A comparison of lifted lead defect inspection system for surface mount technology

Rizauddin Ramli¹*, Dzurai'dah Abd Wahab¹, Jaharah Abd Ghani¹ and Raime M Zain²

¹Department of Mechanical and Materials Engineering, Faculty of Engineering and Built Environment, University Kebangsaan Malaysia, 43600 Bangi, Selangor, Malaysia
²Freescale (M) Sdn. Bhd. Petaling Jaya, Selangor, 47300, Malaysia

Received 20 September 2011; revised 23 March 2012; accepted 26 March 2012

This study presents development of an automated lead defect inspection system by using Visual Mechanical Inspection Scanner (VMIS) in semiconductor industry. In any device seated out of cavity, VMIS detects misplacement error (ME), a quality defect in surface mount technology (SMT). ME causes a lifted lead defect on lead packages. MEs that can be analyzed are of two kinds: i) device seated out of cavity; and ii) double devices imbedded in the same cavity. The system was successfully tested on devices with 90% accuracy of inspection. Thus VMIS can inspect device seated out of cavity and hence prevents lifted lead from occurring.

Keywords: Lifted lead defect, Surface mount technology (SMT), Vision camera

Introduction

Most of the electronic products today are using printed circuit board (PCB), where components are placed on top of circuit boards for end-user product assembly lines. Through-hole method of device insertion has been essentially replaced by surface mount technology (SMT)¹,². Cost effectiveness and higher quality are prerequisites in surviving the market competition³. In most of today’s advance SMT factory automation, a pick and place (PnP) transfer machine has been used as one of the main facilities to achieve company’s productivity. However, PnP, an automated expensive equipment, constitutes to the bottleneck of production line⁴. Two types of PnP transfer machines (simultaneous and sequential placement PnP systems) have been largely used in SMT factory⁵-⁷. Even some studies on using visual inspection to observe SMT abnormality in production line have been carried out; a very little attention has been paid on selecting appropriate method of camera setting⁸-¹⁰. Visual inspection in SMT inspections uses fibre optic sensors that are designed for device protrusion above 0.8 mm. However, for devices thinner than 0.4 mm, fibre optic sensors have less accuracy as they are unable to inspect if two devices are located in the same cavity. Such inspections are very important in order to confirm the PCB works correctly because any lifted lead (LL) will cause a major accident. For instance, if a PCB for an automatic breaking system is malfunctioned, a moving vehicle will fail to stop and can cause death to driver and passengers.

This study presents comparison between two methods of vision camera mounting at Visual Mechanical Inspection Scanner (VMIS) for the detection of device seated out in tray cavity at the output module area.

Experimental Section

Pick and Place (PnP) System

This study focused on sequential PnP transfer system, in which every single defect component will be seized and placed on the designated matrix tray. Sequential PnP transfer system consists of three main parts (magazine tray feeder, table that holds PCB, and transfer system with an end effectors that collects components from magazine). PnP probe uses a vacuum suction system and servo motor for its Y and Z axis movement. In most cases, a misplacement error (ME) occurs (Fig. 1) because device is seated out of cavity and probe collides with device during its down movement, hence causing a LL problem. ME that occurs due to feedback information from vision camera cannot give a correct value of the distance between probe and device.

---

*Author for correspondence
E-mail: rizauddin@eng.ukm.my
Experimental Set up

A vision detection system (VDS) for continuous inspection of any protrusion part of device seated out of cavity was used as experimental platform. There are three situations when device is seated on cavity: i) device is located properly inside the cavity (Fig. 2a); device is seated out of cavity (Fig. 2a); and iii) two devices are mistakenly occupying the same cavity. Both latter situations (Figs 2a & b) are regarded as defected. Main problem of device seated out of cavity is that it can create a higher possibility of the device to be bent. As a result, LL defect will increase when stacking action is carried out onto the output stacker module. This is because defective device will be stacked up under a heavy load of existing number of trays that are filled with devices.

VDS (Fig. 3) can inspect in two modes (test mode or run mode). In test mode, VDS does not link with handler and allows operator to confirm the machine setup by testing few samples before running the system. In run mode, VDS starts the inspection sequence once it detects any device on the tray. So, if VDS detects any protrusion part on the image, it will send a signal to VMIS controller through its interface board, which triggers VMIS to stop. Selection of parameter detection value was obtained by setting the camera using trial and error technique. It was done by setting the camera mounting distance from tray edge. Also, camera focal point targeted on the image was set by selecting three points in order to determine the best focal point, where camera is focusing.

**Fig. 1**—Pick and place probe clashed with device

**Fig. 2**—Conditions of device seated on cavity: a) device is located properly inside the cavity; b) device is seated out of cavity; and c) two devices are mistakenly occupying the same cavity

**Fig. 3**—Flowchart of vision detection process

**Lifted Lead (LL) Coplanarity**

In PCB manufacturing, coplanarity is one of the defects for LL, caused by the distance between lead tip
Most specifications in SMT limit coplanarity at a maximum value (0.1-0.2 mm) from the device seat plane. In this study, a VDS was used to visualize coplanarity. During setting of VDS, limitations of space available to install vision camera, lighting, computer system and associate parts were considered. This is necessary to ensure that VDS would not interrupt the movement during PnP operation. In this case, since LL occurs after PnP operation at output module, vision camera was mounted under PnP module. Thus VDS can immediately detect any misplaced device and feedback the machine to stop PnP operation upon receiving the error signal.

**Results and Discussion**

Two types of protrusion failures and a non-failure device were established to be tested. These parts with protrusion failures were randomly put on the tray and experiments were done in run mode. For optimal form of camera mounting, experiments were done by both top and side view detection methods. For each experiment, 10 occurrences were used to simulate the actual manufacturing condition.

For top view detection method (Fig. 4), a front lighting system was used as light source, which is attached near to vision camera but located facing the image that need to be captured. In addition, a ring type assembly lighting source was also used. The ring type assembly requires to be fixed together with vision camera so that it can capture image through middle area of the ring. In top view detection method, only few kinds of defects such as device seated out of cavity is suitable. However, if there are any double unit stacked up together in the same cavity, only 60% can be detected. For side view detection method (Fig. 5), a rear lighting system was used, where light source is attached opposite to the target image that faced vision camera. Side view detection method used a rectangular assembly lighting source, in which the arrangement allows lighting source to gleam on the image in front of vision camera. Hence, it was able to project a clear image of any protrusion parts of the device above tray. Side view detection method gave better detection than top view detection method (Fig. 6).

Thus VMIS can detect completely all 10 occurrences of device seated out of tray cavity and have failed 9 out of 10 occurrences for the double units seated in the same cavity.
cavity. It means that 90% of double unit stacked up together in the same cavity can be detected. It is thus ascertained that this method can improve the capability of detecting misplace occurrences. Both methods were efficient in detecting the device seated out of cavity tray. However, in detecting double device seated in the same cavity, side view detection method gave 90% efficiency compared to top view detection that gave only 60% accuracy. Thus side view method is better compared to top view method.

Conclusions
Two types of vision detection methods (top view detection and side view detection) were tested, where both camera orientations are different from each other. Experiments with 10 occurrences were carried out for each detection method with two kinds of defects (device seated out of tray cavity and double device seated on the same tray cavity). Both methods were efficient in detecting the device seated out of cavity tray. However, in detecting double device seated in the same cavity, side view detection method gave 90% efficiency compared to top view detection that gave only 60% accuracy.

References