COMPARATIVE STUDY OF TWO SCANNING TECHNIQUES IN AUTOMATIC SIDE VISUAL INSPECTION OF WETTABLE FLANK QFN PACKAGES

Rohn Kenneth L. Serapio
Jerry T. Diwata
Ernesto T. Antilano Jr.

New Product Development & Introduction, Back-end Manufacturing & Technology
STMicroelectronics, Inc., 9 Mountain Drive, LISP II, La Mesa, Calamba City, Laguna 4027 Philippines
rohnkenneth.serapio@st.com, jerry.diwata@st.com, ernesto.antilanojr@st.com

ABSTRACT

Automatic visual inspection is an integral step in the assembly of wettable flank Quad Flat No Lead (QFN) packages. It is a process wherein components with external flaws are separated and removed from the good ones. Selection of correct scanning method is essential to have effective inspection and to avoid false detection of rejects. Therefore, this paper aims to discuss two scanning techniques used in a typical vision system and to compare which one is better in preventing false detection of side rejects. Actual experiments were conducted in an ICOS™ leadless inspection module using a considerable quantity of wettable flank QFN samples. Data obtained were then arranged and statistically analyzed. From here, it was found out that between pad inspection and body inspection, pad inspection has the smaller false side rejection rate, making it a better pick over the side body inspection.

1. 0 INTRODUCTION

Quality control is indeed an integral part of any manufacturing assembly. It is a set of procedures done in order to guarantee that customers acquire finished products free from any defect. Effective quality control in place not only saves the manufacturers from costly product recalls but also increases customer satisfaction and gains new customers, which in turn improves position of the business in the market[1].

One of the aspects of quality control is the outgoing visual inspection. Visual inspection screens out both cosmetic and functional defects of a product. It can be done manually, but most manufacturers are now inclined towards the use of automation to eliminate human error and bias, improve product quality, and increase productivity[1].

In automatic visual mechanical inspection, an object is scanned repetitively with the use of advanced computer vision system to spot external abnormalities. This begins with the emission and directing of light rays to the surface of an object. The reflected light rays are then captured by a sensing module and transmitted to a computer for analysis. The optical data obtained will be compared subsequently to a reference pattern or model in which characteristics of normal and defective components are predefined. This comparison of optical data to that reference model will be the basis whether the component inspected will be accepted or rejected[1].

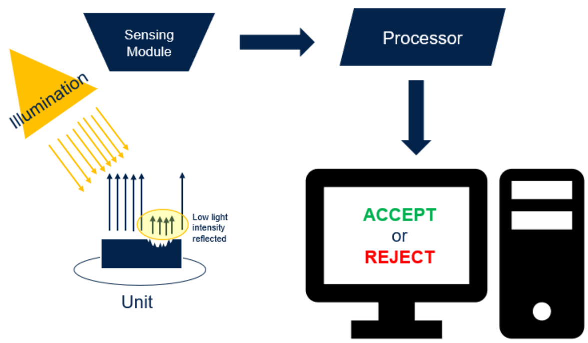

Fig. 1. Schematic drawing of a vision system

Visual mechanical inspection has found its valuable application in the assembly of Quad Flat No Lead (QFN). QFN is an integrated circuit (IC) package whose function is to link a silicon die physically and electrically to a printed circuit board through surface mount technology. One configuration of this package is known as wettable flank QFN (see Figure 2). Unlike other standard QFNs, wettable flank QFNs have plated, solderable sidewalls that form solder fillets during soldering[4,6].

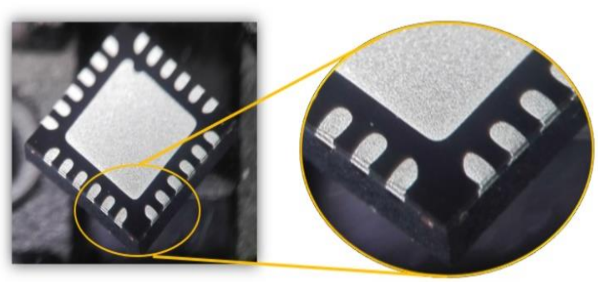

Fig. 2. Saw step cut Wettable flank QFN

The typical side defects encountered in a saw step cut wettable flank QFN package are foreign matter, metal smearing and metal burrs (see Figure 3). These are usually produced by improper handling, contamination from environment, and defects from full cut singulation process. With these side defect occurrences, it is very important that the inspection is executed effectively in order to detect and screen out bad components correctly.

