

TFT-LCD Panel AOI and Repair Equipment Technology and Market Analysis

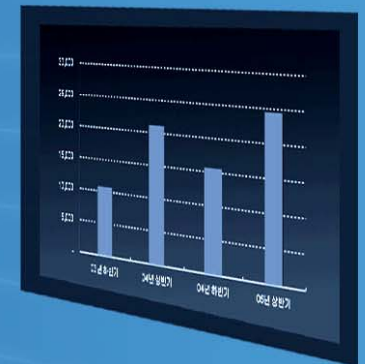
(Comparison of Repair Technologies, Analysis of COO, and Market Shares of AOI

and Repair Equipment)

SAMPLE

This sample is designed to help understand the composition of the report and the type of description.

May 2008



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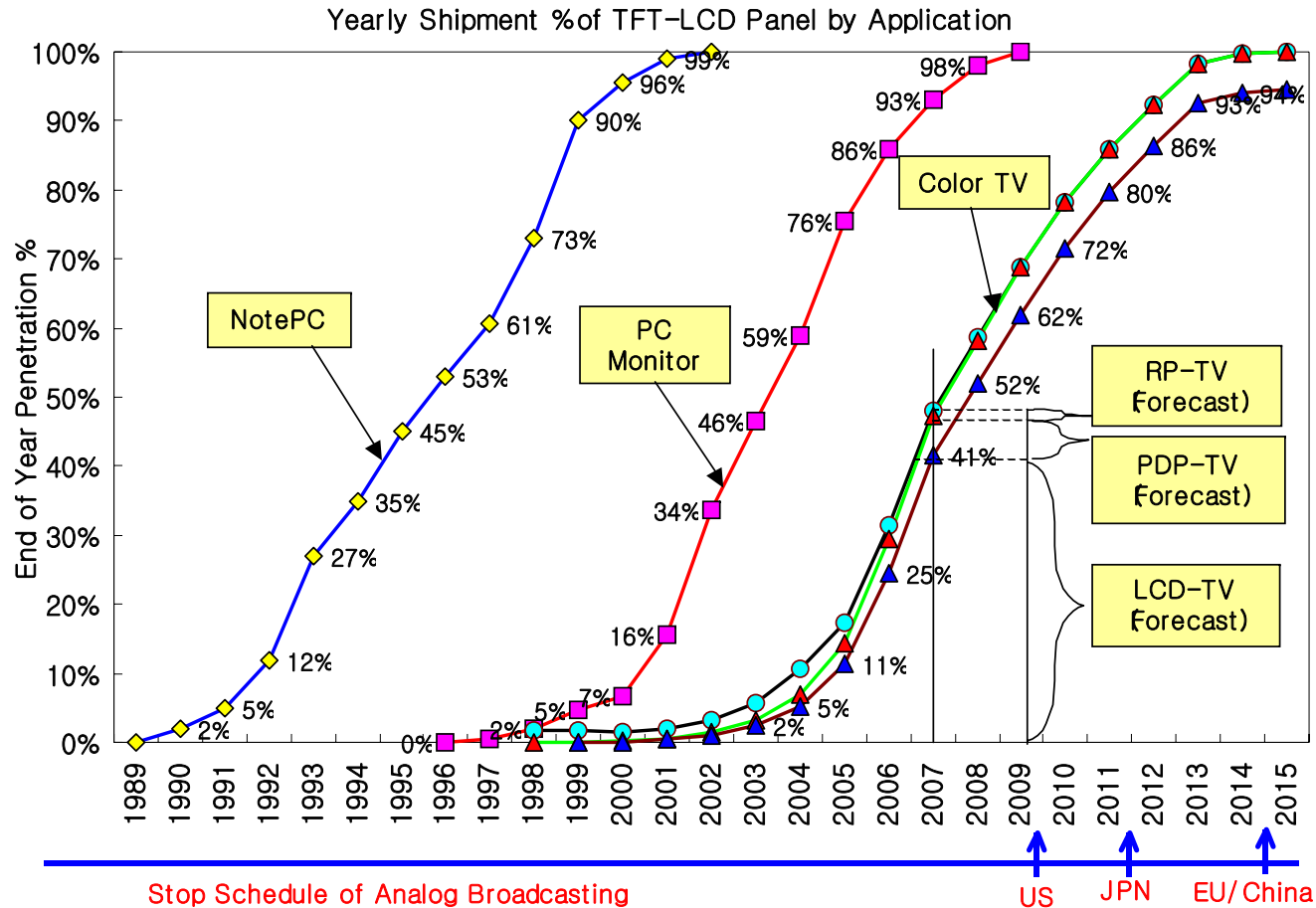
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1. Introduction

