A novel AOI system for OLED panel inspection

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Abstract. Organic light emitting diode (OLED) technology uses substances that emit red, green, blue or white light. An OLED panel consists of stacks of several thin layers of different materials, as such it is not easy to inspect the common OLED defects. In this paper, an auto-optical inspection (AOI) system which can detect such defects effectively and robustly was proposed and developed. The proposed system can also identify, in which layer the defect occurred. Meanwhile, a moving mechanism coupled with a lighting mechanism was proposed and implemented for grabbing clear images. The proposed AOI system would provide great help in improving the OLED production process and the quality control process.

1. Introduction

An OLED panel consists of stacks of several thin layers, including a PF layer, a metal layer and an ITO layer, of different materials. OLED materials can present bright, clear video and images which are easy to see at almost any angle without any other source of luminance. This makes OLED a booming product. But, many OLED manufacturers face the problem of low yield rate, as a result of defects such as dark point, surface scratch, non-uniform luminance, lack of color uniformity, and insufficient rubber width, etc., as listed in table 1. Generally, a 7cm*4cm OLED component has 1600 lighting spots (cells), so a defect may be as small as 0.01 mm^2. To inspect such a defect humanly means that the quality and measurement standard of OLED cannot be quite assured. An AOI system which can inspect all the listed defects effectively and robustly was developed and described below.

Table 1. Common occurred defects of OLED.

Type of defect (Class No.)	Caused in production process
Dark Point (Class I)	Grow of organic polymer of ITO panel, Array process of ITO panel
Non-uniform luminance(Class I)	Grow of organic polymer of ITO panel
Surface scratch(Class II)	Package、 test process
Insufficient rubber width(Class II)	Package process
Lack of color uniformity(Class IIII)	Immature of OLED display technology

2. System structure and image processing method

Figure 1 shows the structure of the proposed system. This AOI system is a PC-based system. A lighting mechanism which includes a conducting fixture, UV light, coaxial LED light and back light was devised. An OLED is mounted on the conducting fixture manually, and then the lighting mechanism is switched to a suitable light source automatically according to which kind of defect is to

be inspected. Each image grabbed by the CCD will cover one-third of the OLED. A moving mechanism is used to capture the whole OLED. Because luminance, outward appearance and color uniformity are important quality indicators of OLED panel, we classify the common occurred defects of OLED in table 1 into three classes.

2.1. Class I Defect – Luminance Inspection

A Class I defect is related to OLED luminance, including dark point (see figure 2a) and non-uniform luminance (see figure 3a), hence luminance defects are also called light-on defect. This kind of defect can be highlighted by using the self-luminance feature of OLED. When the OLED panel is mounted on the conducting fixture, it is lit up with 3 Voltage DC. This makes the cells with dark point or those non-uniform illuminant cells easily detectable. Non-uniform luminance is a macro defect, so OLED cells are divided into several square blocks. To each block, the brightest gray value of the pixels in it is used as the gray value of that block. This gray value of the block is then compared with that of its 4-neighbor blocks. The algorithm for dark point and non-uniform luminance detection are shown in figures 2b and 3b, respectively.

As an OLED panel consists of stacks of several thin layers of materials, when light-on defect occurred, it means at least one of the PF layer, metal layer, or ITO layer is broken. To make sure which layer is wrong, we use (a) a UV light to stimulate the PF layer, and (b) a back light to illuminate the metal layer for grabbing an image. The image of a PF layer and metal layer obtained accordingly is shown in figures 4a and 5a, respectively. The corresponding inspection process for PF layer defect and metal layer defect is given in figures 4b and 5b, respectively. In the case of a light-on defect existing, and both the PF layer and the metal layer pass inspection, the ITO layer is the most likely source of defect.

2.2. Class II Defect – Outward Appearance Inspection

Class II defect is related to outward appearance, including surface scratches and insufficient rubber width. Surface scratches impose a great impact on display quality, and insufficient rubber width will decrease the OLED life time. The coaxial LED light is used to highlight the outward appearance for image grabbing. The grabbed image of a surface scratch and insufficient rubber width is shown in figures 6a and 7a, respectively. The corresponding procedures for surface scratch and insufficient rubber width inspection are shown in figures 6b and 7b, respectively.