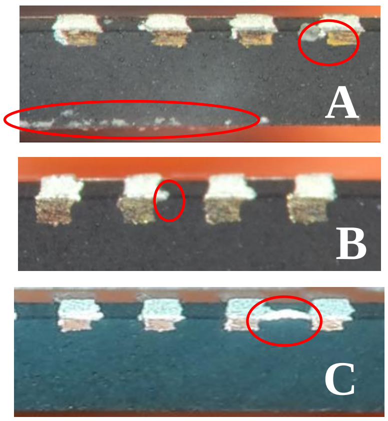

Fig. 3. Side defects: (a) foreign matter, (b) metal smearing, (c) metal burrs

A typical vision system has different methods to scan an object of interest. For an ICOS™ inspection module, these are (1) alignment, (2) pad inspection and, (3) body inspection. Alignment is used to locate pad position. Pad inspection is utilized for measuring pad characteristics such as spacing, width, length, terminal dimension, pitch, span, offset and distance to edge. On the other hand, body inspection is for the measurement of body features such as edge straightness, dimension, edge orthogonality and parallelism[3].

One of the challenges in the side inspection of wettable flank QFN is the inevitable rejection of good units. This wrong judgement can be attributed to the misalignment of side pad termination with the inspection area during inspection. A right selection of scanning technique is thus crucial for accurate visual mechanical inspection result.

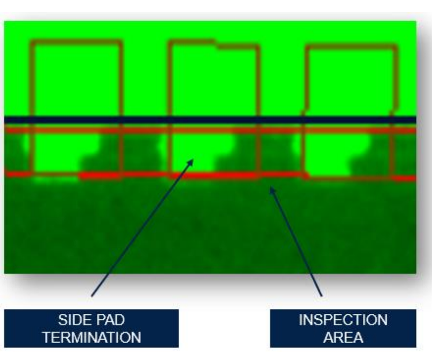

Fig. 4. Misaligned pad termination with inspection area

The purpose of this work is to perform two scanning techniques in ICOS™ vision system and to determine which one is better in preventing false side rejection.

2. 0 REVIEW OF RELATED WORK

Refer to 1.0 Introduction.

3.0 METHODOLOGY

For this study, a 6x6x1.0 wettable flank QFN package with 0.5 lead pitch were used as experimental samples. They underwent typical end of line back-end manufacturing assembly process flow as shown in Figure 5. Visual mechanical inspection was done in an ICOS™ leadless inspection module (see Figure 6.)

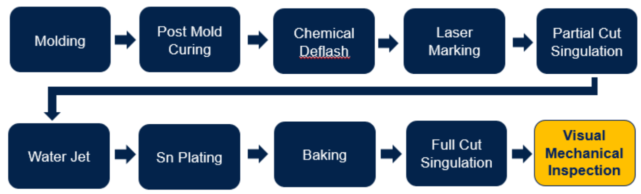

Fig. 5. End of Line Assembly Process Flow for Wettable Flank QFN packages

Fig. 6. ICOS™ leadless inspection module[2]

Pad inspection and body inspection were the two scanning techniques performed and evaluated in this work. For both techniques, alignment is done first to have a more accurate placement of search windows. Here, the X and Y positions as well as component rotation are computed by the system according to the pads located. Alignment can be fine-tuned further through modifying parameters such as pad quality, contrast, and pad position and dimension tolerances[3].

A total of 30 lots with an average of 2600 units per lot were used to test each scanning technique. False side rejection rate was calculated by dividing the quantity of false rejects recorded by the total quantity of units inspected times 100%. Statistical analysis was then carried out through JMP® software to assess the normality of data, to test for equal variances and to compare the rejection rate means.