[Figure 1-1] Yearly Shipment % of TFT-LCD Panel by Major Application



The three major TFT-LCD panel markets are laptop computers, PC monitors, and large screen color TV sets. TFT-LCD panel for laptop computer application first appeared in 1989 and, after fourteen years by 2002, 100% of laptop computer units shipped featured TFT-LCD panels. First TFT-LCD panel for PC monitor application was introduced in 1996 and, similar to laptop computers, 100% of PC monitors shipped will be TFT-LCD panel based by 2009. Lastly, TFT-LCD panels were first featured in large color TV sets in 1999. Also like the two aforementioned products, complete conversion into TFT-LCD panels is being realized at a blistering rate in large color TV sets as well.

This fast-paced transition served as the main impetus behind increased TFT-LCD panel performance and continuing decline in panel prices. In the LCD industry, strategic and consistent capital investment determines the survival of panel makers. While capital investment is rooted in economic conditions, demand on the other hand increases in a linear manner. Because of this, a unique supply and demand relationship known as the crystal cycle emerged in the LCD panel market. Under this relationship, excessive supply results in plummeting panel prices and severely affects the profit margins of panel makers. In addition, stagnant economic conditions force panel makers to strive to maintain the operating rates of their new, large scale production lines that would otherwise depreciate immensely. This consequently results in panel makers offering at attractive prices larger panels whose yield is greater from their new production lines. Set makers in turn wait for vitalization of the market and quickly manufacture new products featuring such large panels. They then focus heavily on promotional activities, causing the excessive supply to be surpassed by demand in about a year's time. Crystal cycle repeated over and over and increased TFT-LCD panel sizes from 7" back in 1990 to today's 70" and beyond.

In addition, TFT-LCD panel's range of application has drastically expanded from laptop computers only in 1990 to now include large screen television sets as well. Meanwhile, lowering the cost of TFT-LCD panels relies critically on high production yield. However, increasing panel sizes means proportionate increase in number of defects and consequently diminishing production yield. It's possible for general manufacturers to increase their yields by streamlining the production

lines, but TFT-LCD panel manufacturing involves rapid generational conversions and streamlining the production lines alone cannot achieve increased yield. For these reasons, the TFT-LCD panel manufacturing industry has long relied on the help of repair technologies. Generally, TFT-LCD panel's defect modes include two types: short defects involving connected sections that should not be connected and open defects involving disconnected sections that should be connected. There is an overwhelmingly greater number of short defects than there are open defects in TFT-LCD panels. In 20" grade PC monitor panels, it was possible to maintain a high level of production yield by implementing zapping (laser cutting) against short defects. However, it was not possible to avoid decline in production yield with short defect repairs alone in 28" or above LCD TVs, and the importance of open defect repair became ever so greater. In response to such need, in 2002 Omron Laserfront (formerly known as Laser Front, a spin-off of NEC) became the first company to introduce open defect repair devices for application in G5 production lines. Korean panel makers that adopted this new repair device saw increased yield, and open defect repair devices were included in production lines of all panel makers since G6 lines (1500mm x 1800mm) and on. Meanwhile, LCD TV production kicked into high gear in color filters as well, resulting in addition of wide viewing angle and photo spacer processes to the conventional 4-stage photo process and subsequently an increase in number of defects. These developments in turn made demand for repair devices skyrocket. As depicted in Figure 1-2, repair device market scales by individual generations have shown amazing growths that surpass even glass size growth.

This report deals with the subject of TFT-LCD TVs and therefore focuses of G6 through G8.5 production lines. Highlights of this report include:

- ① Inspection and repair device roles at each processing stage
- ② Comparison of latest repair technologies
- ③ Repair device COO by generation

- ④ Repair device market's investment models by generation
- ⑤ Technological innovations in inspection and repair devices by generation
- ⑥ Fluctuations in inspection and repair device output, average price, etc. by generation
- ⑦ Introduction to inspection and repair devices by manufacturer
- ⑧ Inspection and repair device market shares by generation and region

As such, this report comprises of in-depth and never before seen information. Therefore, the report will prove to be beneficial and informative to members of the inspection and repair device industry and those who wish to learn more about the LCD industry.

