子能量分佈效果 (IED < 15 eV)。
- Traditional plasma modules with single-frequency bias voltage produce ion energy distributions that are too broad (IED > 45 eV) to meet the requirements of atomic layer processes (ALE or ALD). This innovative technology constructs a bias mixed waveform control module to suppress the discrete distribution of plasma sheath potential and achieve precise and narrow ion energy distribution (IED < 15 eV).

應用與效益 Applications and Benefits

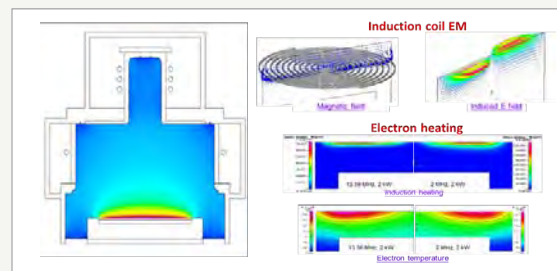
- 本創新技術可用以掌握電漿腔體特性，深入製程核心機制，應用於設備開發以及製程即時監控，同時電漿

精準離子能量分佈控制技術，除先進半導體節點製程應用之外，也可運用於精微表處、mini-LED、SiC、Diamond 和二維材料…等新興產業。

- This innovative technology can be used to understand plasma chamber characteristics and delve into the core mechanisms of processes. It can be applied to equipment development and real-time process monitoring. Furthermore, this technology can be used not only for advanced semiconductor node processes but also for emerging industries such as precision surface treatment, mini-LED, SiC, diamond, and 2D materials.



原子層級電漿 ALE 製程技術
Plasma Enhanced Atomic Layer Etching Press Technology



ICP 電漿源模擬分析
Inductively Coupled Plasma Simulation Analysis

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快速製造之霧化氣噴印微細圖案化系統

Atomizing Aerosol Jet System for Fine Line Patterning

簡介 Introductions

本技術自行開發霧化氣噴印圖案化技術，透過整合超音波霧化器、精密氣流限縮模組與高精度噴印頭，使得 2D/3D 電子線路產品在初期打樣時得以快速進行驗證，縮短目前打樣階段所需耗費的冗長驗證時間，與昂貴的模具費用。

This technology for aerosol jet printing integrates an ultrasonic atomizer, a precision air flow limiting module, and a high-precision printing head. This allows for rapid verification of 2D/3D electronic products during the RD stage, shortening the lengthy verification time and expensive mold fabrication costs that are currently required.

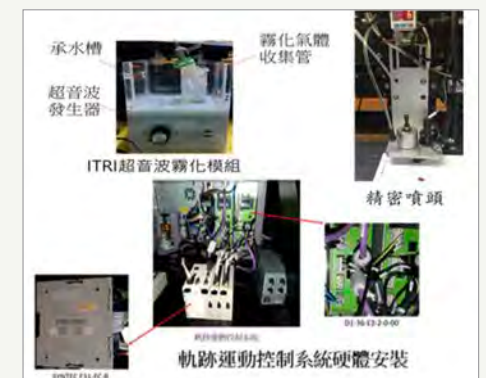
特色與創新 Features and Innovations

- 透過流速參數調整產生之壓力差，將霧化後之膠體限縮，搭配行程可控制之噴印模組與高精度位移平台，使其可於 500*500 mm 之基板上形成 20 μ m 之細微導線，達到快速、任意圖案且大面積之圖案化製程。
- The atomized colloid is confined together with a controlled printing module and high-precision stage due to the pressure difference generated through the flow rate adjustment, which allows for the forming of fine micro-wires of 20 μ m on a substrate of 500*500 mm. This achieves a fast, arbitrary pattern and large-area pattern-making process.

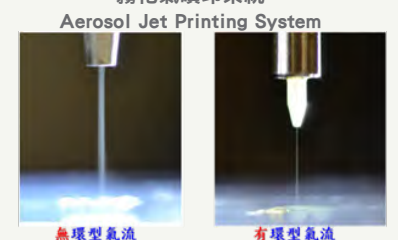
應用與效益 Applications and Benefits

- 高精密噴印圖案化系統可進行兆赫波共振晶片、印刷電路板線路修補、無線通訊天線、近場通訊等產業領域之微細圖案化製程。此外，噴印系統亦可整合機械手臂進行商標印製自動化製程。

- Applicable to micro-patterning processes in industrial fields such as megahertz resonant chips, printed circuit board circuit repairs, wireless communication antennas and near-field communication. Moreover, the integration of the system and the robot can be applied to trademark printing automation process.



霧化氣噴印系統



霧化氣噴印結合機器手臂於 3D 管件噴印之應用
Aerosol Jet Printing Integrated with Robot Arm for 3D Patterning

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高精度 PCB 電測機

High-precision PCB Tester

簡介 Introductions

全自動印刷電路板電性測試設備，為專用型治具測試，設備包含自動進出料系統，測試平台具有 4 組 CCD 進行視覺辨識。

Fully automatic printed circuit board electrical testing equipment, designed for testing with dedicated fixtures. The equipment includes an automatic feeding system and the testing platform has 4 sets of CCD for visual recognition.

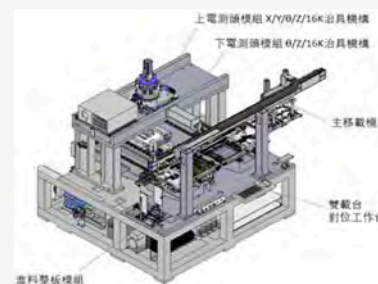
特色與創新 Features and Innovations

- 全自動高階 PCB 電性測試設備技術，具有 CCD 視覺辨識系統、高精度工作台及電測頭，可對 PCB 物料的線路自動取像，與測試探針治具進行自動對位，對位精度可達 $\pm 5 \mu\text{m}$ 。
- Fully automated high-end PCB testing technology, equipped with CCD visual recognition system, high-precision working stage, and electrical testing probes. It can automatically capture images of the circuits on PCB materials and perform automatic alignment with the testing probes and fixtures, achieving $\pm 5 \mu\text{m}$ alignment precision.