4.0 RESULTS AND DISCUSSION

4.1 Statistical analysis

The false rejection rate data distribution was first assessed using goodness of fit test. According to Shapiro-Wilk test of normality, the data are normally distributed if P-value (Prob<W) with 95% confidence level is greater than 0.05. Figure 7 shows the normality test result. From here, it can be seen that the data is positively skewed and the calculated Prob<W is <0.0001. Since it is not greater than α = 0.05, the data are hence non normal.

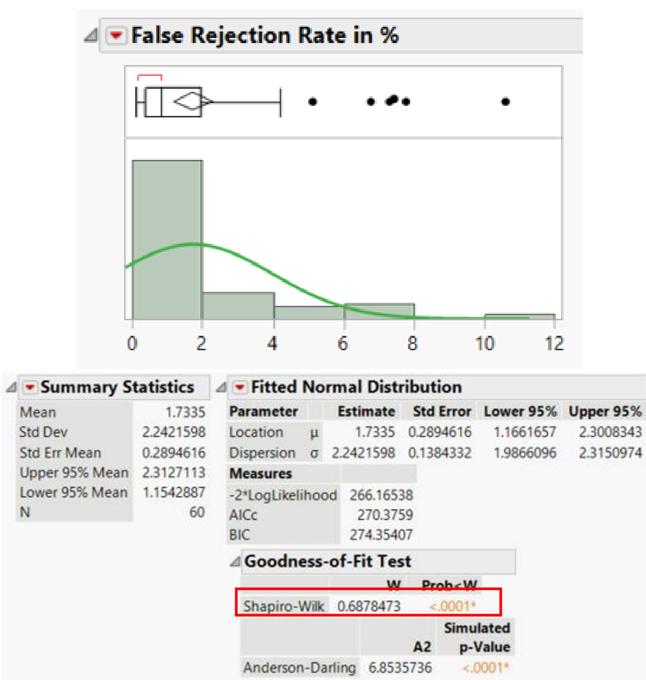

Fig. 7. False rejection rate data distribution

The test for equal variances was then performed. Because the data distribution is non normal, Levene test was used. The computed Prob > F value at 95% confidence level is <0.0001 (see Figure 8). Because it is less than α = 0.05, it can be said that the variances of two inspection types are not equal. There is also a huge gap between the standard deviations of the two inspection types. For side body inspection, the standard deviation is 2.65 while for side pad inspection, it is 0.37.

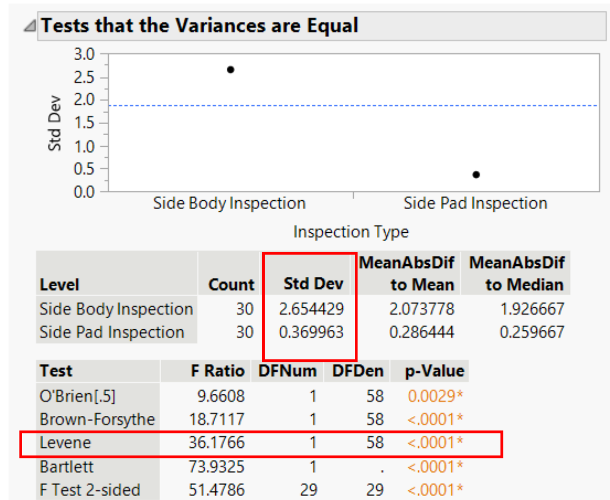

Fig. 8. Test for equal variances

Figure 9 shows the graph of false rejection rate against inspection type. It is obvious from the graph the large difference between the false rejection rate data of two scanning techniques. t-Test was conducted for the comparison of two means. The resulting Prob > |t| value of the test was <0.0001. Thus, at 95% confidence level, there is a significant difference between the average false rejection rates of two inspection types. For the side body inspection, the mean rejection rate is 2.94%, while for the side pad inspection, it is just 0.37%.

