Journal of Engineering Research and Reports

22(11): 1-6, 2022; Article no.JERR.88624
ISSN: 2582-2926

Understanding the Cause and Effect of Bent Side Rail in Molding Process

Mariane Mendoza [a], Maria Virginia Buera [a], Joel Pablo [a] and Jerome Dinglasan [a*]

[a] STMicroelectronics, Inc., Calamba City, Laguna- 4027, Philippines.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/JERR/2022/v22i1117573

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/88624

Original Research Article

Received 22 April 2022
Accepted 30 June 2022
Published 04 July 2022

ABSTRACT

During processing of Quad Flat No-lead (QFN) on the production line, it has been observed that strips were found with bent rails after the molding process. Mold is a process in the semiconductor industry where package encapsulation happens by filling the cavities with molding compound, depending on the required package thickness. Succeeding processes of post-mold cure, strip etching, and laser marking were not affected by the encountered bent rails at mold but singulation process feedback that the affected strips prompted jig alignment errors which prevents the strip to be successfully auto processed at jig saw singulation. The problem on hand have encouraged the authors to understand the cause of bent rails thru process mapping and validation of its effect on the downstream processes.

Keywords: Jig alignment error; mold process; bent side rail; QFN; transfer mold.

1. INTRODUCTION

Transfer molding is a process where the units build with die and wires are being unified thru encapsulation. After the strips were molded, they will undergo another downstream process such as post-mold curing, strip etching, and laser marking before it reaches the singulation process where the strips will be cut into single units. Relevant topics are discussed and briefly elaborated on [1-4] with various ideas and learnings that can be related to this topic.

**Corresponding author: Email: jerome.dinglasan@st.com;*

For the strips to proceed with singulation, alignment should satisfy the limit settings at the machine. If the alignment settings were not met, the machine will prompt errors for assistance. One of the errors that was frequently encountered was the jig alignment error, that was mentioned on [5-8]. Strips that have been encountered with jig alignment errors were inspected and found to have a bent side rail. Other strips without bent rails were successfully processed at jig saw singulation without any errors.

The occurrence of bent side rails was traced back to be induced after the mold process. Strips that were loaded on the molding machine have been validated to have flat side rails, but upon unloading bent rails were evident.

Data on hand have pushed the authors to come up with a technical study on how these bent rails were induced and how it can affect the jig saw singulation process. The authors aim to come up with recommendations that would address the occurrences of bent rail.

2. METHODOLOGY

The authors have taken the study of the mold process and validated how the process can produce strips with bent rails. Although bent side rail will not reject products, it has been observed that it will take a longer time and assistance for the strips to be processed at singulation. The authors have also studied why the bent side rails affect the downstream process of singulation. Once data were collected, the next activity is to analyze how to address the occurrence of bent rails. Lastly, the authors conclude and recommend the alternatives that can be considered with the encountered issues considering the results and validations that were brought about by the methodology.

2.1. Studying the Mold Process

The Mold Process is where to perform package encapsulation by filling the cavities with molding compound. Molding compound used in the production line is coded to avoid issuance of expired and wrong molding compound for the product. The process starts on a loading module where the strip magazines are loaded to a platform, followed by input indexing or strip pick-and-place module to transfer strips from the magazine to the preheater. The pre-heat module was then used to heat up the strip in preparation for the higher temperature of molding. Shown in Fig. 1 is the pre-mold transfer module that transfer of strips and molding compound pellets into a molding module. Molding module shown in Fig. 2 is where package encapsulation occurs by filling the cavities with molding compound. After molding, strips will be picked and place on the de-culling module show in Fig. 3 where mold culls were removed from molded strips. Culls were the cured mold compound that remains after transfer molding. Strips will be unloaded after the de-culling processes.

The molding process was done to ensure that the components inside the units were secured and protected. Mold compound pellets were melted before transferring and occupying the mold chase. From Mold, several process steps such as Post Mold Cure (PMC), Strip Etching, and Laser Marking were done before the strips reaches singulation, this process flow is shown in Fig. 4.

After Molding, strips were stacked on the magazines for PMC then it will be etched to remove the unnecessary areas of the strips. Marking comes after etching where the unit traceability will be marked on top of the strips. Bent rails were not an issue from mold to marking, but it induces issue on the singulation process.

