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Redesigned Chuck Table: Deep-grooved Chuck Table for Higher Vacuum Suction of Singulated Package

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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Original Research Article

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ABSTRACT

Singulation machine frequently encounters Z-Picker errors and occasionally, worst case of unit scattering which leads on the gross unit rejection and scrappage. As analyzed, shifted units found on the chuck table module upon singulation of strip. Shifted units were induced on the last 3 cut lines when the units were dragged by the blade as the area held by chuck table vacuum suction gets smaller. These shifted units caused misalignment on the next singulation modules to the turn table module and Z-Picker module that resulted to vacuum loss. With the situation at hand, the authors have assessed the current design of the chuck table. The authors have found out that chuck table have shallow-grooved rubber jig pockets that flatten upon suction of units resulted to lesser area for vacuum application. As referenced to the formula F=PA, larger area multiplied by suction pressure results to better force to hold the units, thus redesigned chuck table with deep groove was introduced. The study also pertains to the analysis and validation on the application of deep-grooved rubber jig pockets of chuck table aiming to solve the unit shifting during sawing. Elimination of unit shifting was validated to be effective upon application of the deep-grooved chuck table. The study and validation of redesigned chuck table is essential to avoid unit scattering and unit missing.

Keywords: Chuck table; jig saw singulation; z-picker; shifted units; Scattered Units.

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1. INTRODUCTION

Production of units that came from high dense strips has been the practice of Semiconductor as it is cost effective and process efficient [1-3]. These high dense strips were cut into single units once it successfully assembled and reached the singulation process.

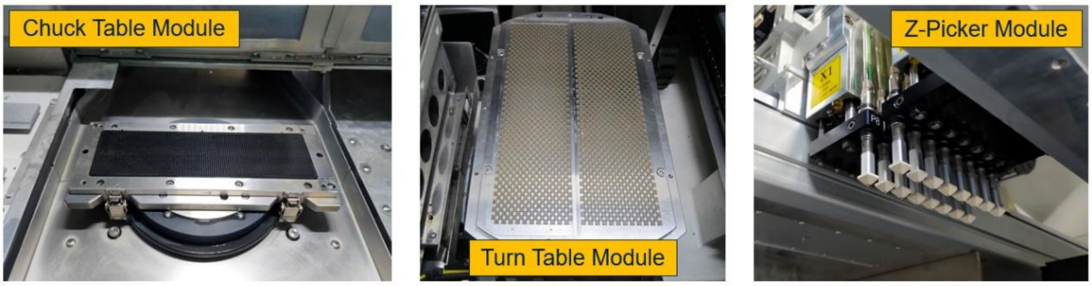

Fig. 1. Jig Saw Singulation Modules

Note: Chuck table module, Turn table module, and Z-Picker modules held the units using vacuum suction

Jig saw singulation is the process where the high dense strips are being cut into single unit assembly. Jig saw singulation consists of the three modules to successfully process the strips and these are the chuck table module, turn table module, and Z-Picker module. The modules are shown in Fig. 1.

Strips were held through vacuum suction upon singulation at the chuck table module. Each pocket of the chuck table corresponds to each unit after the strip is singulated. Strip that is cut into units will be transferred at the turn table module in preparation for unit pick up and placing into tray pockets. Unit transfer from turn table module to tray pockets are done by the Z-Picker Module. The activity for unit pick and place is also done through the vacuum suction of Z-pickers [4].

Alignment of the units from one module to another is one of the critical conditions that is assessed and calibrated at singulation. Specially for small units, misalignment of the units to the pockets from chuck table, turn table, and z-picker might induce vacuum leaks leading to gross unit rejection.

Upon processing of high dense strips with small package size, production highlighted machine downtime, frequent assistance, and gross missing units at singulation [5-7]. The machine encounters multiple Z-Picker errors upon pick and placing of units from the turn table module to the tray [8-10]. Occasionally, machine also encounters unit scattering upon pick up of singulated units from chuck table module to turn table module. This issue not only disturbed the productivity but also the delivery of the unit requirement to the customer.

