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Chip Appearance Inspection Using Machine Learning Techniques

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Abstract:

In recent years, the increasing demand for chips has put forward higher requirements for chip production quality and production efficiency. After the chip manufacturing is completed before leaving the factory, it needs to be detected after packaging, which makes the development of chip detection and localization system difficult due to the small size and large number of chips and the high precision requirements for them. Therefore, this paper aims to design a fast, high-precision chip detection and positioning system for the positioning and detection needs of the chip packaging process, the chip detection and positioning system for in-depth research, to achieve the accurate positioning of the chip as well as the deformation produced by the detection of the main work is as follows: the first chapter is mainly about why this paper is mainly aimed at discovering the problems in the chip packaging process. The second chapter is about how to take pictures of the chip. Chapter 3 focuses on the pre-processing of the pictures. Chapter 4 focuses on determining whether the chip is deformed through different machine learning and deep learning techniques. Finally, the conclusion section summarizes the whole paper.

Keywords: YoloV5, system design, chip packaging, chip check

1. Introduction

Today's artificial intelligence era, semi-conductor chips as an essential electronic product, it has become an indispensable component in many fields. With the increasing demand for chips, the chip production has increased accordingly, but the production of chips is not very mature. In the process of chip encapsulation, you need to use the tape machine to tape the chip, the chip is positioned to ensure the smooth encapsulation of the chip. At the same time in the production of the chip surface characters there are characters incomplete, character leakage, stains, and other defects, the need for defect detection of the chip surface characters, detecting the chip characters to meet the production requirements, to avoid unqualified chips into the market. Although the artificial detection is accurate, but the efficiency is too low, and for the detection of precision instruments artificial price is too expensive. Automation is the trend of chip detection, and machine vision learning is one of the main tools used in this paper, compared with the human eye has the advantages of high efficiency, good accuracy and cost savings [1,2]. And machine vision is well suited to small production models. Image acquisition can be captured with a simple camera, and there are platforms that can be referenced and learned on the software side [1,3].

This paper focuses on the analysis of why chips have problems in the packaging process and, the detection of the problems [3]. The main design of a simple and easy to implement system for chip detection. The operation process of this system can be divided into the following steps, first through the electronic camera technology for the semiconductor chip appearance shooting, and then need to be shot on the finished data image analysis, and finally through machine learning and deep learning technology for the pre-processed data to detect the chip appearance whether there is a problem [4,5].

First, it is mainly about why this paper mainly aims at discovering the problems in the chip packaging process [6]. Specifically, the whole preparation process of semiconductors is described, and it is understood that packaging is a later stage of semiconductor manufacturing process, and there are many problems that may occur in the process of packaging, which directly lead to the possible defects after packaging [7]. Secondly, it focuses on how to choose different optical components, including light sources, electronic cameras, and how to combine these components for chip shooting[5,7].

As well as in comparing different light conditions for the positioning of the chip is to determine whether the strong light source or weak light source is easier to locate. At the same time, different light sources have different life, price and characteristics, from the economic consideration of which light source is the most cost-effective. Then, it focuses on the noise that may appear in the process of taking pictures, compares the differences between various filtering methods in processing the captured images; at the same time, the captured images are divided into multiple parts, and the detection is carried out in each part [8,9]. Lastly, it focuses on determining whether the chip is deformed through different machine learning and deep learning techniques and locating and detecting the chip through the YOLOv5 chip localization algorithm.

2. System Design

2.1 Manufacturing of semiconductor chips

The processing of semiconductor chips is usually divided into front-end process, back-end process, testing, and packaging. The wafer handling process and wafer pinning process are called front-end processes, and the assembly process and testing process are called back-end processes.