2.3. Class III Defect – Color Uniformity Inspection

Class III is about color uniformity. The HSI (Hue, Saturation, and Intensity) color model is used for color uniformity inspection. The reference values of HSI parameters of a standard OLED are derived first, and then the HSI values of an inspected OLED are calculated. Comparing the two sets of parameters, we can find out the color uniformity defect.
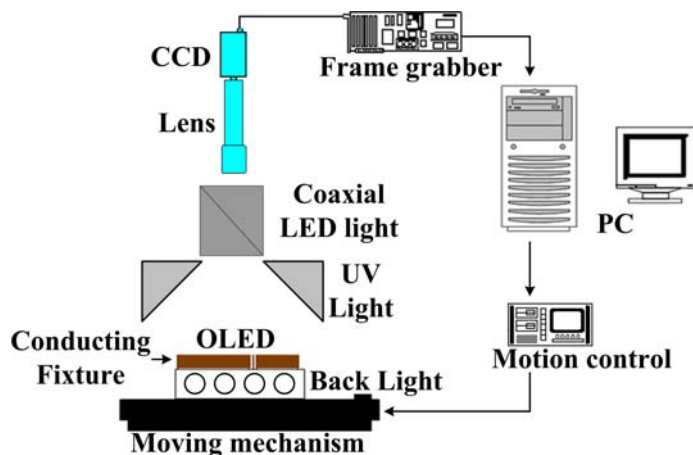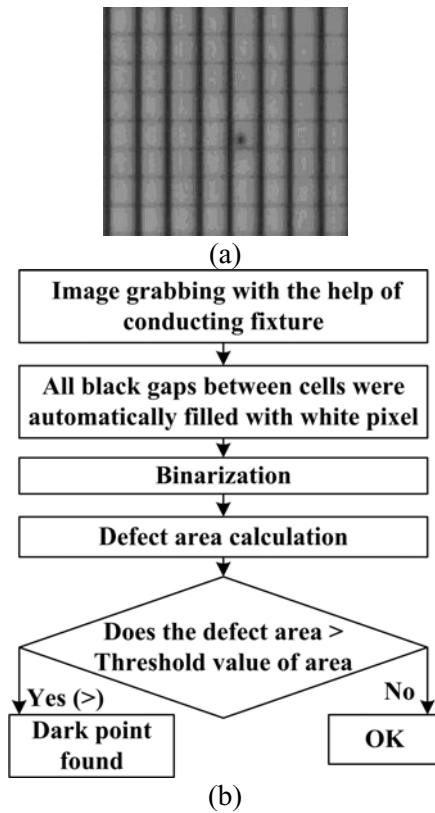

Figure 1. Structure of the proposed AOI system.

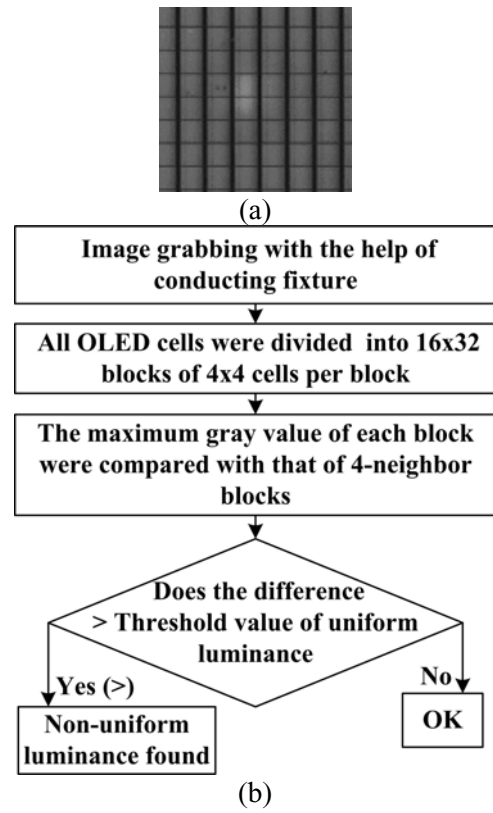Figure 2. (a) The grabbed image with dark point, (b) inspection flowchart.

Figure 3. (a) The grabbed image with non-uniform luminance, (b) inspection flowchart.
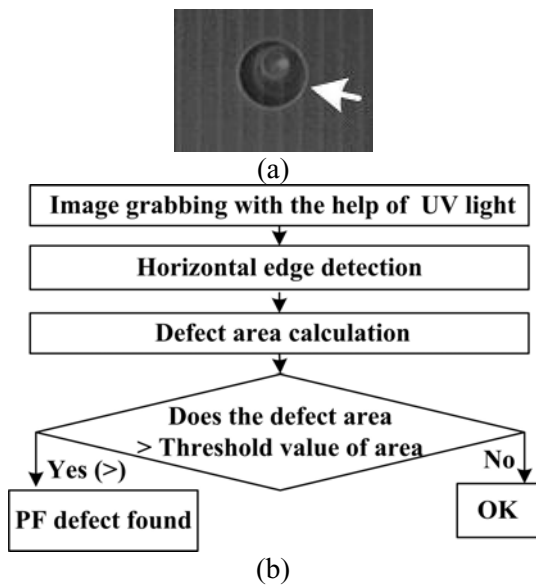

