平面顯示技術概論

平面顯示器檢測技術與設備

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內容大綱

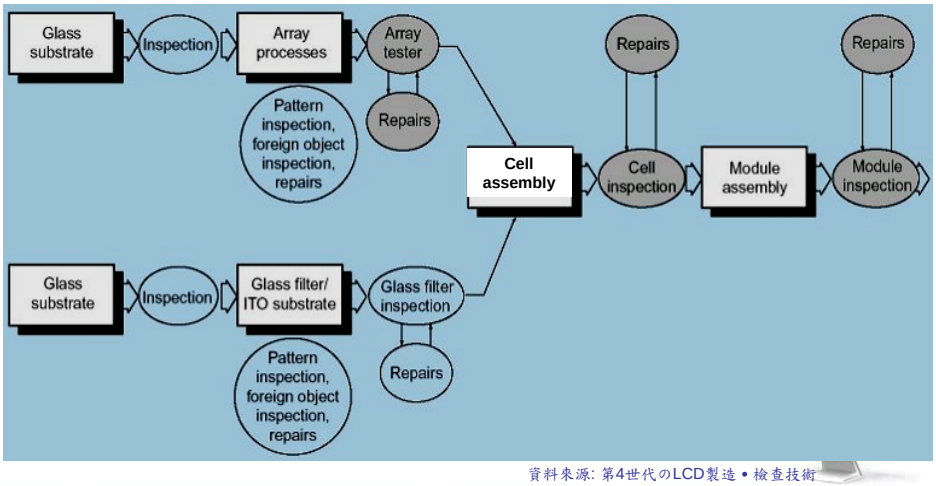
- LCD製程與設備簡介
- LCD檢測設備
- 彩色濾光片檢查機
- 國內檢測設備的發展與機會
- 自動化光學檢測發展趨勢

參考資料

- 徐家彬，"LCD檢測設備"，工研院機械所。
- 宋身修，"TFT-LCD製程設備"，均豪精密公司。
- 范光照，"AOI發展趨勢"，台灣大學機械系。

LCD製造工程

陣列工程



資料來源: 第4世代のLCD製造・検査技術

LCD設備分類

TFT-LCD Manufacturing Process & Equipment

A. ARRAY PROCESS CYCLE & EQUIPMENTS

B. C/F PROCESS EQUIPMENTS

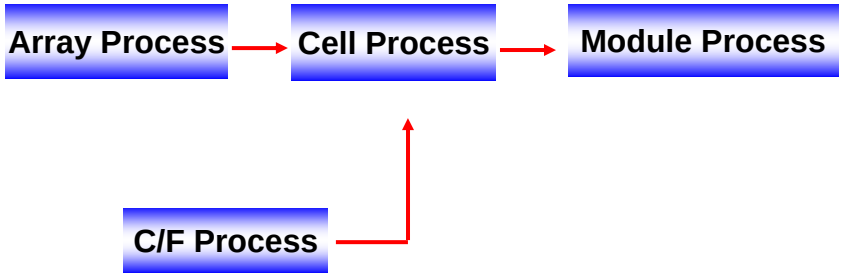
C. CELL PROCESS & EQUIPMENTS

D. MODULE PROCESS & EQUIPMENTS

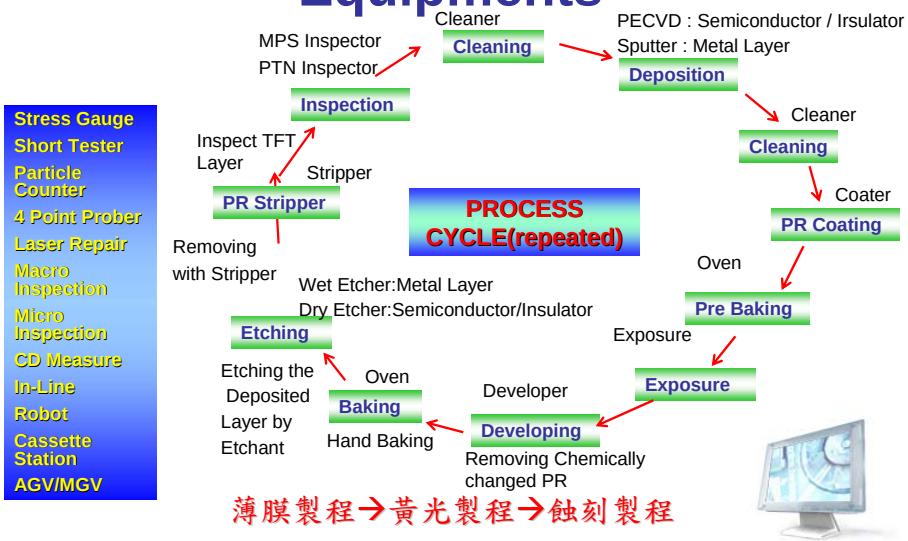
. TCP PROCESS

. COG PROCESS

TFT-LCD Process

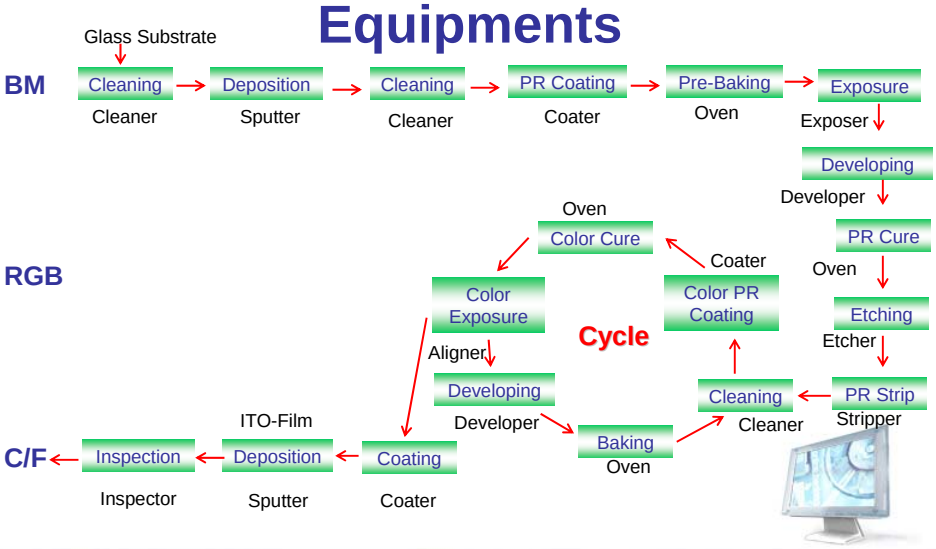


Array Manufacturing Process & Equipments

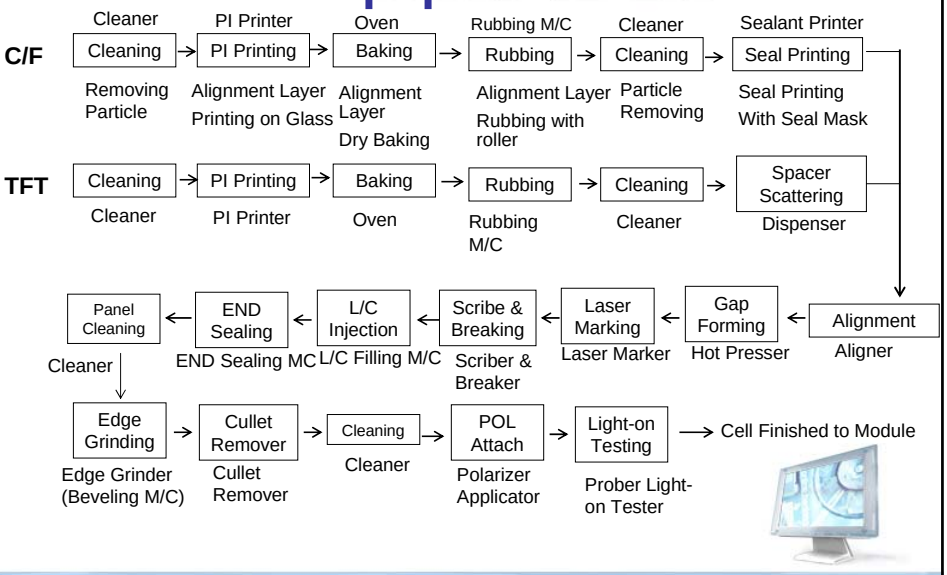


薄膜製程→黃光製程→蝕刻製程

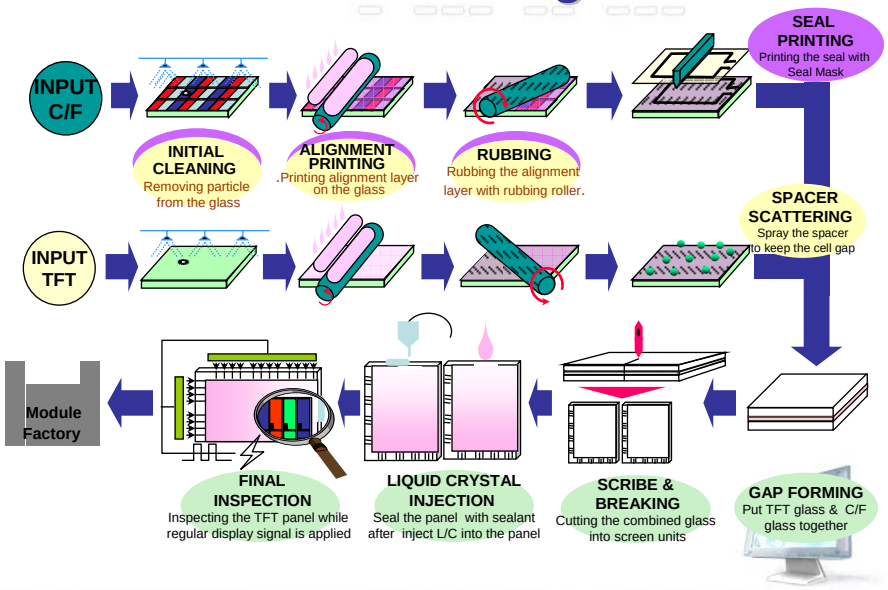
C/F Manufacturing Process & Equipments



Cell Manufacturing Process Equipments



Cell Manufacturing Process



Cell Process

In-lined processes from TFT glass & C/F glass input process to gap forming process to manufacture desired panel.

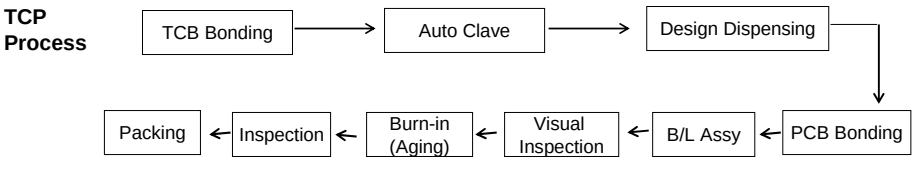
C/F : Color Filter
PI : Polyimide

C/F TFT	Input TFT glass & C/F Glass into an initial cleaner to remove particle after incoming inspection.	Cleaning Machine
Pi PRINTING	Printing alignment layer (Polyimide) with roller printer	Pi Printer
RUBBING	Applying force to the Polyimide layer to make Liquid Crystal alignment layer	Rubbing Machine
SEAL PRINTING SPACER SPRAY	Printing sealant to attach C/F glass & TFT glass Then spray spacer to keep the gap between C/F glass & TFT glass	Sealant Printer Dispenser
GAP FORMING	Put C/F glass & TFT glass together with exact alignment	Aligner

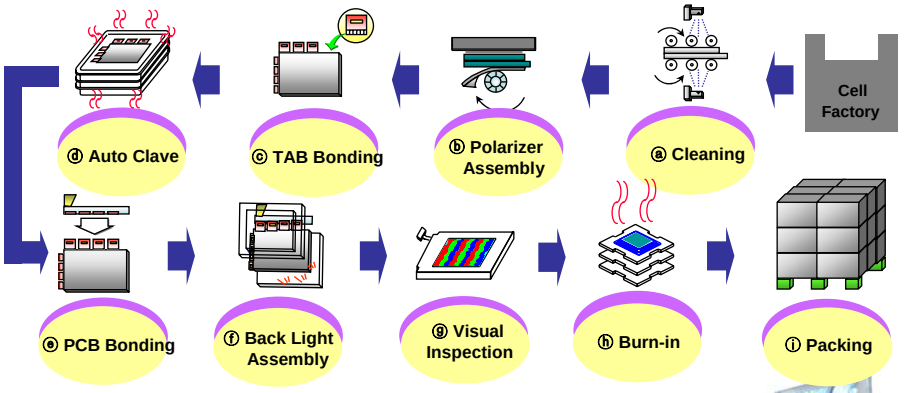
Cell Equipment

- Polyimide Printer
- Rubbing Equipment
- Spacer Scattering Equipment
- Gap Forming & Hot Pressing
- Scribe & Break
- L/C Injection and End Sealing Machine
- Panel Edge Checking System
- Edge Grinder (Beveling M/C)
- LCD Testing
- Laser Short-ring Cutting System
- Block Controller

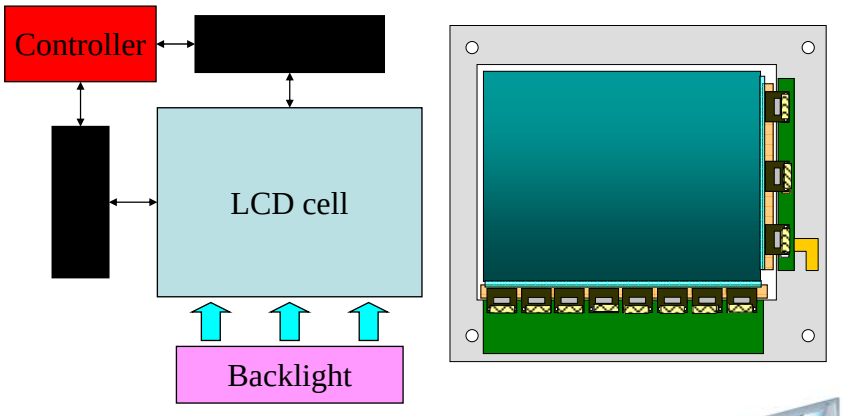
Module Manufacturing Process & Equipments



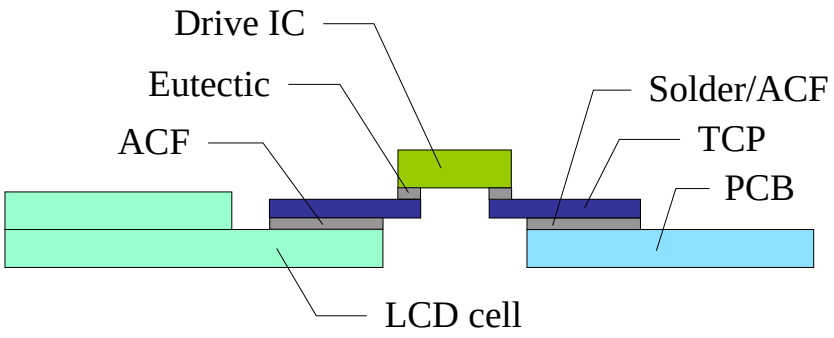
MODULE MANUFACTURING PROCESS



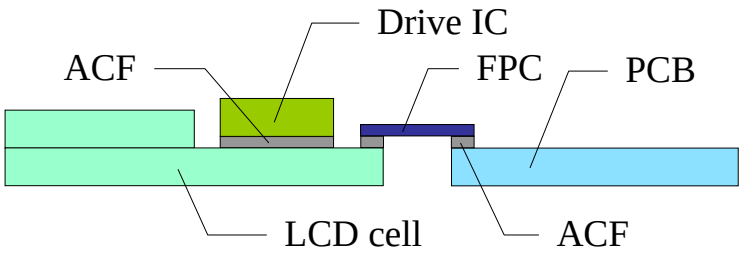
Construction of LCM



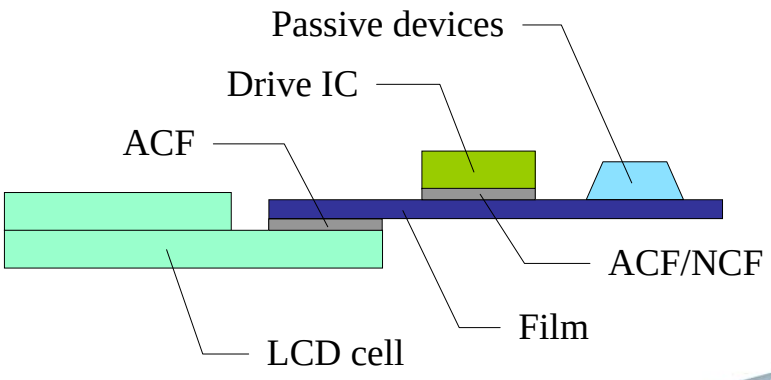
Tape Automated Bonding(TCP)



Chip on Glass(COG)



Chip on Film(COF)

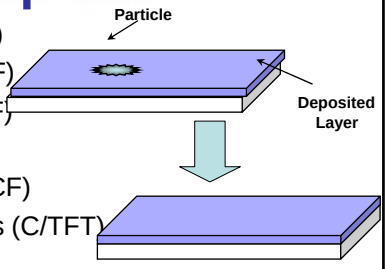


Array Equipments

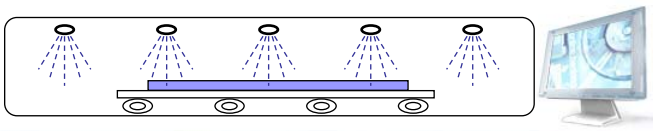
- Cleaning Equipment
- Deposition Equipment
- Photoresistor Coater
- Oven
- Exposurer
- Developer
- Etching System
- Photoresistor Stripper
- Inspection Zone
- Glass Substrate Handling
- Cassette

Cleaning Equipment

Application : Before Deposition Process (A, CF)
Before PR Coating Process (A,CF)
After PR Stripping Process (A, CF)
Before PI Printing Process (C)
Before Seal Printing Process (C/CF)
Before Spacer Scattering Process (C/TFT)
After End Sealing Process (C)
After Edge Grinding Process (C)



Purpose: Raise the Yield by removing Particles, Foreign Material & Pollution by Operator, Environment, Equipment and works etc., and to avoid the film Delamination, Pin Hole, Particle Bump etc.



