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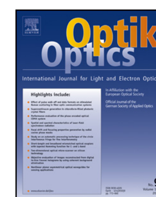

Automatic alignment and testing system for wafer with ball grid array

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ABSTRACT

In order to develop automatic testing system for wafer with ball grid array, a method of pattern matching using the feature of ball grid array is proposed, and a new testing system with optical system and motion control system is integrated. It was found that the accurate position of wafer can be found before wafer probe testing, and the relative position between probe array and every chip can be calculated. The wafer can be aligned precisely by image process and motion control. Results show that the automatic testing of wafer can be carried out, and the electrical properties of the chip can be effectively evaluated.

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1. Introduction

In order to find defective chips on the wafer, it is necessary to do wafer probe testing before the process of wafer dicing. With the rapid development of wafer fabrication, testing on wafer is becoming more and more important in recent years [1–5]. And ball grid array (BGA) is widely used in microelectronic industry, so there are usually many ball grid arrays on wafer. Wafer probe testing is to make the probes and solder balls contact, so that the electrical properties of chips on the wafer can be detected [6–9]. Though some non-contact wafer probes have been reported to do wafer probe testing, the cost is expensive and the technology is immature [10]. The wafer alignment is the difficult and critical part in the wafer probe test process. So an accurate automatic method for wafer with ball grid array is greatly needed in current industry [11–13].

Many studies have been conducted on the problem of wafer alignment. Chen et al. [14] reported that an image inspection and accuracy positioning system have been developed as automated measurement machine to deal with ball grid array type printed circuit boards (PCB). Langlois et al. [15] used a pattern tracking method to make the alignment of two wafers and build a automatic alignment system, which includes an image processing system and a wafer bonding system. A wafer pre-aligner system is reported to solve the problem of alignment, which uses a new algorithm of image processing to capture the special area of wafer edge [16]. An algorithm regardless of rotation center is used to make the wafer alignment by proposing an equation, which can be applied to PLC-based system [17]. Alexander H. Slocum et al. [18] reported a passive mechanical wafer alignment technique, which is based on the principle of elastic averaging.

In this paper, an automatic alignment system for wafer with ball grid array is integrated with motion stage, vision module and probe card. Based on the align system, wafer probe testing can be done smoothly and the test results turned out to be accurate.

2. Description of the automatic wafer alignment system

The automatic wafer alignment system includes a mechanical movement module, a wafer image capture module, a probe card module, an electronic performance test module, a human machine module, as shown in Fig. 1.

The mechanical movement module consists of XYZ motion guides, which are driven by three serve motors, a precision rotating platform, which is driven by a stepper motor, a motion control card, which is used to control the movement of all the above motion mechanism. The type of serve motor is Panasonic A4, which can provide a high-speed and high-accuracy motion. Before the automatic test process, wafer will be loaded on the wafer chuck, and the wafer chuck is installed on the rotating platform. It is necessary to adjust the wafer to a right angle, so the accuracy of the rotating platform and the stepper motor is very important. Here in the system, the type of rotating platform is HY10DX200G offered by Beijing Hengyuan Zhonglian Instruments Co., Ltd, whose resolution is 0.00125°and the maximum speed can reach 25°/sec. The type of

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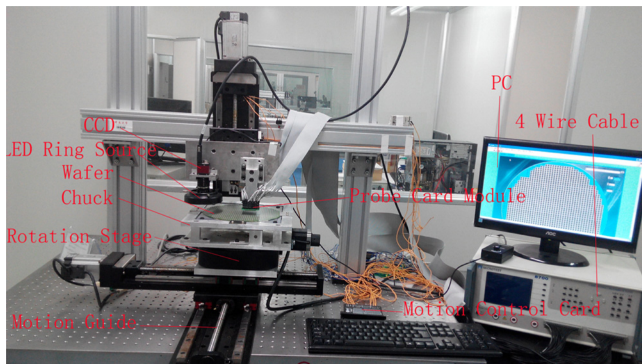

Fig. 1. Structure of automatic alignment system.

motion control card is DMC432 C offered by Leadshine Technology Co., Ltd. DMC432 C is a four-axis motion control card based on ASIC technology, which has the advantage of high performance and high reliability and uses PCI bus to realize the link with computer. And its four encoders can help to obtain the current position information, which can meet the requirement of this wafer alignment system.

The wafer image capture module includes a Charge-coupled Device (CCD) and a LED ring light source and it is installed on the Z motion guides. The resolution of CCD is 1624×1234 and pixel size is 4.4 μm. During the process of wafer alignment, the CCD will obtain some local gray images follow the instructions from PC. And the LED ring light source can improve clarity of the images, which will contribute to subsequent image processing.