With this study, the authors aim to understand on how the frequently encountered issues of Z-picker error and scattered unit occurs at singulation that leads to gross yield losses. The authors also focus to find solution to the problem with the objective to improve the process together with its productivity and support production delivery.

2. METHODOLOGY

The authors have aimed to have a strategical methodology to conduct on the study. First, the authors focused on understanding how the problem happens which contributes to both Z-Picker and unit scattering issue. The authors assess where on the singulation modules does the problem occur. The authors have conducted process mapping analysis between strip transfers from chuck table module to turn table module, from turn table module to Z-picker module, and from Z-picker module to Tray loading. Objective of this methodology is to identify where does the problem manifest.

Once the problem source location is identified, the authors next step is to validate and verify the cause of the problem. Strips were inspected and closely monitored through every step of the singulation processes for any occurrence of process abnormality. After validation of the problem at hand, the authors aim to understand the defect mechanism that would lead to the workable solutions that can be made to resolve the issue.

Vacuum suctions that have high contributions to the identified problem for Z-Picker errors and scattered units were considered for effect validation. The authors have assessed the existing designs of the singulation jigs and fixtures per module. Various research and reference for the study has been explored by the authors to guide on the study. Supported by measurements, calculations, theoretical formulas, and validation run for the current jigs and fixtures, the authors aim to improve the vacuum suction of the units.

Lastly, any changes and ideas for improvement will be validated and monitored for the effectiveness of actions that will be identified to resolve the problem at hand.

3. RESULTS AND DISCUSSIONS

3.1 How Z-Picker Errors and Unit Scattering Occur

Units that are successfully singulated are individually picked and placed by the Z-Picker Module from the turn table module to the tray pockets. However, singulation of small MEMS devices has been frequently interrupted by multiple occurrences of Z-Picker errors and at worst – the singulated strip encounters unit scattering.

Two conditions were validated on how Z-Picker errors occur. One is when the unit was failed to be picked up from the turn table module due to unit stuck-up or two, the units were already missing upon pick and place due to low vacuum suction caused by vacuum leak that was brought about by unit misalignment with the Z-Picker. Unit scattering happen when vacuum was turned off upon failure to reach the target vacuum limit that was caused also by vacuum leaks detected from unit transfer per singulation modules.

In this study, it has been observed that shifted units are evident at the machine turn table making the intermittent Z picker Vacuum Error and scattered units during Pick and Place which is a result of domino effect from saw at chuck table module. Fig. 2 shows that shifted units are found on the certain areas of the turn table and is already evident at the chuck table module.

Orientation and condition of the singulated strips at chuck table, included the shifted rows of units will be picked and then placed on the turn table module. At worst case shown on Fig. 3, unit shifting can already induce yield loss upon transfer from chuck table to turn table which results to unit scattering. Unit shifting causes vacuum leaks which prevents the vacuum suction measurement be lower that the acceptance limit.

Encountered Z-Picker errors and scattered units were frequently assisted by the operators through stopping of machine and arranging the units, but units were already missing or damaged resulting to yield loss.

3.2 Root Cause of Shifted Units

Validation and analysis of Z-picker errors and unit scattering have led the authors that the problem came from the shifted units started at the chuck table module. From the whole strip, only the last three cut lines are affected of unit shifting.

Machine used is running on a dual spindle set-up, wherein two blades were installed and simultaneously cut on the strip. Z1 is the blade on the Right, Z2 is another blade on the Left. The set-up together with the cutting sequence is illustrated on Fig. 4 where the last 3 cut lines is the small remaining area held by chuck table module. The blade drags these units during cutting which resulted in unit shifting.

