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# Design of defect detection system for semiconductor plastic packaging based on machine vision

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**Abstract.** At present, the ability of defect detection system to detect the position of semiconductor plastic packaging defects is poor, so a defect detection system of semiconductor plastic packaging based on machine vision is designed. In terms of hardware, based on machine vision technology, the system framework is determined, the camera, lens and light source models are selected, and the detection target image acquisition parameters are determined. In terms of software, according to the target image obtained by machine vision technology, the image is preprocessed, segmented and feature extracted to identify and detect the target image and detect the semiconductor plastic packaging defects. Experimental results: compared with the system selected in this experiment, the design system can accurately detect the defects in the semiconductor plastic packaging and the location of the defects.

## 1. Introduction

Nowadays, with the development of electronic equipment, semiconductor components are widely used in electronic equipment. However, due to the special properties of semiconductor components, it is necessary to plastic package the semiconductor components to protect the chip and transistor of semiconductor components. Therefore, only the packaged semiconductor components can be installed in electronic equipment, so the molding process of semiconductor can determine the service life and quality of electronic equipment [1]. When molding semiconductor components, it is very easy to be affected by molding equipment, environment, technology, etc., which leads to molding defects and affects the electrical performance of semiconductor equipment with molding defects. Therefore, the defect detection technology of semiconductor plastic packaging is studied to detect the defects of semiconductor plastic packaging. For defect detection, scholars also put forward their own research views. Literature [2] has studied the current material defect detection technology, and found that it can only detect the surface defects of materials, so the laser infrared thermal imaging technology is used to detect the quantitative defects of materials. The above research results are applied to the defect detection of semiconductor plastic packaging, but the defect location detection is not comprehensive. Therefore, machine vision technology is used to improve the quality of image acquisition and enhance the ability of defect location recognition. A defect detection system based on machine vision is designed.

## 2. Hardware design of defect detection system for semiconductor plastic packaging

### 2.1. System composition framework

The machine vision technology is used to design the defect detection system of semiconductor plastic



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packaging. The hardware is mainly used for image acquisition.

According to the system framework shown in Figure 1, the detection process of semiconductor plastic packaging defects is as follows: 1; 2. Focus of semiconductor plastic packaging and camera light source; 3. Through the camera lens, the semiconductor plastic packaging image is collected; 4. Image transmission to computer; 5. Processing, analyzing and detecting the image defects of semiconductor plastic packaging on the processor.

## 2.2. Hardware selection

The design of the system, hardware mainly for image acquisition part, so need to choose camera, lens and light source, to ensure the quality of semiconductor plastic packaging image acquisition.

### 2.2.1. Camera.

At present, there are mainly two kinds of machine vision cameras used for defect detection, CCD and CMOS, which have their own advantages and disadvantages. Considering the image quality and image post-processing requirements of this design, the CCD camera meeting the technical parameters in Table 1 is selected, and its camera model is stc-sb202poehs.

### 2.2.2. Camera lens.

When using stc-sb202poehs CCD camera to obtain semiconductor plastic image, we need to focus on the semiconductor plastic area, so we need to consider the zoom, distance, focal length, image plane and other factors of camera lens. For this reason, we choose xf-mt1x110d lens with lens C interface, working distance of 110mm, image plane size of  $2/3"$ , depth of field of 1.2mm and magnification of 1x.

### 2.2.3. Light source.

The light source can directly affect the image quality of the semiconductor plastic packaging obtained by the camera. When the target area of the image is not prominent, fuzzy and other problems, it will directly affect the detection results of the semiconductor plastic packaging defects. At present, the light sources used with CCD camera include high frequency fluorescent lamp, halogen lamp and LED lamp. The performance comparison is shown in Table 1.

Table 1. Performance comparison of three kinds of light sources

light source	High frequency fluorescent lamp	Halogen lamp	LED
colour	White, greenish	White, yellowish	Red, yellow, green, white, blue
luminance	bright	It's very bright	Brighter
Life / thousand hours	5-7	5-7	60-100
characteristic	cheapness	More heat, cheaper price	Less fever

Based on the performance comparison results of the three light sources shown in Table 1, the LED light source which can highlight the target area, work stably and for a long time, and have uniform brightness is selected.

It is more suitable for transparent components and component contour detection; It's easier to highlight the target in open field shooting. Therefore, the design system chooses bright field lighting method to obtain semiconductor plastic image.

