칩의 문자들을 검사하기 위한 마크 자동 검사 시스템

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A Mark Automatic Checking System to Inspect Character String on Chip

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요 약

칩의 마크는 종류별로 다르고 매우 작아서 작업자가 육안 검사로 처리하기에는 매우 어려운 작업이다.
본 논문에서는 칩의 마크를 인식하여 잘못된 마크를 판별하는 마크 자동 검사 시스템에 대하여 제안한다. 불량 항목을 검사하기 위해서 템플릿 매칭 방법과 다양한 불량 판별 조건을 사용한다. 그리고 불량판별 조건은 문자 ROI 명암도, 문자 ROI 매칭, 문자 명암도, 브로컨, 브렌치로 분류된다.
제안된 방법은 마크 불량 판별에 커다란 성능향상이 보임을 일련의 실험들을 통하여 보여준다.

ABSTRACT

The character strings on chips and components are so tiny and numerous that it is a very difficult work for people to perform.
In this paper, we propose a mark automatic checking system, which will determine whether chip is wrong-mark or not by recognizing characters on chips. Lots of faulty detection conditions and template matching methods are used to inspect the faulty mark items. The faulty detection classifies conditions as five kinds-darkness, matching, area, broken and branch.
A series of experimentation show that the method proposed here can offer an effective way to determine wrong-mark on chips.

키워드

mark, template matching, broken, branch

Ⅰ. Introduction

According to industry development, since chip manufacturing processes are complicated ones and final products are obtained after many fine processes, the inferior likelihood of chip is very high due to both mechanical and environmental factors. Because these inferior chips influence PCB quality, all manufactured chips are to be given a priority to get inspection to prevent PCB from faulty in case that the faulty chips are combined with PCB board.

Generally, to inspect a semiconductor elements, dimension is roughly examined by mechanical contact method and an enlarged shape image is tested with the naked eye inspection method. A criterion with naked eye inspection is varied because the basis differs from an inspector's condition and skill. Yet chip kind has a diversity and a tininess through semiconductor industry development, the naked eye inspection is very difficult and causes

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nonhomogeneous production time.

The mark inspection among chip surface examinations is conducted by observing originally produced chip number and manufactured company name printed in chip surface. The naked eye inspection is very difficult to do since chips are not only diverse but tiny. Therefore, if this conventional method is replaced with inspection automation, the level of productivity and quality development will be enhanced.

In this paper we propose automated mark inspection system, which discriminates the wrong string by recognition of recorded strings in chips. The faulty items are as follows: (1) In string omission with string typography; (2) Different character size comparable to other characters; (3) The dim characters comparable to other characters; (4) The double printed characters; (5) The printed characters in wrong position; (6) The broken characters.

To keep higher recognition rate in spite of a variety of faulty and chip kind, the chip inspection algorithm must be robust. Satisfaction of this condition calls for template matching method [3,4,5] and various discriminations. The bad distinction conditions proposed in this paper are classified with teaching and recognition step.

In the teaching step, the character area is taught to inspect mark inferiority. The taught items are ROI(Region Of Interest) brightness, character brightness in the ROI inner, branches, and broken number. ROI means the rectangle teaching area which contains characters to want teaching. The ROI brightness is the sum which adds up gray value of all pixel in the ROI inner area. The character brightness represents sum that adds up gray value of pixel consisted characters in the ROI inner. The broken numbers mean the number closed loop area of a character inner ROI. The branches are number of feature points.

In the recognition step, the items taught in the teaching step are compared with items which are found in the input image such as ROI brightness, character brightness, branches, and broken number.

We are organized as follows. The mark automating system is described in chapter 2. The teaching step for mark inspection is explained in chapter 3. The recognition step is illustrated in chapter 4. Finally the experimental results are elucidated in chapter 5.

