



# **Rubber-tip Design Improvement for Die Crack Elimination at Diebond Process**

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## **Authors' contributions**

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

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## **ABSTRACT**

The paper focused on the elimination of die crack occurrence at the diebond process. Design of experiment (DOE) was done on the pick and place rubber-tip design and an improved design was finalized. The improved rubber-tip configuration with smaller vacuum design and full contact surface eventually resolved the die crack issues, improving the manufacturability of thin silicon die during diebond process. For future works, the configuration could be applied for packages with similar requirement.

*Keywords: Diebond process; rubber-tip design; semiconductor; assembly.*

## **1. INTRODUCTION**

Rubber-tip material is an important tool for pick and place or diebond process as it is used to hold the ejected silicon die from the wafer tape or dicing tape prior transfer to a semiconductor carrier, either on substrate or lead frame.

A typical rubber-tip material is shown in Fig. 1. The material is integrated in the pneumatic controlled system inside the diebond equipment. A cycle of vacuum is supplied to the pick assembly when holding the ejected silicon die, and then deactivating the vacuum supply upon reaching the place position.

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Thinning requirement on silicon die opens the window for the breakthrough of miniaturized integrated circuit assembly. However, there are different assembly challenges identified associated with the thinning requirement. This paper presents the effect of different rubber-tip or pick-up tool configuration on thin silicon die during diebond process. The quality of attached silicon die with reference to the condition of the rubber-tip design is also included in the discussion.

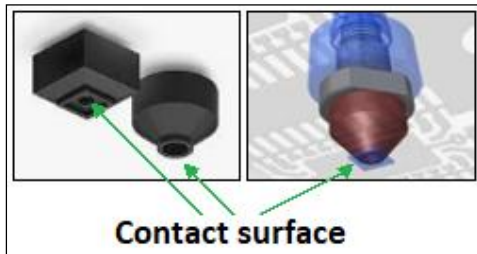


Fig. 1. Typical rubber-tip material used in semiconductor manufacturing

## 2. LITERATURE REVIEW

The typical assembly process flow of a semiconductor package is shown in Fig. 2.