- Omitted -

3. Technology Comparison of Various Repair Systems

3.1. Technology Comparison of Open Defects Repair Systems

- Omitted -

<Table 3-1> Technology Comparison of Open Defects Repair Systems

Vendor Name	Omron Laserfront			Charm&Ci			Omron Laserfront			V-Technology			MJC			Hitachi		
Model	6G	7G	8G	6G	7G	8G	6G	7G	8G	6G	7G	8G	6G	7G	8G	6G	7G	8G
Equip. Price (M\$)																		
Average Repair Time / Defect (sec)																		
Type of Repair																		
Technology																		
Materials																		
Material Cost																		
Resistively ($\mu\Omega$.cm)																		

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TFT-LCD AOI and Repair Equipment Technology and Market Analysis

Curing Technology						
Minimum Line Width						
Advantage						
Disadvantage						
Vendor's Nationality						
Major Customer						

Note: UHA(Ultra High Aperture), PFA (Polymer Film on Array) as Organic Passivation Structure

3.2. Technology Comparison of Grind Repair Systems for Color Filter

- Omitted -

<Table 3-2> Technology Comparison of Grind Repair System for Color Filter

Vendor Name	V-Technology			Lasertec		
Model	6G	7G	8G	6G	7G	8G
Price (M\$)						
Average Repair Time / Defect (sec)						
Type of Repair	<div style="border: 2px solid orange; padding: 10px;"> <p style="font-size: 48px; margin: 0;">SAMPLE</p> <p style="font-size: 18px; margin: 0;">This sample is designed to help understand the composition of the report and the type of description.</p> </div>					
Technology						
Advantage						
Disadvantage						
Vendor's Nationality						
Major Customer						

3.3. Technology Comparison of Ink Repair Systems for Color Filter

- Omitted -

<Table 3-3> Technology Comparison of Ink Repair Systems for Color Filter

Vendor Name	V-Technology			Lasertec			NTN		
Model	6G	7G	8G	6G	7G	8G	6G	7G	8G
Price (M\$)									
Repair Time / Defect (sec)									
Type of Repair									
Technology									
Materials									
Material Cost									
Curing Technology									
Minimum Dot Size									
Advantage									
Disadvantage									
Vendor's Nationality									
Major Customer									

- Omitted -

8. Cost of Ownership (COO) Analysis

8.1. G5.5 TFT-LCD Panel

2008 G5.5 (1100mm x 1300mm) 32" wide HD panel production of company A, under glass input of 120K/Mo.

8.1.1. TFT-LCD Array Panel

8.1.1.1. Assumption

<Table 8-1> Assumption for G5.5 TFT-LCD Array Repair COO Analysis

Glass Size		(mmxmm)
Production Panel		
Glass sheet / Month		sheets/Mo
Numbers of 32" Panel for 5.5G		Panels/5.5G
Array Yields with Repair		
Cell Yields		
Module Yields		
TFT Array Total Yields		
Total 32" Yielded Panels/Year		Panels/Yr

8.1.1.2. Fixed Cost

<Table 8-2> Fixed Cost for G5.5 TFT-LCD Array Repair COO Analysis

ASP @G5.5 of Open Defects Repair System		\$
Numbers of Open Defects Repair System		Units
Total Open Repair System Costs		\$
ASP @G5.5 of Short Repair System		\$
Numbers of Short Repair		Units
Total Short Repair Costs		\$
Total Repair System Costs for TFT Array		\$

Total Building Cost of TFT Array Fab		\$
Total Footprint of TFT Array Equipments		m2
Total Footprint of TFT Array Repair Systems		m2
TFT Array Repair System Ratio of Total TFT Array Footprint		%
Total Building Costs of TFT Array Repair System		\$

SAMPLE

This sample is designed to help understand the composition of the report and the type of description.

Total Facility Cost of TFT Array Fab		\$
Total Footprint of TFT Array Equipments		m2
Total Footprint of TFT Array Repair Systems		m2
TFT Array Repair System Ratio of Total TFT Array Footprint		%
Total Facility Costs of TFT Array Repair System		\$

Total Indirect labors of TFT Array Fab		People
Yearly Indirect Labor Cost Per Person in Korea		\$/Yr
Total Yearly Indirect Labor Cost of TFT Array Fab		\$/Yr
Total Number of Equipment of TFT Array Fab		Units
Total Number of Repair Equipment of TFT Array Fab		Units
Repair System Equipment Ratio of Total TFT Equipment		%
Total Yearly Repair Indirect Labor Cost of TFT Array Fab		\$/Yr