### 3. Software design of defect detection system for semiconductor plastic packaging

Based on the machine vision acquisition method of semiconductor plastic packaging image, the obtained semiconductor plastic packaging image  $f(k,l)$ , where  $(k,l)$  represents the image pixel, needs to go through three steps of preprocessing, segmentation and feature extraction to detect the semiconductor plastic packaging defects.

#### 3.1. Image preprocessing

Using machine vision technology, the image obtained will be affected by the camera, there will be noise, so the mean filtering technology is used to deal with the image noise. Before processing the image, the mean filter template  $M$  should be selected first, and then the semiconductor plastic packaging image  $f(k,l)$  should be processed according to the mean filter template; In the process of image processing, a smoothing filter  $g(i,j)$  is generated, where  $(i,j)$  represents the pixel after smoothing, and the image noise processing formula is as follows:

$$g(i,j) = \frac{1}{S} \sum_{k,l \in M} f(k,l) \quad (1)$$

(1) Where  $S$  is the sum of pixels in the template.

After formula (1), the semiconductor plastic image is  $f'(i,j)$ . at this time, the image  $f'(i,j)$  can be segmented.

#### 3.2. Image segmentation

The threshold segmentation method is used to segment image  $f'(i,j)$ , and the image segmentation formula is as follows:

$$h(i,j) = \begin{cases} 1 & f'(i,j) \geq \delta \\ 0 & f'(i,j) < \delta \end{cases} \quad (2)$$

(2) Where  $h(i,j)$  is the image after threshold segmentation;  $\delta$  represents the selected image segmentation threshold point [3].

As shown in formula (2), the segmentation effect of semiconductor plastic packaging image is directly related to the image segmentation threshold. If the threshold is too large or too small, it will lead to misjudgment. If its value is too large, the segmentation target will be incomplete; If the value is too small, the range of the target image will be too large.[4]

Based on this, the iterative threshold algorithm is used to select the threshold points of image segmentation

In the first step, the initial image threshold  $\delta_0$  is selected according to the intermediate value between the maximum value and the minimum value of the image pixel;

In the second step, the threshold  $\delta_0$  is used to segment the image, and the set of pixels whose brightness is less than  $\delta_0$  is recorded as  $A_1$ ; The set of pixels greater than  $\delta_0$  is denoted as  $A_2$ ;

The third step is to calculate the average brightness  $A_1$  and  $A_2$  of  $L_1$  and  $L_2$  respectively.

In the fourth step, the formula  $\delta = \frac{1}{2}(L_1 + L_2)$  is used to calculate the new threshold  $\delta$  of image segmentation;

Step 5, repeat steps 2-4. When  $\delta < \delta_0$ , it stops repeating and outputs the final threshold.

By substituting the threshold selected in step into formula (2), the image obtained by formula (2) is  $h(i,j)$ .

#### 3.3. Text in figures

After (2) segmentation, the image features of semiconductor plastic packaging are clear. Because the

semiconductor plastic packaging has obvious geometric features, the target image is recognized by extracting the geometric features of the image.

The geometric features of the image include area  $S$ , perimeter  $L$ , aspect ratio  $\gamma$ , density  $\rho$ , moment features, etc

$$S = \sum_{(i,j) \in U_1} I$$

$$L = \sum_{(i,j) \in U_2} J$$

$$\gamma = \frac{h}{l}$$

$$\rho = \frac{4\pi S}{L^2}$$

$$\varsigma_{p+q} = \sum_{i=1}^G \sum_{j=1}^H i^p j^q (i, j) \quad p, q = 0, 1, 2, \dots$$

$$m_{p+q} = \sum_{i=1}^G \sum_{j=1}^H (i-x)^p (j-y)^q h(i, j) \quad p, q = 0, 1, 2, \dots$$

(3) Where  $U_1$  is the image target area;  $I$  is the pixel of the target image;  $U_2$  is the set of edge pixels  $J$  of the target image;  $h$  and  $l$  represent the width and length of the minimum bounding rectangle of the target image respectively;  $\varsigma_{p+q}$  is the geometric moment of order  $p+q$  of the image in discrete state;  $m_{p+q}$  represents the central moment of order  $p+q$  of the image in discrete state;  $H$  and  $G$  represent the width and height of the image respectively;  $(x, y)$  is the center of gravity of the image. According to the calculation process of formula (3), the geometric feature of the image can be obtained. According to this feature, the target image recognition is completed, and the obtained target image is  $G(i, j)$ . [5-6]