Working Method

- Physical Method : US Wave(10KHz to MHz), Brush, Cavitation, Air Knife
- Chemical Method : Organic Solution, Neutral Solution etc.
- Dry Method : UV Light, EUV Light, Ozone, Plasma, AI-Plasma, US Wave Air Knife
- Combined Method : From above Methods

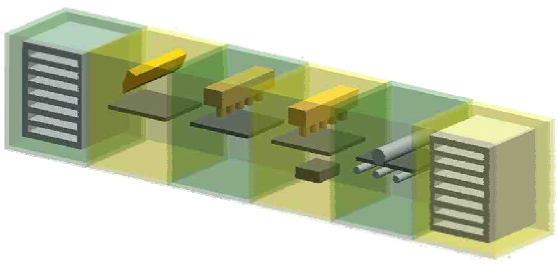
Dring Method after Wet Cleaning

- Air Knife Dring
- Spin Dring : High Performance, Longer Processing Time, Safety Problem
- Mild Temperature Watering Dring
- IPA Vapor dring

Equipment Type
Batch Type (分批式)
Single Type (枚葉式)
Brushing Cleaning : for big particle,higher cleaning effect,contact problem,cleaning uniformity problem
Cavitation Cleaning : for medium size particle,applying the bubble breaking in solution, controllability
US Wave Cleaning : to remove micro particle / sub-micron particle especially for pattern surface,
difficulty to monitor
UV Light Cleaning : to remove the organic contamination O3 happen organic resolve safety problem
US-Wave Air Knife : for medium size particle ESD problem

清洗工程(Cleaning)

物理式：刷子、超音波、高壓水
化學式：中性洗劑、有機溶劑
乾式：UV紫外線



Deposition Equipments

A. Sputter : Deposit a Metal Layer onto Glass Substrate

Application : For C/F

ITO Film & Black Matrix

For TFT

Gate Pattern Electrode (Al,Cr,Mo,ITO)

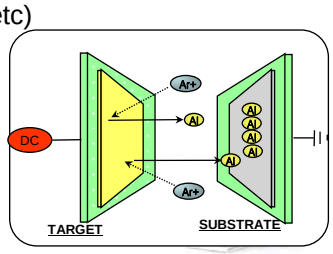
Source / Drain Pattern Electrode (Al,Cr,Mo,TI)

ITO Pixel Electrode

Working Principle : Strip off metal elements from Metal Target by activated argon gas.

Raw Material : Metal Targets (Al,Cr,Mo,ITO…etc)

Argon, O2



Equipment Type :

- In-Line Type : High Throughput
- 枚葉式 : High Yield, Small Footprint

Requirements of Equipment

- High Throughput
- High Quality Performance
- No Thin Film Delamination
- No Particle Pollution
- ESD

Quality Performance Issues

- Thin Film Thickness
- Thin Film Thickness Uniformity
- Film Material Uniformity
- Adhesive Between Film and Film, Film and Substrate
- Low Stress between Film and Film, Film and Substrate

Target Material

- Low Electric Resistance
- Corrosion Resistance
- Heat Resistance

Deposition Equipments

B. PECVD (Plasma Enhanced Chemical Vapour Deposition)

Purpose : Deposit the Insulator, Semi-Conductor Layer onto Glass Substrate

Application : Gate Insulation Film (SiNx, SiOx)

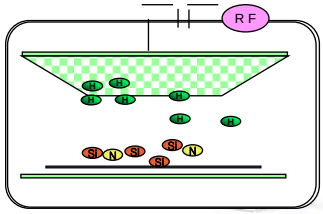
Amorphous-Silicon Layer (a-Si)

Source / Drain Contact Layer (N^+a-Si, N^+ μ C-Si)

Protection Film (SiNx)

Working Principle : Decompose the reactant gas into plasma state with radio frequency(RF), then deposit the Layer onto glass by chemical reaction in a vacuum chamber

Raw Material : NH3, SiH4, H2, N2, PH3



Equipment Type :

- In-Line Type :
- Cluster Tool 枚葉式:

Requirements of Equipments

- Same as sputter

Quality Performance Issues

- Same as sputter

Photolithographic Area

Photolithographic process to form a desired pattern on the glass.

Photoresistor Coating → Expose → Develop

PHOTO

PRINCIPLE

▶Photoresistor Coating

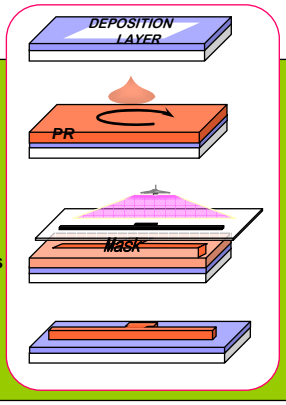
Coat PR on the glass with Spin Coating method.

▶Expose

Expose the mask pattern on the glass to change the structure of the PR.

▶Develop

Remove the unnecessary PR with developer.



RAW MATERIAL

Photo Resist

Mask

Developer

Photoresistor Coater

Purpose : Coating Photoresistor onto the Glass Substrate, usually by Spin Coating Method

Application : For C/F (Black Matrix, RGB & ITO Process)
For TFT (Gate, Source/Drain, ITO Pixel)

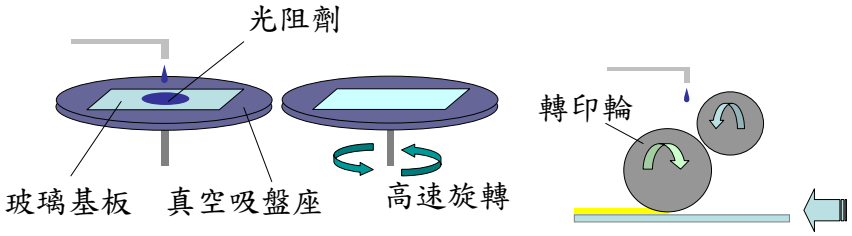
Requirements of Equipment

- High Throughput
- PR Film Thickness
- PR Film Thickness Uniformity
- Reduce the PR Consume
- Avoid PR Pollution/Contamination

Reduce the PR Consume

- Slit & Spin Method

光阻塗佈工程(Resist Coating)



Spin 式塗佈　　滾筒式塗佈

製程要件：膜厚均勻；光阻使用率；產能

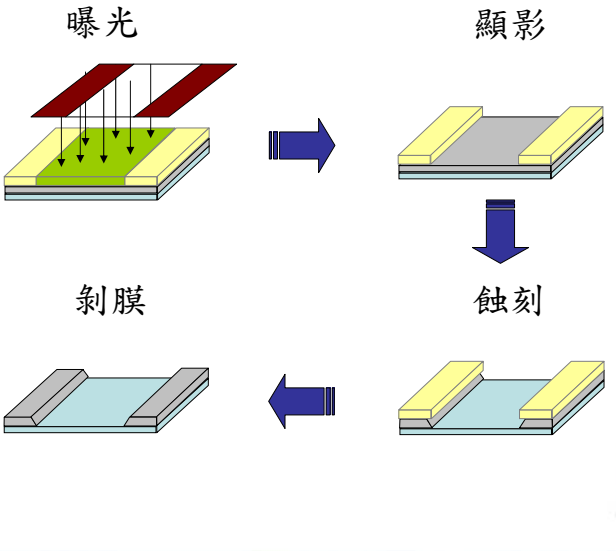
Purpose : Dring or Pre-Baking Oven or Baking Glass Substrate or Panel
Application : Dring after Cleaning Process
Pre-Baking after PR-Coating
Baking after Developing
Baking & Pre-Baking after PI-Printing
Requirements of Equipment

- High Throughput
- ESD
- Temperature Distribution Uniformity in Oven
- Temperature Profile
- No Particle & Contamination
- Avoid Crack Glass Substrate

Equipment Type:

- Batch Type : Higher Throughput, Smaller Footprint, Worse Temperature Distribution, More Particle Contamination
- 枚葉式 : Better Temperature Distribution, Less Particle Contamination, but Bigger Footprint

曝光、 顯影、 蝕刻、 剝膜



Exposure

Purpose : Expose the mask pattern on the glass substrate to change the structure of PR

Application : For C/F

For TFT Array

Working Principle for TFT-Array

- By Stepping Method or Mirror Projection Method

Stepping Exposure(by moving glass substrate)

- Higher Yield(No contact between Mask & Glass Substrate)
- Higher Precision(Resolution 3 μ m, repeatibility 0.5 μ m)
- Smaller Mask & Cost Down

Mirror Projection Exposure(Projection moving with same speed as glass substrate)

- Higher Throughput
- Bigger Mask & Seamless
- Higher Yield (No contact between Mask & Glass Substrate)
- Bigger Mask but Higher MasK Cost
- Higher Precision (Resolution 3 μ m, Repeatibility 1 μ m)

Working Principle for C/F

by Proximity Exposure Method

- Higher throughput
- Equipment cost not high
- One stop exposure
- Easily defected in Mask & Glass Substrate
- Worse precision (Resolution : 8 μm, Repeatability : ± 1 μm)

Horizontal Type:

- Contact between Mask & substrate for bigger size, cause by self-weight bending defection

Vertical Type :

- Reduce the particle contamination
- Reduce the Mask/Substrate contact

Developer

Purpose : to remove the unnecessary PR after Exposure

Application : For all Post-Exposure Process

Working Method:

- Dipping Method
- Shower Method
- Puddle Method

Main Engineering Issues:

- Reduce the required quantity of developing solution
- Avoid the contamination from developing solution
- Assure the developing uniformity
- Precision control the temperature and concentration of developing solution
- Raise the throughput

Etching System

Purpose : To remove the unnecessary part of the metal Layer to obtain the desired pattern

Application : Gate Electrode Film
Source/Drain Electrode Film
ITO & Insulator Film

Type of Etched : Wet & Dry

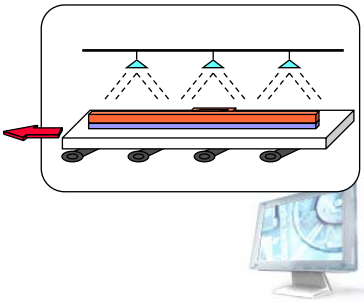
Wet Etch

Working Principle

- Removing unnecessary metal layer by chemical reaction between metal & etchant

Etchant

- For Al Layer
- Phosphoric acid + Acetic acid + Nitric acid
- For Cr Layer
- C.A.N.+Nitric acid
- For ITO Layer
- Hydrochloric acid + Nitric acid
- Target Layer
- Al, Mo, Cr, ITO Layer



Equipment Type

- Dipping Type
- Shower Type

Main Engineering Issues:

- Etching Speed : Faster
- Side Etching : Bigger
- Ascent Forming : Difficulty
- Aspect Ration : Bigger
- Uniformity : Medium
- Throughput : Big
- Etchant Consume : Big
- Footprint : Big
- Price : Lower

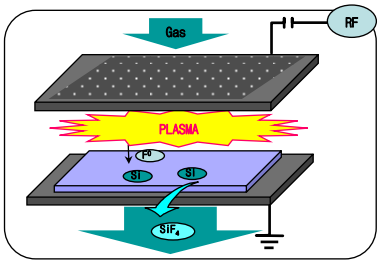
Dry Etch

Working Principle

- Decompose the deposited layer into plasma state with radio frequency, then remove the deposit layer from the glass by chemical reaction in a vacuum chamber

Raw Material

- SF6, O2, He, Hcl, Cl2 Gas



Target Layer

- Semiconductor Layer : a-Si, n+a-Si
- Insulation Layer : SiNx

Equipment Type

- Batch Type
- Single Type

Coupling Method

- Anode Coupling (by plasma etching)
- Cathode Coupling (by plasma etching or microwave plasma etching)

Main Engineering Issues

- Etching Speed : Slow
- Side Etching : Small
- Ascent Forming : Easy
- Aspect Ratio : Small
- Uniformity : Better
- Throughput : Small
- Etchant Consume : Less
- Footprint : Small
- Price : Higher

Photoresistor Stripper

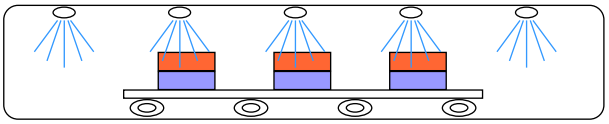
Purpose :To remove the unnecessary hardened photoresisitor after the etching process

Working Principle

- Remove the hardened PR by chemical reaction between PR & Stripper

Type of PR Stripper

- Wet & Dry



Wet Stripper

Equipment Type

- Batch Type
- 枚葉式 Dipping Method, Dipping + US Method, Shower Method

Equipment Structure

- Stripper Tank, Water Cleaning Tank, Air Knife Dryer or IPA Dryer

Engineering Issues

- Reduce the Stripper consume
- Keep the stripping uniformity
- Higher Throughput

Dry Stripper

- Working Principle:
- Apply Ozone Gas & Plasma to oxidize & remove the reacted PR – Ashing (灰化法) method

Currently Method

- First by dry stripping, then wet stripping

Glass Substrate Handling

Internal

1.Through Belt Conveyor
- Lower Cost

2. Through Roller Conveyor
- Higher Transfer Speed
- Lower Cost

3. Through Walking Beam
- Reliable
- Higher Cleanness

4. Through Robot
- Reliable
- Higher Cleanness

Between Process Equipments

1. AGV / MGV
2. MGV / RGV / STOCKER

Roller Conveyor

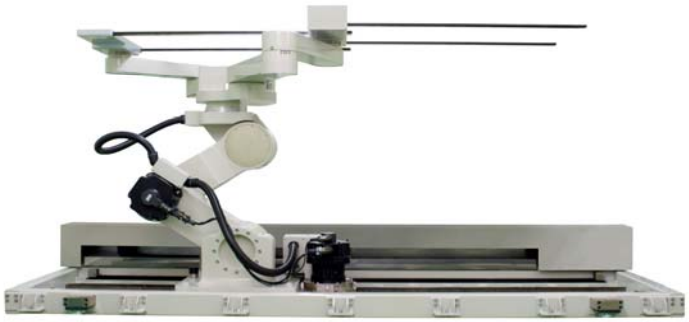
LCD handling Robot for Cell and Array Process

Array-use Robot

Features

1) **With payload of 20 Kg/arm, able to transfer large size LCD panel of up to 1,250 x 1,100 mm by high speed**
2) **Wide operating range, small rotating radius makes robot layout easye**
3) **Compact design by articulated arm assures the high repeatability and rigidity.**

Array-use Robot



Robot Specification

Terms		Specification
Robot type		Articulated type robot
Number of controlled axes		Up to 5 axes including traverse axis
Working range	Z axis (Up / Down)	900 mm
	θ axis (Rotation)	340 deg
	R axis (Fwd/ Bwd)	2,360 mm
	S axis (Traverse)	2,000 mm
Max speed	Z axis (Up / Down)	950 mm/sec
	θ axis (Rotation)	230 deg/sec
	R axis (Fwd/ Bwd)	2,700 mm/sec
	S axis (Traverse)	2,300 mm/sec
Max. payload		20 Kg/arm including hand
Glass passing line		1,100 mm from the floor
Min. rotation radius		960 mm
Allowable glass		1,250 x 1,100 mm
Cleanliness		Class 10
Hand positioning repeatability		±0.1 mm

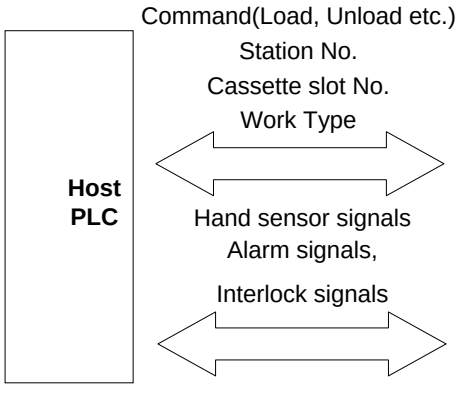
Robot Controller

Type code	TS1000	TS2000	SR7000	SR－5500
Target Robot	TH series	SR-HSP	SR-HSP	SR-HS
Target Servo motor	MAX300W	MAX900W	MAX900W	MAX900W
Dimension (WxHxD)	170 x 290 x 280	290 x 230 x 280	430 x 230 x 330	430 x 300 x 600
Volume ratio	１７・８％	２４・１％	４２・２％	１００％
FAN	No FAN	No FAN	No FAN	with FAN
Controlled axis (Max)	4(5)	4(5)	4(5)	4(5)
Embeded PLC	with PLC	with PLC	no PLC	no PLC
Comment	for small robot	newest model	2nd generation	initial generation

Communication between Host PLC

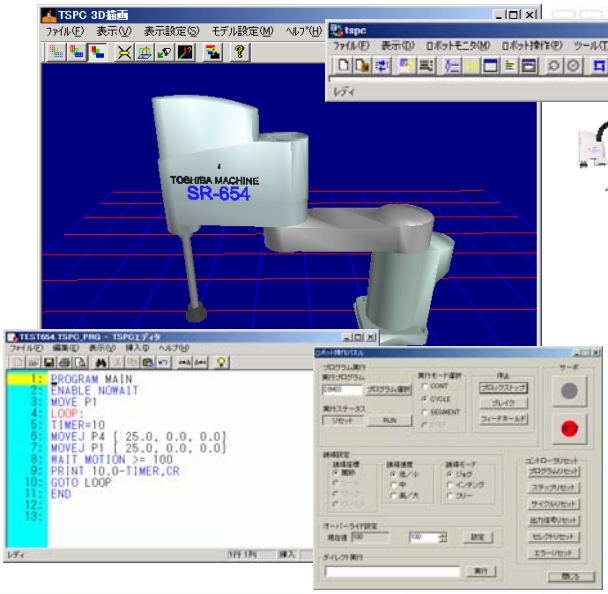
Robot controller(TS2000) and Host PLC communicate each other through parallel I/O signals to exchange commands, sensor signals etc. to operate robot .

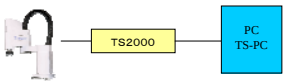
Built-in robot program is provided to support necessary LCD transfer operation.