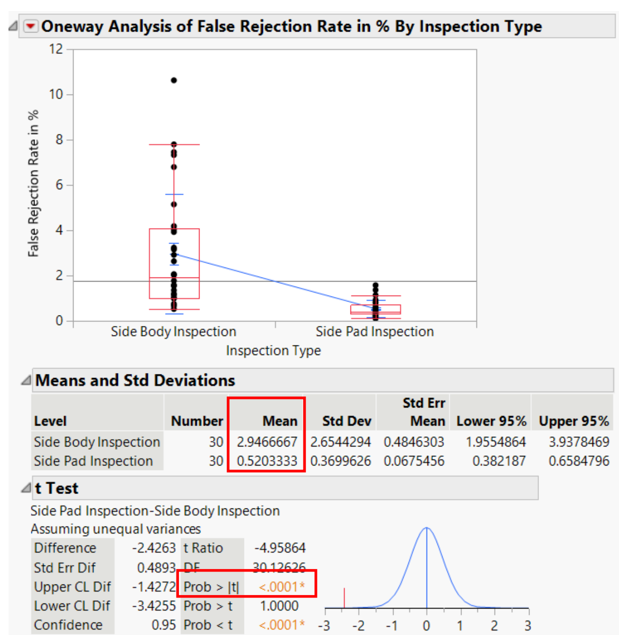

Fig. 9. Graph of false rejection rate vs inspection type and t-Test for means

4.2 Side body inspection versus side pad inspection

From the statistical analysis, it is obvious that side pad inspection is a better choice over side body inspection because of its very small false rejection rate. A relatively high rejection of good units in side body inspection can be attributed to tilted units during processing.

Figure 10 illustrates the inspection of tilted and non-tilted units using side body inspection scanning technique. There are no problems with non-tilted units. However, when inspecting tilted units, the inspection area (in green box) is offset because the other side is recognized by the alignment reference (in blue box). This gives false visual machine judgement.

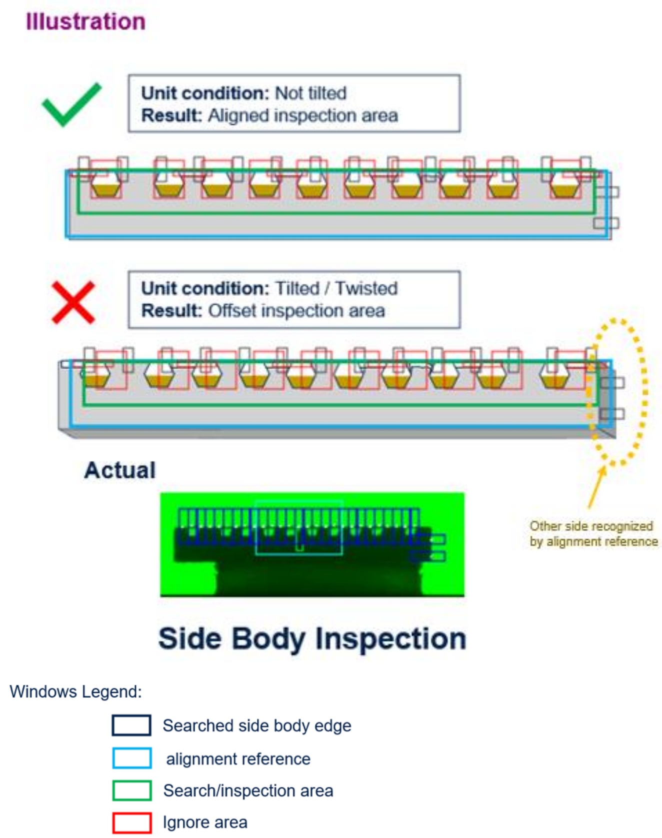

Fig. 10. Processing by side body inspection

On the other hand, in side pad inspection, the alignment reference (in blue box) is focused on pad areas. With that, even if the units are tilted, the inspection area (in green box) will still be aligned and same as non-tilted ones. Therefore, false rejection is minimized. See Figure 11.

