FROM MATERIALS TO MODULE ASSEMBLY: APPLICATIONS OF AUTOMATED VISUAL INSPECTION IN THE FPD SUPPLY CHAIN

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APPLICATIONS ENGINEERING MANAGER

As Radiant’s Applications Engineering Manager, Eric Eisenberg has developed solutions to help display manufacturers and their upstream suppliers ensure quality and improve efficiencies in their process. With extensive hands-on experience incorporating imaging technology into production facilities worldwide, he has a deep understanding of the technical considerations required for a successful implementation.

Prior to joining Radiant, he held Optical Engineering roles at Lockheed Martin and Terabeam. He is the owner of multiple patents and has a BS in Laser and Optical Engineering from the Oregon Institute of Technology.
• Automated visual inspection (AVI) for display devices
• The flat panel display (FPD) manufacture process
• Applications for AVI in the upstream supply chain
• Summary
• Q&A
AUTOMATED VISUAL INSPECTION
Display quality requirements are constantly increasing driving the need for repeatable and accurate automated vision inspection systems.

Automated Visual Inspection System

Sophisticated cameras autonomously scan a screen under inspection for a variety of defects including pixel, blob, illumination, edge, and color defects
BENEFITS OF IMAGING COLORIMETER

• Designed specifically to reproduce the average response of the human eye
• High dynamic range and very low noise reduces systematic errors
• Built in calibrations for luminance and color
• Extremely high repeatability
• Flexible lens options for various fields of view and working distances
• Multiple resolution options up to 29MP
• Intuitive software interface for analysis and simple interface for production
• Fully programmable interface and analysis options
• World class service and support, worldwide
# TYPICAL AVI SYSTEM COMPONENTS

<table>
<thead>
<tr>
<th>Imaging Colorimeter / Photometer</th>
<th>Software</th>
<th>PC</th>
<th>Fixture</th>
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<tbody>
<tr>
<td><img src="image1.png" alt="Imaging Colorimeter / Photometer" /></td>
<td><img src="image2.png" alt="Software" /></td>
<td><img src="image3.png" alt="PC" /></td>
<td><img src="image4.png" alt="Fixture" /></td>
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- Pin-points and quantifies quality issues and defects
- Allows pass/fail determinations to be automated against a consistent standard
COMPREHENSIVE TESTING

Uniformity testing

Defect detection

Mura detection and JND evaluation
**BENEFITS IN FINAL ASSEMBLY:**
- Improved Product Quality & Brand Perception
- Fewer Returns
- Decreased Labor Costs

**BENEFITS IN UPSTREAM MANUFACTURING:**
- Reduced Scrap
- Defect Trend Tracking for Countermeasures
- Decreased Labor Costs
APPLICATIONS FOR AUTOMATED VISUAL INSPECTION IN THE FPD SUPPLY CHAIN
THE FPD MANUFACTURE PROCESS

Backlight Unit Fabrication → Array Fabrication → Cell Assembly → Module Assembly → Final Assembly

- LED Assembly
- Film
- BLU
- TFT Array
- Glass
- Light Guide
- Cell
- LCM
- Assembled Device
- Glass
THE FPD MANUFACTURE PROCESS

- IQC - Incoming quality control
- OQC - Outgoing quality control

- Proactive and/or reactive testing
- At end of line and/or in-line

Backlight Unit Fabrication  Array Fabrication  Cell Assembly  Module Assembly  Final Assembly

LED Assembly  IQC  OQC  IQC

Light Guide  IQC  OQC

BLU  QQC  IQC

Film  IQC  OQC

TFT Array  OQC  IQC

Glass  IQC  OQC

Cell  IQC  OQC

LCM  IQC  OQC

Assembled Device  OQC

Glass  OQC
AUTOMATED VISUAL INSPECTION IN BLU FABRICATION

Backlight Unit Fabrication

- LED Assembly
- Film
- Glass
- TFT Array
- Cell
- LCM
- Assembled Device

Array Fabrication

Cell Assembly

Module Assembly

Final Assembly

• IQC - Incoming quality control
• OQC - Outgoing quality control
• Proactive and/or reactive testing
• At end of line and/or in-line

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BACKLIGHT UNIT TESTING

- LED Assembly & Light Guide
  - Uniformity
- Assembled BLUs
  - Uniformity
  - Light leakage
  - Particle & fiber detection
  - Scratches
BACKLIGHT UNIT TESTING - EXAMPLE

- **Common Issues:** Light Leakage, Uneven Colors (ie, Yellow Mura).