TS2000 & TP

Robot Programming Supporting Tool : TSPC





Function

- Robot status monitoring
- Robot motion 3D display
- Programming simulation
- Control robot motion
- Programming edition

Effect

- Can spare time by enabling off line debugging until robot is actuary used.
- Reduce lead time till line operation is started

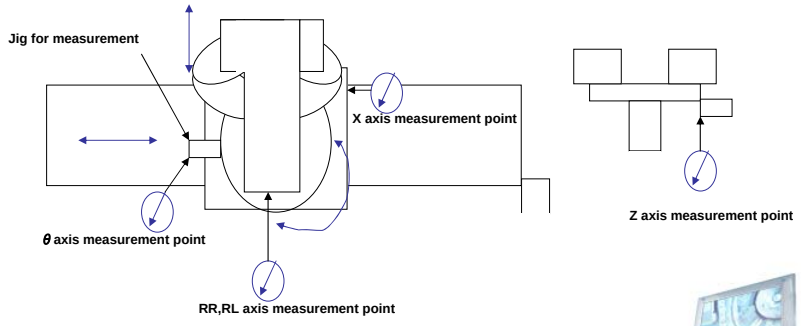
Repeatability of Positioning Accuracy

Measure repeatability of each axis' positioning accuracy (one way)

Each axis data is measured 15 times continuously using data logger

Motion pattern: SPEED=100%

P1(Start point) -> Dwell(3 sec) -> P2(Measured point) -> Dwell(3 sec)

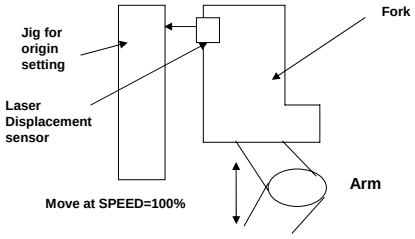


Straightness of Arm Motion

- Measure the straightness of arm motion in the direction of RR, RL axis
- Amplitude of vibration in the horizontal and vertical direction is measured by laser displacement sensor mounted on top of the fork.
- Line between P1-P2, P3-P4 is used as a reference line and maximum amplitude of vibration is recorded in the data logger

RR: P1(Start point) -> Dwell(3 sec) -> P2(End point) -> Dwell(3 sec) -> P1

RL: P3 (Start point) -> Dwell(3 sec) -> P4(End point) -> Dwell(3 sec) -> P3

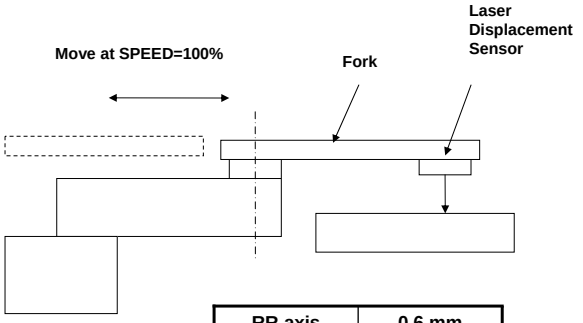


Horizontal Direction

RR axis	0.9 mm
RL axis	0.9 mm

Straightness of Arm Motion

Vertical Direction



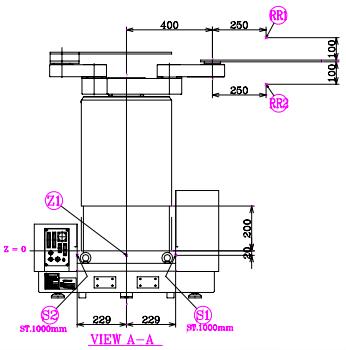
RR axis	0.6 mm
RL axis	0.6 mm

Particle Test

Cleanliness is measured by particle counter while robot is operating.

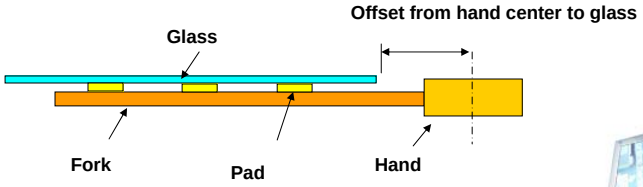
Measurement condition:

- **Sampling time per measurement : 1 min.** • **Measurement number: 10 times**
- **Measured particles: Count the particles with diameter of more than $\phi 0.3\,\mu$m included within 1ft^3 (28.3 L).**
- **Measured points: 5 points as shown below.**



Example of 3D Analysis for glass deflection

CONDITIONS OF GLASS DEFLECTION ANALYSIS	
Constraint Condition	
PAD X 3 / 1FORK	dia 19
PIN X 5 / 1FORK	dia 8
Each Fork is Symmetric	
Load Condition	
Glass Weight	Density 2.5
Analysis Method	
FEM by Pro/Mechanica	



MGV

Array Use Cassette

- Plastic
  - Hi PC
  - PEEK
- Feature
  - High temperature resistant
  - High hardness
  - Static resistant
- Cassette Size:

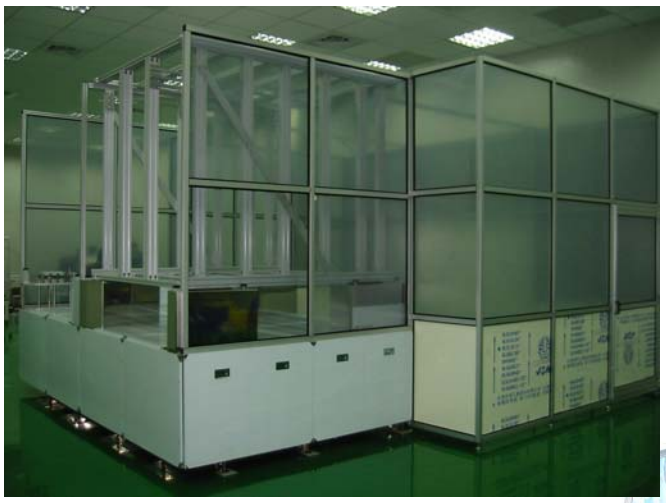
	A (wide)	B (long)	C (high)	D (distance side plate)	E (range RIB)
Dimension (mm)	**653±1.5**	**755±1.5**	**655±1.5**	**627±1.0**	**510±1.0**

	F (glass max. dimension)	G (first slot)	H (pitch)	Verticality	Electric resistance
Dimension (mm)	617±1.0	65±0.4	532±0.8	±2.0mm	10E4~10E6

G6 Cassette

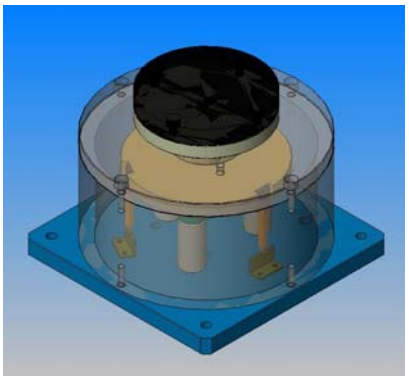
G6 Cassette

G6 Cassette Station

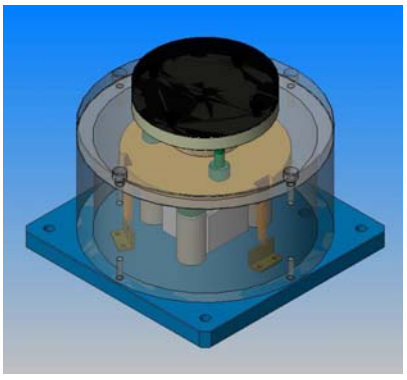


G6 Cassette Station

Floating Unit Module

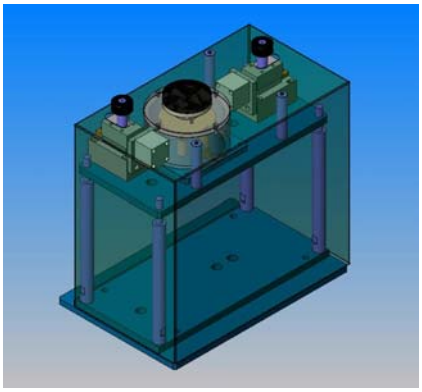


Floating without Lock

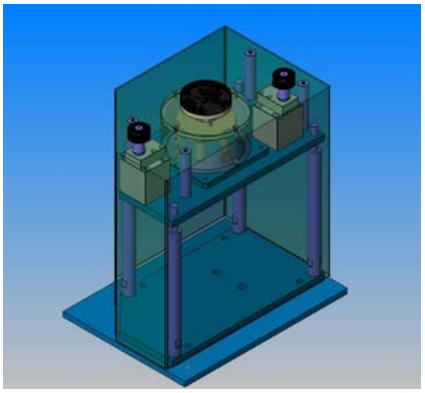


Floating with Lock

Floating Unit Module With CST Clamp

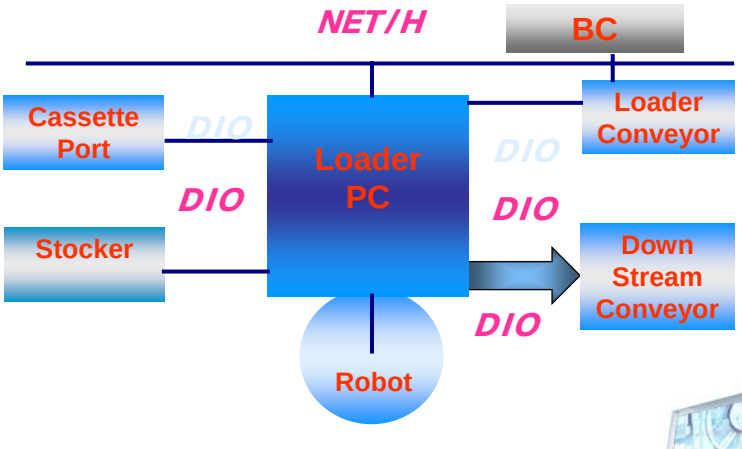


左後

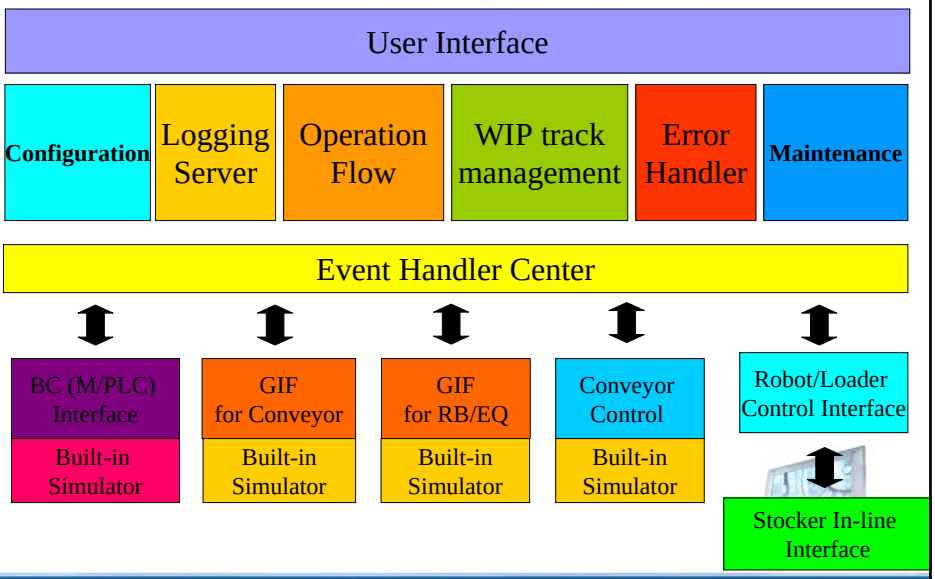


右前

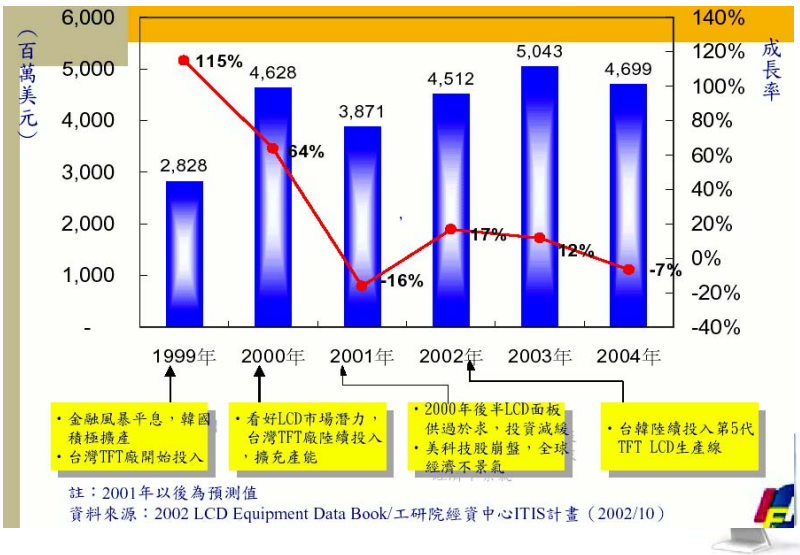
System Diagram (BM Loader)



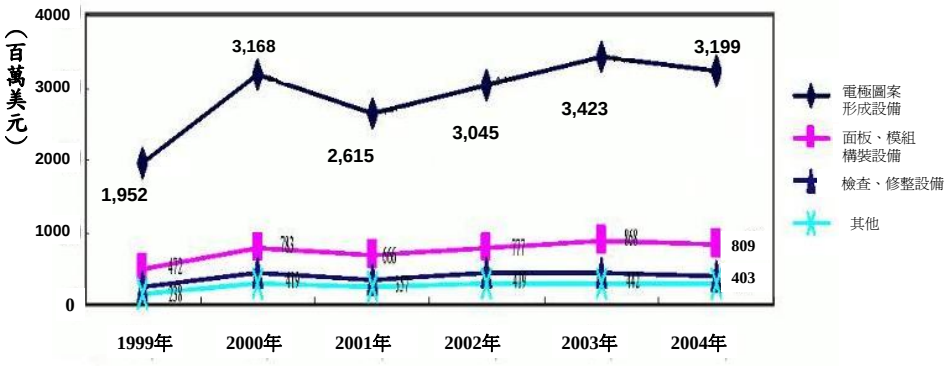
S/W Block Diagram



全球LCD生產設備市場現況



全球LCD生產設備市場現況(設備別)



電極圖案形成設備佔有率	69.0%	68.1%	67.6%	67.5%	67.9%	68.1%

註:2001年以後為預測值
資料來源:2002 LCD Equipment Data/Book/工研院經資中心ITIS計畫(2002/10)

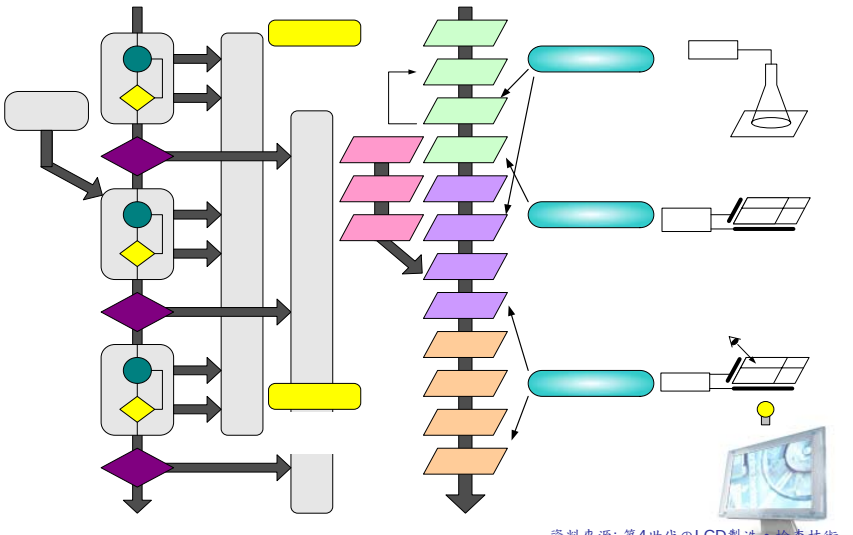
檢測-從製程看到需求

精細化
大型化
薄膜化
經濟化

→

工程安定化
產品高良率

檢測的目的與手法



資料來源: 第4世代のLCD製造・檢查技術

目 的

工程管理檢查

掌握工程異常
（異常檢知、監控
工程安定化）

陣列工程

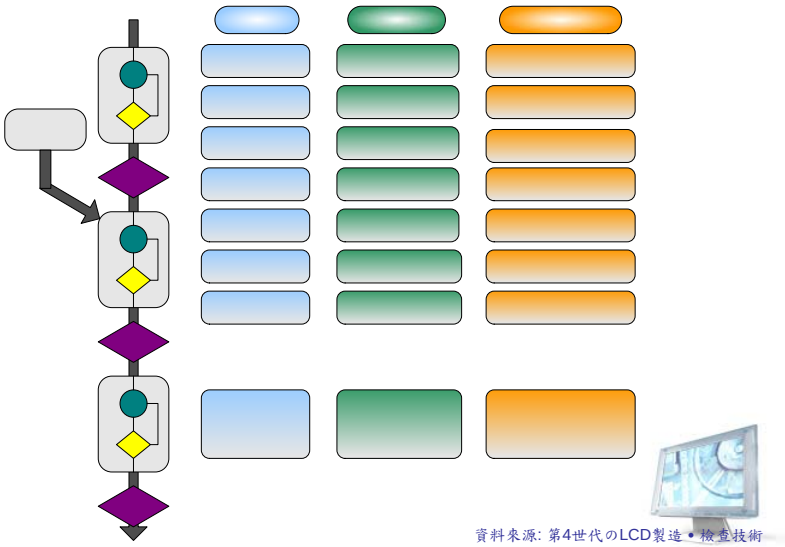
彩色濾光片

彩色濾光片

配向膜處理

間隔粒封口

工程管理檢查



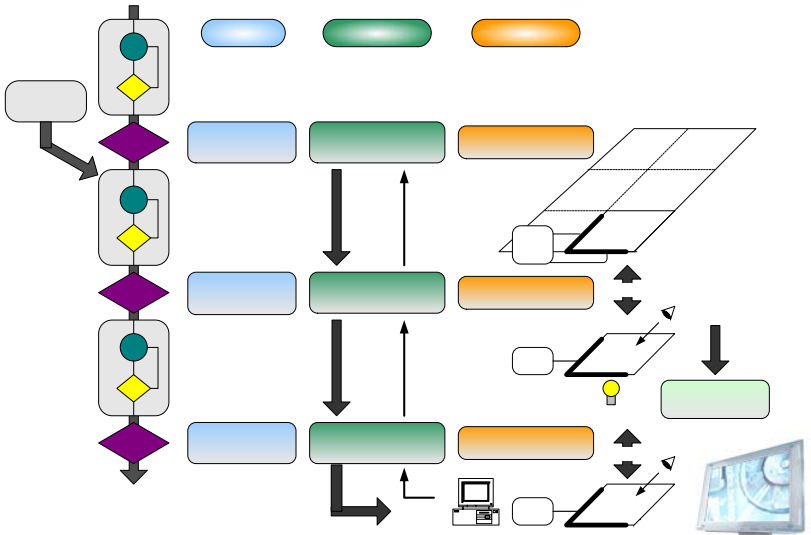
資料來源: 第4世代のLCD製造・檢查技術

產品選別檢查

產品選別檢查

產品的合格判定
（不良品的排除、
出貨檢查）

產品選別檢查



資料來源: 第4世代のLCD製造・検査技術

工　程　　檢查項

彩色濾光片

陣列最終檢查　　開路、短路
TFT功能

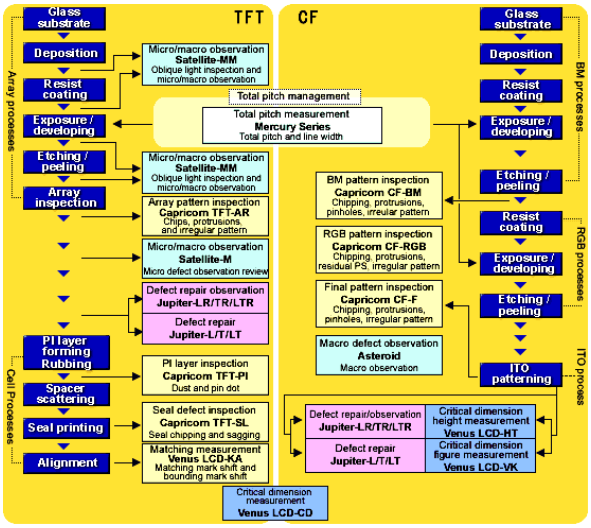
LCD檢測設備與分類

檢查(inspection)設備	• 玻璃基板檢查設備 • CF檢查設備 • TFT圖案檢查設備 • 陣列測試設備 • 配向膜檢查設備 • Macro檢查機 • 點燈測試設備
量測(measurement)設備	• Micro檢查機 • 膜質/膜厚測定 • 阻抗測定 • 精密座標量床
修整(repair)設備	• Laser修整機 • ：
評價(evaluation)設備	• 色彩、視角、應答速度… • 環境、機械、外觀

最終檢查　　畫質(點缺陷、
不勻)
外觀

最終檢查　　畫質(點缺陷、
不勻)
外觀

Array和CF的製程與檢測



資料來源:V Technology Co.,Ltd.