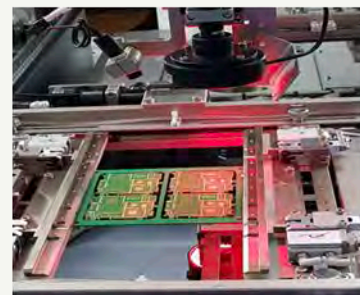
應用與效益 Applications and Benefits

- 已開發完成單載台、雙載台及分度轉盤等不同架構的機型，可適用於 HDI 板、FPC 軟板、陶瓷基板、軟硬複合板及 IC 載板，並可滿足客戶對於測試設備高精度及高產能的要求，目前已在 PCB 市場上有超過 100 台以上的銷售實績。
- Models with different structures such as single stage, dual stage and indexing turntable have been developed, which can be applied to HDI, FPC, ceramic substrates and

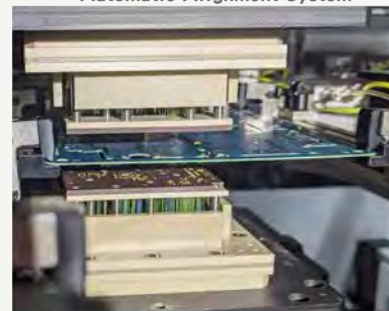
IC carrier boards, and can meet customer requirements for high precision and high productivity. At present, there have been more than 100 sales in the PCB market.



雙載台電測機
Two Shuttles PCB Tester



視覺自動取像對位
Automatic Alignment System



細線路 / 大點數線針治具測試
Wire Probe Fixture



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AI 輔助研拋墊磨耗估測

AI-assisted Estimation Technology for Grinding Pad

簡介 Introductions

在機器人研磨或拋光的加工過程中，往往無法線上量測研拋墊的狀態，藉由開發 AI 輔助研拋墊磨耗估測技術，解決加工品質不一及效率不彰的問題。

During the robot automation grinding or polishing process, it is challenging to measure the states of the grinding pad while under process. Therefore, there is a need to develop reliable and accurate methods to resolve this problem in order to maintain consistent processing quality and efficiency.

特色與創新 Features and Innovations

- 利用麥克風與加速規擷取機器人在研磨拋光工序中，研拋墊磨削之聲音與振動訊號，藉由訊號處理與 AI 演算法對其進行即時狀態解析，以便適時更換，維持加工品質與效率。
- The sound and vibration signals are captured by microphones and accelerators while the grinding pad is under grinding or polishing process. Signal preprocessing methods and AI algorithms are used to monitor the states of the grinding pad while under process in order to replace the grinding pad in time to maintain processing quality and efficiency.

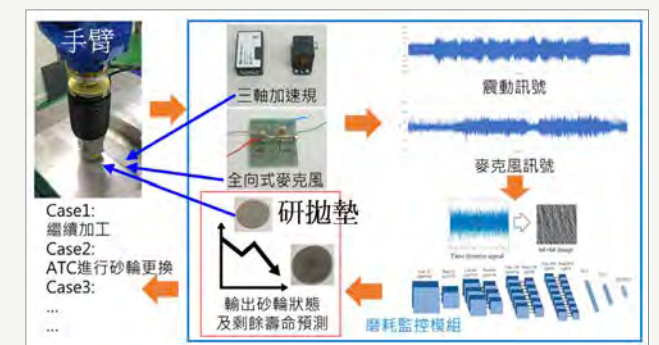
應用與效益 Applications and Benefits

- 應用於機器人研磨拋光產業中，解決現階段無法即時檢知研拋墊表面狀態之產業痛點，亦可應用於加工機刀具狀態監測。

- Applied in the industry of robot grinding and polishing, it solves the current challenge of being unable to instantly detect the surface condition of the grinding and polishing pad. It can also be applied to monitor the tool status in machining equipment.



機器人研拋加工平台
Robot Automation Grinding Platform



AI 輔助研拋墊磨耗估測示意圖
Schematic of AI Assisted Estimation Technology for Grinding Pad



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薄膜製程優化模擬器與設備技術

Thin Film Deposition Simulator and Equipment Technology

簡介 Introductions

目前精密鍍膜國內自主化技術正待建立，亟需解決 ALD 產能慢與 PECVD 薄膜緻密性低之問題，藉由多重物理耦合結合 AI 技術，以降低設計模型的不確定性和搜尋最佳製程參數，協助工程師加速設定製程參數的時間，提升 Time-To-Market 的能力，優化縮短設備模組開發時程。

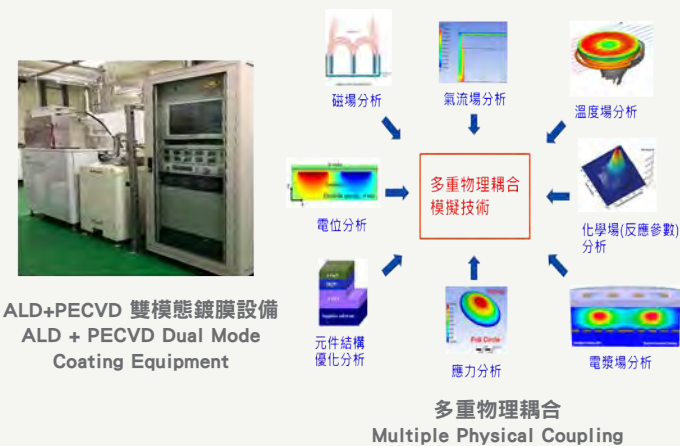
The current domestic precision coating technology is yet to be established for the urgent need to solve the problems of slow production of ALD and PECVD film low density. Combining AI technology with multiple physical couplings reduces model uncertainty and searches for the best process parameters, assists engineers in accelerating the time to set process parameters, improves the ability of time-to-market and optimizes equipment module design.

