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랩뷰 비전 빌더를 이용한 LED 결함 검출 시스템

(LED Deformity Detection Using LabVIEW Builder)

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요 약

LED와 같은 소형 제품의 불량검색은 제품의 질을 향상 시키는 것만 아니라 생산성 향상에서 중요한 역할을 한다. 본 연구에서는 LED에 발생하는 여러 가지 불량을 자동으로 검사하는 시스템을 구성하였다. LABVIEW Builder를 사용하여 그래픽 인터페이스 상에서 LED의 불량을 검출을 자동판단하며, 사용자가 쉽게 사용 가능하도록 설계하였다. 1394 카메라를 통해 영상을 획득하고 Vision Builder의 각 영상처리 요소를 적용하였다. 에지탐색, 기하학 위치 설정, 거리측정 등의 영상처리 알고리즘을 조합하여 색과 크기가 다른 다양한 LED의 불량을 검출하는 알고리즘을 설계하였다.

Abstract

Deformity detection in a Light Emitting Diode (LED) is an important aspect for improving its quality. These LED deformities can be checked through several methods. This paper details the automatic deformity detection inspection system of a LED using the LabVIEW Builder 3.6 software. This software has a graphical user interface which makes it easy to observe and modify the behavior of its element. The LabVIEWs essential elements are also presented and explained aside from its image acquisition system. Details on how to build an inspection system and how to implement vision inspection algorithm which mainly consists of edge detection, geometry point location, and distance measurement are included in this paper.

Keywords : Vision Builder, LED, Industrial Inspection

I. Introduction

Alight emitting diode or LED is a semiconductor diode which emits lights when an electric current is applied in the forward direction. LEDs are usually used as indicator lights and/ or illuminating lights, where they can light up a very small area and emit different colors. It can be used to sterilize water, disinfect devices and even promote photosynthesis[1~2].

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The LEDs are produced in various shapes and sizes where the most common is the one with a 2 - 5mm cylindrical body and a dome-shaped hat package in which the diode is in the center of the package. For this research, we need to find any deformities in three (3) kinds of LEDs: DLM4441-u (encapsulated in a green epoxy hat), ULM32R3-SH (encapsulated in transparent pink epoxy), and SCR54010-ST (encapsulated in pink epoxy hat). In the encapsulation part of the LED manufacturing process, the following cases can happen if the epoxy is not infused equably: shallow and deep fault, bubble fault, and cracked LED as indicated in Figures 1.(a), 1.(b), and 1.(c).

Yang[3] used the programming language C and

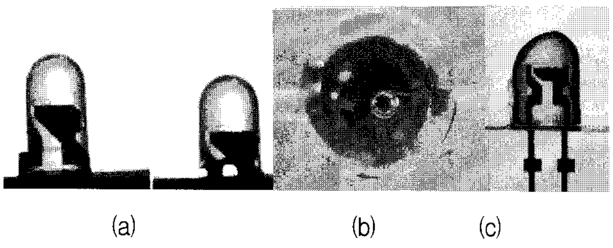

그림 1. (a) 뜸-박힘 (b)기포 (c) 외형 불량
Fig. 1. (a) Shallow & Deep Fault, (b) Bubble Fault, (c) Cracked Fault.

VISILOG to develop a LED shape recognition system, but there were insufficient experimental results and the image source was not good enough. Huan[4], Kim[5], and Larios[6] discussed recent applications of machine-vision in industrial inspection. All of them showed that LabVIEW is a powerful development environment to build an applied inspection system based on image processing. The hardware component of the image acquisition system is presented in Section Ⅱ. We introduce edge detection, morphological operation, geometry points, and distance measurement in Section Ⅲ.

Ⅱ. The Component of Image Acquisition System

2.1 Image acquisition

The image acquisition system is composed of lighting, power supply, charge coupled device (CCD) camera, image acquisition board and the development computer refer to Figure.2.

Figure 3 shows the set-up done to fix the distance between the LED sample and the camera during image acquisition. We used a Dragonfly 2 DR2-H1BW camera which is an IEEE-1394 digital Black and White with maximum resolution of 1032 x 776 pixels at 30 frames per second. A 1/3 inch CCD lens was attached and the working distance was set at 15mm to provide high quality image captures. The Dragonfly 2 camera is easy to interface with an 1394 image acquisition board and its trigger time is fast enough for our need.