CF生產線的檢測設備

- 光罩(Photo Mask)檢查裝置
  - 藉由大型光罩瑕疵檢查裝置來管理各工程的光罩。使用透射光源進行圖樣的比較檢查。
- 黑色矩陣(Back Matrix, BM)圖案檢查
  - 進行矩陣部的白色脫落瑕疵、黑色瑕疵檢查。白色脫落瑕疵品進行再製處理，黑色瑕疵以雷射修整裝置修補。
- 濾光片圖案檢查
  - 進行RGB部的異物、突起瑕疵、白色脫落瑕疵、黑色瑕疵檢查。在保護膜形成前對在這裡檢出的異物、突起瑕疵進行研磨修補。

CF生產線的檢測設備

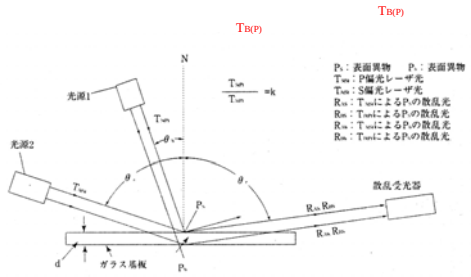
- 保護膜(Overcoat)檢查
  - 進行外膜部的異物/突起瑕疵檢查。為了在ITO膜形成前，進行外膜部異物/突起瑕疵研磨修正的檢查。
- 異物/突起修整
  - 以自動檢查所檢查出來的異物/突起瑕疵的座標為基準進行自動修整。測定研磨修整後的高度判斷良品或不良。以研磨帶進行突起的研磨，以共焦點型雷射顯微鏡進行高度測定。
- 出貨檢查
  - 進行彩色濾光片的異物、突起瑕疵、白色脫落瑕疵、黑色瑕疵檢查。ITO膜玻璃也是檢查對象，是該工程的最後檢查。

玻璃基板檢查設備

- 目的
  - 玻璃基板的異物檢查是用在玻璃基板的搬入檢查或製造過程中途的異物管理，是針對製程設備的發塵檢查或洗淨前後的評價等製程條件用。
- 規格
  - 對應配線圖樣微細化的高檢出感度：異物ø1μm以上
  - 高檢出再現性：95%以上
  - 對應各種塗佈膜玻璃基板
- 檢出技術
  - 以雷射光從低角度照射玻璃基板正面，利用反射特性檢出玻璃基板表面上的附著異物。
  - 2向斜向照射的亂射光比較法的異物檢出原理。

玻璃基板檢查設備

- 2向斜向照射的散亂光比較法
  - 玻璃基板上只要有異物存在，光線就會從整個異物向外反射成散亂光。以散亂光受光器接收一部分的散亂光當作電力訊號來檢出異物。
  - 光源來自2個系統，光源1的$T_{B(P)}$為高角度θ_b，光源2的$T_{A(S)}$為低角度θ_a，交互照射到玻璃基板表面。以同一個受光器來接收照射在異物上反射的散亂光。



① 低角度散亂光量>高角度散亂光量成立時，判斷為表面異物
② 低角度散亂光量<高角度散亂光量成立時，判斷為背面異物

資料來源: 第4世代のLCD製造・檢查技術

Hitachi: GI4830 Glass Plate Inspection

- High throughput
  - approx.: 180sec/730mm x 920mm
- High inspection sensitivity
  - Φ 0.3 μm particle.
  - Φ 3.0 μm pinhole.
- Front surface / back surface separate detection.
- Possible to particle observation by TV monitor.

Hitachi: GI6100 Glass Plate Inspection System

- Glass size
  - 1200mm x 1350mm (5th generation)
- High speed inspection
  - 80 seconds (1100mm x 1250mm substrate)
- High inspection sensitivity
  - Φ 0.3 μ m : bare glass
  - Φ 3.0 μ m : patterned glass
- Front surface / back surface separate detection.
- TV monitor for high-magnification particle review
- Thin glass application and cleanness by vertical inspection

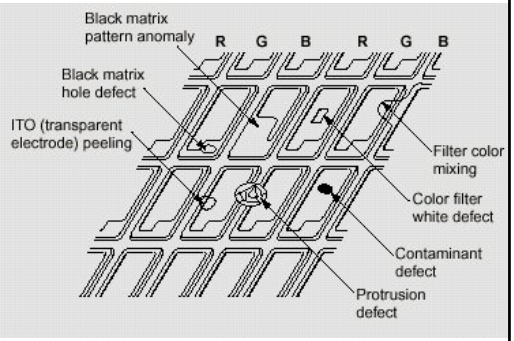
Hitachi GI6100

玻璃基板檢查設備

- 未來課題
  - 由於玻璃基板大型化、薄型化，玻璃基板的彎曲是個大問題。
  - 為了對整個玻璃基板面做高速檢查，雖然可以將雷射光的掃描幅寬盡可能的加大，可是與前述的檢出再現性的關係知道，勉強加大掃描幅寬並不是好的對策。
  - 玻璃基板的配線圖樣會進一步的微細化，也會要求異物檢查能做sub-micro level的高感度檢出。

CF的瑕疵

- Micro 瑕疵(點瑕疵)
  - 有白色脫落、混色、BM圖樣異常、針孔瑕疵、突起瑕疵等。
  - 白色脫落、BM的針孔瑕疵等屬於白瑕疵，異物、混色等屬於黑瑕疵。由於白瑕疵在LCD上會形成白點，檢查要比黑瑕疵嚴格。
- Macro瑕疵
  - ムラ(mura)為代表性的macro (面積)瑕疵，是因為大範圍微小的色彩不均。



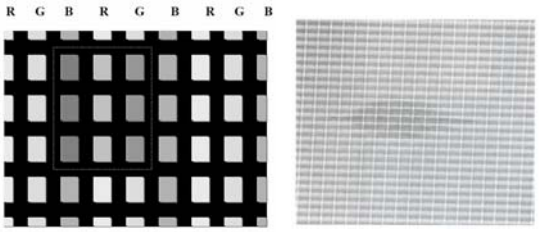
資料來源: Current Status of Color Filter Inspection and Repair Systems

C/F的瑕疵分類

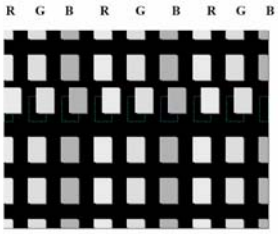
- Defects
  - Macro defects
    - unevenness of color IRO-MURA)
    - stain (SIMI)
    - misalignment of color cells (IRO-ZURE)
  - Micro defects
    - black martix hole
    - color area shortage in filter cell
    - particle

Color Filter之缺陷

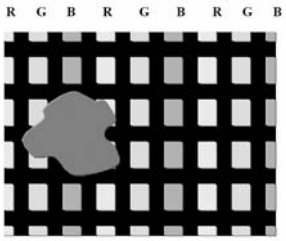
IR-MURA (色彩不均勻)



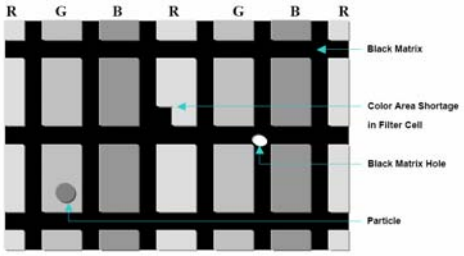
IRO-ZURE錯誤對位



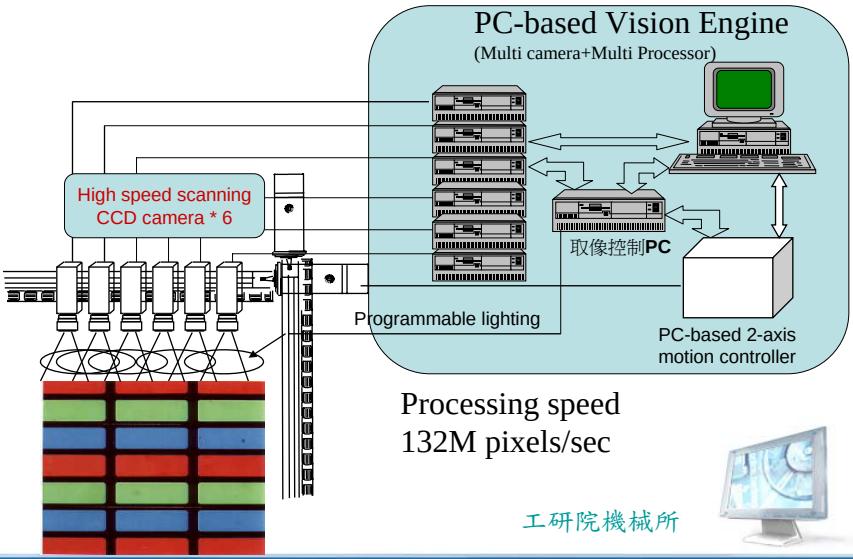
SIMI基板上有污點



微觀缺陷



Color Filter內層版檢查機架構圖



Processing speed
132M pixels/sec

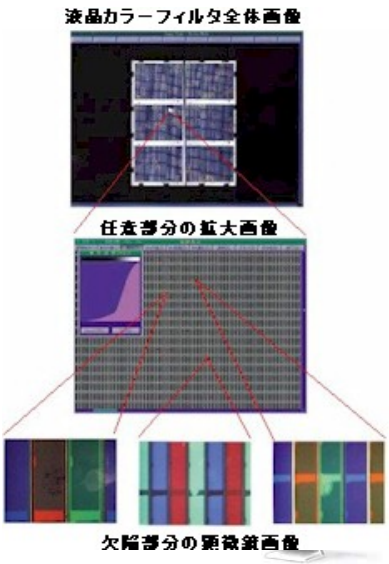
工研院機械所

CF瑕疵的檢出原理

- **透射/反射檢測頭**
  - 進行的是白色脫落瑕疵、黑色瑕疵、異物的檢出。
  - 利用line CCD攝取影像，再以cell shift的訊號處理方法進行影像處理。這個方法可以對像彩色濾光片般等間隔連續排列的圖樣進行瑕疵檢查。
- **雷射檢測頭**
  - 有突起存在時，雷射光會向所有方向散亂出去，藉著在這裡架設空間濾鏡可以選擇性的抓取從突起發出的散亂光。
  - 藉著旋轉的稜鏡反射雷射光來掃描彩色濾光片，以受光元件攝取通過空間濾鏡而來的散亂光來檢出突起瑕疵。
  - 檢出能力雖依瑕疵的形狀而不同，通常可檢出高度3μm的突起瑕疵。

Kubotek: LCD inspection

- Max. workpiece size (mm)
  - 730 x 920.
- Tact time
  - Approx. 45 sec.



V-Technology: Capricorn inspection CF series

- Model：**Capricorn XXXX-RGB/BM/F/SL/SP/PI**
- Max. workpiece size (mm)：1500 x 1850.
- Inspection resolution：7 μ m.
- Tact time：Approx. 25 sec.
- Detected defects：Lack of color, pattern defect, spacer defect etc.
- Detected area：CF substrate, cell process substrate.

Lasertec: LCD inspection system (CF series)

- Automatic inspection of LCD color filter and TFT defects.
- High speed inspection at one time, for clear defect, opaque defect, and protrusion defect, etc.

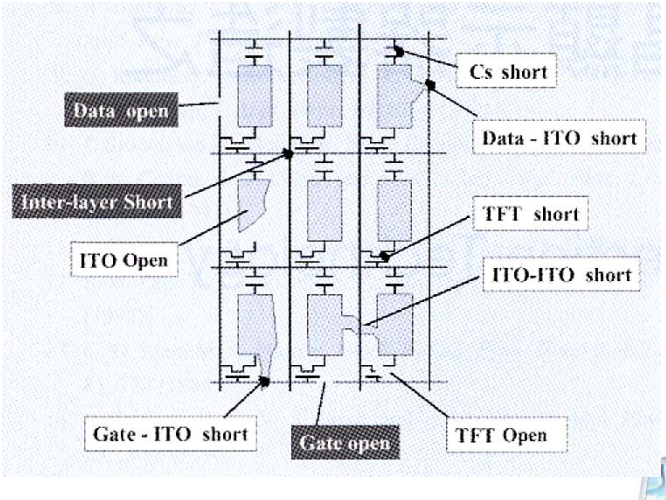
CF檢測的未來課題

- 檢查TACT time的縮短
  - 提高平台的掃描速度
  - 增加檢測頭的個數
- 瑕疵分類的細分化
- 檢出能力的提升
- CF的柱狀spacer
  - 外形的測定(高度、面積)
  - 缺陷檢出

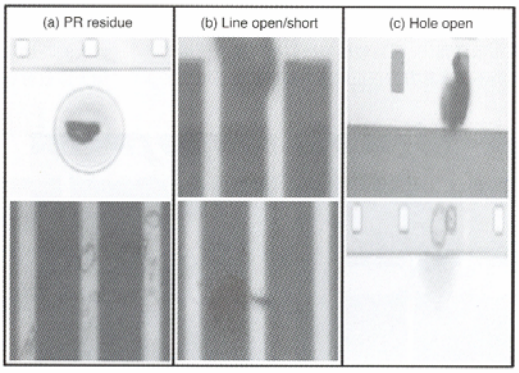
TFT陣列工程的檢查

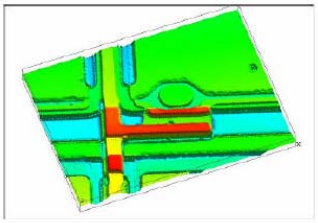
- 於玻璃基板上，Gate配線、Data配線、TFT、畫素電極(ITO)被形成的階段即稱為TFT Array，於此階段的檢查即所謂的Array檢查。
- 通常可以分為中間工程檢查和最終出貨檢查兩類。檢查項目有圖案形狀、折射率、斷線/短路、線缺陷、點缺陷、膜厚和薄膜阻抗等。
- 使用設備包括圖案檢查設備、陣列測試、膜厚測定設備、TFT特性測定設備、阻抗測定設備等。

薄膜電晶體面板缺陷示意



薄膜電晶體製程之缺陷





白光干涉儀檢測

TFT陣列工程的檢查分類

- TFT陣列工程的檢查大致分為光學式、電氣式和其他三種，依照用途和目的分別來使用。
- 光學式
  - 運用了影像處理的非接觸式檢查裝置。檢查結果與產品的合格/不合格的相關性比電氣式差。但是也可應用在中間工程的檢查，不只是產品本身的檢查，也可運用在製程或製造裝置診斷上。
  - 可分為光學式外觀檢查法和電壓映像法(Voltage Imaging) 。
- 電氣式
  - 數千支的探針與面板上的圖樣接觸，量測其電氣特性進行檢查，得到的電氣特性與產品的合格與否的相關性良好。
  - 又可分為傳達電導法(Transfer Admittance Test Method)、畫素電荷測定法、放電電壓比較法、開短路測定法四種。

陣列圖案的檢出原理

- 陣列圖案檢出的方法是把光投射在TFT上，藉由感測器檢測反射光，利用影像處理技術，將鄰接的像素的圖案加以比對，藉此檢查圖案是否相異。
- 陣列部的瑕疵檢出
  - 從鄰接陣列的圖樣的差異部份檢出的演算法。
  - 陣列的設計形態已趨安定，因此檢測的基本原則變化不大。
- 週邊部的瑕疵檢出
  - 抽取出週邊部(形成引腳、pad部)的重複圖樣部份，把錯亂的部份當作瑕疵檢出的演算法。
  - 由於週邊部的圖案設計可以說是各式各樣，尤其窄框化的趨勢使得設計的型態產生很大的變化，更增加檢測的複雜度和困難度。

Orbotech: InVision-8000 series

- High-Speed In-Line Inspection
  - For 5th generation glass sizes
  - Layers inspection
    - TFT multi layer arrays
  - Inspection method
    - Periodic area : comparison of pixel with neighboring pixels
  - Defect resolution
    - 5 μ m or 10 μ m
  - TACT time
    - under 55 sec/glass
  - Unique contactless transport mechanism
    - Nozzle air system floats the glass at a stable height on a layer of air above the table.