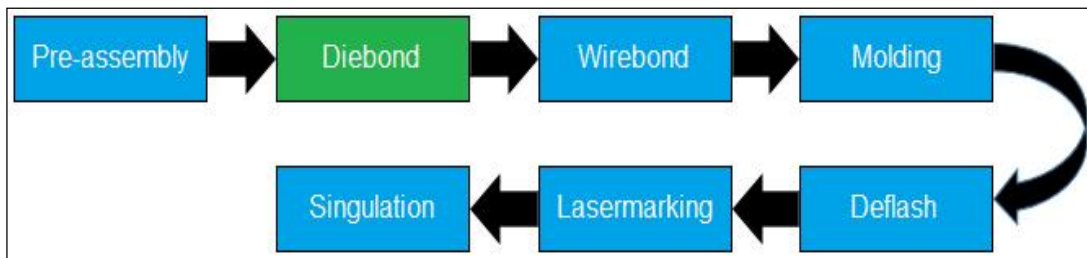


Fig. 2. Assembly process flow

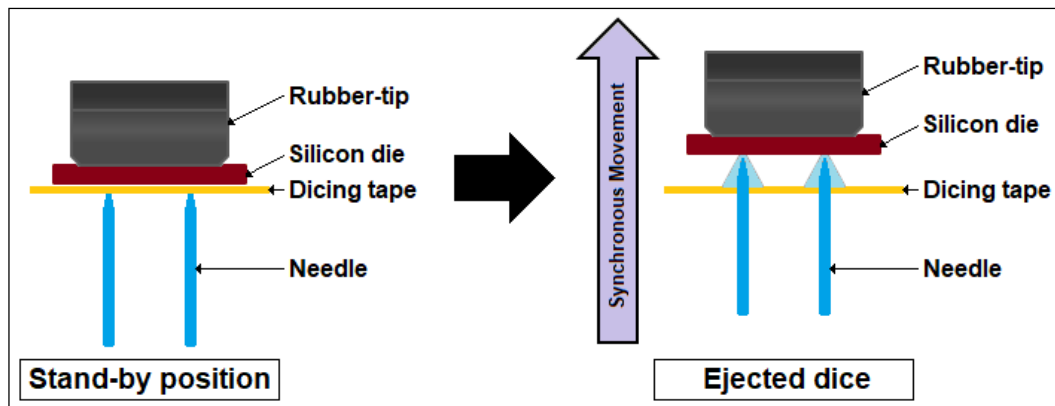


Fig. 3. Bond head movement during diebond process

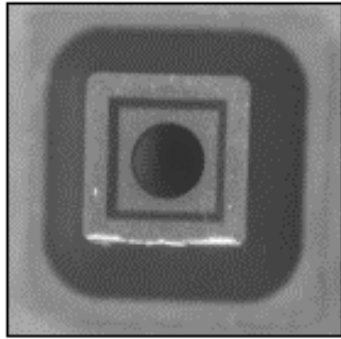
Diebond process is responsible for bonding or attaching the silicon die or dice into a semiconductor substrate or lead frame carrier. Worthy to note that assembly manufacturing process flow differs with the product and the die technology [1-3].

Pick and place sequence of a diebond machine depicted in Fig. 3 emphasizes on the synchronous upward movement of bond head and needle with regards to individually cut die. Individual dice were separated into the wafer tape by the ejection movement of needle against the vacuum hold wafer tape. Different studies in diebond process are discussed in [4-7]. With new and continuous technology trends and breakthroughs [7-9], challenges in semiconductor assembly manufacturing are inevitable.

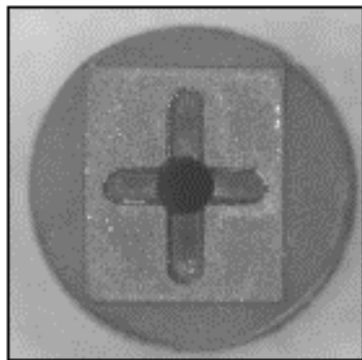
## 3. METHODOLOGY

The contact surface of the rubber-tip material became the focus of the study due to its potential significance in the quality of bonded silicon die. Two different contact surface design of rubber-tip materials are evaluated in this experiment. The first tool shown in Fig. 4 has a larger vacuum hole design with relief type corner support.

The improved rubber-tip material given in Fig. 5 is with smaller vacuum hole design and full contact surface. Design of experiment (DOE) is done to measure each material according to its actual response in terms of picking and bonding capability.



**Fig. 4. Rubber-tip with standard vacuum hole and relief type corner support design**



**Fig. 5. Rubber-tip design with smaller vacuum hole and full contact surface**

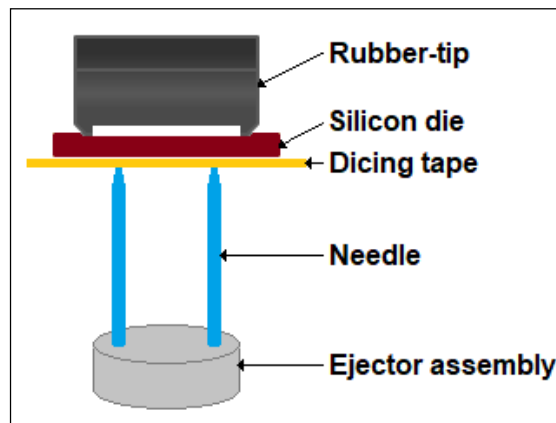
#### 4. RESULTS AND DISCUSSION

Two sets of experiment were performed for picking and bonding of dice, summarized in Table 1. Rubber-tip material with larger vacuum hole design is found in this experiment to fail at both pick and bonding requirements while a smaller vacuum design meets both criteria. However, a mis-picking of silicon die is encountered during the evaluation run but it was treated as a minor defect since it does not affect the functionality of the die.