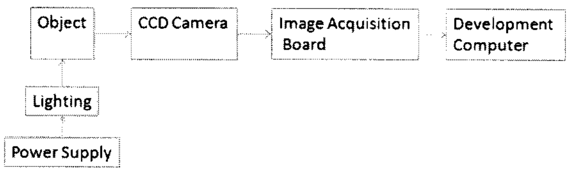

그림 2. 영상 획득 시스템의 구성
Fig. 2. Image Acquisition System.

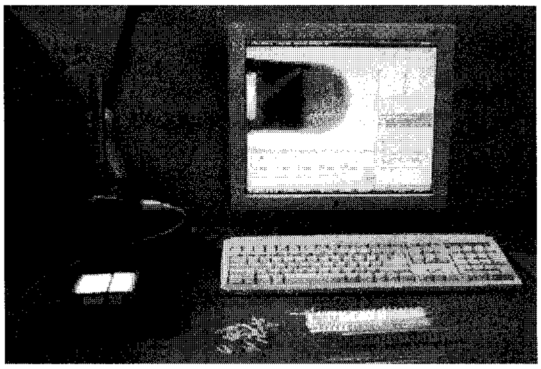

그림 3. LED 검사 시스템의 구성
Fig. 3. Inspection System Set-up.

2.2 Lighting

For this experiment, the image were acquired from the top using arch-shape diffused white light while we used a white backlight for images taken from the side. Diffused light is usually used to reflect light, providing a non-directional soft light free of harsh shadows that is well suited for highly specular objects. This illuminating effect has been likened to the kind of lighting on an overcast day which is flat and non-directional. Backlighting on the other hand provides an even field of illumination causing the

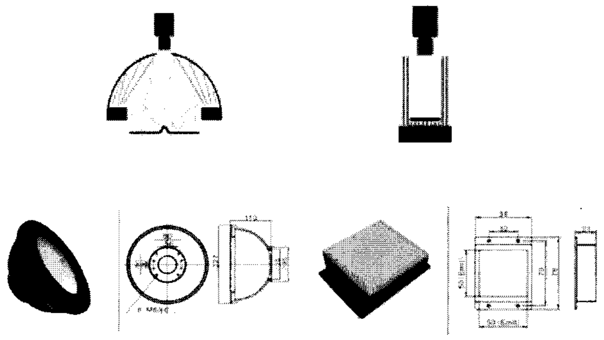

그림 4. 타원형 조명과 백라이트 조명
Fig. 4. Arch-shape Lighting and Backlighting.

object to be seen as a silhouette by the camera. This kind of lighting is commonly used for taking measurements and determining the orientation.

III. Methods

3.1 & Deep Case

For this type of fault detection we need to use the Simulate Acquisition of LabVIEW to load the prepared sample image then we experiment on it using preprocessing and gauging steps.

As shown in Figure 5.(a) D is the distance from the top of the semiconductor chip to the bottom of the epoxy case. If D exceeds or is short of the standard set length by 0.1 millimeter, then this LED is classified as a shallow and deep LED. This standard set length varies for different LEDs.

For the inspection part, we first get the gray intensity image of the sample then migrate this processed image into the Vision Assistant. Inside the Vision Assistant window, we choose the Extract Color Plane to extract the green plane from the color image and then we process the image using Find Straight Edge.

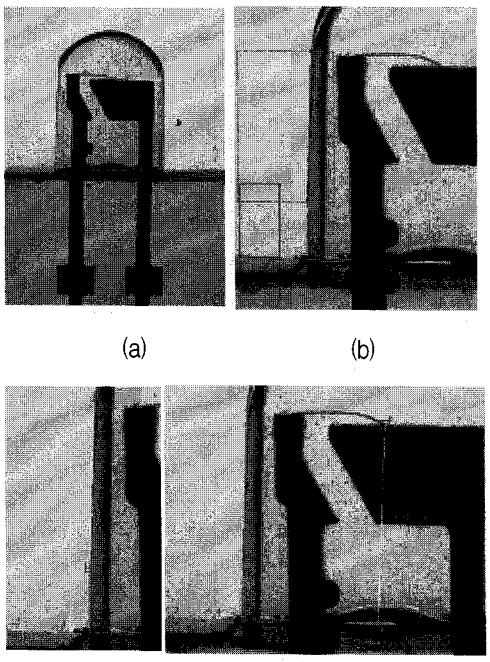

그림 5. (a) 거리D의 측정 (b) 직선라인 탐색 (c) 좌표축 탐색 (d) 거리 측정

Fig. 5. (a) Definition of D, (b) Find Straight Line, (c) Geometry Point, and (d) Measure the Distance.