Orbotech: FPI-6000 series

- **Inspection Methods**

  Periodic area — Comparison of TFT pixel with neighboring pixels

- **Defect Resolution**

  Normal resolution - 3μ and High resolution - 2μ

- **Inspection Time (sec.)**

Defect resolution	Detection sensitivity (μ)	Inspection time*
Normal	3	127
High	2	440

- **Options**

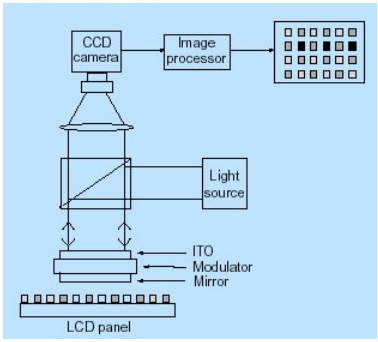
  Critical Dimension and Overlay Measurement (CD/Overlay)
  Peripheral Circuit Inspection
  EYES-2020™

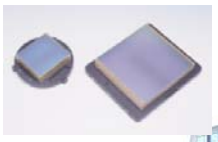
- **System Output**

  Defect files
  Color video images

電壓映像(Voltage imaging)測定法

- 另一種TFT Array工程的非接觸方式檢查技術，即電壓映像測定法。
- 利用電氣光學調變元件(modulator)光學的方式讀取依TFT的切換動作而被充電於畫素電極(ITO)的LCD驅動電壓，被稱為Voltage Imaging 。
- 對於液晶注入的cell階段的光學的行為能於Array階段直接觀察可謂是最大的特徵。
- 檢出點缺陷、線缺陷及不勻(mura)等缺陷。

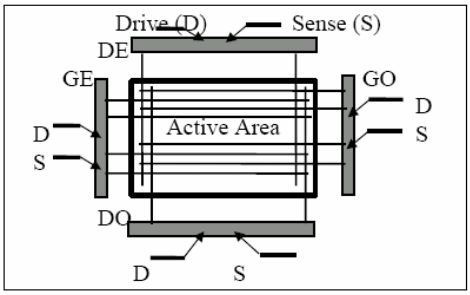




資料來源:Photon Dynamics

Shorting bar驅動方式

- 另一個特徵為使用能防止ESD的Shorting bar來驅動TFT Array。因為是以數支至數十支的接觸探針來外加信號，故於安定性及經濟性方面，與其他方式相比時，非常具有優勢。
- Shorting bar驅動方式通常是使用被稱為2G2D的一種配線，其係於Gate、Data兩方向皆是施以櫛齒狀每隔1支的短路配線。
- 於缺陷檢出方面，2G2D為最有利的配線。



2 gate and 2 data (2G2D)
shorting bar

資料來源:Photon Dynamics

Photon Dynamics: Array Checker 3000

- Supports 1,200 mm x 1,250 mm substrate with precision air-bearing stage.
- Provides faster, more reliable modulator gapping via an air bearing on the electro-optical **Voltage Imaging** sensor for improved defect detection, throughput, system stability and reduced operating costs.
- Improves spatial resolution to 60 microns with improvement targeted for sub-60 micron support.
- Offers a 20 percent increase in camera frame rate allowing high throughput on large glass.
- Tests 14-inch arrays in 24 seconds each, or 6.2 minutes for a 16-up substrate.

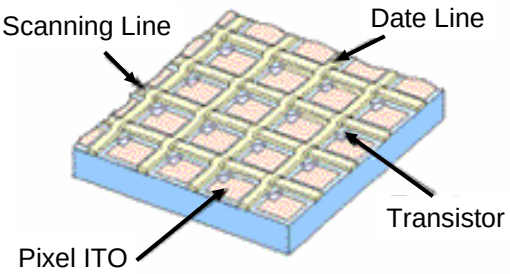
Photon Dynamics: Array Checker 3500

- Improve TACT time by up to 40 percent
  - The AC-3500 features a number of enhancements designed to improve both total average cycle time (TACT), or throughput, and system sensitivity.
- Larger Voltage Imaging Optical Sensor (VIOS)
  - Our fifth-generation non-contact, electro-optical modulator features a 131-mm-square sensor, four times as large as the previous generation sensor.
- Advanced Optical System
  - A new 16.7 mega-pixel digital camera - the first industrial use of such an advanced camera supports both high-resolution images and a large field of view.
- Automatic Bright/Dark Classification for Repair
  - The system can automatically determine if array defects will result in either a bright or dark pixel.

陣列工程的電性測試

- There are two important functional inspection for LCD panel: the array tester and lighting inspection.
- The array tester is the final inspection of the array process, this is the functional inspection of TFT circuit which was manufactured on the glass substrate and OPEN/SHORT test of the wires.
- The array tester and the array prober are used for these inspections.

Structure of TFT Glass substrate (Figure 1)



(Transparent electode for LCD driver)

資料來源: Micronics

Micronics: Array inspection

Fully-automatic prober

Model LP-4800

Fully-automatic prober for handling 5th generation

glass size (1300cm x 1300cm).

Fully-automatic prober

Model LP-4500/LP-4600

Fully-automatic prober for Array inspection

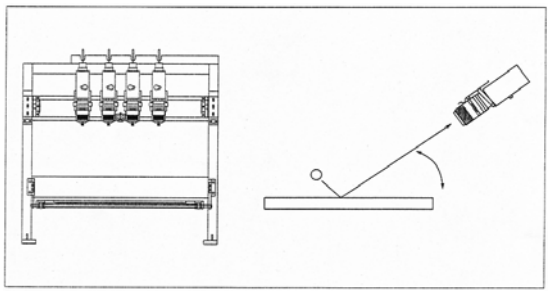
LP-4500 can handle a 550 X 650mm glass substrate

LP-4610 can handle a 600 X 720mm glass substrate

Probe Unit for T.E.G. testing can be integrated on.

配向膜的缺陷檢查

- 配向膜檢查之目的在於檢出配向膜印刷後的CF、Array基板的印刷不良，以排除不良基板，並且消除後工程的材料損失。
- 配向膜的代表的缺陷為針孔(pinhole)、異物及不勻等，許多是因為於印刷工程的污染物、印刷板不良及玻璃基板的不良等而發生的。
- 依影像處理的自動檢查，對由line CCD sensor取得的灰階輸入影像可配合缺陷特性，進行Filtering處理以檢出缺陷。



資料來源: 第4世代のLCD製造・檢查技術

Polyimide Printer

Polyimide(PI) is a Alignment Layer for Liquid Crystal Molecule

- Heat Resistance, Chemical Stability, Easy Printing & Alignment

Purpose : Printing the PI onto substrate & C/F for LC Alignment

Equipment Type

- Spin Coating Type : PI Material consume
- Printing Type

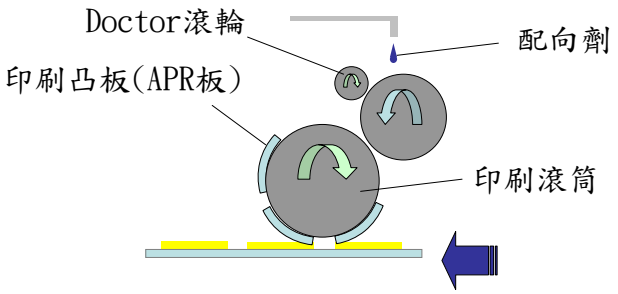
Equipment Layout(In-line Type)

- Loader, Cleaning, Buffer Area, Dispensing, Pre-Baking(70° ~80° C), Buffer Area, Baking Oven(180° ~190° C), Unloader

Engineering Concerns:

- PI Layer Thickness(40~80 μ m)
- PI Layer Thickness Uniformity
- Temperature Uniformity
- Printing Speed
- PI Concentration
- Engraving Roller

配向膜塗佈



製程要件：膜厚度；均勻度

Rubbing Equipment

Purpose : Apply force to the polyimide layer to let the LC molecule keep in definitely direction

Working Principle:

- Roller enveloped by cloth, and rolling on the surface of C/F or Glass substrate, through the rolling friction force to make LC alignment layer

Cloth : Rayon, Nylon

Engineering Concerns:

- Rotation precision of roller rotation shaft
- Moving precision of roller shaft
- ESD (through the friction)
- Equipment rigidity
- Duct(from PI & cloth)

ESD

- Cloth against induced ESD
- Deionizer
- Ceramic stage
- Vacuum holding

Rubbing Direction

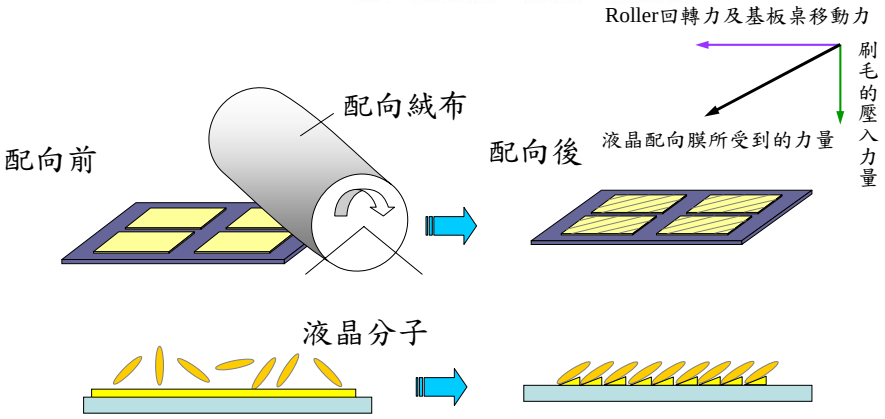
Roller Direction Changeable

- Roller Moving
- Stage Moving

Stage Direction Changeable

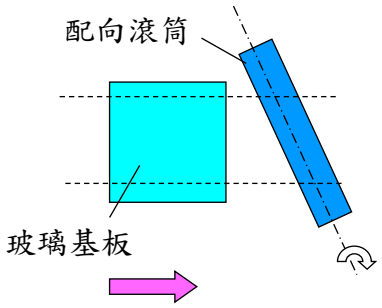
- Roller Moving
- Stage Moving

配向工程

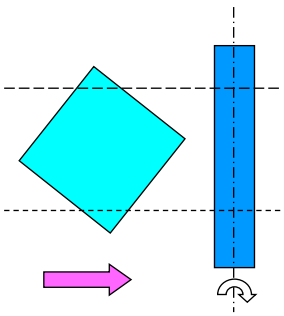


製程要件：消除靜電；均勻下壓力；軸心偏擺角度；進給精度

配向設備

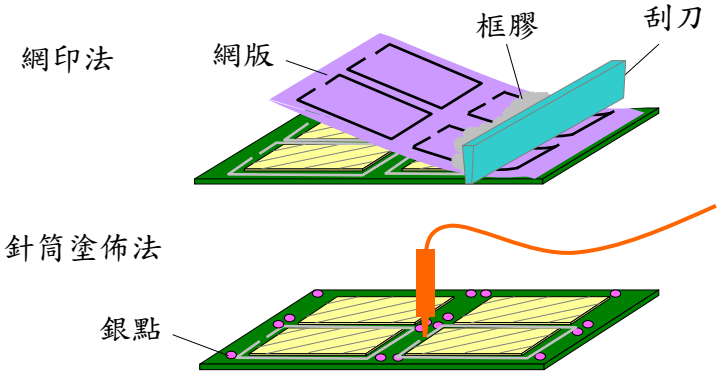


滾筒角度可調



基板角度可調

框膠印刷、銀點膠



製程要件：線寬均勻；對位精準；預烤

Kubotek: PI-4100

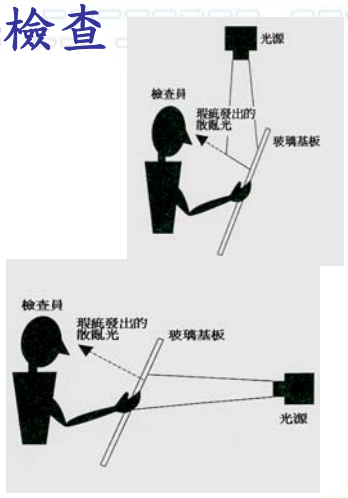
- Glass size
  - 1000X1200 mm
- 檢出CCD
  - Line CCD X 8
- defect size
  - 10 μm
- TACT time
  - 40 sec
- Load/Unload

目視Macro檢查

- 目的
  - 以人的肉眼進行瑕疵檢出、缺陷的種類判別到合格判定為止所有的目視檢查。
  - 用光照射基板，由瑕疵反映的散亂光檢出缺陷，可以以高S/N比將微小的瑕疵檢出。
  - 合格判定是使用特定的檢查光源，看在規定的照度下可否檢出。
- 判別種類
  - 點狀、線狀、面狀，或是以打光方法的不同來進行。
- 外觀規格
  - 傷痕、附著物 - 在10,000 Lux光源下看的到就不合格
  - 裂縫、破損 - 在1,500 Lux光源下看的到就不合格
  - 內含物(inclusion) - 100μm以下

目視Macro檢查

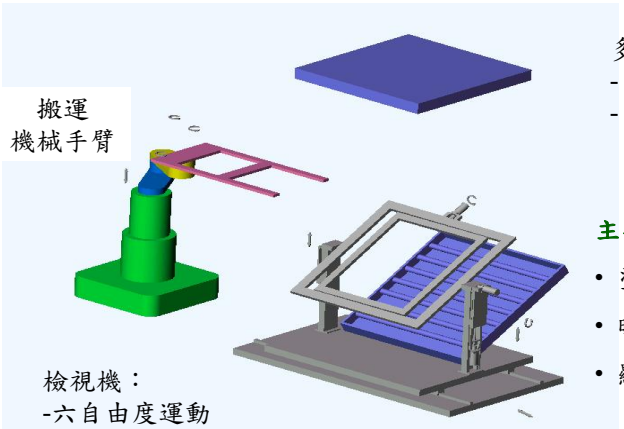
- 光源照射方向
  - 反射光的方法
    - 背景和瑕疵發出的散亂光的對比高，所以容易做種類判別。
    - 從正面和背面看出瑕疵的方法不同，容易判定正反面。
  - 透射光的方法
    - 內部有異物時，光線因與周圍的密度差產生曲折擴散，異物會比實際看起來大，所以檢出度高。
    - 缺點是不容易做瑕疵的正反判別或模式判別。



資料來源: 第4世代のLCD製造・檢查技術

面板 Macro Inspection設備

- 系統架構



搬運
機械手臂

檢視機：
-六自由度運動
-動力輔助驅動
-自動瑕疵檢測/分類

多色多角度光源：
- 鈉光、綠光、螢光
- 透射、斜射

主要檢視項目：

- 塗佈錯誤/不均勻瑕疵
- 曝光錯誤/失焦瑕疵
- 顯影錯誤瑕疵

V Technology : Macro review station

- Macro review station - Asteroid series
- Typical applications
  - Oblique lighting visual inspection
- Specifications
  - Max. workpiece size （mm）
    - 400 x 500 - 1100 x 1300
  - Observation part
    - Visual observation by oblique lighting /diffusion light
  - Functions
    - Inspection and judging for irregular layer forming, dust, scratches on glass

Control: Macro Inspection System MA-100

Advantage

- Application to the maximal 680mmx880mm Glass
- Three light types for observation flaw
- Simplification to teaching point mode
- High Luminous Back-Light
- Adaptable to large sized Glass.....<Glass input\output by robot>
- Precision Alignment
- The equipment employs direct glass viewing method for observation
- Stage have speediness of change

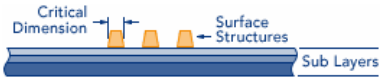
Specification

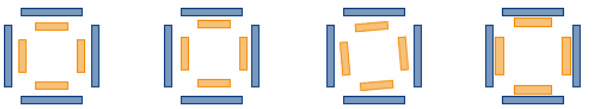
Applicable Glass Size	620mm ×750mm & 680mm ×880mm
Alignment Time	2.5 Minutes or less
Power	220V, 1P, 50/60Hz
Air	0.5Mpa, 5kgf/cm^2, 70~80psi
Vacuum	-66.5kPa
Dimension	1.5M(W) ×2.002M(D) ×2.5M(H)
Weight	1500kg approx
Light Type	Na light (2*90W).....<mura inspection> PL light (3*96W).....<transmission inspection> Manual PL light (18W).....<scratch inspection>
Change Key Type	Sliding green Light (AC 100V 50/60Hz).....<Option> Type A ：550mm ×670mm Type B ：620mm ×750mm Type C ：680mm ×880mm

Contrel MA-100

Micro檢查

- 先做目視macro檢查，然後將檢查出來的瑕疵用顯微鏡觀察大小與識別，然後進行合格判定。特色是將目視檢查的高檢出能力和顯微鏡觀察對瑕疵種類的高識別能力合併運用。
- 功能
  - 瑕疵的複檢(review)與判別。
  - 瑕疵位置的影像自動儲存。
  - CD(Critical dimension)或OL(Overlay)量測。





資料來源: Nanometrics Japan LTD.