Fixed Cost of Repair for TFT Array	Depreciation Year	
Repair Equipment Cost of TFT Array Fab		\$ @32"Panel
Repair Building Cost of TFT Array Fab		\$ @32"Panel
Repair Clean room Cost of TFT Fab		\$ @32"Panel
Repair Indirect labor Cost of TFT Array Fab	NA	\$ @32"Panel
Total Repair Fixed Cost of TFT Array Fab	NA	\$ @32"Panel

8.1.1.3. Variable Cost

<Table 8-3> Variable Cost for G5.5 TFT-LCD Array Repair COO Analysis

Total Number of Repair Equipment of TFT Array Fab		Units
Number of Operator Per System (w/ 3-shifts)		Person
Yearly Direct Labor Cost Per Person in Korea		\$/Yr
Total Yearly Direct Labor Cost of TFT Array Fab		\$/Yr

Estimation of W (CO)6 Laser CVD Gas Cost		
CVD Gas Cost of TFT Array of 32"Panel		\$ @32"Panel
W (CO)6 Gas Cost is about 1% of CVD Cost		\$ @32"Panel

Variable Costs of TFT Array Fab		
Repair Direct Labor Cost of TFT Array Fab		\$ @32"Panel
W (CO)6 Gas Cost of TFT Array Fab		\$ @32"Panel
Total Repair Variable Cost of TFT Array Fab		\$ @32"Panel

8.1.2. Color Filter

8.1.2.1. Assumption

SAMPLE

<Table 8-4> Assumption for G5.5 Color Filter Repair COO Analysis

This sample is designed to help understand the composition of the report and the type of description.

Glass Size		(mmxmm)
Production Panel		
Glass sheet / Month		sheets/Mo
Numbers of 32" Panel for 5.5G		
Color Filter Total Yields		
Total 32" Yielded Panels/Year		Panels/Yr

8.1.2.2. Fixed Cost

<Table 8-5> Fixed Cost for G5.5 Color Filter Repair COO Analysis

ASP @G5.5 of Grind Repair System		\$
Number of Grind Repair System		Units
Total Grind Repair System Costs		\$
ASP @G5.5 of Ink Repair System		\$
Number of Ink Repair System		Units
Total Ink Repair System Costs		\$
Total Repair System Costs for Color Filter		\$

Total Building Cost of Color Filter Fab		\$
Total Footprint of Color Filter Equipments		m2
Total Footprint of Color Filter Repair Systems		m2
TFT Color Filter Repair System Ratio of Total Color Filter Footprint		%
Total Building Costs of Color Filter Repair System		\$

Total Facility Cost of Color Filter Fab		\$
Total Footprint of Color Filter Equipments		m2
Total Footprint of Color Filter Repair Systems		m2
Color Filter Repair System Ratio of Total Color Filter Footprint		%
Total Facility Costs of Color Filter Repair System		\$

Total Indirect labors of Color Filter Fab		People
Yearly Indirect Labor Cost Per Person in Korea		\$/Yr
Total Yearly Indirect Labor Cost of Color Filter Fab		\$/Yr
Total Number of Equipment of Color Filter Fab		Units
Total Number of Repair Equipment of Color Filter Fab		Units
Repair System Equipment Ratio of Total TFT Equipment		%
Total Yearly Repair Indirect Labor Cost of Color Filter Fab		\$/Yr

Fixed Cost of Repair for Color Filter	Depreciation Year	
Repair Equipment Cost of Color Filter Fab	5	\$ @32"Panel
Repair Building Cost of Color Filter Fab	15	\$ @32"Panel
Repair Clean room Cost of TFT Fab	n	\$ @32"Panel
Repair Indirect labor Cost of Color Filter Fab	A	\$ @32"Panel
Total Repair Fixed Cost of Color Filter Fab	NA	\$ @32"Panel

SAMPLE

This sample is designed to help understand the composition of the report and the type of description.