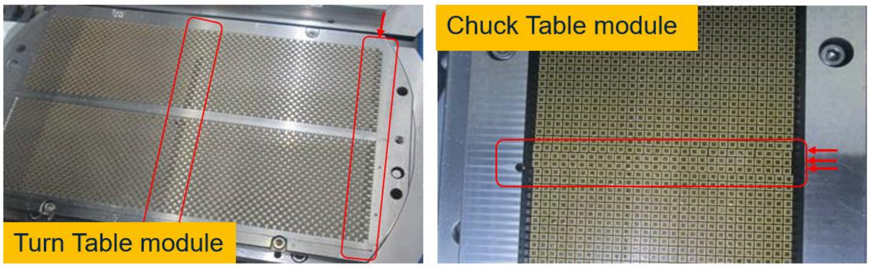

Fig. 2. Shifted Units on the Turn Table and Chuck Table Modules

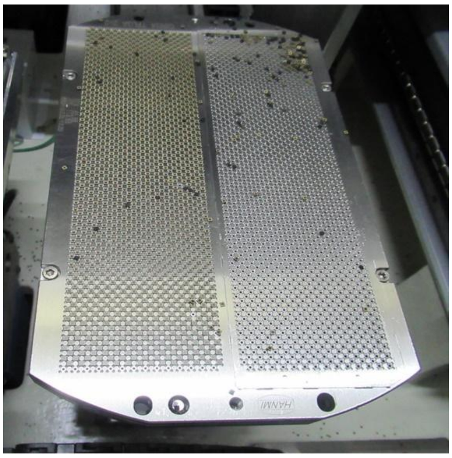

Fig. 3. Scattered Units from Chuck Table to Turn Table Module

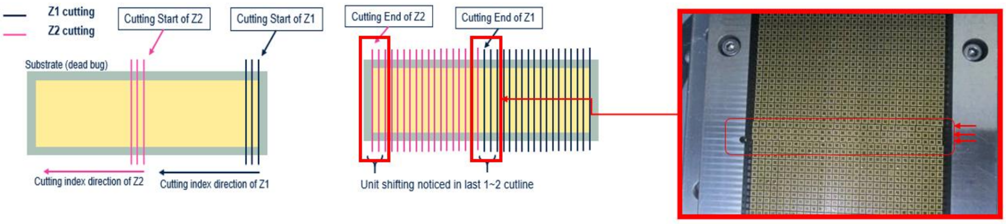

Fig. 4. Singulation Set-up and Cutting Sequence

These shifted units caused misalignment on the next singulation modules that results to vacuum loss. With the situation at hand the authors have dig deep on the design of the chuck table.

3.3 Chuck Table Assessment and Modification

On the existing design shown on the red boxes of Fig. 5, the groove depth of chuck table rubber is only 10% of the total height. This shallow groove was flattened once the unit are placed and vacuumed. Thus, the suction area holding the units will be area of the hole and not the groove. The Area of the hole is only 80% of the ideal area from the groove.

Theoretically suction or holding Force is equivalent to the Pressure multiplied with the Area (F=PA). Increasing the holding area will increases the holding force or vacuum force. Considering the existing design of chuck table together with the application of the formula the authors are motivated to redesign a deep grooved chuck table.

The pocket depth is increased from 10% to 50% of the whole rubber depth. Compared to the previous design, the increase of the pocket depth will prevent reduction of holding area caused by the flattening of chuck table rubber groove. 100% of the groove will be the holding area, and this will allow vacuum to have stronger holding force.

Shown on Fig. 6 is the comparison of the existing shallow-grooved design and the deep-grooved design. Deep Groove Chuck Table has a low chance of flattening that can reduced the vacuum suction area. High holding force aims to prevent the unit shifting.

3.4 Validation on the Effects of Redesigned Chuck Table

The redesigned deep-grooved chuck table is validated for the occurrence shifted units that gives domino effect from the chuck table module to turn table and z-picker modules. As represented on Fig. 7, there are no shifted units were observed upon validation on the use of deep-grooved chuck table. Assistance for Z-Picker errors are minimal to none. No occurrence of unit scattering encountered as well.