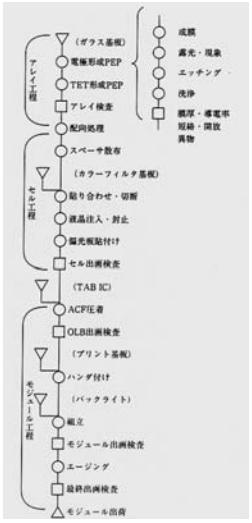
Micro檢查機

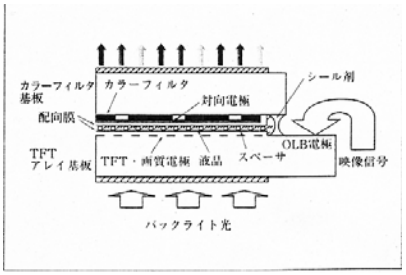
- 系統組成
  - XY移動平台
  - Microscope
    - 5X, 10X, 25X, 50X, 100X
    - Z軸上下移動
    - Auto Focus
  - 透射與反射光源
    - Remote控制光源強弱與RGB濾光片

V Technology - Satellite Series

- Micro/macro review station - Satellite Series
  - Array substrate visual inspection
  - Macro inspection
  - CF visual inspection
  - line width measurement
- Specifications
  - Max. workpiece size（mm）
    - 400 × 500 - 1100 × 1300
  - Observation part
    - metal microscope with electric revolver and color 3 CCD camera
  - Functions
    - Detailed observation and judgment of defect part on LCD glass substrate

面板與模組製程的檢查設備





資料來源: 第4世代のLCD製造 • 檢査技術

LCD Testing

Array Prober

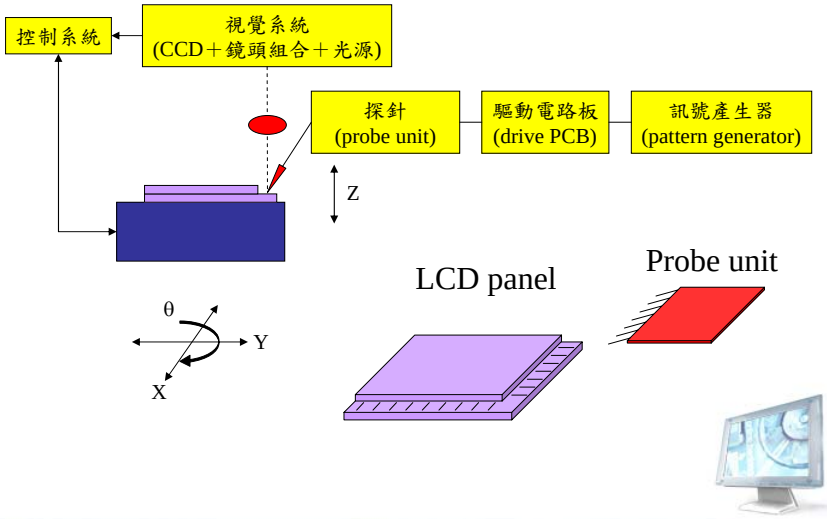
- Array Test
- Open / Short Test
- TEG Test

Cell Prober

- Lighting Test (Visual)
- Lighting Test (CCD Camera)

Probe Unit

點燈檢測



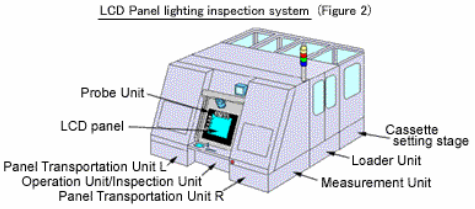
LCD Testing

Engineering Concerns

- Automatic Vision Check
- Finer Pitch Capability
- Probe Unit Cost Down
- Probing Stability
- Contact Resistance
- Alignment Accuracy
- Tact Time & Testing Time

Cell點燈檢查裝置及效用

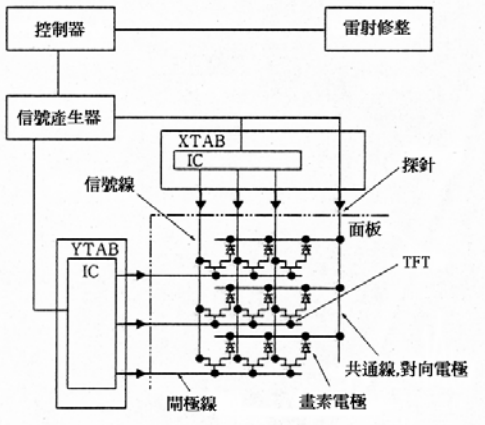
- 避免於模組工程的資源浪費
  - 去除的不良cell
- 防止於Array工程的重複不良
  - 異常的feed back
- 能以cell單位出貨
  - 確保模組的動作正常
- 使Array工程的投入資源變為有效
  - 將缺陷的位置及種類等提供給Repair裝置。
- 賦予工程改善、製品設計的方向
  - 不良的解析與特性的評估



資料來源: Micronics

點燈測試裝置的組成

- 係由與OLB電極接觸的探針、產生驅動電壓的TAB、對TAB給予影像信號的信號發生器、控制品名、驅動條件及缺陷情報等的控制器以及做為保持構造及接觸點位置的prober機構所組成。若採用自動檢查時，須再附加影像處理裝置。



資料來源: 第4世代のLCD製造・檢查技術

點燈測試的缺陷種類

- 點狀的缺陷
  - 當特定的畫素電極有障礙時
- 縱線的缺陷
  - 當信號線的一部份有障礙時
- 橫線的出現
  - Gate線的障礙

Micronics Japan: LCD Cell Prober

Semi-automatic Prober
Model LFP-330
Semi-automatic Prober for CELL lighting VISUAL inspection; LFP-330 has auto-alignment function. This Prober is for 12"-24"WIDE,QXGA Panel.

Semi-automatic Prober (High speed type)
Model LFP-1600
LFP-1600 is high speed type of LFP-330.
Tact time is 9.9sec.

Full-automatic Cell Test System
Model LFP-2000 Series
Full-automatic CELL test system LFP-2000 series is designed for mass-products, is adapted to dot/line defect inspection and color irregularity inspection. These system can record the fail bits address for use in repair process.

Tokyo Cathode: LCD Cell Prober

LCD/a-Si TFT Array Test
Model 9100
最大基板大小：850mmx1000mm
高剛性XYZθ stage
因應Array測試的防靜電干擾
可連接各家Load/Unload
CIM、AGV、BCR、VCR的對應

LCD Lighting Test
Model 1541
最大基板大小：21“
面板的Y軸移動以節省空間

Contrel : Light On Tester

Advantage

- Application to the maximal 24" Panel
- Twin-Arms for Loading/Unloading to reduce TACT TIME (TACT Time means the time required from completion of one cycle of test to contact of next panel loaded for inspection)
- PAA to simplify Device Conversion
- High Luminous Back-Light
- Group Probing Method
- Adaptable to large sized Panel
- Precision Alignment
- Maintenance of Probe Needles
- The equipment employs direct panel viewing method and also features a microscope for observation

Specification	
Applicable Panel Size	8~24inches
Alignment Accuracy	±3 μ m <total>
Alignment Time	1.5 seconds or less
TACT Time	13 seconds
Power	220V, 1P, 50/60Hz
Air	0.5Mpa, 5kgf/cm^2,70 ~ 80psi
N2	0.2Mpa
Vacuum	-66.5kpa
Dimension	1.9M(W)×1.9M(D)×2.3M(H)
Weight	1380kg approx
Work Stage	Stroke X:±3.0mm, Y:±3.0mm, Z:117.0mm, θ : ±0.04° Resolution X:3.0 μ m, Y: 3.0 μ m, Z:3.0 μ m, θ :0.00086°
Microscope Arm	Stroke X-axis:540mm, Y-axis:717mm Magnification:12.6 ~ 80
Base Plate	Installable P/U Type A:8" under 14" Type B:14" under 16" Type C:16" to 24" or less

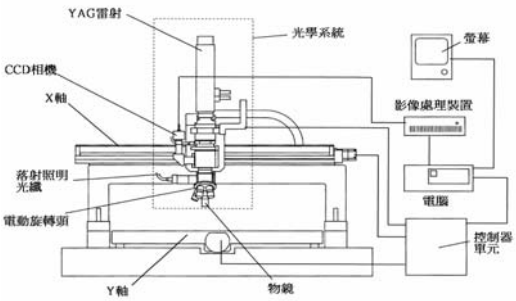
Model LOT-100
Semi-automatic inspection prober for TFT-LCD.

Laser修整機

- 生產無缺陷面板以降低成本的是業界努力的目標。
  因此利用Repair裝置來修補缺陷是提升良率的一種手段。
- 於LCD工程，有包括於前工程(Array process)的Repair與於後工程(Cell process)的Repair，各自皆會進行線缺陷、點缺陷及其他情況的修復。

LCD Laser repair的裝置

- 基板固定在Stage上，並且辨識基板的對位mark 。
- 依據缺陷的種類與位置資訊，手動/自動移動光學系統至缺陷位置，自動對焦與確認瑕疵。
- 依據缺陷的種類，YAG laser進行斷路或短路的修補工作。



資料來源: NTN

NEC: LCD Laser Repair SL455E2

LCD Laser Repair SL455E2

- **Overview**
  - The SL455E2 is an LCD laser repair used in a production line to repair short-circuit defects on the wiring of LCD panels with high accuracy and in a wide area.
- **Features**
  - Newly integrates 650 x 550 mm X-Y stage with positioning accuracy of 2.5 μm
  - High-accuracy, stable and thermal-deterioration-less repairing enabled with a tried-and-true laser oscillator and imaging optical system
  - Equipped with the high-speed line cutting function with a high repeatability laser as standard
  - Can be used as review equipment
  - Equipped with size measuring software as standard

NTN: 液晶 Laser Repair

レーザ部	発振器	種　類	Qスイッチ付YAGレーザ（EO-Qタイプとパッシブ Qタイプの2種類）
		発振波長	基本波(1,064nm),第2高調波(532nm),第3高調波(355nm)用途に応じて選択
		出力エネルギ	40mJ／pulse以上（基本波，EO-Qタイプの場合）
		パルス幅	10nsec以下（基本波，EO-Qタイプの場合）
ステージ部	XYステージ	有効ストローク	標準は，340×240mm，400×400mm，500×500mm，700×700mm（これ以上のサイズのものもご相談に応じます）
		分解能	1μm／pulse（標準）
	Zステージ	有効ストローク	100mm（標準）
		分解能	0.4μm／pulse（標準）
光学系	パワーコントロールユニット	透過率	0.25%～100%，NDフィルタ組み合わせ方式
	スリットユニット	スリットサイズ	0×0～1.5×1.5mm（標準）
	顕微鏡部	対物レンズ	超長作動アポクロマート　標準で5×，10×，20×，50×の4本
		レボルバ	5穴電動レボルバ
		照　明	落射照明，透過照明（オプション），ガイド光照明

レーザ部	発振器	種　類	EO-Qスイッチ付YAGレーザ
		発振波長	1,064nm（532，355nmオプション）
		出力エネルギ	40mJ／pulse以上
		パルス幅	10nSec以下
ペースト塗布部	ペースト塗布針	塗布針本数	1本
		針先端径（標準）	φ30，φ50，φ70，φ100μm
	塗布針の駆動	駆動方法	電動リニアアクチュエータによるZ軸方向駆動
		塗布時の基板への加圧力	10gf以下
	ペースト選択	ペースト容器	最大4個
	回転機構	洗浄剤容器	1個，DCモータにより洗浄剤攪拌
		塗布針乾燥容器	1個，エアー吹き付けによる乾燥
ステージ部	XYステージ	有効ストローク	340×240～1,650×1,050mm
		分解能	1μm／pulse
	Zステージ	有効ストローク	50mm
		分解能	0.044μm／pulse

Control: LCD/CELL Laser Repair

- Applicable Panel Size
  - 32": 14.1" ~ 32" Cell (214.9x286.5mm ~ 490x720mn
  - 50.1": 14" ~ 50.1" Cell (220x290mm ~ 647.5x1132.6
- Applicable Panel Thickness
  - 1.0 ~ 2.2mm(w/ or w/o polarizer)
- Laser System
  - Repair function: cut by dot, line, area
  - Laser type: Nd: YAG Laser with Q-Switch
  - Slit size: Minimum 2x2 μm and Maximum 50x50 μm at 50X
  - Minimum 2x2 μm and Maximum 125x125 μm at 20X
- Microscope and Vision System
  - CCD type: Color camera (640x480 pixels)
  - Auto focusing: by manual or auto (depends on user's requirement)
  - Alignment: ±1 μm
  - Direct light source, Back light source, Spot light

Laser repair未來的課題

- **更精細pattern的缺陷修補**
  - 修整10μm以下的電極寬度
  - 薄膜和厚膜兩種pattern
- **自動化的對應機能**
  - 強化瑕疵自動檢出和缺陷分類機能
  - 附加瑕疵修補後的確認

背光模組簡介

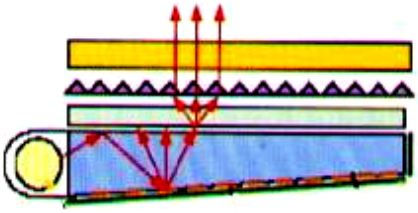
一般而言，背光模組可分為潛光是與背光式兩種，而背光式可依其規模的要求，以燈管的位置做分類，發展出下列三大結構：

- 側光式結構
- 直下型結構
- 中空型結構

背光模組簡介

側光式結構

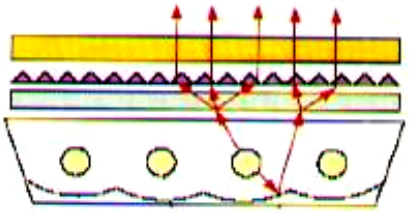
發光源為擺在側邊支單支光源，導光板採射出成型無印刷式設計，一般常用於18吋以下中小尺寸的背光模組，其側邊入射的光源設計，擁有輕量、薄型、窄框化、低耗電的特色，亦為手機、個人數位助理（PDA）、筆記型電腦的光源。



背光模組簡介

直下型結構

超大尺寸的背光模組，測光式結構已經無法在重量、消費電力及亮度上佔有優勢，因此不含導光板且光源放置於正下方的直下型結構便被發展出來，適用於對可攜性及空間要求較不挑剔的LCD monitor與LCD TV。



背光模組簡介

中空型結構

隨著影像要求尺寸增加，LCD也朝向更大尺寸的方向發展，使用監視器及壁掛式電視，不僅要求大畫面、高亮度及輕量化，在電器上亦要求高功率下的低熱效應。

背光模組之結構

背光模組有六大結構，詳細說明如下：

- **發光源**

須具備亮度高及壽命長的特色，目前有冷陰極螢光管、發光二極體LCD及電激發光片EL等，其中冷陰極燈管具有高輝度、高效率、壽命長、高演色性等特性，加上圓柱狀外型因此很容易與光反射元件組合成薄板狀照明裝置，故目前已冷陰極螢光管為主流。

背光模組之結構

- **導光板**

應用於側光型背光模組，是最影響光效率的重要元件，用射出型的方法將PMMA製成表面光滑的板塊，然後用具高反射率且不吸光的材料，在導光板底面用網版印刷印上圓形或方形的擴散點。導光板主要功能在於導引光線方向，以提高面板光輝度及控制亮度均勻，生產導光板專用射出成型機性能有幾點要求：

- 模版平行度要求
- 射出壓縮成型技術功能
- PMMA光學專用料管開發
- 成型環境控制

背光模組之結構

- **反射板**

一般側光式背光模組的反射板放置於導光板底部，將自底面漏出的光反射回導光板中，防止光源外漏，以增加光的使用效率。

- **擴散板**

擴散板之功能未提供液晶顯示器一個均勻的面光源，一般傳統的擴散膜主要是在擴散膜基材中，加入一顆顆的化學顆粒，作為散射粒子，而現有之擴散板其微粒子分散在樹脂層之間，所以光線在經過擴散層時會不斷的在倆個折射率相異的介質中穿過，在此同時光線就會發生許多折射、反射與散射的現象，如此便造成了光學擴散的效果。

背光模組之結構

- **增亮膜**

光自擴散板射出後其光的指向性較差，引此必須利用菱鏡片來修正光的方向，其原理藉由光的折射與反射來達到凝聚光線、提高正面輝度的目的，以增加光線自擴散板射出後的使用效益，使能整體的背光模組的輝度提高60%-100%以上。

背光模組之結構

- **偏光轉換膜**

  因在現有的LCD液晶面板設計中，對光源模組給予過濾掉S-ray平行光，允許P-ray光源通過，並利用這單一的偏極態光來驅動或照明LCD液晶面板，產生所要的功能。所以會在光線進入液晶面板前會先經過一偏光板，以一偏光板會有吸收掉某一偏光方向的能量，而冷陰極管所產生的光為非極化光，在通過第一片偏光板時，有一半以上的光能量會被吸收掉，使得光的使用效率非常差，為解決這各問題須採用偏光轉換技術使光源做偏極態轉換。

背光板輝度、均勻度量測系統簡介

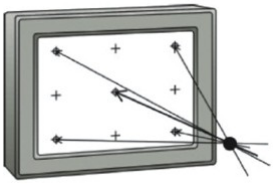
- 液晶顯示器 (liquid crystal display, LCD) 是我國目前最重要也最具競爭力的產業之一，其中背光板模組 (backlight unit, BLU) 為提供 LCD 光源的關鍵元件之一，約佔 LCD 30% 左右的成本。由於 LCD 必須依靠 BLU 產生光源，因此 BLU 的品質直接影響了 LCD 的良窳，其中輝度 (luminance) 及均勻度 (uniformity) 即為評估 BLU 品質的兩大指標。目前常用的量測方法有以人工目視檢驗及使用機器視覺檢驗兩種，為了兼顧品質與產能，自動化的機器視覺檢驗方式勢必將成為主流。

輝度與均勻度定義

- 輝度為每單位面積、單位立體角、在某一方向上，自發光表面發射出的光通量，單位為 cd/m2 或以 nits 表示。均勻度為量測螢幕表面或平面發光體表面上輝度變化的程度，若 *L*min 及 *L*max 分別為量測的最小及最大輝度值，均勻度則由 *L*min 與 *L*max 來量化。

BLU 量測點位置定義

- 目前業界常使用的量測點數為 9 點及 25 點，9 點量測點的位置如圖一。

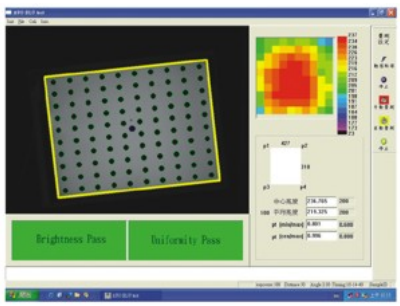


BLU 量測點位置

BLU 輝度、均勻度量測系統

量測系統介紹

本中心自行研發的 BLU 輝度、均勻度量測系統係以機器視覺為架構的自動化光學量測系統 ，量測系統則由 CCD 照相機、量測平台、控制電腦及操作軟體所組成。



軟體操作介面

操作軟體為架構在 Windows 下的應用程式，使用者經由簡單的操作介面即可進行量測參數設定及在短時間內完成量測。程式除了顯示 BLU 輝度、均勻度的量測數值，亦可由一彩色圖形介面定性顯示輝度、均勻度的分布。

量測參數設定介面

- 經由量測參數設定介面，使用者可輸入量測點數、視角及符合允收的標準值，若量測結果符合允收範圍，程式顯示綠色燈號表示通過標準。反之，顯示紅色燈號則表示未通過標準，並以嗶嗶聲通知線上人員。
- 本量測系統目前可量測小於 4 吋的 BLU 模組。

量測系統規格

表一、量測系統規格				
量測項目	**範圍**	**單位**	**精度**	**重複性**
輝度	10–15000	cd/m^2	3%	1%
均勻度	0–1			

- 量測系統規格**量測項目範圍單位精度重複性**輝度10–15000cd/m23%1%均勻度0–1

量測系統特性

- 待測 BLU 的發光亮度自動決定 CCD 照相機曝光時間。
- 可進行多點量測，並在 3 秒內完成量測。
- 量測點數及視角可由使用者自行輸入。
- 待測之 BLU 不需夾具來固定方位，程式可即時在任意方位中完成量測點的定位。
- 量測結果由 Excel 格式儲存，方便使用者對量測值進行後續的統計分析。

膜質/膜厚測定

- **Nanometrics : Flat Panel Display Film Analysis System**
  NanoSpec 6500

Size : 1100mmx1250mm

非接觸式光干涉式膜厚測定裝置

- **Toray : Film Thickness Measurement System**
  OP-50L

Non-contact and Non-destructive Measurement

BPR --- Advanced Measurement Technique

Multi-parameter, Multi-layer Measurement

Up to 3 parameters (thickness(t), index(n), and extinction coefficient(k)) can be measured simultaneously for structures consisting of up to 3 layers of films.