Edge detection is by far the most common approach to detect meaningful discontinuities in intensity values[8]. The basic idea of edge detection is to find parts of the image where there is a rapid change in intensity (the first derivative of the intensity is greater than a specified threshold). For LED images, the reason why the edge is selected as the primitive image is that the most distinctive edge pixels appear along boundaries and contours.

Let the image be f(x, y) while the gradient magnitude function is approximated by vector ∇f.

$$\nabla f = [G_x \; G_y]^T = \left[\frac{\partial f}{\partial x} \; \frac{\partial f}{\partial y}\right]^T \tag{1}$$

The magnitude of the vector, one of the important physical quantities, is defined by the following equation:

$$\nabla f = [G_x^2 \; G_y^2]^{\frac{1}{2}} \approx |G_x| + |G_y| \tag{2}$$

The Find Straight Edge step searches for a straight edge in a two-dimensional region of interest. We give a ROI by as it shown in following figure.

The object under inspection often appears shifted or rotated in the image being processed that is why we need to define a sub-coordinate relative to a feature in the image. The intersection point of the two straight lines can be set as the origin of a coordinate system, we call this intersection point as Geometry 1 in Figure.5 (c).

For the Find Straight Edge step we first choose a rectangular area around the reflective cup, which is the tiny bowl on the top of semiconductor chip. We then get the middle point (Geometry point 8, Figure 5.(d)) of the line and measure the distance from this point to the bottom line (the rectangular area detected at the first Find Straight Edge step). Lastly, we calculate the number of pixels for this measured distance and compare this with the

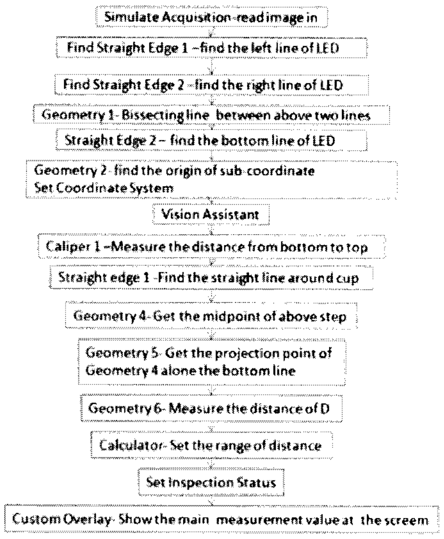
Simulate Acquisition-read image in
Find Straight Edge 1 –find the left line of LED
Find Straight Edge 2 -find the right line of LED
Geometry 1- Bissecting line between above two lines
Straight Edge 2 – find the bottom line of LED
Geometry 2- find the origin of sub-coordinate
Set Coordinate System
Vision Assistant
Caliper 1 –Measure the distance from bottom to top
Straight edge 1 -Find the straight line around cup
Geometry 4- Get the midpoint of above step
Geometry 5- Get the projection point of
Geometry 4 alone the bottom line
Geometry 6- Measure the distance of D
Calculator- Set the range of distance
Set Inspection Status
Custom Overlay- Show the main measurement value at the screem

그림 6. LED의 뜸과 박힘 오류 검사 순서도 (녹색투명)

Fig. 6. Flow Chart for LED Shallow & Deep Fault Checking (transparent green).

standard range of 250 - 260 pixels. The LED will be classified as Shallow & Deep fault case if the measured no of pixels is out of this given range.

3.2 Bubble Case

The bubble fault LED always shows more noise after subjecting the sample image to edge detection procedure. We designed an algorithm to detect and distinguish bubble fault case in a LED based on this characteristic.

First, we perform basic "Prewitt" filter (which is also an edge filter) to extract the actual LED image from the background (Figure 7). We use "Prewitt" operator because it can preserve the contour of the object as much as possible. The "Prewitt' operator mathematically uses two 3-by-3 kernels which are convolved with the original image to calculate approximations of the derivatives, one for horizontal and another for vertical changes. If we define F as the source image and G_x, G_y as the two images which contains the horizontal and vertical approximations, then we can solve for them by:

$$G_x = \begin{bmatrix} -1 & 0 & +1 \\ -1 & 0 & +1 \\ -1 & 0 & +1 \end{bmatrix} * F \text{ and } G_y = \begin{bmatrix} -1 & -1 & -1 \\ 0 & 0 & 0 \\ +1 & +1 & +1 \end{bmatrix} * F \qquad (3)$$

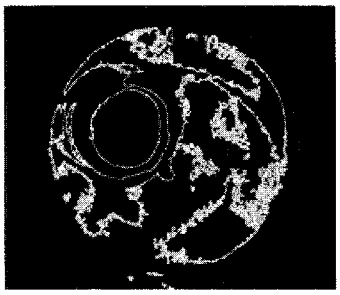

그림 7. LED의 중심점 탐색

Fig. 7. Find the center of LED.

