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Redefining Strip Orientation and Singulation Program for Accommodation of MEMS Partial Populated Strip at Jig Saw Singulation

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Abstract— *Semiconductor devices are high in demand for the growing technology and smart devices that has been developed. High demands of products pushed the manufacturability of devices which are assembled in high dense materials and robust processes under mass manufacturing. One of the vital semiconductor processes is singulation where high dense strips of microelectromechanical systems (MEMS) were singulated into singular unit. One of the challenges under singulation is the processing of partially populated strip and it was encountered for every lot batch. The authors first dwell to study the strip condition and assembly of partially populated strip and next was to study the singulation program to arrive with successful manufacturability of the device. The authors found out that the orientation of the partially populated significantly helped to make it processable at jig saw and the increase of measurement points of pattern recognition system resulted to more accurate measurements. Application of the learnings in the study concluded beneficial to the manufacturability of the partially populated strip at jig saw singulation.*

Keywords— *Microelectromechanical Systems (MEMS), Package Singulation, Partial Strip, Pattern Recognition System, Semiconductor, Vacant Pads*

I. INTRODUCTION

High demand of semiconductor products to support the evolving technology of automotive and commercial devices have pushed to develop the industry to assemble thousands of units contained on the single high-dense MEMS strip as shown on Fig.1. The semiconductor industry uses jig saw singulation to individually separate the units from the strips and be ready for board mounting to serve its purpose.

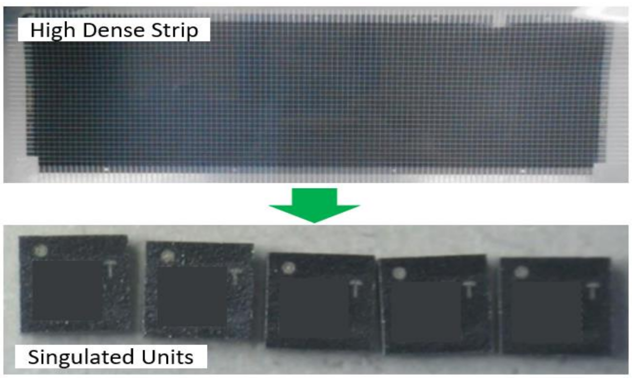

Fig. 1. High-Dense Strip Singulated to Unit

Jig saw singulation use vacuum suction to transfer the strip from loader to cutting process up to tray loading. However, the challenge of jig saw singulation lies on the successful alignment of cutting to produce good and functional units. Misalignment of cutting results to rejected parts in terms of electrical test failures due to cut wire or dice, and misalignment of pogo pins to units upon testing.

One of the features of the singulation machine to ensure the cutting alignment is through pattern recognition system (PRS). PRS is where the strip alignments and measurements were analysed by the machine algorithm based on the parameters that was programmed per device configuration. PRS measures and prompts an error if alignment was not acceptable. PRS errors surfaces when the strip has damage or abnormalities that fails to meet the target acceptable measurement tolerances and might result to unit misalignment as discussed on [1-2]. The affected strip will be subjected to out-of-control-action-plan (OCAP) to proceed in tape saw singulation which requires additional cycle time and sub-processes of mounting, UV Curing, and tray loading.

High occurrence of PRS errors of jig saw singulation is due to processing of partially populated strips. One lot batch consists of 18 strips, and 1/18 strips is partially populated thus needed to process under tape saw singulation. The remaining 17/18 strips done at singulation were not delivered as the partial strip undergo OCAP.

Given the situation at hand, the authors found an opportunity to study the jig saw singulation PRS features together with the condition of the partially populated strips. The objective of the authors is to successfully process the partially populated strip at jig saw singulation to avoid long cycle time due to OCAP assistances.

II. METHODOLOGY

The authors proceed with the methodology to study and understand the relationship of PRS with regards to the partially populated strip condition.

A. *Study the Partial Populated Strip Condition*

The authors first assess the strip condition of the partially populated MEMS strip. One batch production lot consists of at least 18 strips which contains at least 1500 units per complete strip assembly. However, 1 out of 18 strips were partially populated which contains only hundreds of units on a single strip. This partially populated strip significantly causes high errors of misalignment at singulation and was processed at tape saw as OCAP.

Upon assessment of partially populated strip, dice were attached horizontally in the middle of the strip, and this was shown on Figure 2. This affects the strip condition on the area where the dice were built. Wire bond then follows the die attach orientation, and then the strip will reach the Singulation.