Small Spot Size: 0.9 micron spot size can realize fine pattern construction measurement.

評價設備

Otsuka Electronics: LCD Evaluation System

Maximum sample size

410x256x60 mm(LCD-7000)

250x220x50 mm(LCD-5100)

Measurement items

V-T, Contrast ratio, Response time, Spectra, Chromaticity/ brightness/color difference, and 3D measurement (option)

Variable parameters

Temperature/humidity (option), XY measuring point coordinates, Light projecting/receiving angles, Rotational angle and LCD drive waveform

彩色濾光片瑕疵檢查機

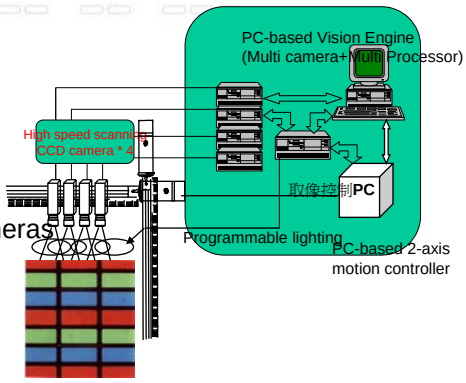
FPD 檢測的領導廠商

	第一名	佔有率	第二名	佔有率	第三名	佔有率	備註
玻璃(Glass)基板檢查設備	日立 Deco [2]	49 %	Hugle Electonics	15 %	岩谷機械工業	10 %	
陣列(Array)檢查設備	Photon dynamics [1]	28 %	Orbotech	23 %	Micronics Japan [3]	21 %	
彩色濾光片(Color filter)檢查設備	Takano	45 %	Kubotek	23 %	Lasertec (Laser)	13 %	V-Technology

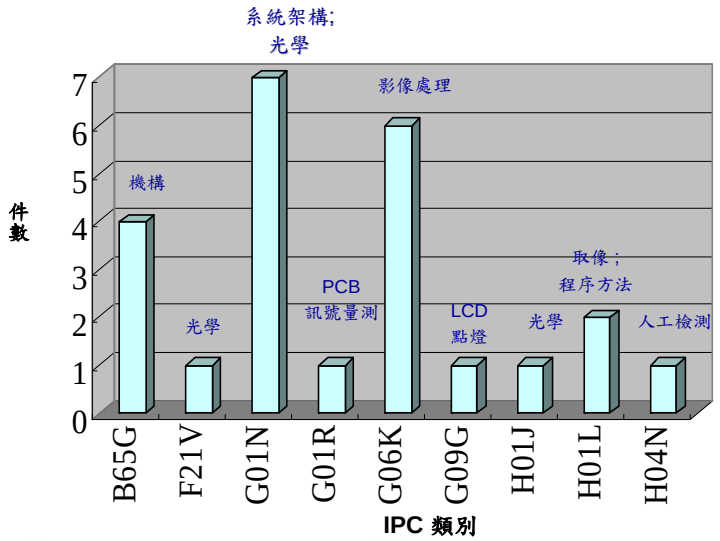
ITIS, 2002/10

Key technology

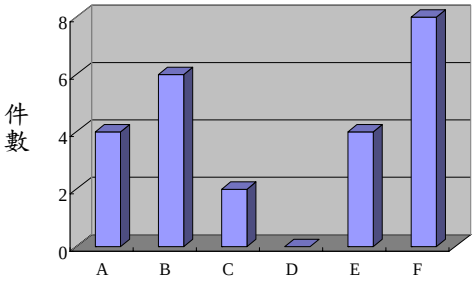
- Imaging optics
  - Hybrid light sources design
  - Polarized optics module
  - Opto-mechanics integration
- High speed electronics and interface
  - High speed imaging
  - Calibration of multi-line CCD cameras
  - New control architecture
- Image processing
  - *Defect inspection algorithm*
  - Multi-CPU parallel processing
  - Automatic defect classification
- High speed positioning and driving
  - Integration of vision and motion system



Orbotech AOI 相關美國專利技術
領域落點分析



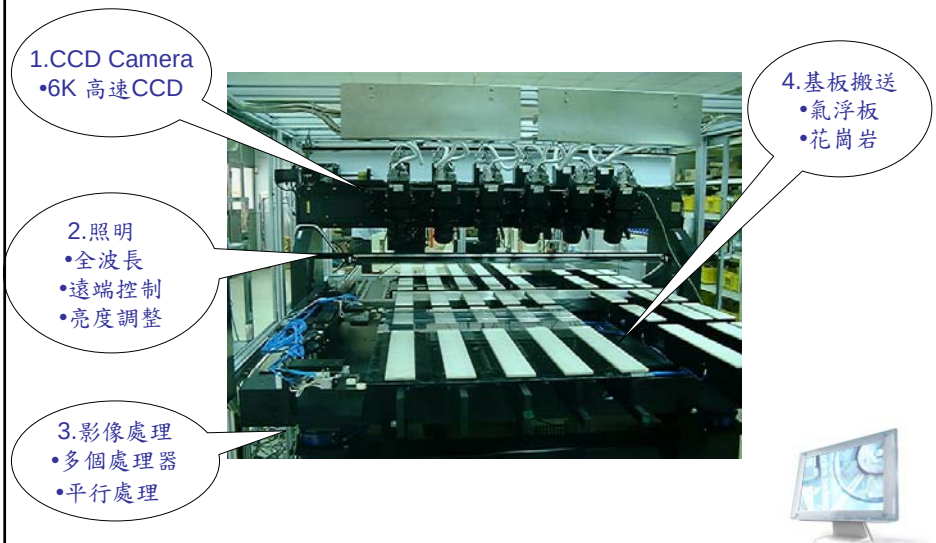
Orbotech 相關美國專利之技術領域落點分析



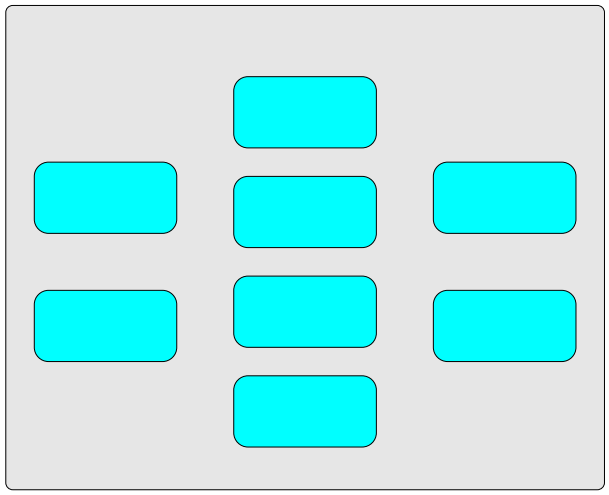
A : Image Optics
B : Image Processing
C : High speed electronics and interface (imaging)
D : High speed positioning and driving
E : 機構
F : 系統架構

- 專利數量以**系統架構**、**光學**與**影像處理**佔大多數
  - **機構**之專利數量次之

彩色濾光片檢查機的組成



檢測系統架構圖



彩色濾光片瑕疵檢測系統

運動控制模組

系統規格

檢測對象：Color filter, glass substrates
檢測尺寸：1250x1100mm, t = 0.6 mm
像素分解能：15 μm
掃瞄分解能：10 or 15 μm
掃瞄速度：50 or 75 mm/sec
掃瞄方式：往返各一次
TACT time：40 sec (for 15 μm scan resolution)
檢測精度：　白缺陷：15 μm
　　黑缺陷：30 μm

Review CCD 模組

光源控制模組

VR/C模組

系統規格(續)

輸出格式:

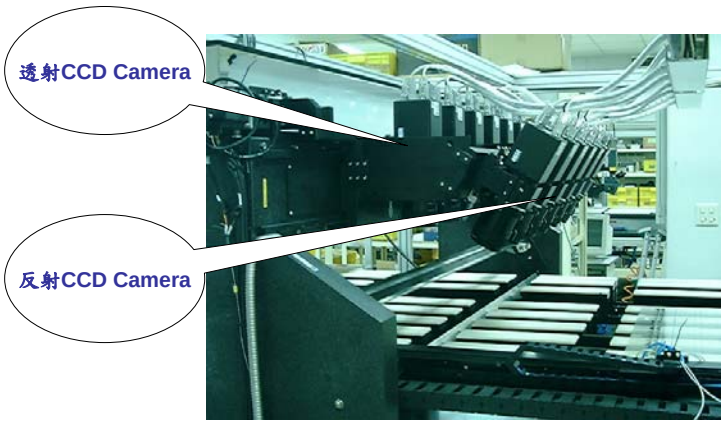
- Auto inspection screen
- Inspection date
- Kind of defect with comment
- Number of inspections
- Number of OK
- Number of NG
- Defect number
- Classification display in defect map (defect position) by size, common defect

CCD Camera

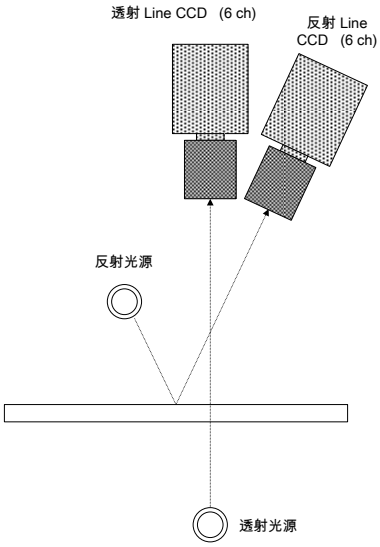
Specification	CT-P4	CL-P4
Resolution	6144 and 8192	
Pixel Pitch	7μm x 7μm	
Max. Line Rate		
6144	15.6kHz	7.9kHz
8192	11.8kHz	6.0kHz
Data Bits	8 per channel	
Data Rate	4@25MHz	2@25MHz
Data Format	EIA-644 (LVDS)	
CE-compliant	Yes	

資料來源: DALSA

CCD Camera排列



照明光學系統



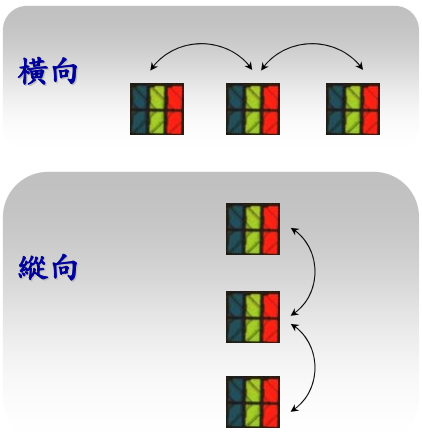
- 視覺檢測系統主要包含透射和反射兩個視覺模組，
- 透射視覺模組是檢測透射白缺陷、透射黑缺陷和圖案異常，
- 而突起和反射白缺陷、反射黑缺陷是反射視覺模組來檢視。

光源

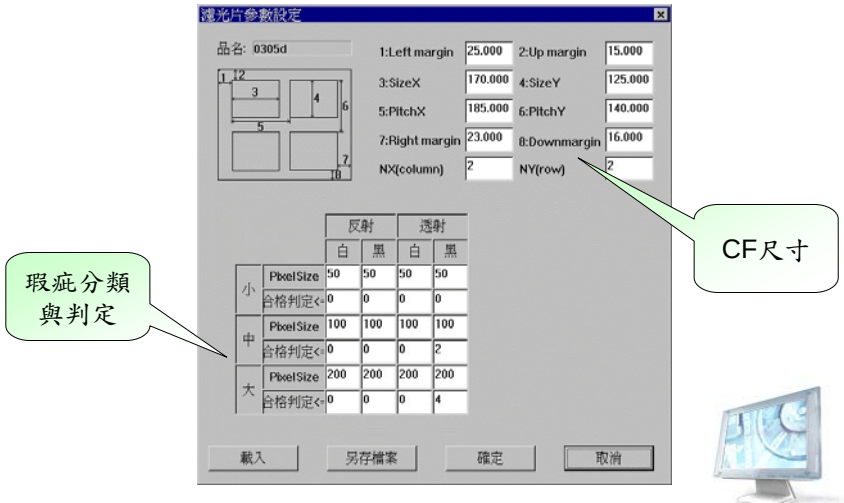
1. 全波長光源
2. Remote Control
3. 反射光源:光源亮度控制(256階)，透射光源:ON/OFF控制

影像檢測法則

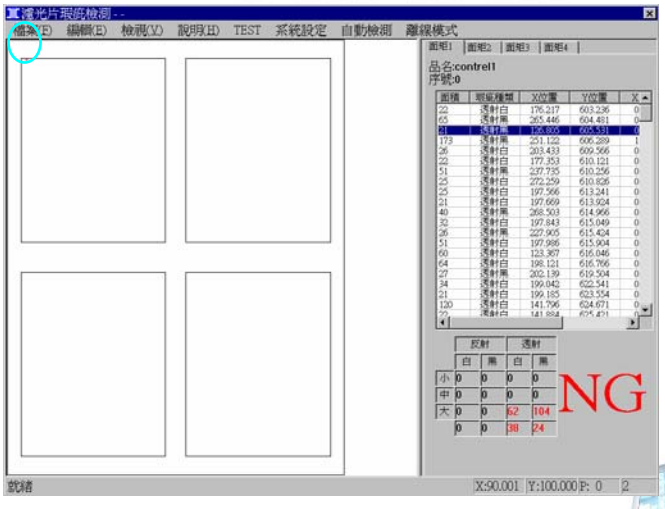
Cell-to-cell 橫向/縱向 比較法



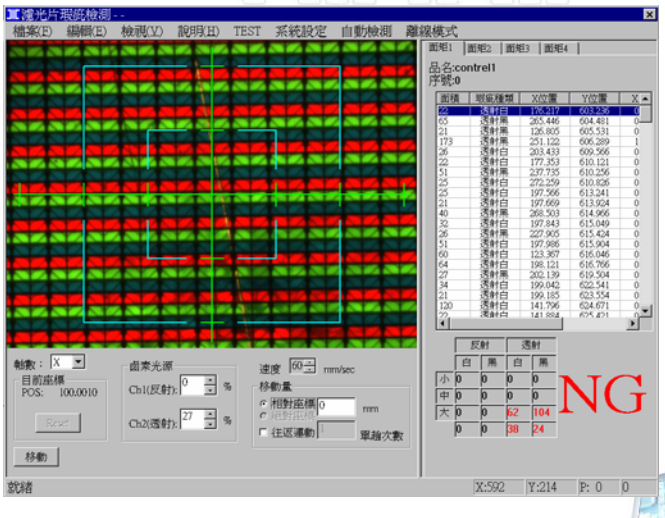
參數設定-
CF尺寸與瑕疵分級與合格判定



瑕疵 map



瑕疵 review



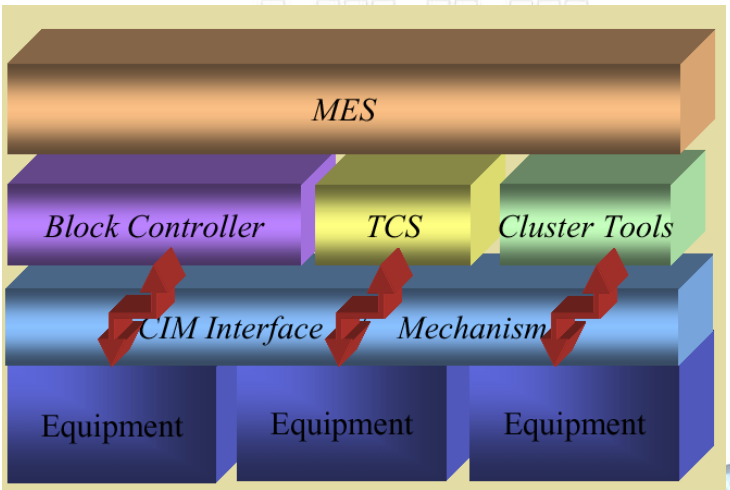
基板搬送

- 氣浮搬運方式：玻璃不摩擦，不產生二次污染。
- 防振機台：玻璃不受外界震動干擾，檢測及Review時，取像穩定。
- 線性馬達：沒有背隙，運動平順而且穩定，定位精度佳。

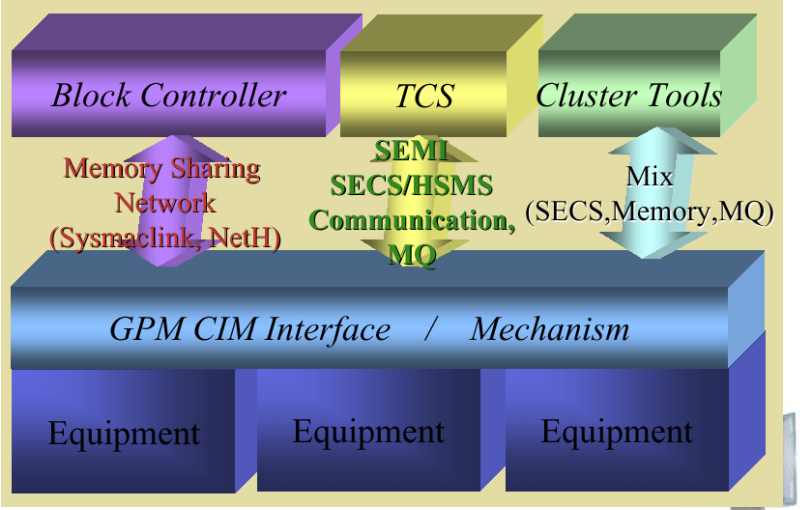
Technology trends

- High speed (High throughput).
  - Multi-CCD cameras.
  - Multi-CPU processing.
  - IEEE1394, DSP, etc.
  - Dedicated defect inspection algorithm.
- High accuracy (High sensitivity).
  - Using line CCD cameras.
  - Dedicated defect inspection algorithm.
- Intelligent software.