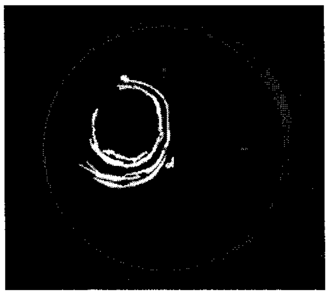

그림 8. 검사체의 픽셀 계산

Fig. 8. Calculate pixels in a given ROI.

We then apply the "Find circular edge" function to locate the centre of the circle. The following images shows some of the location-result.

For the second step, we get a sub-region of the LED then do smooth function of this region which would remove much noise that can affect the distinguishing performance. We then remove small objects twice after using "Sobel" filtering to extract the contour of the bubble (Figure 8). Some good LEDs also contain noise but it is not as much as in a bubble fault case. The number of front pixels in the sub-region is counted, the percentage rate of front pixels in the sub-regionis calculated and then threshold rate is set at 2%. The LED is classified as a Bubble Case fault if the calculated percentage rate is more than 2%. Figure 8 shows the last step of bubble detection.

3.3 Cracked Case

We consider the dissymmetry aspect using images of the LED taken from the side for the cracked fault case. The difference of dissymmetry between two Geometry points along the parallel line is compared

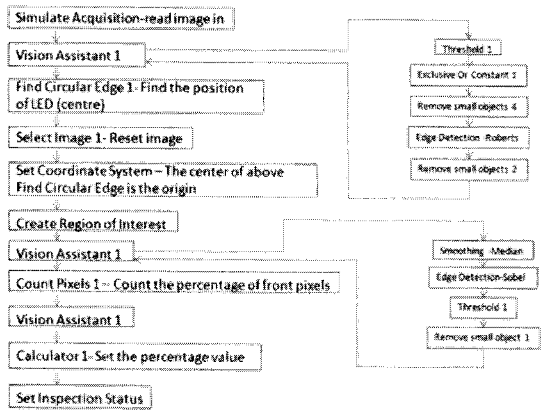
Simulate Acquisition-read image in
Vision Assistant 1
Find Circular Edge 1- Find the position of LED (centre)
Select Image 1- Reset image
Set Coordinate System – The center of above Find Circular Edge is the origin
Create Region of Interest
Vision Assistant 1
Count Pixels 1 – Count the percentage of front pixels
Vision Assistant 1
Calculator 1- Set the percentage value
Set Inspection Status
Threshold 1
Exclusive Or Constant 1
Remove small objects 4
Edge Detection Roberts
Remove small objects 2
Smoothing Median
Edge Detection-Sobel
Threshold 1
Remove small object 1

그림 9. LED 기포 탐색을 위한 순서도(투명핑크)
Fig. 9. Flow Chart for LED Bubble Fault checking (transparent pink).

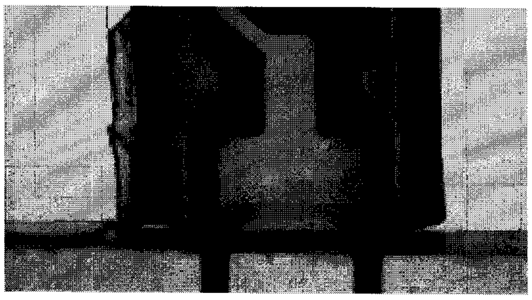

그림 10. 두 개의 검사축을 적용
Fig. 10. Two Geometry Point.