The wafer handling process is to install circuits and electronic components on the wafer through photolithography, and then through deposition, various thin films are deposited on the chip surface, such as insulating layers, conductive layers and so on [1,10]. The layers of material on a wafer are flattened to ensure a smooth surface for subsequent fabrication. Modern chips often have multiple layers of metal interconnections, which are connected by perforations (through-holes). After processing the wafers, it's time for testing and dicing. Once fabrication is complete, each chip unit on the wafer undergoes an initial electrical test to ensure there are no functional anomalies. After confirming the completion of the chip, the wafer is cut into individual chips using a laser or diamond cutting tool. Afterwards, all chips are constructed and tested to ensure that they meet the requirements [6,10]. And this time the chip cannot be used directly but need to be encapsulated into an independent whole to use [11]. encapsulated chip has a fixed, sealed and protect the function of the chip, but also to enhance the chip's thermal conductivity, at the same time, you can use wires to connect the chip and shell pins, these pins can also be connected to other devices and produce contact, so that the chip and the outside world associated with each other, it can be said that the shell is the key to contact the chip and the external circuit[4,5].

However, during the semiconductor packaging process, there are a variety of damages that may occur due to labor and technical defects, which may affect the normal operation of the chip, including scratches on the chip or deformation caused by uneven force. The following figure 1 shows the possible deformation of the chip due to extrusion or the amount of material [12].

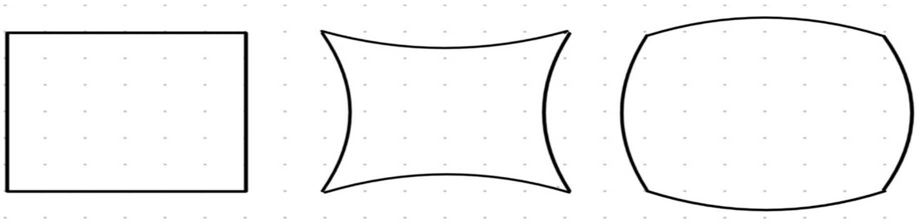

Fig. 1 Possible deformation

2.2 Select Optical Components to Form a Vision Inspection System

The function of an image inspection system is to take pictures of the chip instead of the human eye and record the data for the subsequent operation of the process.

There are many things to consider in the image acquisition process, including cameras and lenses to determine whether the acquisition of high-resolution images, lighting to determine the degree of visualization. Reasonable lighting scheme design, help to obtain uniform illumination, brightness appropriate, defects highlight the detection of the image. And have a certain degree of resistance to external noise.

Because of the financial and time problems this experiment uses the Sony ILCE-7CM2 A7C2 camera; the lens uses the Sony FE 50mm F2.8 SEL50M28 fixed focal length, as an entry-level shooting tools, their pixels are enough to support the shooting of a certain degree of chip deformation and text smudging.

The light source is very important to a vision system, and it directly affects the quality of the data captured by the camera, and thus the accuracy of image recognition [10]. Common light source these three fluorescent lamps, metal halide lamps, LED lamps. Different types of light sources have their own advantages and disadvantages, as shown in the table below [8].

Table 1. Three Light sources comparing

Type	Price	Flexibility	Life Span	Characteristic
High-frequency fluorescent lamps	Low	Low	1500-3000h	Good diffusion and suitability Larger plots of land square, but slow to respond, Somewhat dark
Fiber optic halogen lamps	High	Mid	1000h	High brightness, slow response, The light is not easily exposed to the outside world effect
LED	Mid	High	10000-30000h	The response is fast and the brightness is acceptable. The line is adjusted, and the wavelength is possible to choose according to the application

We can understand that to make the irradiation clear, LED light source is the best light source, his imaging is clear, in order to facilitate the subsequent operation.

2.3 Pre-processing of Images After the Shooting Process

Image pre-processing is the preliminary processing of the image obtained in advance, to lay a good foundation for the next operation.