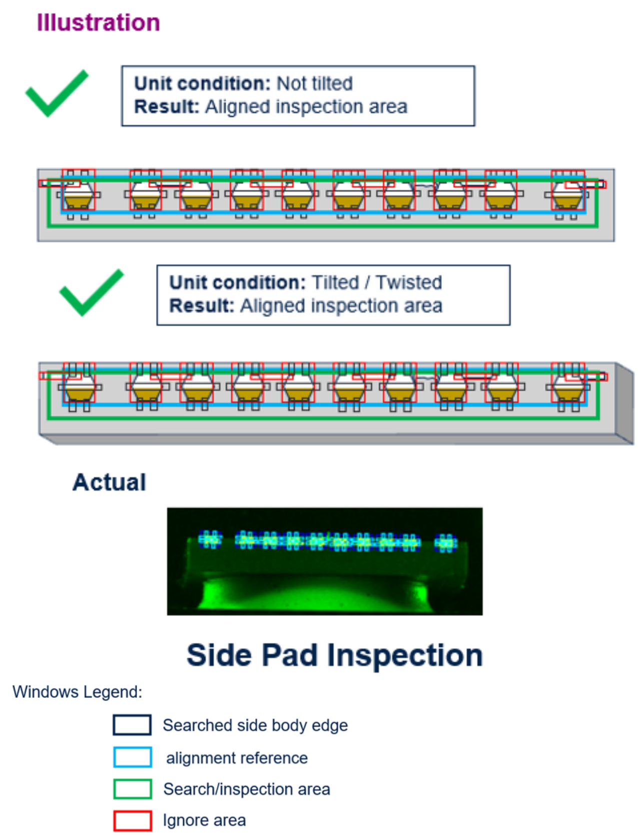

Fig. 11. Processing by side pad inspection

5.0 CONCLUSION

This work successfully determined which scanning technique in ICOS^{TM} vision system is better in terms of side inspection of wettable flank QFN packages. From experimental results, it was revealed that side pad inspection is achieving lower false side rejection rate compared to side body inspection.

Since pad inspection is focused on pad areas, there will be no misalignment in inspection area even if the units are tilted. This leads to a reduced chance of false detection of rejects. In contrast, the body inspection is focused on package body. If the unit is tilted, the other side of the unit is also recognized, giving inspection misalignment and false visual machine judgement.

6.0 RECOMMENDATION

It is recommended that more experimental runs be made to confirm the results. Since one of the sources of false rejection of good units is loose foreign matter, it is also proposed to use air blower prior automatic visual inspection to eliminate this source.

7.0 ACKNOWLEDGMENT

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9.0 ABOUT THE AUTHORS

Rohn Kenneth SERAPIO is a Senior Engineer at New Product Introduction, Back-End Manufacturing and Technology of STMicroelectronics, Inc. He spearheads the development of end of line chemical processes, particularly Sn plating, Cu backside leadframe etching, chemical de-flashing, water jet, and electro-deburring processes. He received his bachelor's degree in Metallurgical Engineering, *cum laude*, from the University of the Philippines Diliman. He has 5 years of relevant experience in electronic component and semiconductor manufacturing industries. Before joining STMicroelectronics, he served as Plating Technical Engineer at Samsung Electro-Mechanics Philippines Corporation.

Jerry DIWATA is a BS in Industrial Technology major in Electronics graduate from Catanduanes State University of the Philippines. He has been working at STMicroelectronics Inc. since February 2020. He is currently a member of ST New Product Development & Introduction group focusing on the end of line processes, particularly in lasermarking and visual mechanical inspection. Before joining STMicroelectronics, he served at Amkor Technology Philippines as End-of-Line Equipment Specialist for 6 years.

Ernesto ANTILANO Jr. is a Staff Process Engineer at Back-end Manufacturing & Technology, New Product Development & Introduction at STMicroelectronics, Inc. leading mold process development. He has twenty-four years of experience in the industry and gained his first semiconductor experience at Team Pacific Corporation as FOL wirebond technician. He graduated from the Technological University of the Philippines–Visayas with a degree of Electronics Technology and earned his bachelor's degree in Electronics and Communication Engineering from Technological University of the Philippines Taguig.