The probe card module consists of microprobe array, PCB board, probe plate and probe guide plate and this module moves with the Z motion guides. One end of the microprobe contacts with the pad on the PCB board, and the other end contacts with the solder ball on the wafer, then electrical circuit is formed and information of chip can be detected.

A kind of four-wire cable tester is used in electronic performance test module. The resistance testing accuracy of the cable tester is 0.001 Ω, and it can also provide many other test items, such as capacitors, inductors, leakage test and so on.

3. Experiment

3.1. Accurate calibration of the relative position

The wafer tested by this system is showed in Fig. 2, it is a kind of CIS (CMOS Image Sensor) wafer with many ball grid arrays. As shown in Fig. 2(b), it is a CMOS chip in every rectangle box and there are 55 solder balls on every chip. All these solder balls are arranged in array on the chip, which can be used for the wafer alignment.

Before the wafer alignment, we should make accurate calibration of the relative position between the FOV (Field of View) center of CCD and the center of probe card. As shown in Fig. 3, a microprobe is installed on the chuck and it is performed as a reference. During the process of calibration, this microprobe will be moved from the FOV center of CCD to the center of probe card. Another CCD is used to detect if the microprobe moves to the center of probe card. Relative position between the FOV center of CCD and the center of probe card can be obtained by the movement distance of the microprobe.

3.2. Principle of image processing

During the process of wafer alignment, the system should put one chip on the wafer in the center of CCD FOV. There is a position error for many factors, so it is needed to make image processing to find the accurate position of wafer. The gray image captured by CCD is showed in Fig. 4 and the chip in the red rectangle is target

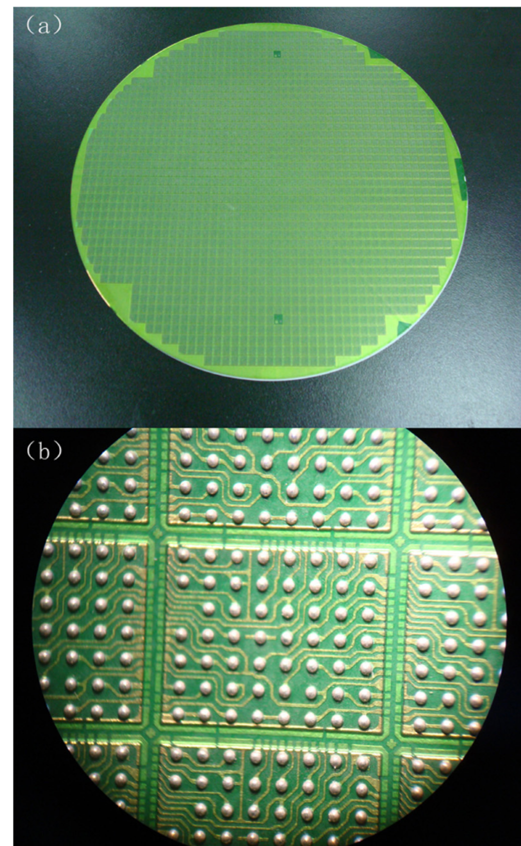

Fig. 2. Wafer to be tested. (a) Overall image. (b) Local image.

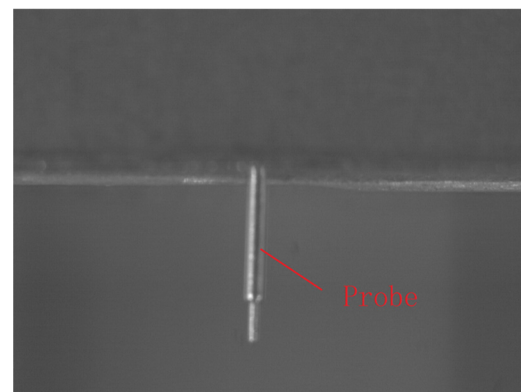

Fig. 3. Reference for calibration.

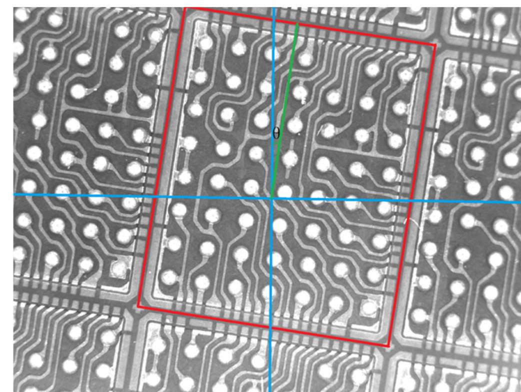

Fig. 4. Gray image of wafer.

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