The first step in image processing lies in the gray scaling of the image, which can make the picture only black and white, no matter whether it is to judge whether there is wear and tear on the surface of the encapsulated chip, or to judge whether there is deformation of the chip in the process of encapsulation as long as the determination of the number of black and white pixels can be. For the second step of image processing lies in the image filtering. Image filtering is a basic technique in digital image processing, designed to process the image through specific algorithms to achieve the purpose of denoising, enhancement, edge detection and so on. Filters can be linear or nonlinear, and each type of filter has its specific application scenarios and effects. In this paper, we use Gaussian filtering, which uses Gaussian function as weights and weighted average of pixel neighborhood, which is suitable for removing Gaussian noise [4,5]. The third step for image processing lies in the segmentation of the image, segmenting the image into several different wholes is beneficial for analyzing the problems that occur in each block. The fourth step for image processing is threshold segmentation, threshold segmentation is a region-based image segmentation technique, the principle is to divide the image pixels into several classes. This method is suitable for images where the target and background occupy different gray level ranges. It not only greatly compresses the amount of data, but also greatly simplifies the analysis and processing steps [2,7].

2.4 Image processing through artificial intelligence technology

First, the standardized version of the chip must be manually inspected to ensure that it meets the set criteria. In this process, the standard chip needs to be divided into different regions, and the selection of appropriate calibration plate parameters is particularly important in this step. Correct parameter settings can not only improve the clarity of imaging, but also enhance the accuracy of calibration, laying a solid foundation for subsequent inspection.

Next, the chip is accurately positioned using the YOLOv5 chip positioning algorithm. Since the chip is usually placed manually on the inspection table, the position may have some deviation [13]. The YOLOv5 algorithm is able to accurately recognize and locate the chip to determine the actual position of the chip and correct the image as necessary to ensure the accuracy of the detection [8]. YOLOv5 is an advanced target detection algorithm with the significant advantages of high-speed real-time detection, high accuracy, and multi-target detection. A single detection is used to quickly localize and classify targets through convolutional neural networks [4][14]. Its lightweight design and efficient architecture enable it to achieve fast response while maintaining detection accuracy, and it is suitable for multi-target recognition in complex scenes.YOLOv5 performs particularly well in small-target detection and has good portability to run on resource-constrained devices. It divides images into grids and utilizes an anchor frame mechanism to detect objects at different scales. In chip inspection, YOLOv5 can precisely locate chips, identify subtle defects, support multi-target detection, and is fast and accurate, making it well suited for real-time inspection tasks[2,9,11].

Finally, by automatically comparing the pixels of the chip image with the standard pixels through the software, it is possible to quickly recognize any problems in the appearance. In this way, the system can accurately detect defects in the chip's appearance, ensuring that every chip that leaves the factory meets strict quality standards.

3. Summary

This paper focuses on designing a chip inspection system that can be easily implemented in the laboratory, hoping to enhance the accuracy of recognition as well as reduce labor costs through machine learning. Firstly, a shooting system is designed to clearly capture pictures of chips, and then machine learning algorithms are used to determine whether there is a problem or not after the pictures are processed.

Machine inspection greatly improves the efficiency and accuracy, can quickly complete the inspection of many chips, and accurately identify small defects, reducing the generation of defective products. In addition, machine inspection avoids subjective errors and the effects of fatigue in manual operations, ensures the consistency of inspection standards, and reduces the error rate. It also saves significantly on labor costs and can work 24hours a day to increase production capacity. Machine inspection also features automatic data recording and analysis, facilitating optimization of the production process and enhancing quality control. More importantly, in harsh environments or scenarios where hazardous materials are handled, machine inspection guarantees operational safety and maintains a high degree of repeatability, helping to maintain product quality stability over time.

This paper does not have hands-on practice to build such a system, but rather proposes a scheme for low-cost rapid chip inspection in university laboratories. And it has a variety of shortcomings, and a variety of problems that have not been solved, including how to design a software to automatically compare different pixel grids. And because of the inevitable tolerances in the process of chip manufacturing, so in different parts of the chip, in the end, that kind of degree can be regarded as broken, cannot be used, but also through many experiments to generalize and summarize.

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