Figure 4. (a) The grabbed image with PF layer defect, (b) inspection flowchart.
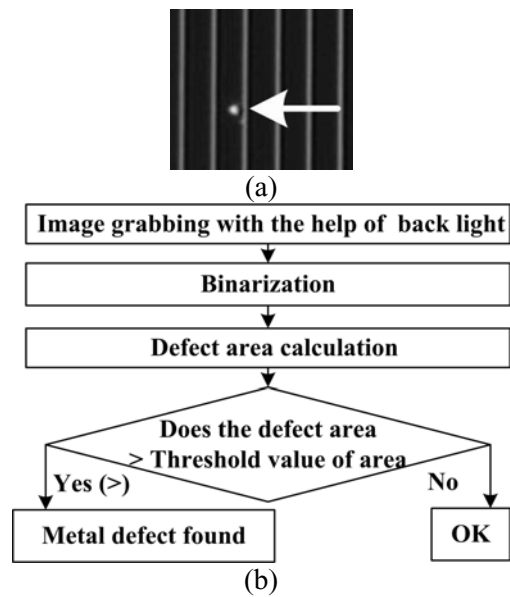

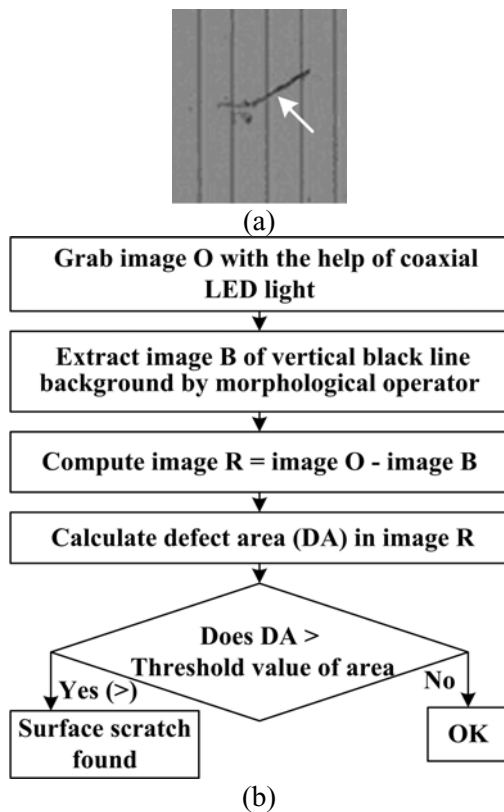Figure 5. (a)The grabbed image with metal layer defect, (b) inspection flowchart.

(a)

(b)

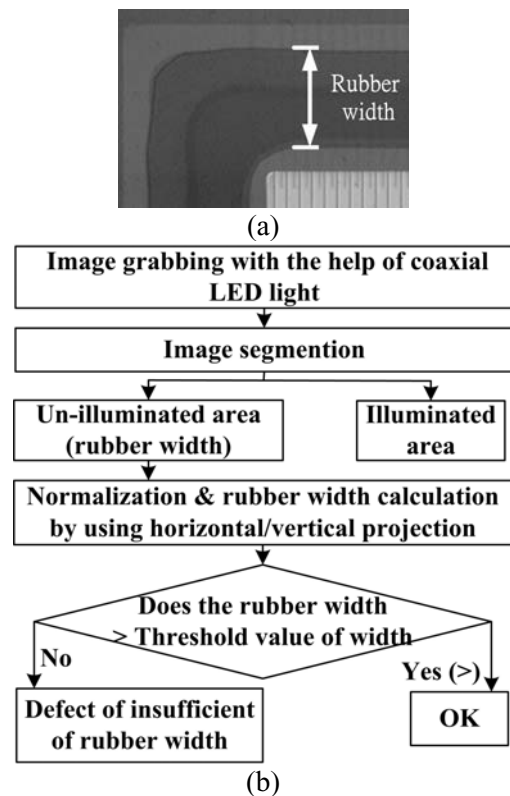Figure 6. (a) The grabbed image with surface scratch, (b) inspection flowchart.

(a)

(b)

Figure 7. (a) The grabbed image with insufficient rubber width defect, (b) inspection flowchart.

3. Summaries and conclusion

An AOI system which can robustly detect the commonly occurring OLED defects of dark point, surface scratch, non-uniform luminance, lack of color uniformity, and insufficient rubber width was proposed and implemented. An OLED panel of 7cm*4cm can be successfully inspected within 10 seconds. The proposed system can also identify which layer the defect occurred. Each of the threshold values used in the above inspection flowcharts has to be determined beforehand by a learning process. The threshold value is varied and adjustable for different OLED products.

References

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