### 3.4. Defect detection

According to the identified target image, the defects in the target image are detected by using the double template matching method. It is necessary to use the defect free semiconductor plastic packaging as the detection template, and record it as  $F(a, b)$ ,  $(a, b)$  for the template image pixels. In this case, we only need to subtract the pixels of image  $G(i, j)$  and image  $F(a, b)$  to get the deviation between the two images. The calculation formula is as follows:

$$Q = \begin{cases} 0 & |F(a, b) - G(i, j)| > \sigma \\ 255 & \text{other} \end{cases} \quad (4)$$

(4) Where  $\sigma$  is the gray value difference threshold. When the calculation results meet the calculation formula shown in formula (4), the defect detection calculation formula indicates that there is a detection error in the image to be detected; If the formula shown in (4) is not satisfied, there is no detection error in the image to be detected.

Based on the above calculation process, machine vision technology is used to form the system hardware to obtain the detection target image. After image processing, segmentation and feature extraction, the target image defect detection is realized.

## 4. System test

The defect detection system based on infrared thermal imaging technology is selected as the test object. Taking the semiconductor plastic packaging defects as the experimental defect detection object, verify the design of the semiconductor plastic packaging defect detection system. The two systems were compared to detect the position of defects in semiconductor plastic packaging.

#### 4.1. Experimental preparation

In this experiment, the selected semiconductor plastic is a kind of professional transparent adhesive, plastic encapsulated semiconductor, as shown in figure a in Figure 1.

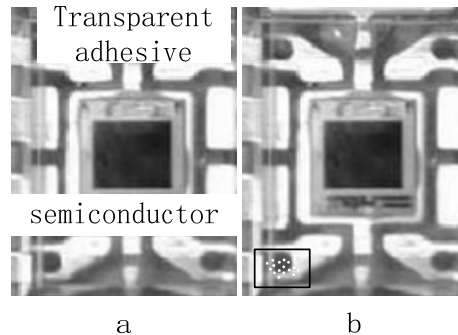


Figure 1. Semiconductor plastic packaging drawing

The semiconductor molding diagram is based on the semiconductor molding diagram shown in figure a in Figure 3. During the molding process, the semiconductor molding diagram generates molding bubbles as shown in the black box in Figure 3B. Due to the use of transparent plastic sealant, the molded semiconductor presents transparent color, and the color of bubbles generated in the process of plastic encapsulation is consistent with that of plastic encapsulation, which increases the difficulty for the two groups of systems to detect the defects of semiconductor plastic encapsulation.

#### 4.2. Experimental result

Two groups of systems are used to detect the semiconductor plastic packaging defects shown in Fig. 3 and B respectively, and the detection results are shown in Fig. 2.

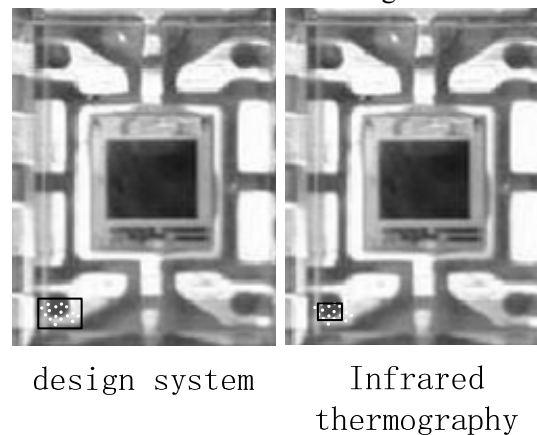


Figure 2. Comparison of test results of semiconductor plastic packaging defects

It can be seen from Figure 4 that the defect detection system based on infrared thermal imaging technology detects incomplete bubble defects in semiconductor plastic packaging, and the detected bubble defects range is small; the system is designed to detect the bubble defects in the semiconductor plastic packaging, which is completely consistent with the bubble defects. It can be seen that the defect detection system designed in this paper can accurately detect the defects existing in the semiconductor plastic packaging and the location of the defects.

#### 5. Conclusion

Due to the poor effect of defect location in the current detection methods, it is necessary to make full use of machine vision technology to obtain high-quality semiconductor plastic packaging image to improve the defect location and detection ability of semiconductor plastic packaging. Through the hardware and software design of the system, the extraction and processing of the target image are

strengthened, and the defect detection effect of the system is improved. Through the comparative test, the effectiveness of this design is fully proved, which can be used in this field.

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