Ⅱ. A defective detection initialization

To inspect various kinds of chips and bad items the recognition algorithm must be robust. The whole inspection algorithm is shown as Figure 1. The inspection system is classified into teaching and recognition step. The teaching step is organized with the reference image acquisition with good image, mark area and template image selection, mark boundary detection, and mark thinning. The broken number, branch number, and pixel distribution which are basic information about each character by using boundary and thinning information in mark area, are stored. The recognition step is constructed with the input image acquisition in manufacturing environment, template matching, bad discrimination. In this step, after each character informations are obtained by using template matching, various bad items are detected with correlation of the basic informations founded in the teaching step.

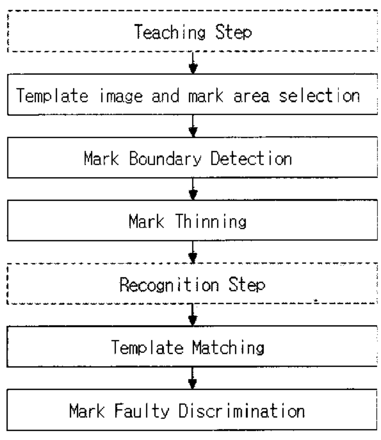


Fig. 1 Mark inspection system flowchart

Ⅲ. The teaching step for mark inspection

In the teaching step, two templates and a mark area in the reference image are selected. The center coordinates of two templates are applied to calculate chip angle on the base line. The center coordinates of two templates are appropriated to calculate the relative coordinate to each character in the ROI. The boundary detection of mark area is used to find the ROI brightness, character brightness, and broken number. The mark thinning is employed to find branch number of a character.

3.1 Template image and mark area selection

The image used in the teaching step must not include any bad items. If the image containing bad items are used, the good input images are recognized with bad product because the extracted informations from bad image are stored even though the input images do not implicate bad items. The image selected with mark and template area from good image appears in Figure 2. The characters' features are extracted from mark areas. The two template areas to execute template matching with input image in recognition step are selected the most fitness areas to alignment chip. In this paper, the two template areas containing various characters are selected, shown as Figure 2. The angle between two templates is calculated to align input image with the base line. When two template areas are selected, to enhance the template matching rate, an area which embraces different character each other must be selected. If only one character is contained when template area is selected, the rate is very low in case input image used detection step holds bad factors.

Fig. 2 Mark areas and template areas on chip

3.2 The mark boundary detection

The boundary has to be detected to find position, ROI brightness information, broken number of character in mark area[6,7,8]. Chain code is employed to trace interior and exterior boundary of characters following binary using Ostu method. Figure 3 represents binary image of mark area and Figure 4 displays the established ROI area about interior and exterior boundary.

The characters' positional information which are relative coordinates from center point of template area to center point of character ROI is required to locate characters' position in the recognition step. The ROI brightness is the sum which adds up gray value of all pixel in the extracted ROI boundary. The character brightness means sum that adds up gray value of pixel consisted characters in the extracted ROI boundary. The broken number represents fragmented rate of each character. The splitted number can be found by means of chain code. A character cracked, broken number will increase. In the case of the character 'A', the broken number comes two in that the boundaries of interior and interior are two. However, if the character 'A' is cracked, the broken number will come out more than two.

Fig. 3 Binary image using Otsu method

Fig. 4 Broken numbers of each characters

3.3 Mark thinning

The characters' thinning algorithm in the mark area is reckoned applied to find the branch number and position coordinates of characters. The branch number represents subsampled feature points of thinned character to increase calculation speed.

To find branch number of characters the 5x5 space filter is applied in order to reduce data throughout after the image is thinned. The thinned image appears in Figure 5 and the reference image applied space filter is given in Figure 6. The subsampled result is shown as Figure 7. The position information of branch is calculated as relative coordinates from the center coordinates of template area to each branch coordinates.