特色與創新 Features and Innovations

- 整合「多重物理耦合技術」，研發「表面化學反應路徑決策技術」，精簡化學反應式，縮短分析模擬時間及提昇模擬分析之準確度。如開發 ALD+PECVD 複合鍍膜製程設備，鍍超薄複合薄膜結構（膜厚 <10 nm）達到晶體複合結構功能或隔絕層需求。其薄膜厚度不均勻性 $\leq 3\%$ ，奈米堆疊 (nano-laminat) 水氣穿透率 (WVTR) $\leq 5 \times 10^{-6} \text{ g/m}^2 \text{ day}$ 。
- Integrates “multiple physical coupling technology” and develops “surface chemical reaction path decision technology” to simplify chemical reaction equations, shorten the analysis simulation time and improve simulation analysis accuracy. As an example, development of ALD + PECVD composite coating process equipment to coat ultra-thin composite film structures (film thickness <10nm) that achieve crystalline composite structure function or insulation layer requirements. The film thickness non-uniformity is $\leq 3\%$, and nano-laminate vapor transmission rate is $\leq 5 \times 10^{-6} \text{ g/m}^2 \text{ day}$.

應用與效益 Applications and Benefits

- 創新 ALD+PECVD 專利鍍膜設備兼顧產能與薄膜緻密性，符合高規的 3C 鍍膜產品開發。此模擬器技術可應用於光電半導體產業之鍍膜製程上，可提高高亮度 LED、大功率、無線通信等光電元件的品質，亦可用於其他半導體、太陽能產業等薄膜製程和設備（如 PECVD，PVD）上。
- Innovative ALD+PECVD patented coating equipment achieves production capacity and film densification, meeting the high standards for developing 3C coating product. This simulator technology can be applied to coating processes in the optoelectronic semiconductor industry to control the quality of optoelectronic components, such as high-brightness LEDs, high-power devices, and wireless communications. It can also be used in semiconductor and solar energy industries and other thin-film processes and equipment (such as PECVD, PVD).



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晶圓級探針卡技術

Wafer-level Probe Card Technology

簡介 Introductions

開發 3D 陶瓷電路板及微機電探針，取代環氧樹脂探針，探針精微化容易，提高一次測試晶粒數（16 → 30 或 32）。結合微機電探針製程可發展模組化探針組裝技術，可將探針組裝由單根 / 次大幅提升百根 / 次以上，大幅減少組裝人力與成本。

3D ceramic circuit boards and MEMS probes have been developed to replace epoxy resin ring probes. The probes can reach fine pitch and increase testing grains (16 → 30 or 32) in one test. Combined with the MEMS probe process, modular probe assembly technology has been developed, which can massively increase the probe assembly efficiency from a single probe per time to more than one hundred probes at a time, greatly reducing assembly labor and cost.

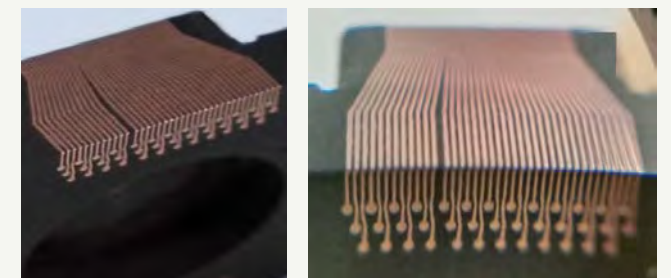
特色與創新 Features and Innovations

- 結合雷射圖案化與高選擇性金屬化技術，於 3D 陶瓷表面製作 3D 金屬線路，具有低成本與高彈性優勢。
- 發展高硬度三元合金金屬化技術（硬度 $\geq 800 \text{ HV}$ ），進行微機電探針製作。開發高精度積體化 3D 探針接合技術與雙面對準接合設備，進行模組化百根探針以上接合。
- Combining laser patterning and high-selective metallization technology, 3D metal circuits can be fabricated on the 3D ceramic surface, which has the advantages of low cost and high customization ability.
- High-hardness ternary alloy metallization technology (hardness $\geq 800 \text{ HV}$) has been developed and applied for the production of MEMS probes.

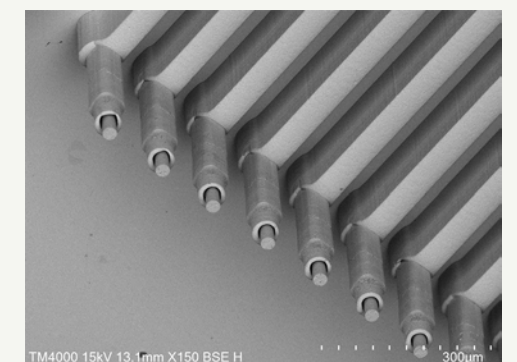
- High-precision integrated 3D probe bonding technology and double-sided alignment bonding equipment have been developed to achieve modular bonding of more than 100 probes.

應用與效益 Applications and Benefits

- 水平式探針卡、微機電探針、3D 陶瓷電路板。
- Horizontal probe card, MEMS probe, 3D ceramic circuit board.