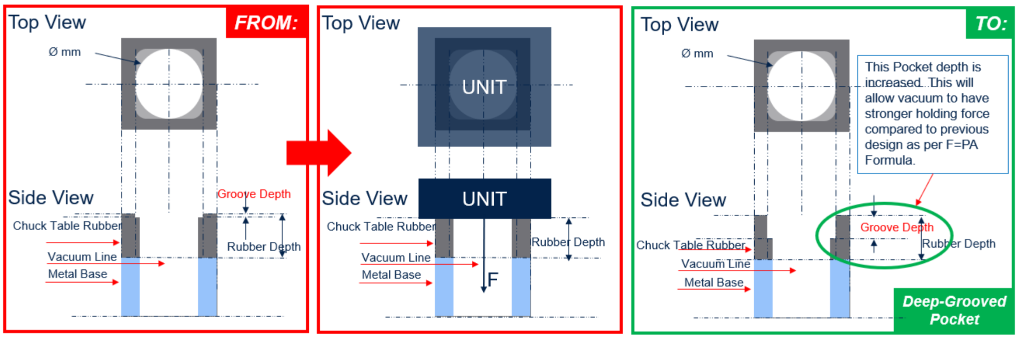

Fig. 5. Chuck Table Before and After

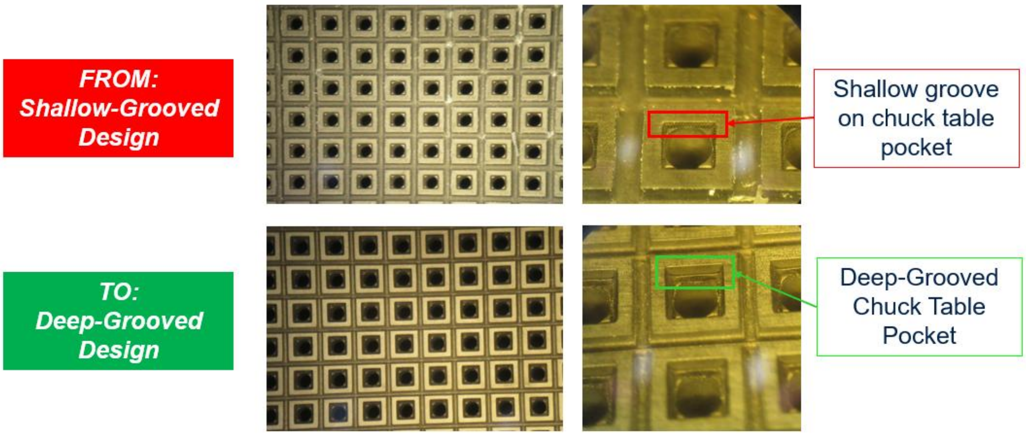

Fig. 6. Actual Chuck Table Designs

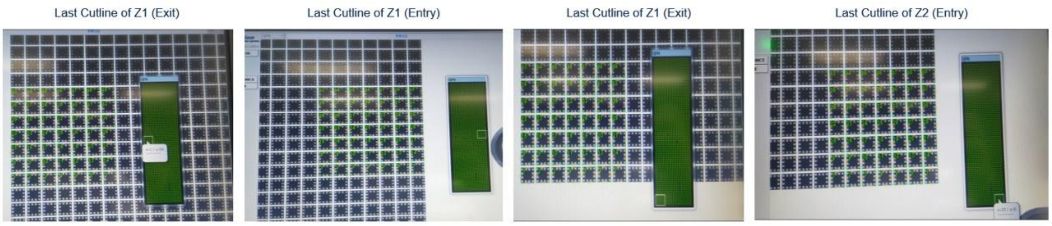

Fig. 7. Validation of Redesigned Chuck Table

4. CONCLUSION AND RECOMMENDATIONS

Given with all the data and results from validation, it is concluded that the issue of Z-Picker and unit scattering was contributed by the shifted units at chuck table that become domino effect to the turn table and z-picker modules. Shifted unit caused misalignment upon transfers from one module to another. Units were dragged as the area held by vacuum is smaller and vacuum leaks are evident.

It is also concluded that the redesigned deep-grooved chuck table effects with high vacuum suction compared with shallow-grooved ones. With high vacuum suction, the singulated units were held in place after package sawing and was placed on the succeeding singulation modules with good alignment upon transfer.

Development and application of deep grooved chuck table is recommended specially with the small package devices.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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