- **Solution:** Defect detection with TrueTest™ Uniformity Tests & ProMetric I16 Imaging Colorimeter.

- **AVI Benefits:** finding defects on the BLU rather than the display significantly reduces rework costs.
AUTOMATED VISUAL INSPECTION OF RAW MATERIALS

- IQC - Incoming quality control
- OQC - Outgoing quality control
- Proactive and/or reactive testing
- At end of line and/or in-line
GLASS & FILM INSPECTION

- Particles
- Mura
- Cracks
GLASS & FILM INSPECTION - EXAMPLE

• **Common Issues:** Particles, mura, & cracks can impact the quality of displays assembled with these components.

• **Solution:** Inspection with TrueTest™ *Particle Defects* Test and ProMetric® Y Series Photometer and external lighting. Color imaging is not required.

• **AVI Benefits:** Improve the quality of the final display by ensuring its components meet objective standards. Reduce rework costs by identifying problems early in the process.
AUTOMATED VISUAL INSPECTION IN THE FPD MANUFACTURE PROCESS – DEFECT DETECTION AT CELL ASSEMBLY

- IQC - Incoming quality control
- OQC - Outgoing quality control
- Proactive and/or reactive testing
- At end of line and/or in-line
CELL ASSEMBLY INSPECTION

• A Cell Inspection system is used in TFT LCD manufacturing to detect defects and to judge panel grade.

• Cell vs. Open Cell Assembly
  • Cell Inspection is more complex than Open Cell.
  • Cell does not have driver board on it; the inspection equipment is more expensive and complex.
DEFECT DETECTION AT CELL ASSEMBLY - EXAMPLE

• **Common Issues:** Takt time is critical for a cell inspection system. False defects on polarizers, BLU, and cell surfaces will introduce some overkill.

• **Solution:** Two I16 ProMetric® Imaging Colorimeters with TrueTEST™ software communicates with host, PG, and fixture.

• **AVI Benefits:** Cell quality is ensured as the assembly moves to the next step of the manufacture process. Some defects detected at this step can be repaired.
AUTOMATED VISUAL INSPECTION IN THE FPD MANUFACTURE PROCESS – MURA DETECTION AT MODULE ASSEMBLY

- IQC - Incoming quality control
- OQC - Outgoing quality control

Proactive and/or reactive testing
At end of line and/or in-line
MURA DETECTION AT MODULE ASSEMBLY

- Mura Defects
  - Color Mura
  - Polarizer Deformation
  - Black Mura
  - Blob Analysis
MURA DETECTION AT MODULE ASSEMBLY - EXAMPLE

- **Common Issues:** Mura is common defect on a display; its subtle nature is difficult to detect so high end imaging colorimeters are required.

- **Solution:** A ProMetric I16 or Y16 with TrueTest™; TrueMURA algorithm detects blobs and mura. Each is scored with a JND value.

- **AVI Benefits:** Cell quality is ensured as the assembly moves to the next step of the manufacture process. Some defects detected at this step can be repaired.
AUTOMATED VISUAL INSPECTION IN THE FPD MANUFACTURE PROCESS – FINAL ASSEMBLY

- IQC - Incoming quality control
- OQC - Outgoing quality control
- Proactive and/or reactive testing
- At end of line and/or in-line

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IN SUMMARY

• Applications for automated visual inspection in the FPD supply chain
  • BLU Testing
  • Inspection of Raw Materials
    • Film
    • Glass
  • Assembly Testing
    • Cell
    • Open Cell
    • Module Assembly
  • Final Assembly QA
Implemented at key points of the display manufacture process, imaging colorimetry based systems ensure quality, improve process efficiency, and reduce costs for both brand owners and their suppliers.
THANK YOU!

If you have questions regarding this topic or presentation, please contact us at Info@RadiantVS.com