陶瓷 3D 電路板
3D Ceramic Circuit



三階 MEMS 探針
3D MEMS Probe

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高深寬比濕式晶種層與銅填孔技術

Wet Glass Metallization and High Aspect Ratio TGVs Filling Technologies

簡介 Introductions

結合電鍍銅藥液開發、流場分析技術、電化學分析技術與高深寬比銅電鍍治具設計等，能於深寬比 15 之玻璃基板上完成濕式晶種層與銅填孔製程，面銅厚度 0.5 kN/m，填銅之孔隙 <1 μm。

The wet metallization and High Aspect Ratio Through Glass Via (HAR-TGV) filling technologies has been developed by combining various technologies, such as Cu electroplating formulation, flow field analysis, electrochemical analysis and the plating fixtures design. In this work, we demonstrated a defect-free Cu filling for HAR (AR>15) TGVs by an all-solution process. Furthermore, the Cu surface thickness (Cu overburden) can be less than 5μm and adhesion reaches to 0.5 kN/m between glass & Cu interface.

特色與創新 Features and Innovations

- 開發複合金屬氧化物表面處理技術，增加金屬薄膜與玻璃基材附著力，附著力達 0.5 kN /m，且低表面粗糙度 <50 nm。
- 開發雙功能型單劑填孔電鍍配方，取代傳統三劑配方（平整劑 / 加速劑 / 抑制劑），電鍍填銅深寬比可達 AR 15。
- The Adhesion Promoting Layer (APL) has been developed from a novel metal-oxide materials to promote the adhesion between glass & Cu interface. The adhesion reaches to 0.5 kN/m between glass & Cu interface. The APL provides lower surface roughness (< 50 nm) on glass surface.
- A novel dual-functional plating formulation system (leveler only) has been developed to replace traditional

plating formulation (leveler/accelerator/suppressor) for high aspect ratio TGVs filling technology.

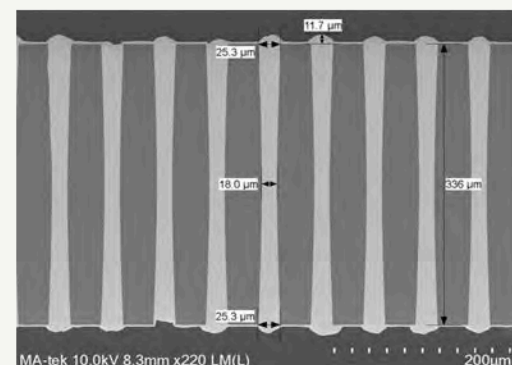
- We demonstrated the void-free filling in HAR-TGV filling (AR>15) in the novel dual-functional plating formulation system.

應用與效益 Applications and Benefits

- 3D IC 封裝、玻璃中介層、IC 載板。
- 3D IC packaging, glass interposer, IC carrier.



高深寬比電鍍銅架橋技術 (AR>15)
High Aspect Ratio TGV Cu Bridge (AR>15)



低面銅，減少研磨時間
Low Surface Cu Overburden Reduces CMP Process Time

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積層式 3D 電路元件製造技術

Multi-layer 3D Circuit Manufacturing Technology

簡介 Introductions

開發雷射誘導金屬化技術 (Laser Induced Metallization, LIM)，利用奈米觸發膠體材料，輔以噴塗技術，可於任何 3D/2D 基材表面佈植高濃度之活性粒子，以完成金屬圖案化結構，故不受基材之限制，而能應用於高分子、陶瓷、玻璃、金屬等基板上，最小線寬可達 30 μm。所開發之觸發膠體可同時為絕緣層與觸發層，故可進行積層式 3D 線路之製作。

The Laser Induced Metallization (LIM) technology has been developed with the use of laser-triggered colloidal Nanomaterials and is supplemented with spraying technology, which can implant high concentrations of active nanoparticles on any 3D/2D curved surface to create metal patterned structures. Therefore, it is not limited by the substrate materials and can be applied to polymer, ceramic, glass, metal and other substrates with a minimum line width of 30 μm. The developed trigger colloid can simultaneously serve as an insulating layer and a triggering layer, making it possible to produce layered 3D circuitry.

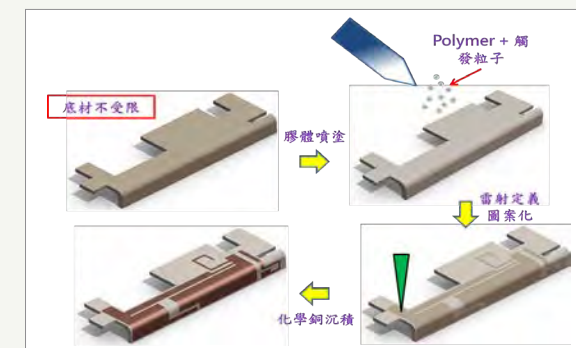
特色與創新 Features and Innovations

- 雷射誘導金屬化技術能製作『積層式 3D 天線』，可有效縮小天線面積，解決未來手機天線可用空間不足的瓶頸。
- 雷射誘導金屬化技術因可製作於多種基材上，能應用於玻璃手機天線、5G MIMO 高頻天線等。
- 能於 3D 陶瓷表面製作 3D 金屬線路，且能於高深寬比 10 之孔內完成金屬層製作。
- LIM technology can produce a "multilayer 3D antenna", which can effectively reduce the antenna area and solve the bottleneck of insufficient space for mobile phone antennas in the future.

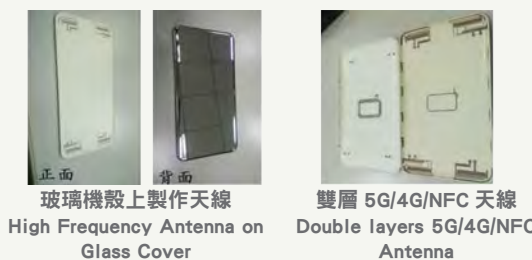
- LIM technology can be fabricated onto various substrate materials, and can be applied to glass mobile phone antennas, 5G MIMO high-frequency antennas, and more.
- Capable of fabricating metal circuit on 3D ceramic surface, and can complete metal layer in high aspect ratio (AR: 10) vias.

