LED Cosmetic Flaw Vision Inspection System

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Abstract: The paper describes a vision inspection system that is developed to detect diffused LED defects, namely scratches, bubbles, contamination, blister/blemish, fuzzy dome and off centre defects in less than 200 ms using a 200 MHz Pentium PC, a Matrox Genesis frame grabber and a Pulnix high speed camera. Various image-processing techniques are utilised for the inspection task. A machine vision approach that comprises pre-processing, image segmentation, clean up and feature extraction operations is implemented to perform the automated cosmetic flaw inspection. Based on 200 LED samples, the system was found to be 100% accurate in detecting LED dome defects on LEDs of different colour and intensity. The system can also classify defects into different categories and was found to be 90% accurate.

Keywords: Feature extraction; Image processing; LED cosmetic flaw; Vision inspection

1. INTRODUCTION

Currently, in the Light Emitting Diode (LED) component industry, one of the challenges encountered by most manufacturers is how to effectively eliminate cosmetic rejects from the finished products. Since there is no solution to totally eliminating cosmetic rejects from the product by improving their manufacturing processes, various visual inspection checkpoints need to be established to prevent the reject units from reaching customers. This cosmetic flaw inspection process is currently performed visually by humans, though it is not particularly effective. If the inspection process is fully automated, it can reduce manufacturing costs drastically, increase productivity and improve outgoing product quality.

2. OBJECTIVE, PROBLEM DEFINITION AND SCOPE

The objective of the study is to identify techniques and algorithms in image processing for automated LED Cosmetic Flaw Inspection System (LEDCIS) [1–3]. Tt LEDs will be considered in the study.

The scope of the study is to focus on developing a practical vision inspection system that discriminates LED cosmetic rejects from acceptable LEDs. The LED images of each defect are shown in Fig. 1.

2.1. Defect Characteristics

From observations of dome reject LEDs, defects can be seen to be scattered around the dome. These defects are characterised into a number of categories, outlined below.

Contamination. Contaminations are round shaped defects that are found inside or on the surface of the LED's dome. These defects are normally found inside LEDs, and are due to contaminated mould cups. Contamination appears as a black spot located inside the
epoxy. There is also contamination formed by dust particles on the surface of the LED.

Under a camera view, contamination appears to be a flat, black region on or inside the epoxy, and is easily discerned from the uniform background. In image processing terms, it is a region in an image with a significant local intensity change in the image.

A reject criterion is thus developed as follows. Any defect greater than 5 mils in diameter (Fig. 2).

Figure 3a shows an image of an LED with contamination near the dome surface and two line profiles (lines a and b). Figures 3b and 3c show the line profile diagrams of lines a and line b, respectively. It can be seen in the line profile diagram of Fig. 3b that a contamination is manifested as a steep valley in the intensity level.

Scratches. Scratches are elongated black or low contrast regions on the surface of LED’s dome when the LED is lit up. Mishandling of a unit normally causes this type of defect. Scratches can occur at the sides of an LED, however side defects are hard to see from the top view of an LED, and these defects are considered acceptable from the customer point of view.

Bubbles. Bubbles are defects that can only be found inside the LED dome. This defect may be located near to the dome surface and/or inside the mould cup region. This type of defect is normally round in shape, and appears like a small bubble. The defect is normally the result of improper curing process control. For a diffused LED, it can only be seen when the device is lit. It usually appears as a small black circle, and may look like a small ring if the bubble is big enough to reflect the light out (internal reflection) from the bubble region. An example of a bubble is shown in Fig. 4.

Blister/Blemish/Fuzzy Dome. Blister, blemish and fuzzy dome are defects that appear as a group of scratches on the surface of LED under the camera. Although they look similar in appearance, they are caused by different manufacturing process deviation. For automatic inspection purposes and simplicity, they are categorised as scratches.

2.2. Scope of Investigation (Problem Analysis Phase)

Listed below are areas of investigation on the automated LED cosmetic inspection system.

1. Due to the inconsistency and non-uniformity in the brightness of LED light output, it is impossible to represent an image with the same brightness to the system for processing all the LEDs using a preset supply current. The intensity range of LEDs can vary from 2 milli-candela (mcd) to 500 mcd for diffused LEDs, and 20 mcd to 2000 mcd for clear LEDs. Since all the defects can only be made visible by lighting up the LED, the intensity level