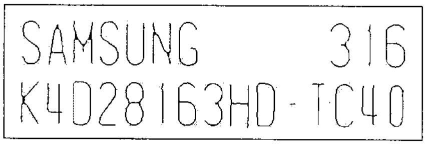


Fig. 5 Thinning of an image

0	0	0	0	0
0	0	0	0	0
0	0	1	0	0
0	0	0	0	0
0	0	0	0	0

Fig. 6 A 5×5 filter mask

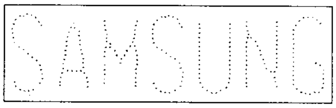


Fig. 7 Branch numbers of each characters

Ⅳ. The recognition step

In the recognition step, all of the processes are performed in the input image. The inferiority discrimination procedure is as follows. The center coordinates of two templates are computed by means of template matching. Also, the chip angle is calculated by using two center coordinates of two templates to figure out the position and branch of a character. The ROI brightness, character brightness, branches, and broken number are calculated. Finally, the ROI brightness rate, character correlation coefficient, and character brightness rate are reckoned.

4.1 Template Matching

To increase accuracy of inspection items in chip mark faulty detection, the correct template matching must be done. The conventional template matching method[1,2] increases computation since correlation coefficient of all distortion area must be calculated in case the input image is shifted, rotated, scaled. In this paper, to reduce the computation and time, the feature point extraction method with two step is proposed.

In the first step, 20 feature points are used to fast move template of reference image into approximate position of input image template. The 20 feature points are estimated by difference value between pixel's maximum and minimum value of each cell, which M×N image is divided into 2×10 cell. 9 feature points approximated position among 20 feature points between reference and input template image are selected.

In the second step, 100 feature points are used to find the real position in the input image. To find 100 feature points, template image is divided into 10×10, as Figure 8. The template matching between reference and input image is done using Eq. (1).

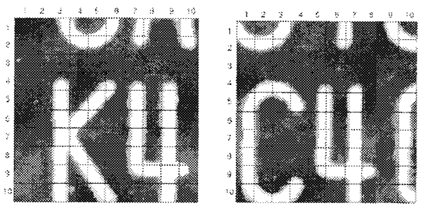


Fig. 8 Template images (10×10 area segmentation)

$$r=\frac{\sum_{i=0}^{M-1}\sum_{j=0}^{N-1}a(i,j)b(i,j)}{\sqrt{\sum_{i=0}^{M-1}\sum_{j=0}^{N-1}a(i,j)^2\times\sum_{i=0}^{M-1}\sum_{j=0}^{N-1}b(i,j)^2}} \quad (1)$$

where,

r = correlation coefficient

$g(i,\ j)$: input image

$t(i,\ j)$: template image

$\overline{m}$: average of $g(i,\ j)$

$\bar{t}$: average of $t(i,\ j)$

$a(i,\ j)=g(i,\ j)-\overline{m}$

$b(i,\ j)=t(i,\ j)-\bar{t}$

M: width of template image

N: height of template image

If the center points of two templates are settled by template matching, chip angle on the base line can be calculated. This angle is compared with angle calculated in the teaching step. The coordinate transformation based on the reference image is described as Eq. (2) and Eq. (3).

$$x' = (x - x_0)\cos\theta - (1/D)(y - y_0)\sin\theta + x_0' \quad (2)$$

$$y' = D(x - x_0)\sin\theta + (y - y_0)\cos\theta + y_0' \quad (3)$$

where,

(x_0, y_0) : the center points of template on the reference image

(x_0', y_0') : the center points of template on the input image

α : the angles between two templates on the reference image

β : the angles between two templates on the input image

$\theta = \alpha - \beta$

D : a ratio of x axis distance to y axis distance

4.2 The mark faulty discrimination

The position information of each character and branch can be calculated by center coordinates and chip angle. The ROI brightness, character brightness, broken number, and branch number are reckoned by these position information. To discriminate the mark faulty, the ROI brightness rate, character correlation coefficient, and character brightness rate between reference image in the teaching step and input image in the recognition are calculated. Figure 9 represents character ROI and branch number about input image.