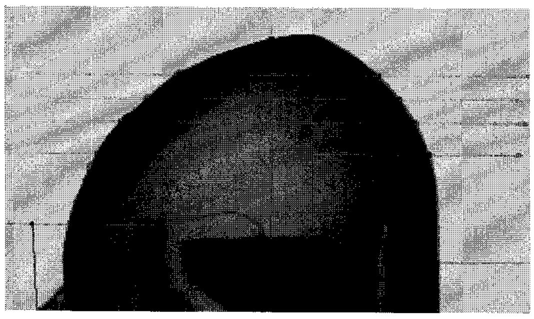

그림 11. 대칭점 비교
Fig. 11. Compare the Symmetry Position.

to the bottom line. The pre-treatment step is the same as that in the shallow & deep fault case.

The sub-coordinate system based on one of the geometry points is set after the pre-treatment step. Four lines are chosen as the one-dimensional ROI to apply the "Find Edge" step. We first disable the auto step control and adjust the edge location parameters. The first edge and last edge items at the "Look for"

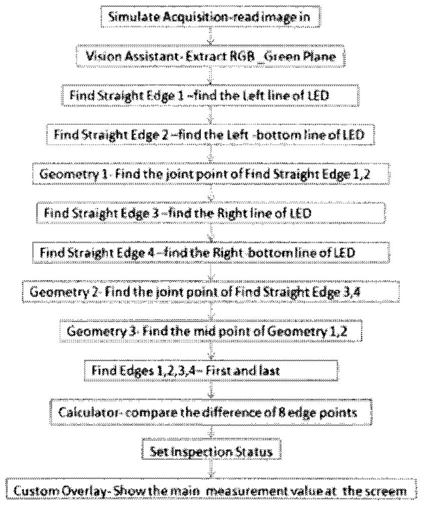
Simulate Acquisition-read image in
Vision Assistant- Extract RGB _Green Plane
Find Straight Edge 1 –find the Left line of LED
Find Straight Edge 2 –find the Left -bottom line of LED
Geometry 1- Find the joint point of Find Straight Edge 1,2
Find Straight Edge 3 –find the Right line of LED
Find Straight Edge 4 –find the Right -bottom line of LED
Geometry 2- Find the joint point of Find Straight Edge 3,4
Geometry 3- Find the mid point of Geometry 1,2
Find Edges 1,2,3,4– First and last
Calculator- compare the difference of 8 edge points
Set Inspection Status
Custom Overlay- Show the main measurement value at the screem

그림 12. 외형불량 검출을 위한 순서도(핑크)
Fig. 12. Flow Chart for LED Cracked Fault Checking (pink).

control are then chosen and the edge polarity is set as "all edges". We can then get the position of the first and last edge located on the one-dimensional ROI. Based on the symmetrical axes, we can calculate the difference between the two positions and if the difference is larger than a certain threshold (such as 5 pixels) then we classify the LED as a cracked case fault.

III. Experiment Device and Result

All the sample LEDs with shallow & deep faults and bubble faults were successfully detected and classified when we used the test algorithm presented above.

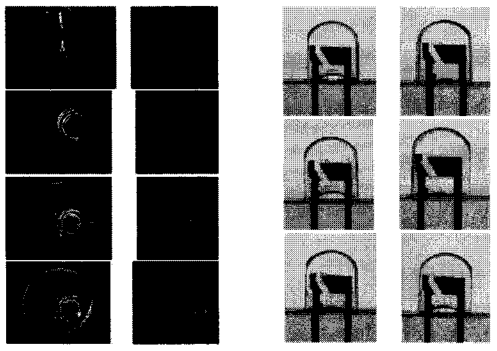

그림 13. 실험 결과
Fig. 13. Experiment Result.

Ⅳ. Conclusion

Our proposed visual inspection system based on LabVIEW has a very high success rate in classifying the LEDs with shallow and deep faults and bubble faults. We were able to satisfy the application requirements and the fast processing time of the designed inspection system made it even better. This experiment showed that Vision Builder 3.5 is a very useful and convenient tool to develop an efficient optical system.

By solving not only the external or surface problems and defects of a LED but also dealing with the problems inside it, we believe that the good results obtained using the proposed inspection system can be used to improve quality control productivity.

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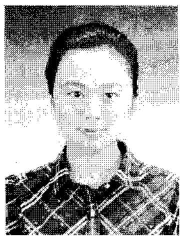
저 자 소 개



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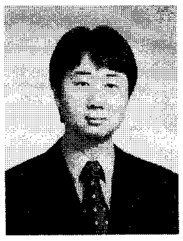

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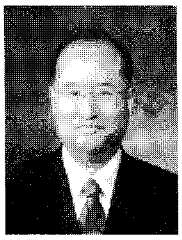

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