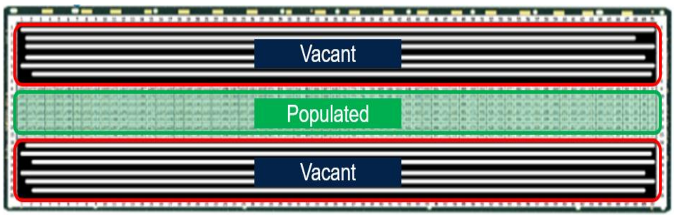

Fig. 2. Partial Populated Strip Horizontal Orientation

The orientation of dice was reported to be processed at die attach and wire bond tediously. The standard pattern of die attaching, and wire bonding is vertical indexing as shown on Figure 3.

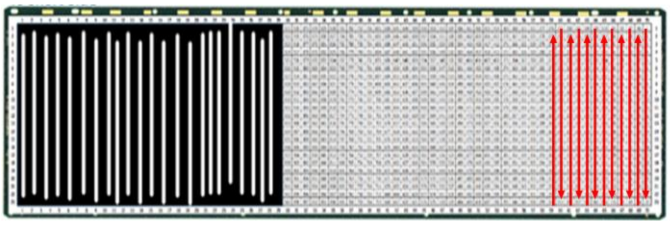

Fig. 3. Standard Vertical Indexing of Die Attach and Wire Bond

Orientation of horizontal bonding were done to consider the existing PRS at singulation, however found to be ineffective. The authors also have the opportunity to return back the vertical orientation that is aligned with the standard indexing of the strip at Die attach and Wire Bond stations.

B. Understanding the PRS Algorithm

The authors next dwell to study on the PRS algorithm of the jig saw singulation. PRS works through measuring the set-up points within the strip and averages the measurement points horizontally and vertically which help to align the strip on the best sawing alignment that would avoid rejections.

Existing measurement only have three points on horizontal and vertical axis of the strip as shown on Figure 4.

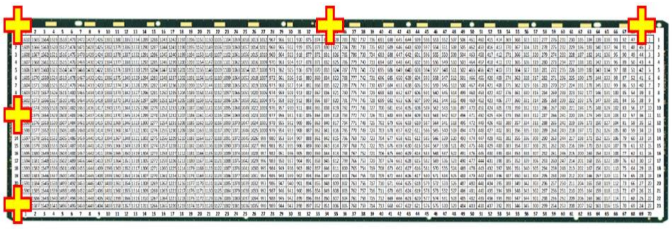

Fig. 4. Existing Reference for PRS

Jig Saw Singulation algorithm measures cut indexing through averaging the PRS measurements per set-up points. Multiple points for PRS measurement results to more accurate cut index, avoiding misaligned cut and accurate measurement as well. With the information at hand, the authors will proceed with exploration of increasing the PRS points to consider the strip condition.

III. Results and Discussion

A. Re-orientation of Die Attach and Wire Bonding

Considering the PRS algorithm and with the existing orientation of the die attach and wire bond, strip condition was not successfully considered during singulation. Shown on Figure 5 is the PRS measurement points vs where units were assembled.

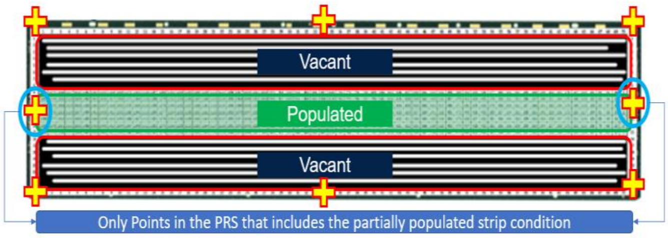

Fig. 5. PRS Points vs the Partial Populated Strip Condition

Strip movements of contraction and expansion are influenced by prior processes on the area where the units were assembled on the strip as discussed on [3-6], however missed upon PRS measurement. Single point to be included as shown on Figure 5 is not enough to consider the strip condition.

The study suggests that assembling the units in the horizontal manner will help the PRS to include the actual strip condition upon strip measurements and alignment. Shown on Figure 6 is the new orientation of the partially populated strip.