應用與效益 Applications and Benefits

- 玻璃手機天線、5G 高頻天線、陶瓷天線、車用電子與感測器。
- Glass mobile phone antennas, 5G high frequency antennas, ceramic antennas, automotive electronics and sensors.



LIM 製程流程圖
Laser Induced Metallization (LIM) Process Flow



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光學晶體奈米精度加工技術

High Precision Optical Crystal Substrate Processing Technology

簡介 Introductions

精密晶體光學元件可應用於雷射源、曝光機等高端系統，在半導體設備之光學零組件市場中，因硬脆材料透鏡具有明顯的異向性及次表層損傷之特性，導致拋光製程不易掌控、製程成本高及量產性低。本技術建立可在大氣環境下運作之微能量束加工平台，以滿足目前精密零組件加工之需求。

Precision crystal optical elements can be applied to high-end systems such as laser sources and exposure equipment. In the optical component market of semiconductor equipment, due to the obvious anisotropy and subsurface damage of hard and brittle material lenses, the polishing process is difficult to control, it is costly and has poor scalability. This technology establishes a micro-energy beam processing platform that can operate in an atmospheric environment to meet the current needs of precision component processing.

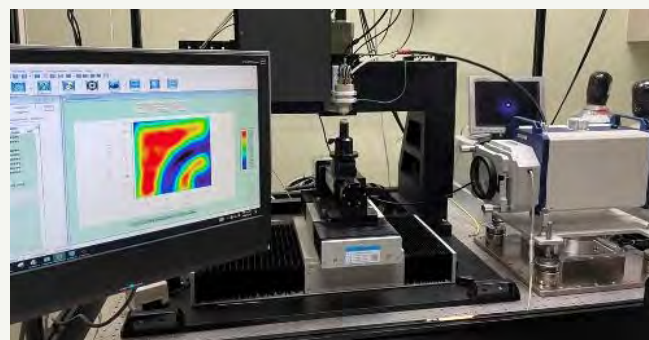
特色與創新 Features and Innovations

- 以脈衝式 RF 驅動實現低工作溫度及高化學反應基密度的微型區域精度修整。
- 可在大氣環境下運作，以 20 nm/s 移除率進行表面加工，可達到形狀精度 $\leq \lambda/10$ 。
- 自主建立能量束刀具庫及蝕刻解析函數，可適應性及最佳化調整處理精度達到 PV-0.05 λ (30 nm)。
- Micro-area precision finishing with low operating temperature and high chemical reactive base density with pulsed RF drive.
- Can operate in the atmospheric environment, achieving PV $\leq \lambda/10$ when performing at a surface processing removal rate of 20 nm/s.

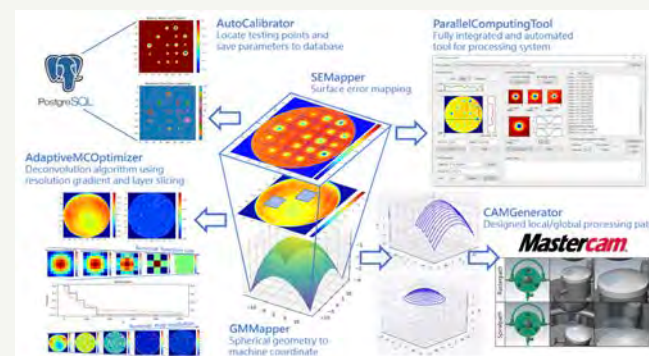
- The energy beam tool library and the etching analytical function are established with a processing accuracy which is adapted and optimized to reach PV $\sim 0.05 \lambda$ (30 nm).

應用與效益 Applications and Benefits

- 光學透鏡、玻璃基板、微區改質加工。
- Optical lenses, glass substrates, micro area modification processing.



微能量束輔助拋光系統
Micro Energy Beam Assisted Polishing System



軟體開發 / 演算法開發
Software Development/Algorithm Development



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硬脆材料複合加工技術

Hybrid-processing Technology of Hard and Brittle Materials

簡介 Introductions

碳化矽可應用在次世代功率元件中，為下世代功率半導體元件的關鍵材料。因高硬度及高耐化性等難加工特性，導致生產率低，阻礙功率元件發展潮流。本技術建立複合式研拋製程平台，透過導入超音波輔助加工技術及大氣電漿輔助改質技術，可大幅提升碳化矽晶圓產能效率及有效降低製造成本。

Silicon carbide can be used in next-generation power components and is a key material for next-generation power semiconductor parts. Due to difficult processing characteristics such as high hardness and high chemical resistance, the productivity is low and the development trend of power components is hindered. This technology establishes a hybrid-processing platform which includes ultrasonic assisted processing technology and atmospheric plasma assisted modification technology. It can greatly improve the production efficiency of silicon carbide wafers and effectively reduces manufacturing costs.

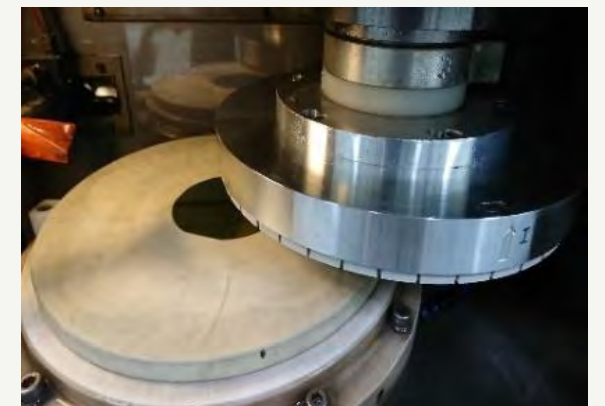
特色與創新 Features and Innovations

- 建立超音波輔助輪磨技術，可搭配高號數砂輪，達到高的材料移除率 $> 10 \mu\text{m}/\text{min}$ ，表面粗糙度 $< 10 \text{ nm}$ 。
- 透過大氣電漿改質拋光技術，電漿作用的面積 $> 200 \text{ mm}$ ，拋光移除率 $> 1.5 \mu\text{m}/\text{hr}$ ，表面粗糙度 $< 0.5 \text{ nm}$ 。
- The ultrasonic-assisted grinding technology has been developed, which, combined with high-number grinding wheels achieve high material removal rate $> 10 \mu\text{m}/\text{min}$ and finished surface roughness $< 10 \text{ nm}$.
- Through atmospheric plasma modification polishing technology, the plasma action area is $> 200 \text{ mm}$, the

polishing removal rate is $> 1.5 \mu\text{m}/\text{hr}$, and the surface roughness is $< 0.5 \text{ nm}$.