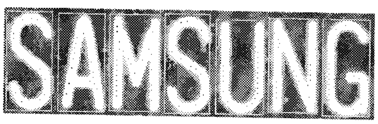
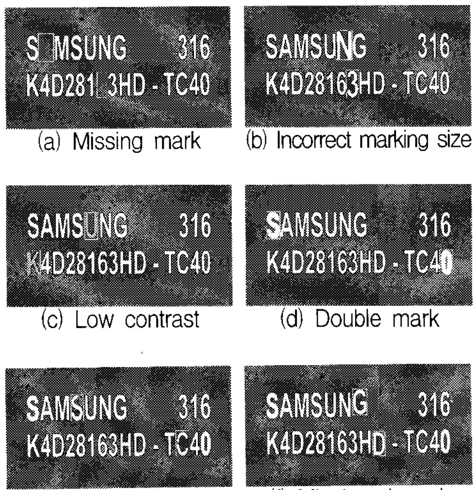


Fig. 9 The ROI of characters and branch numbers on input image

V. The Experimental Results

The vision system used in this research to inspect chip mark consists with 1024×768 camera and Matrox image board, programming language is Visual C++ under window 2000. Like Figure 10 the mark faulty items are classified into string omission, different character size, dim characters, double printed characters, wrong position printed characters, and broken characters. The experimental result applied the proposed matching method with 100 chips is shown in table 1. Figure 11 represents the bad item inspection result image about character 3. Table 2 represents the inspection results for bad items. In Figure 11 the ROI and character brightness, broken and branch number information are applied to discriminate string omission(b). The ROI brightness matching and character brightness and branch number are employed to discriminate different character size. Character brightness is appropriated to discriminate dim character(d) and double printed characters(e). The ROI brightness matching, character brightness, and branch number are used to discriminate wrong position printed character. Lastly, the broken number is of use for discernment of cracked characters.



(a) Missing mark (b) Incorrect marking size

(c) Low contrast (d) Double mark

(e) Broken mark (f) Misplaced mark

Fig. 10 The mark faulty items

Table. 1 Average recognition rate and recognition time of templates (chips:100)

	Template 1	Template 2
Average Time(sec)	0.531	0.52
Average Recognition Rate(%)	98.2	98.8

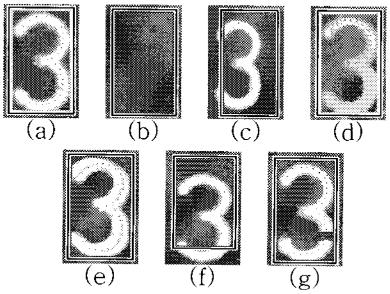


Fig. 11 Inspector results of character 3. (a)Original mark. (b)Missing mark. (c)Incorrect marking size. (d)Low contrast. (e)Double mark. (f)Misplaced mark. (g)Broken mark.

Ⅵ. Conclusion

As is shown above, chip kind is so diverse and tiny through semiconductor industry development that the naked eye inspection is not only hard to do but also incurs nonhomogeneous production time. A chip inspection automation system was proposed to solve such problems. The ROI brightness, character brightness matching, character brightness, branch, and broken number were applied in inspecting six bad items. All of the bad items can be inspected by means of the method suggested in this paper. The result to test 100 chips represents 100% accuracy. We are expected to contribute to semiconductor inspection automation in the next future.

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Table. 2 The inspection results for bad items

	Original mark(a)	Missing mark(b)	Incorrect mark(c)	Low contrast(d)	Double mark(e)	Misplaced mark(f)	Broken mark(g)
Darkness(%)	100	68	90	92	100	91	98
Matching(%)	100	92	86	99	97	86	98
Area(%)	100	0	73	73	64	76	93
Broken(개)	1	0	1	1	1	1	2
Branch(개)	27	13	16	27	27	20	27

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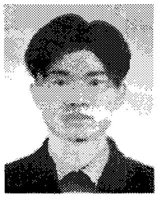
저자소개



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