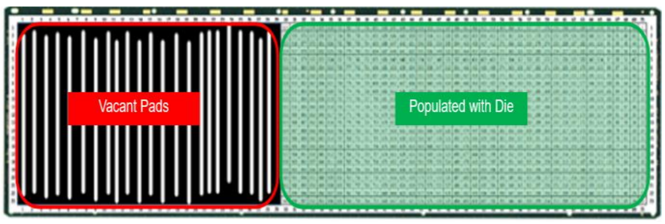

Fig. 6. New Orientation of Partial Populated Strip

Horizontal orientation of strip is also beneficial for both die attach and wire bonding processes as it is the standard orientation and machine indexing to assemble the units.

B. Re-defining the Singulation Program

After modification of the strip orientation, the strip will now be subjected for singulation. Existing PRS is not enough to cover the strip condition as it has a large distance to measure as the reference. Limited points and large distances produce inaccurate average for alignment which results to error or misaligned cut.

PRS points were increased for more measurement points and accuracy of alignment. Shown on Figure 7 is the new assigned PRS points for more accurate measurements. Additional PRS readings increased the cycle time of measurement, however found to be negligible with the unit per hour analysis.

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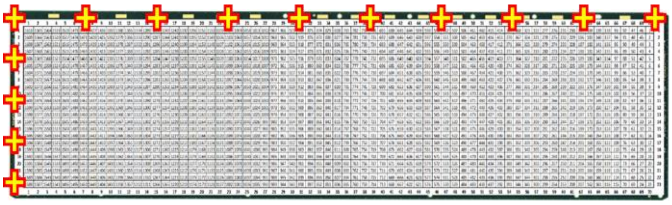

Fig.7. New PRS points for Jig Saw Singulation

Image on Figure 8 is the increased PRS points vs the new assembly orientation of the strip.

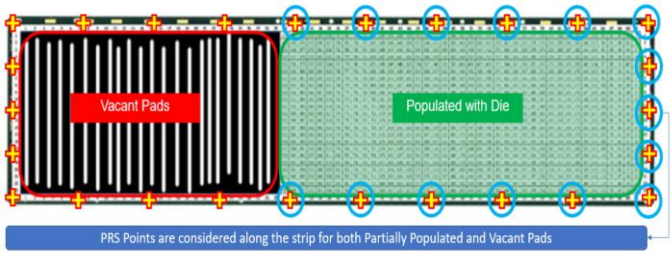

Fig. 8. New PRS points and New Partially Populated Strip Orientation

Using the new program and new orientation of the partial populated strips, PRS points can be seen that it covers both the vacant pads and partially populated units of the strip. Calculation of alignment is more accurate thus resolves the error and misalignment issues at jig saw, as mentioned on the related studies [7-10].

C. Evaluation of the Effectivity of Changes

Implementation of the re-orientation and increase of PRS points have resulted to lowering down the need of OCAP with the partially populated strip. Shown on Figure 9 is the reduction of machine downtime of tape saw that was attributed with manual cutting of units from jig saw. Batches of strips were all successfully processed at jig saw with minimal to zero assistance.

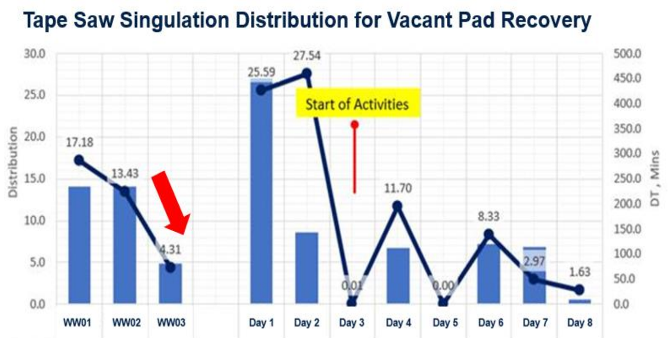

Fig. 9. New PRS points and New Partially Populated Strip Orientation

Die attach and wire bond removed the non-value-added set-ups that was intended and demanded for horizontal orientation of the strip.

IV. CONCLUSION AND RECOMMENDATION

The study has concluded that the re-orientation of unit assembly for partially populated strip from horizontal to vertical successfully helped the manufacturability of the strips at jig saw singulation.

The study also concluded that re-defining the PRS program helped significantly on processing partially populated strip at singulation. Increase of PRS have covered the strip condition for partially populated strip.

The authors recommend to benchmark and apply the study upon processing of partially populated strip at jig saw singulation specially for MEMS devices.

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