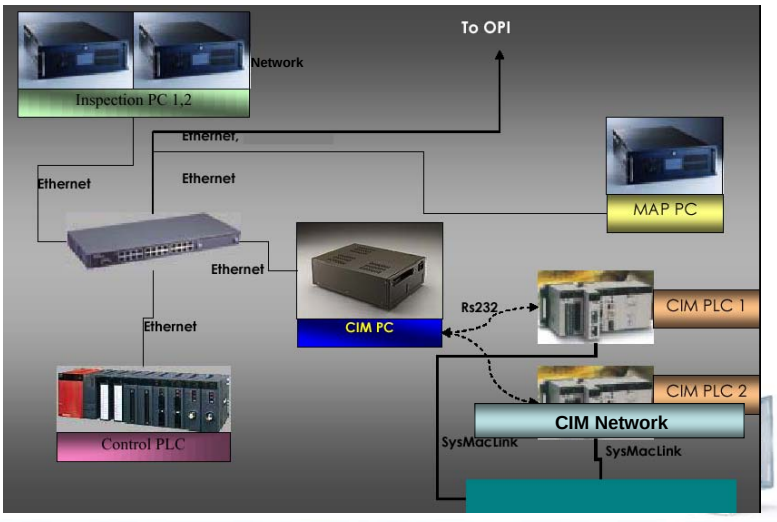
CIM Infrastructure Overview



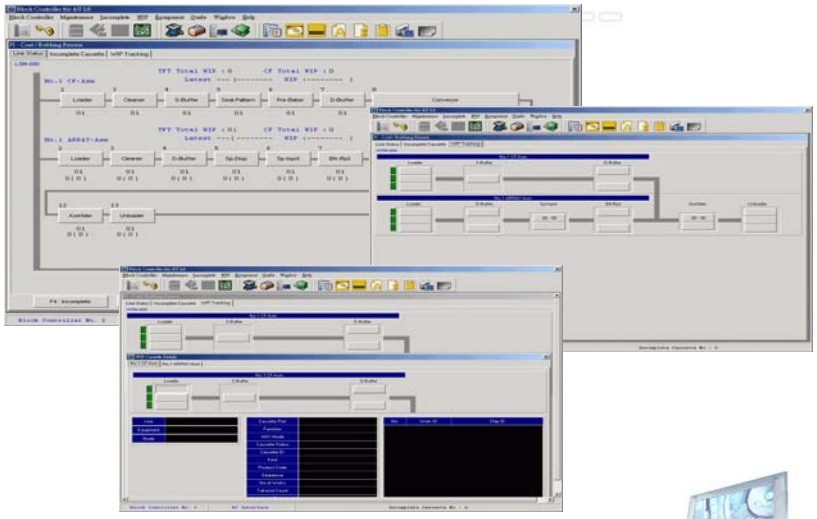
GPM Available Interface Protocol



Sample For Cell Cut Inspection



Block Controller for CIM



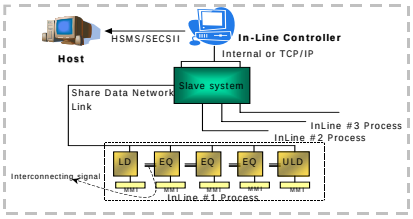
Block Controller for CIM

Function:

1. System Startup
1.1 To start all necessary processes / programs for Block /Controller working
1.2 System shutdown

2. Equipment Working Managements
2.1 Port status management
2.2 Port status / recipe / error/ alarm report
2.3 Process data report

3. In-Line WIP Management
3.1 WIP management
Lot start / complete management
Lot start / end management



Product management
3.2 Message Output
3.3 Host Communication
4. GUI Functions
4.1 Instruction
4.2 Line Monitor
4.3 WIP Monitor
4.4 WIP Management
4.5 EQP Monitor

5. Client Communication Functions
To communicate with slave system

6. Host Report Function
To communicate with Host

7. Log View / Record
7.1 Log View / Record Types
- *Events*
- *Trace*
- *SECS transactions & Events*
- *Alarm*
- *Warning*

國內檢測設備的發展與機會

機會	威脅
1. 預期台灣LCD設備投資額將持續成長 2. 台灣LCD面板廠商面臨成本競爭壓力，尋求設備本土化 3. 台灣LCD面板廠商有意降低對進口設備倚賴，尋求Second Source 4. 國外設備業者有意來台尋求合作伙伴	1. LCD設備世代交替速度快，產品生命週期短 2. 韓國設備業者興起
優勢	**劣勢**
1. 製造成本較低 2. 相關協力體系完整 3. 維修服務速度快	1. 缺乏驗證 2. 精準度不符合LCD廠商需求 3. 可靠度低 4. 對製程掌握程度不足 5. 缺乏專業生產觀念，無法培植核心能力 6. 研發人力素質不高 7. 國內LCD設備業者多為中小企業，資源不足

國內投入LCD設備的策略

- LCD相關計畫
  - 電子所平面顯示器計畫專注於製程技術開發，機械所是執行設備技術研發，並協助電子所開發平面顯示器實驗生產設備及聘請電子所指導構裝設備研發。
- 與國內LCD廠商合作開發。
- 與國外設備廠商合作代工。
- 與國內研發單位共同研發，並且善用政府補助措施。
  - 配合電子所開發之新製程技術，研發新設備共同進入市場。
  - 工研院機械所研發玻璃切割與自動視覺檢測設備。
- 構裝及檢測設備是以精密機械為主，適合國內傳統機械業升級發展。

重要設備技術

- 精密機械定位技術
- 熱壓接合技術
- 視覺技術
- 伺服控制技術
- 自動化連線技術

LCD檢測設備產業是電機、機械、光學、軟體設計等技術的系統整合，是資本、技術與人才緊密配合的產業。

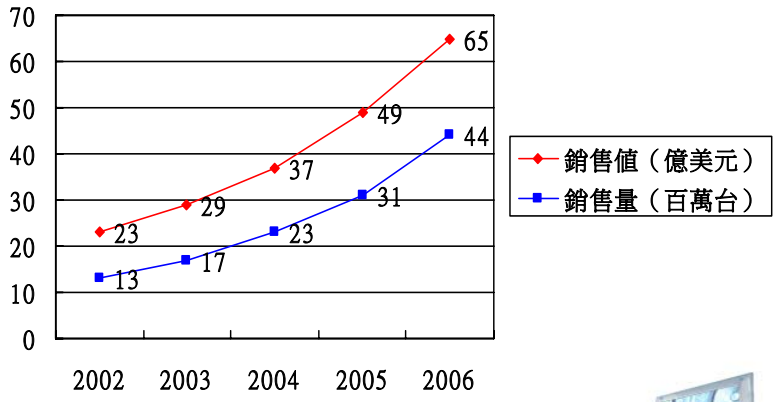
自動化光學檢測發展趨勢
(Automated Optical Inspection, AOI)

AOI定義（狹義）

狹義的AOI設備為目前急需於工業上使用的，如:

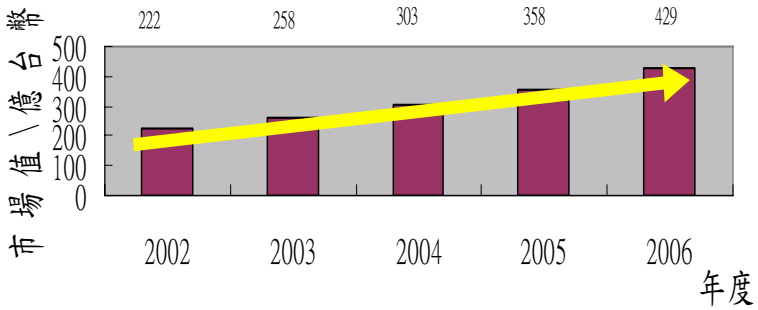
- IC及一般電子業：PCB、BGA、LCD螢幕、被動元件形狀腳位及定位、生產插件、晶元(Wafer)鏡面研磨、生產組裝、被動元件辨識
- MEMS 元件
- 機械工具/自動化機械：零件尺寸、外形、瑕疵檢測、零件分類比對、裝配定位、加工定位、熔焊檢測
- 電機工業：控制器紅外線熱像儀檢測、電線瑕疵、裂縫檢測、纜線配置檢測
- 金屬鋼鐵業：鋼板尺寸檢測、表面瑕疵檢測、鑄件瑕疵檢測、材料金像檢測
- 橡膠/塑膠製品：保特瓶口尺寸檢測、製品顏色分類檢測
- 食品加工/包裝業：瓶內液位高度、異物或灰塵檢測、包裝印刷辨識、打印字形及零件編號檢測與識別
- 紡織皮革工業：表面針織紋路檢測、色差檢測、皮革表面特性檢測
- 汽車工業：陶軸裁切定位、零件塗黃油檢測、白車身檢驗
- 家電/辦公：產品外殼印刷檢測、1維/2維條碼辨識
- 保全/監視系統：人像特徵辨識、指紋辨識等

AOI全球需求市場預估



資料來源: 工研院IEK IT IS 2003.12

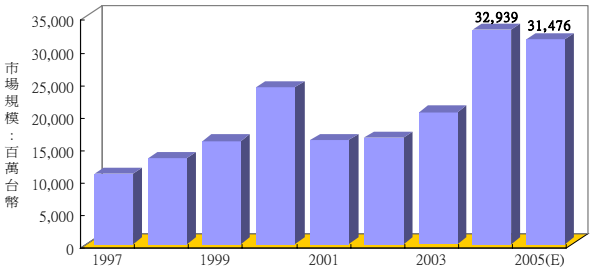
AOI國內需求市場預估



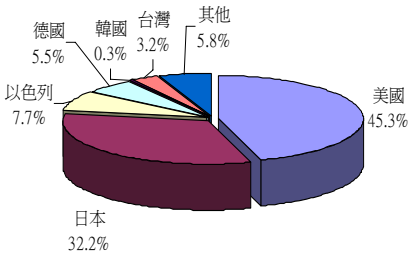
以國內現有AOI設備製造生產能力的廠商於2004年總產值不到40億元台幣，約有90%仍需進口

資料來源: 工研院IEK IT IS 2003.12

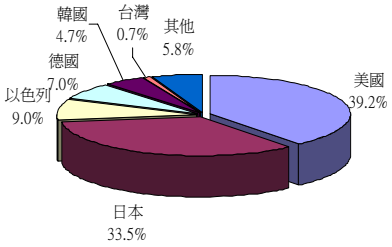
我國光學檢測設備市場規模



2002年

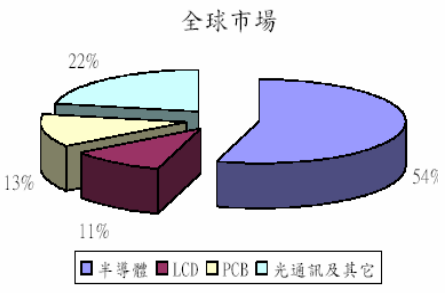


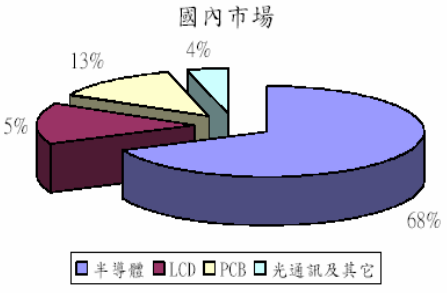
2004年



❑預估2005年我國由韓國進口設備將超過新台幣20億，佔總市場之6.4%

2006年AOI需求產業別



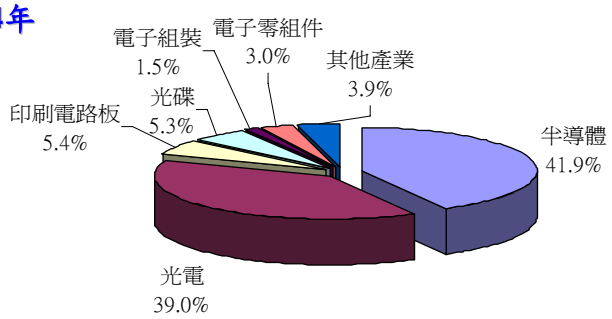


主要產業為: IC, LCD, PCB, 光通訊

資料來源: 工研院IEK IT IS 2003.12

我國光學檢測設備產業別市場

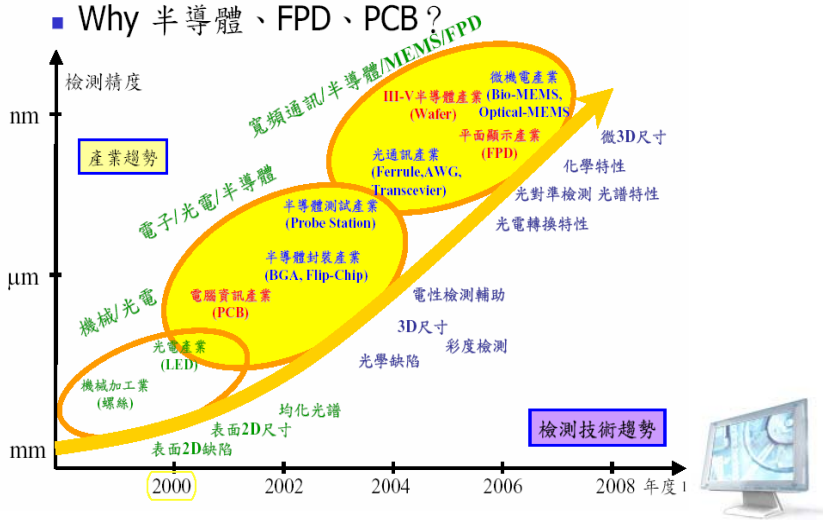
2004年

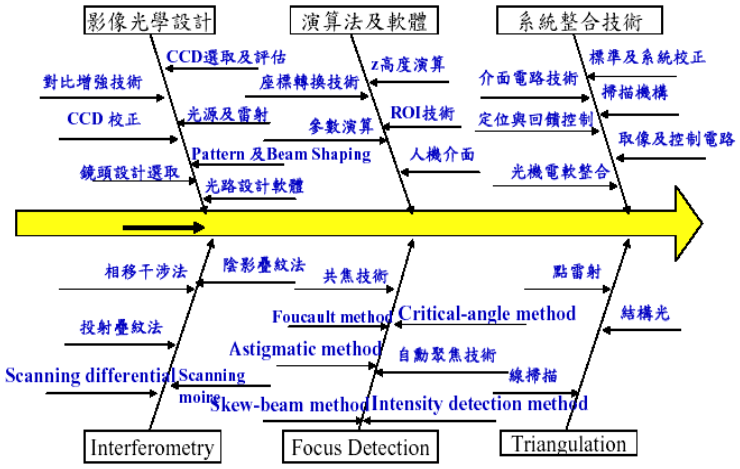


- 在2004年，我國光學檢測設備中，光電和半導體市場合計約佔整體光學檢測設備市場之80%
- 在2004年，我國半導體之光學檢測設備市場值約為新台幣138億元，我國光電業（FPD）之光學檢測設備市場值約為新台幣128.3億元

AOI產業技術發展趨勢

- Why 半導體、FPD、PCB？





其他:光譜法、螢光法、红外光法、X-ray、OCT、橢偏法、頻閃法等可做材質、斷層掃描及動態量測

AOI儀器系統組成

- 照明系統---光源選擇
- 取像系統---鏡頭、CCD(Line&Area)、影像擷取卡
- 機電控制系統---照明、取像曝光、定位平台
- 影像處理與分析—影像前處理、3D重建、圖形辨識(Pattern Recognition)、瑕疵分類、瑕疵驗證(Verification)
- 國內廠商技術---系統整合，缺自有軟體

AOI設備需增強功能(調查整理)

IC	對準度量測儀精度提升 ●晶圓厚度及粗超度量測 ●晶圓Back side AOI 晶圓Macro 缺陷檢視機靈敏度提昇 ●晶圓Outgoing inspection 植球檢查機 ● Bump 檢測能力, BGA 基板翹曲檢測
PCB/BGA	內外層線路檢查解析度到5/4.4 μm (未來要1/4 μm) 線漆上的瑕疵檢測, 彩色AVI, 3D 影像 靶孔校正, XY 偏位, 線路距離, 內外層檢驗, 快速!快速! 快速錫高檢查機, 銲錫點品質,表面標示
TFT/LCD	Autofocus, Layout區域檢查, 打光技巧, 缺陷辨識率到5 μm 貼偏光板前之PI scribing, ODF 檢測 檢出力提高(像素小灰階高) ● Tact time 要快(掃描速度, 多CCD, 快門速度) ● 拍照品質要好 ● Defect要能分類 Align Mark辨識率要高 Stage 定位精度要0.1 μm, Pin defect辨識率要高
光通訊產品	光纖主/被動元件封裝/組裝所需機台 ● 提高光耗損量測之準確度 光纖長度、連結器 、Ferrule 量測 (低價位機) 、WDM eccentricity量測

TFT/LCD 未來AOI檢測需求

1. **機台尺寸不能隨面板增大**
2. **功能複合化，可同時檢測 CD (critical dimension)及 OL (overlay) 偏移**
3. **檢測速度要快**
4. **Pad inspection function (不只是TFT, 連旁邊的電路都要檢測)**
5. **機台穩定度要高**
6. **鏡頭的穩定度要高**
7. **VCR功能 (自動判讀玻璃的Data code)**
8. **MURA 檢出(在簡測中順便看Mura不同灰階值)**
9. **定點拍照 (可設定不同倍率)**
10. **瑕疵分類演算法則(現有均為肉眼分類)**

AOI的核心技術

AOI基本程式庫開發，國內大部分的AOI設備開發廠商均是採購各硬軟體做系統整合的方式，少部份近年來已逐漸可自行發展AOI軟體，但仍有廣大的發展空間。(eg. Mill, WIT)

國產化雙軸移動機台，國內的AOI製造廠幾乎都少用國產元件來組裝各軸之精密定位平台，故研發國內可共用的XY精密定位機台技術亦為急需發展的核心技術、功能需達：定位精度3μm, 重覆性±2μm

光源分析軟體與打光技術，光源種類繁多(如各不同波長光、不同種類燈管)，何種檢測需配何種光源？所選光源須從何角度投入？這些問題都須有一分析及模擬軟體來事先評估 。

(new) 高速影像運算之晶片 ，將可協助AOI系統發展效率之大幅提升。

簡報結束

謝謝指教