8.1.2.3. Variable Cost

<Table 8-6> Variable Cost for G5.5 Color Filter Repair COO Analysis

Total Number of Repair Equipment of Color Filter Fab		Units
Number of Operator Per System (w/ 3-shifts)		Person
Yearly Direct Labor Cost Per Person in Korea		\$/Yr
Total Yearly Direct Labor Cost of Color Filter Fab		\$/Yr

Grind Repair TACT of Color Filter Fab		sec/Repair
Grind Repair Throughput of Color Filter Fab		Repairs/Hr
Grind Repair Monthly Up-time		hour/Mo
Total Number of Grind Repairs Per System/Yr		Repairs/Yr
Total number of Grind Repair Equipments		Units
Total Number of Grind Repairs/Yr of Color Filter Fab		Repairs/Yr
Tape Cost / Repair (10Yen)		\$/Repair
Total Tape Cost /Year of Color Filter Fab		\$/Year
Tape Cost of Grind Repair System of Color Filter Fab		\$ @32"Panel

Ink Repair TACT of Color Filter Fab		sec/Repair
Ink Repair Throughput of Color Filter Fab		Repairs/Hr
Ink Repair Monthly Up-time		hour/Mo
Total Number of Ink Repairs Per System/Yr		Repairs/Yr
Total number of Ink Repair Equipments		Units
Total Number of Ink Repairs/Yr of Color Filter Fab		Repairs/Yr
Ink Cost / Repair (0.2MYen/2M Ink @ Cartridge)		\$/Repair
Total Ink Cost /Year of Color Filter Fab		\$/Year
Ink Cost of Ink Repair System of Color Filter Fab		\$ @32"Panel

Life Time of Yag Laser Excitation Lamp (ink Repair)		Shot
Total Number of Ink Repairs/Yr of Color Filter Fab		Repairs/Yr

Required Excitation Lamp Units/Year		\$/Year
Excitation Lamp for Yag Laser (130,000Yen)		\$/Lamp
Total Excitation Lamp Cost/Year		\$/Year
Yag Laser Running Cost per Color Filter Panel (ink Repair)		\$ @32"Panel

Variable Costs of Color Filter Fab		
Direct Labor Cost		\$ @32"Panel
Grind Repair Cost		\$ @32"Panel
Ink Repair Cost		
Total Repair Variable Cost of Color Filter Fab		\$ @32"Panel

8.1.3. TFT-LCD Panel Cost Summary

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This sample is designed to help understand the composition of the report and the type of description.
<Table 8-7> Cost Summary for G5.5 TFT-LCD Panel Repair COO Analysis

Repair Cost of TFT-LCD Panel in 2008		
Fixed Costs of TFT Array Repair		\$ @32"Panel
Fixed Costs of Color Filter Repair		\$ @32"Panel
Total Fixed Costs of TFT-LCD Panel Repair		\$ @32"Panel
Variable Costs of TFT Array Repair		\$ @32"Panel
Variable Costs of Color Filter Repair		\$ @32"Panel
Total Variable Cost of TFT-LCD Repair		\$ @32"Panel

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Total Repair Cost of TFT-LCD Panel		\$ @32"Panel
TFT-LCD Panel Manufacturing Cost in 2008		\$ @32"Panel
Repair Cost % of TFT-LCD Panel		

- Omitted -

13. Technology Transition by New Generation

13.1. ADI Technology Transition by New Generation

<Table 13-1> ADI Technology Transition by New Generation

Generation		5.0	6.0	7.0	7.5	8.0	8.5	10.0
Glass Size (mmxmm)		1000x1200	1500x1800	1870x2200	1950x2250	2160x2460	2200x2500	2880x3080
Maker & Fab		LPL P4	Sharp K1	SEC T7-1	LPL P7	Sharp K2	SEC T8-1	Sharp S-1
Move-in Year (First Phase)		2001	2003	2004	2005	2006	2007	2008
1st Vendor/Model		Olympus AM1500	Olympus AM2600	Orbotech InVision-7050	Orbotech InVision-70xx	Olympus AM3800	Orbotech InVision-8080	?
2nd Vendor/Model		V-Tech		Nex Ins m 1500	LG PRC			
Equipment Size WxDxH (m)		NA	4.5x2.5x2.6	3.3x3.7x2.2	3.1x3.8x2.6	7.0x4.0x4.5	3.2x9.0x3.2	
Throughput (Sub./Hr)		60	60	60	60	60	50	
ASP (M\$)		1.0	1.2	1.4	1.6	1.7	1.8	
Technology Improvements (Orbotech)	Integrated with Exposure System	Stand-Alone	In-Line	In-Line	In-Line	In-Line	In-Line	In-Line
	Tact Time	Increasing cameras are keeping the same Tact Time for larger Glass						
	Footprint		Camera Sensor is moving Y direction then Table is moving X direction					
	Accuracy Improvement			Air-levitation table is adopted to reduce				

This sample is designed to help understand the composition of the report and the type of description.