應用與效益 Applications and Benefits

- 碳化矽晶圓、玻璃晶圓、鑽石基板。
- Silicon carbide wafers, glass wafers, diamond substrates.



超音波輔助輪磨模組
Ultrasonic Assisted Grinding module



大氣電漿改質拋光組
Atmospheric Plasma Modified Polishing Module



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高效率流體機械設計開發技術

High Efficiency Fluid Machinery Design Technology

簡介 Introductions

由馬達驅動的流體機械（泵浦、風機、空壓機等）在我國工業應用非常廣泛並長時間運轉，用電約消耗台灣電力約 250 億度。本技術改善傳統開發產品時效率低落，搭配測試平台驗證產品品質，協助產業越過國際能效法規標準。

Motor-driven fluid machinery, such as pumps, fans, and compressors, are widely used in industrial applications in Taiwan and operate for long periods of time, consuming approximately 25 billion kilowatt-hours of electricity. This technology improves the low efficiency of traditional product development and verifies product quality through testing platforms, helping industries overcome international energy efficiency Regulations Standards.

特色與創新 Features and Innovations

- 高效率設計、高精度量測、流機系統高效率運轉。
- 採用工作流體作為軸承潤滑，無須冷卻潤滑系統，使冷媒壓縮機組更為簡潔。
- 高能效流體元件設計技術，高於國際基準，可操作區間寬廣 $\pm 10\%$ 。
- 正、負壓工況皆零洩漏之功效，解決潤滑系統洩漏之問題。
- High-efficiency design, high-precision measurement, and high-efficiency operation of fluid systems.
- Utilizes working fluid as bearing lubrication to eliminate the need for a cooling system, making the refrigeration compressor unit more streamlined.
- High efficiency impeller and volute design technology with an Isentropic efficiency which exceeds global standard and has an operating range of $\pm 10\%$.

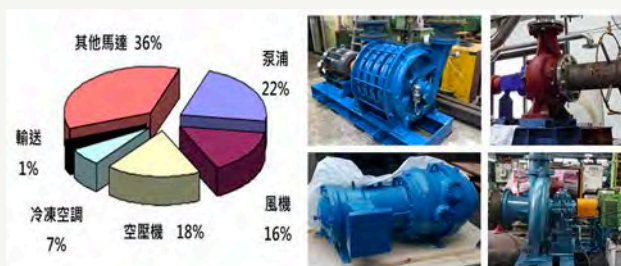
- Positive/negative working condition achieves zero leakage.

應用與效益 Applications and Benefits

- 清水泵、鼓風機、離心冷媒壓縮機、螺桿空壓機與送風機等產業之效率改善技術服務。
- Enhances efficiency of industries such as water pumps, blowers, centrifugal/screw refrigeration/air compressors and fans.



高效率流體元件設計與開發
Design & Development of High Efficiency Fluid Machinery Units



馬達動力設備耗電占比
Motor Power Equipment Consumption

客製化高效率流機設備
Customized High Efficiency Fluid Machinery

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高速飛輪儲能系統

High-speed Flywheel Energy Storage System

簡介 Introductions

高速飛輪可以提供更具環保性的儲能服務，為由 99% 以上的可回收物質所組成的機械式儲能系統，其特點為：使用壽命長（25-30 年）、無充放電深度的限制，相當適合於功率型的儲能應用，所具有的功率密度為化學電池的數倍。

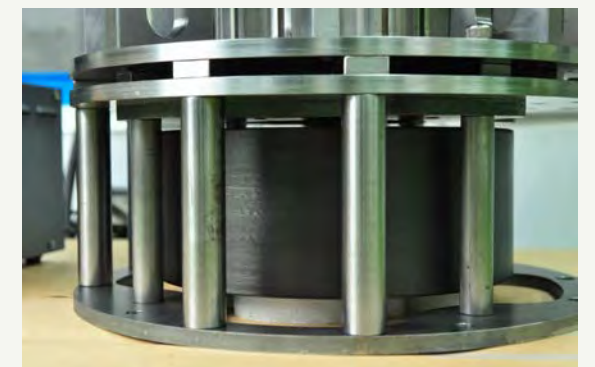
High-speed flywheels provide a more eco-friendly energy-storage service, since more than 99% of its composition is recyclable. Flywheels feature a long life cycle (approx. 25-30 years), no limit on charging/discharging depth, and high power density (several times that of chemical batteries), hence are very suitable for power-oriented energy-storage applications.

特色與創新 Features and Innovations

- 高功率以符合百瓩等級應用。
- 高速儲能，達 50 Wh/kg 以上能量密度。
- 數小時長儲能時間。
- 能量轉換效率 95% 以上。
- 飛輪並聯技術拓展系統功率及儲能量。
- High-power design fit for applications requiring power at hundreds-of-kW level.
- Use of high speed rotor achieves energy density over 50Wh/kg.
- Energy storage which lasts for hours.
- Energy conversion efficiency over 95%.
- Parallel-connected flywheel for higher system power and energy storage capacity.