The die crack defect occurrence on rubber-tip # 1 is observed to be related in the alignment of the vacuum hole and ejector needle assembly in Fig. 6.

During pick sequence, the ejection of the needle is not supported proportionally by the vacuum design of rubber-tip # 1 leading to induced deformation of the silicon die during the pick sequence. The deformation in silicon at die level is found to be the cause of die crack occurrence due to the locality of defect consistently propagating from the needle location. Moreover, the voids occurrence for rubber-tip # 1 shown in Fig. 7 corresponded with the location of vacuum hole design of the material. The locality of the voids is evident on the middle area wherein a deformation in the silicon die take place. Note that criteria for assembly rejects and visual inspection are governed by internal specifications and work instruction documents [10-11].

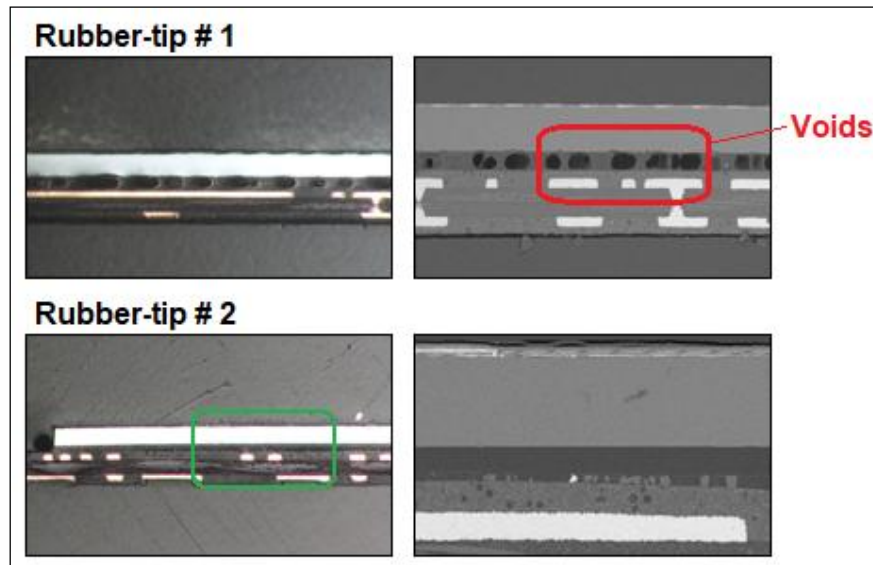
Based on the x-ray photo comparison of the two rubber-tip materials, the bonding quality is better with the rubber-tip # 2, with the reduced vacuum hole design and full contact surface.



**Fig. 6. Rubber-tip # 1 illustration**

**Table 1. Evaluation result**

<b>Trial</b>	<b>Picking</b>	<b>Bonding</b>
<b>Rubber-tip # 1</b> Larger vacuum hole design with relief type corner support	<b>Failed</b> Remarks: With occurrence of die crack	<b>Failed</b> Remarks: With occurrence of voids
<b>Rubber-tip # 2</b> Smaller vacuum hole design and full contact surface	<b>Marginal</b> Remarks: With occurrence of mis-picked die	<b>Passed</b>



**Fig. 7. X-ray photo comparison of two rubber-tip designs**

## 5. CONCLUSION AND RECOMMENDATIONS

The thinning of silicon die requires adjustment in the current design of rubber-tip material wherein the vacuum hole and effective contact surface should be balanced effectively. Decreasing the vacuum hole and increasing the contact surface of the pick-up tool material resolved the die crack assembly issues and improved the manufacturability of thin silicon die material during diebond process.

For future works and studies, the configuration could be considered as a reference in handling thin silicon die technology at diebond process. Discussions and learnings shared in [4-7] are helpful to improve the assembly processes particularly the die attach process.

## DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely

no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

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## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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