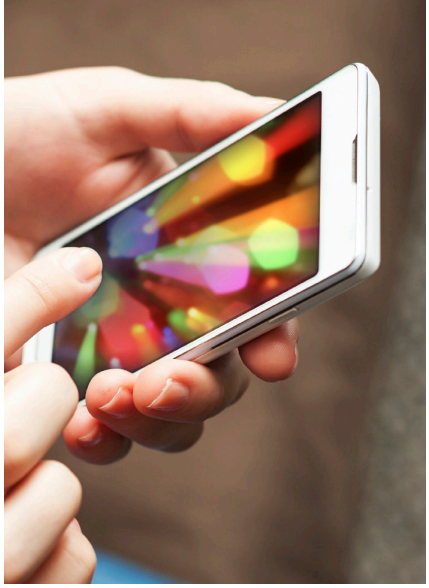
RADIANT
VISION SYSTEMS



TECHNICAL NOTE:

Automated Visual Inspection and Correction (Demura) of OLED Displays

The Radiant Vision Systems solution for OLED inspection and correction helps manufacturers of OLED devices improve product quality and yield. A ProMetric® imaging colorimeter or photometer provides the high optical resolution necessary to measure OLED displays on the pixel and subpixel level. With TrueTest™ analysis software, these measurements can be used to correct individual display pixels. This process, referred to as "demura," adjusts the luminance and/or chromaticity of each OLED pixel to produce displays with an entirely uniform appearance.

Automated Visual Inspection

For automated visual inspection of OLED displays, Radiant leverages its ProMetric I-series (color applications) or ProMetric Y-series (luminance-only applications) imaging systems, which feature the broad dynamic range and high resolution required for OLED inspection.

ProMetric I and ProMetric Y

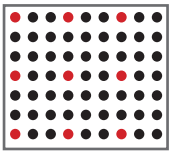
The measurement configuration is determined by the resolution of the device under test:

For standard FHD (1920x1080px) and lower resolution displays, a single ProMetric imaging system offers sufficient resolution for testing.

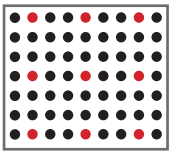
For higher resolutions (i.e., QHD, UHD, 4K, 8K, and so on), multiple ProMetric imaging systems can be optically combined to for ultra-high-resolution testing. Using this method, the resulting measurement images from each camera are combined into a single image for analysis.

Alternatively, a spaced-pixel test pattern devised by Radiant (US Patent 9135851) can be employed using a single ProMetric imaging colorimeter or photometer, whereby the pixels on a display are illuminated in intervals and measured in multiple passes. After the completion of all measurements, the measurement images are combined into a single image.

Sample Patterns:

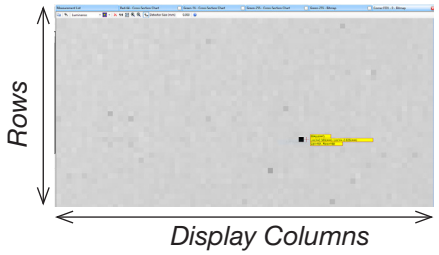


Pattern 1

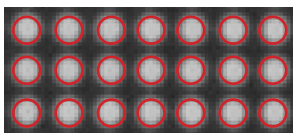


Pattern 2

Whether a single- or multi-camera system is used, the goal is to obtain accurate luminance & color values from each display subpixel and combine them into a single Synthetic Image with the same resolution as the measured display. The resulting image depicts every display pixel in rows and columns, which enables accurate detection of defective pixels and their exact coordinates.



TrueTest automatically registers the ON-pixels in the camera image and places Regions-of-Interest (ROI) around each ON-pixel, measuring the pixel luminance and color. Because a camera(s) with higher resolution than the display itself is used for measurement, each display pixel can be tested by many sensor pixels to achieve a high accuracy measurement. The measurement is repeated for the different dot-matrix patterns until each display pixel is analyzed.



Autoregistration of the ON-pixels

Automated Visual Inspection and Correction (Demura) of OLED Displays

Through automated visual inspection, OLED displays with unacceptable luminance and color inconsistencies can be identified. Non-uniform diplays can then be corrected using the in-line demura process.

The required components of a demura system include a ProMetric Imaging Colorimeter or Photometer, TrueTest Automated Visual Inspection Software, and a system for OLED screen control.

Radiant's process consists of two steps. The first step is to use an imaging colorimeter to measure the display pixels. The second step is to measure the response of the pixel over grey level to create correction coefficients to drive the pixel to the correct level for each grey level.

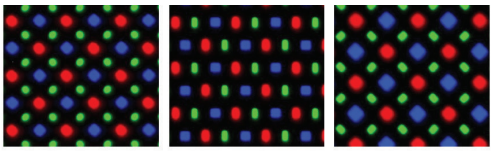
Step One: To generate proper correction coefficients, accurate measurement of each subpixel color and luminance is required. ProMetric imaging systems are selected for their broad dynamic range and high sensor resolutions. These cameras also feature electronically-controlled focus and aperture settings, plus thermoelectric cooling, for further noise reduction. For most OLED applications, only luminance measurment is required, which is accomplished with the ProMetric Y system.

ProMetric Y-series Imaging Photometer

Step Two: Once the results of the measurement are obtained, the correction coefficients are calculated. Measurements are taken at multiple grey levels, and correction coefficients calculated for all pixels in the display based on their deviation from the expected value. For example, if the pixels are uniform, no correction is needed, and the correction coefficient is one. If correction is required, the correction coefficient will be a different number (1.01, for example). All pixels have a correction coefficient, which is then uploaded to the OLED controller. The results can be programmed into flash memory, stored as image files, or lookup tables can be created. When the actual image is displayed, the pixel value will be multiplied by the correction coefficient to display a uniform pattern.

Considerations for successful demura:

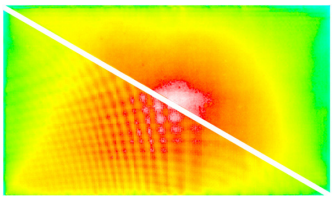
Different Subpixel Shapes and Patterns
TrueTest Software supports multiple subpixel layouts, so ROIs for each display pixel can be automatically set across different subpixel distributions.



Different OLED devices arrange pixels differently.

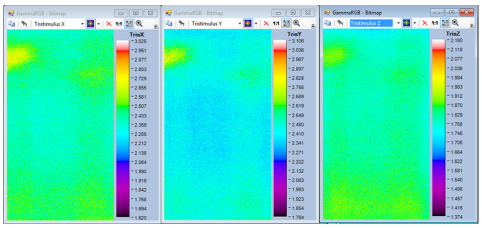
Moiré Pattern Removal
A moiré pattern is an aliasing effect in images that can be caused by camera resolution, lens design, etc., and can interfere with the ability to register details in the image. TrueTest features a proprietary moiré removal algorithm to ensure accurate measurements.

Before Moiré Removal



After Moiré Removal

Gamma Inconsistency
Gamma values may not be consistent at different grey levels, or even at the same gray level. TrueTest applies a gamma correction algorithm to account for this.



Red, green, and blue subpixels can have different responses over grey levels.

A Radiant demura solution can measure and qualify devices based on the severity of mura, and apply corrections to all correctable devices. High-resolution ProMetric imaging systems and novel analysis methods enable registration, measurement, and correction of each subpixel, helping manufacturers of high-resolution OLED and other emissive displays improve quality, reduce waste, and improve yield.

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