應用與效益 Applications and Benefits

- 具開發高速飛輪雛型能力及設施，可協助客戶進行系統應用開發，並進行實際場域建置或硬體在環模擬驗證環境。
- Equipped with the capability and the facilities to prototype high-speed flywheels, assisting customers to carry out system-wise development either through field testing or hardware-in-the-loop testing.



飛輪系統雛型
Flywheel System Prototype

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石墨烯熱管電池熱管理系統

Graphene Heat Pipe for Battery Thermal Management System

簡介 Introductions

電池操作合適溫度為 20~45°C，過高或過低，會大幅影響電池的充放電性能和壽命。而石墨烯熱管比傳統熱管的最大熱傳量增加 50%，熱傳導係數增加 80%，在高熱傳的散熱能力，維持電池性能及壽命。

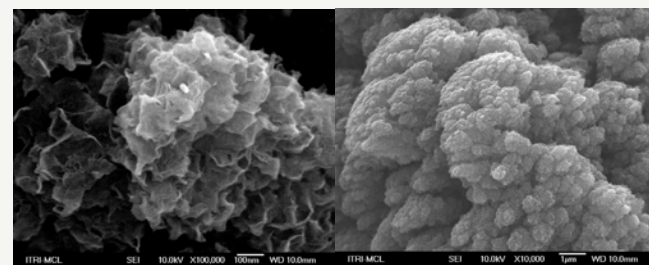
The suitable temperature for battery operation is 20~45°C. If it is too high or too low, it will greatly affect the charging and discharging performance and life of the battery. The graphene heat pipe is 150% better than the traditional heat pipe in terms of maximum heat transfer and 80% better in thermal conductivity. It maintains battery performance and longevity in terms of high heat transfer heat dissipation capability.

特色與創新 Features and Innovations

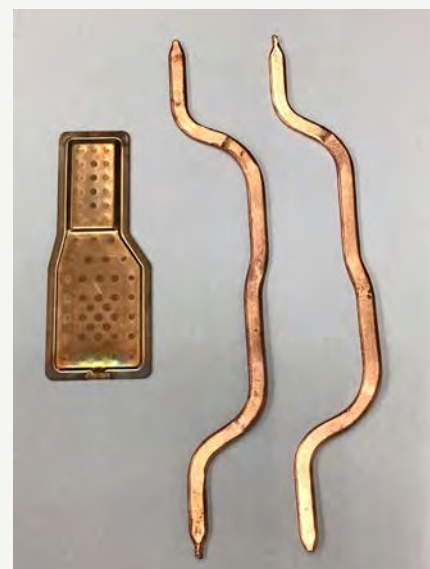
- 石墨烯奈米流體維持懸浮永不沉澱。
- 熱傳導係數 > 15,000W/m-K。
- 石墨烯布局於蒸發區產生核址。
- 電池壽命提升 1.5 倍。
- Graphene nano-liquid maintains suspension and never settles.
- Thermal conductivity > 15,000 W/m-K.
- Graphene is laid out in the evaporation area to generate nucleation sites.
- 1.5 times longer battery life.

應用與效益 Applications and Benefits

- 電動車電池散熱，因電動車電池能量日增、以及電池充放電性能要求越來越高，結合相關車廠進行合作開發。
- Electric vehicle battery heat dissipation, due to the increasing energy of electric vehicle batteries and the higher and higher requirements for battery charge and discharge performance, cooperate with relevant car manufacturers to develop.



石墨烯奈米結構
Graphene nanostructure



石墨烯粉末與熱管
Graphene powder and heat pipes



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精密彈性件生產協作設計開發技術

Precision Elastic Product Collaboration Design and Development Technology

簡介 Introductions

橡塑膠業、紡織業轉型面臨人力短缺、落差，造成技術銜接上斷層，影響產品品質與後續發展。其生產製造整合智機已是未來服務關鍵，而國內技術能量仍嚴重不足，創新產品生產實測數據少且無經驗累積，使製程參數調控不易。

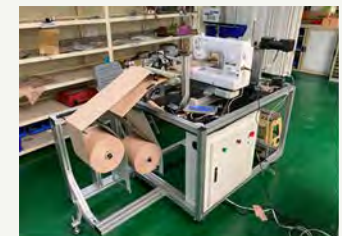
The transformation of the rubber and plastic industry and textile industry has led to a shortage of manpower, resulting in a gap in technology convergence. This affects the quality of products and the subsequent development of the industry. Integrating smart machines into production and manufacturing is already a key service for the future, but domestic technological capabilities are still severely inadequate. The production of innovative products lacks practical data and experience accumulation, making it difficult to adjust process parameters.

特色與創新 Features and Innovations

- 非剛體工件定位與移載，自適應定位治夾具設計，吸收定位誤差。
- 黏性體分離與貼合，依異質物件特性，分析設計其物件運動方式。
- 智慧影像分析：影像分析姿態，自動給予對位驅控決策。
- Positioning and transfer of non-rigid workpieces, adaptive positioning and clamping fixture design, absorption of positioning errors.
- Separation and adhesion of viscoelastic material, analysis and design of object's movement mode based on characteristics of heterogeneous objects.
- Intelligent image analysis: image analysis of posture to provide automatic decision of alignment drive.

應用與效益 Applications and Benefits

- 導入應用於橡塑膠業、食品包裝業、紡織業等傳統且人工密集之產業自動化提升，輔導柔彈形塑之移載與定位分析設計。
- Provides automation upgrade to traditional labor-intensive industries, such as rubber and plastic, food packaging and textile industries. It can assist in the design of flexible molding transfer and positioning analysis.