				substrate vibration which was not taken the clear images by CCD camera.				
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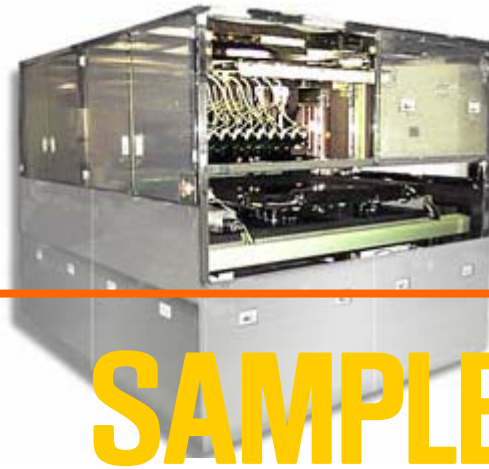
13.1.1. ADI Vendors by New Generation

Sharp's Kameyama 6G (1,500mmX1,800mm) line has become the first company to have opted for total inspection in its in-line type ADI, which has fueled growth in the ADI equipment market. Sharp's Kameyama line incorporates equipment not from the industry's top player Orbotech but from Olympus, which has experiences in macro inspection for Sharp. Since ADI features lower resolutions than AEI's, the price is lower. Nevertheless, the strong pressure on pricing has driven Orbotech through slow responses to lose orders to Olympus. However, Samsung Electronics has placed a large volume of orders for ADI equipment with Orbotech, for equipment which will be used at Samsung's 7G (1,870mmX2,200mm) T7 line. The T7 line has employed equipment from Korea's NI (Next Instrument) as well, but this seems to be a stand-alone type. Meanwhile, LPL has procured equipment for its 7G (1,950mm x 2,250mm) line from Orbotech and LG-PRC, but the total inspection equipment is a stand-alone type. This adoption reflects its intention to solve the problem with IPS-based high viewing angle technology, in which the structure of electrons is complex, making inspection accuracy unstable when it is integrated into an in-line system. As it does at its 6G line, Sharp employs a total in-line inspection type at its Kameyama 8G (2,160mm x 2,460mm) line, and has procured all products from Olympus during its first phase investment and partially from Orbotech during the second phase investment. Samsung Electronics' 8.5G (2,200mm x 2,500mm) T8-1 line is wholly using Orbotech's in-line ADI equipment. For TV LCD panels, a wide viewing angle and a high contrast ratio are critical factors, therefore the pattern of pixels has become more complicated every year. Moreover, future challenges for ADI equipment are to achieve a higher resolution, maintain the tact time and respond to the trend to larger substrates.

- Omitted -

13.1.3. V-Technology ADI

[Figure 13-2] V-Technology G5.0 ADI System (Capricon)



SAMPLE

This sample is designed to help understand the composition of the report and the type of description.

13.1.3.1. Tac Time Improvement

The line CCD camera having high disassembling capabilities obtained by V-Technology ADI equipment boasts high speed processing of (10,000 Lines/Sec). By controlling the difference in wide viewing angles with the camera, lenses with a high resolution are combined, enabling the company to enjoy a high defect detection rate of high precision LCD patterns at a high-speed tact time. Through the readers' image processing board and image PC, the image board is compared with the camera, and a parallel comparison is analysed. With the increasing number of cameras alongside the upsizing of substrates, companies can avoid much more image data processing

time and have a wide range of defect sorting functionalities.

13.1.3.2. Unique Lens Will Fit for Various Resolution

V-Technology's proprietary lens meets requirements from users (by process and required defect) and a topical choice of diverse sorting capabilities (ratio) is available. Moreover, close adhesion of camera housing in a row also offers realization of one-step scan inspection with high disassembly capabilities meeting the required tact time.

13.1.3.3. Adopted Unique Optical Design

With respect to light source, which is important for optical inspection, the luminance mura is reduced by adopting randomly-mixed glass fibers, which can also light the overall range uniformly. The light source itself has been halogen lighting, specifically metal halide light source. The light source color can be changed by CF's RGB luminance adjustment inspection formulas, and the equipment is designed to respond to all color balances. Moreover, the equipment is also embedded with a lamp feedback system as a basic installation, which controls light to the initial setup of formula luminance automatically by perceiving degradations to lamp lifetime as time goes by, and deteriorations in intensity of radiation due to lamp degradation (lifetime).

13.1.3.4. Yields Management System

In addition, some of the images can be captured during the substrate inspection, allowing reading of an alignment mark and correction of defect indexes.

- Omitted -

End of Report Sample