精密循跡協作設備
Precision Tracing
Collaboration Equipment



非剛體移載 / 貼合 / 定位
全自動整合設備
Non-rigid Body Transfer,
Adhesion/Positioning
Fully Automatic Integrated
Equipment



精密對位驅控模組
Precision Alignment Drive
Module



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高電壓超級電容器技術

High Voltage Supercapacitor Technology

簡介 Introductions

超級電容器受限於電壓不足，於有機電解液系統電壓可達 2.5-2.8 伏特。透過機械所自行開發的機台製作，以直接垂直成長石墨烯奈米壁電極（無摻雜與氮摻雜）製作無須接著劑之超級電容系統，正極與負極分別提供廣泛的電位窗至 4.0 伏特。相對於目前的活性碳電極可以達到最佳的電壓耐受性。

Electrical Double-Layer Capacitors (EDLCs) are limited by relatively low cell voltage, with a maximum voltage of 2.5 - 2.8 V in organic liquid electrolytes. MMSL has developed a machine where graphene nanowall electrodes (GNW/N-doped GNW) are directly grown vertically to create binder-free supercapacitors. The positive and negative electrodes provide a wide potential window up to 4.0 V and have better voltage tolerance compared to current activated carbon electrodes.

特色與創新 Features and Innovations

- 使用電漿合成法直接成長及摻雜奈米石墨烯壁。
- 創新離子嵌入法提升奈米石墨烯壁之電容量。
- 最大工作電壓超過 4.0 伏特可與鋰電池直接並聯使用。
- Binder-free, directly grown and doping graphene nanowall via plasma synthesis method.
- Innovative intercalation method enhances capacitance of graphene nanowall.
- Maximum operating voltage over 4 V, which can be used in parallel with LIB batteries.

應用與效益 Applications and Benefits

- 4.0 伏特奈米石墨烯壁超級電容器，壽命長且安全性佳，可廣泛應用於無人搬運車、導軌運輸車電源、醫療電源、軌道交通等儲能系統。
- Long life-span and increased safety 4 V GNW EDLC can be widely used in energy storage systems for AGV/RGV, medical, automotive electronics and others.



工作電壓為 4V 之超級電容器
Supercapacitor with Max. Operating Voltage of 4 V



超級電容器應用於蔬果運輸車
Supercapacitor Application in Fruit Transport Truck



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半導體微波退火技術

Microwave Annealing for Semiconductor

簡介 Introductions

傳統半導體摻雜活化退火需 900°C 以上，隨著線寬縮減，容易造成雜質擴散。因此，開發微波退火以克服日益緊縮的半導體熱預算。工研院領先開發出多重模態微波退火，並符合半導體之低溫退火規範。

The traditional semiconductor doping activation annealing requires more than 900°C, and as the line width decreases, it is easy to cause impurity diffusion. Therefore, microwave annealing was developed to overcome increasingly tight semiconductor thermal budgets. ITRI has pioneered the development of multimodal microwave annealing, which meets the low temperature annealing specifications for semiconductors.

特色與創新 Features and Innovations

- 縱橫奇偶多重模態彌補低頻模態數之不足提升均勻性。
- 對多微波源，開創微波之耦合模態，大幅提升微波均勻性。
- Enhances uniformity of insufficient low frequency modes which is compensated by the vertical, horizontal and odd-even multimode.
- Coupling modes is created for multiple microwave sources which can significantly enhance microwave uniformity.

應用與效益 Applications and Benefits

- 已與國內半導體大廠合作開發下世代半導體微波退火製程及設備，同時擴大應用至化工產業、食品加工業、及資源回收業之節能減碳應用。
- Collaboration with domestic semiconductor manufacturers to develop the next-generation semiconductor microwave annealing process and equipment, while expanding their application to energy-saving and carbon-reducing applications in the chemical industry, food processing industry, and resource recycling industry.



12 晶圓微波退火
Microwave Annealing Tool for 12" Wafer



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高品質檢測與驗證技術服務

High Quality Measurement and Verification Technology Service

簡介 Introductions

機械所『機械特性檢測與校正實驗室（認證編號 TAF 0039）』依據 ISO/IEC 17025 實驗室品質管理系統，提供校正與檢測服務能量，服務過的產業包含國防科技、半導體、航太科技、電動車、工具機、精密模具等，提供公正、專業及有效可信的服務。

The Mechanical Characteristics Testing and Calibration Laboratory (Certification Number TAF 0039) of the Institute of Mechanical Engineering provides calibration and testing services in accordance with the ISO/IEC 17025 laboratory quality management system. Industries served by the laboratory include defense, semiconductor, aerospace, electric vehicles, machine tools and precision molds. Impartial, professional, and reliable services are provided.

特色與創新 Features and Innovations

- 標準、量具、治具之校正量測。
- 齒輪精密檢測與逆向工程。
- 機械性能測試。
- 實驗室認證體系 ISO 17025:2017 驗證輔導。
- Standards, tools and instruments for calibration measurement.
- Gear precision inspection and reverse engineering.
- Mechanical performance test.
- ISO 17025:2017 verification guidance services.

應用與效益 Applications and Benefits

- 尺寸標準、幾何形貌、精密機械檢測服務。
- 移動平台空間、水平、定位精度檢測服務。

- 齒輪箱、傳動軸等各式精密零件檢測服務。
- 拉伸、壓縮、彎曲、剪力、硬度檢測服務。
- Measurement services including dimension standards, geometric shape and precision machinery.
- Inspection services including mobile platform space, level, and positioning .
- Inspection services including gearbox, shaft and other precision parts.
- Testing services including tensile strength, compression, bending, shear and hardness.



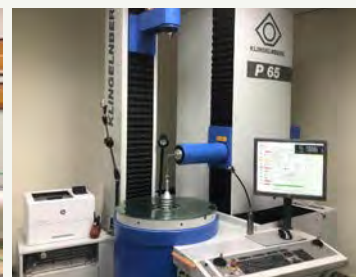
高性能三次元量測儀
C.M.M ZEISS-UPMC 850



非接觸式三次元量測儀
OGP ZIP 250



非接觸式三次元量測儀
Werth Video Check IP



齒輪量測儀
Klingelnberg P65



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