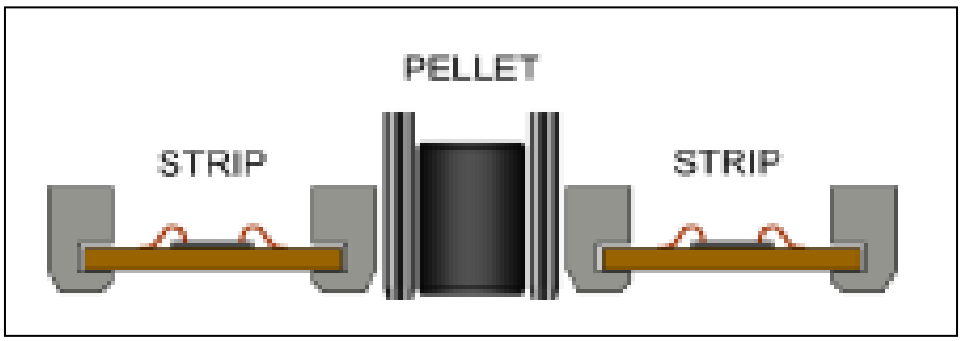

Fig. 1. Pre-mold transfer module

Fig. 2. Molding Module

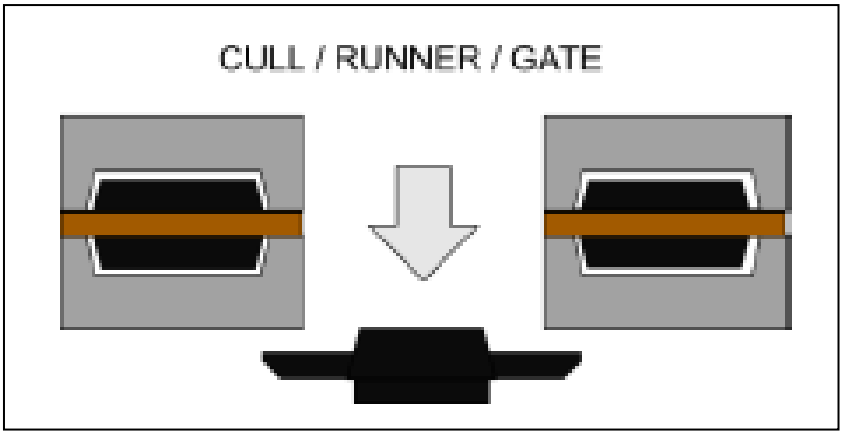

Fig. 3. De-culling Module

Fig. 4. Assembly Process Steps

At singulation, the strip configuration and unit alignment on the strip has been verified prior cutting. Alignment of the strip with bent rail to the jig detects the bent rail with failed alignment and thus prompts jig alignment errors that prevents the strip to be processed.

2.2. Analyzing How Bent Side Rail Occurs

The authors have validated if the bent rail signature can be found prior to strip molding, but the strips were not damaged or bent before loading the strips at the mold. However, an inspection of the strips upon unloading was observed to have bent rails. The authors have focused to find where can bent rail be induced inside of the molding machine and it was found to be on the unloader de-culling area.

When the strips are done molding, the molded lead frames will be picked up by the unloader picker and then will be placed at the de-culling module to separate the strips and removes mold culls. Upon observation, it has been found that the position of the molded strips was misplaced with the de-culling module upon transfer from mold chase, thus making the molded strips placed beyond the position of the strip stopper guide of the de-culling module. Strip stopper guide hits with the strip side rail upon strip placement resulting in side rail bend. Shown in Fig. 5 is the actual validated sample of strips that have resulted with bent side rail.

Strip misplacement happens when the motor pulse rate parameter which is responsible for the unloader position of the strips from the mold chase and de-gating module was not aligned to the proper unloading strip placement. Thru optimization of motor pulse rate parameter, unloader position with respect to the de-culling

module was corrected and resulted with the eliminated occurrence of strip bent rails.

2.3 Jig Alignment Error at Singulation Process

Singulation process was equipped with jig alignment validation to ensure that the strips were aligned with the chuck table rubber nest jig before it proceeded with strip cutting. Jig alignment errors occur when the machine measured that the strip alignment and strip placement with the rubber nest jig was high enough to be compensated. During validation, strips with bent side rail prompt jig alignment errors.

Strips that were affected with bent side rail at mold cause jig alignment errors as the protruded area of the strip induces movement upon loading of the strip, thus causing failure at jig alignment measurement of the machine. The strip can still be processed by using manual jig aligner to ensure that the protrusion of the strip will not induce strip movements upon loading. Yet, the manual process takes time and manpower assistance, unlike the normal automatic singulation process.

3. RESULTS AND DISCUSSIONS

With the data collected and summarized at Table 1, it has been found that the bent side rail of the strip was caused by misalignment of the strip with the de-culling module upon loading placement at molding process. Optimization of the motor pulse parameter has solved the problem by eliminating bent rail occurrence.

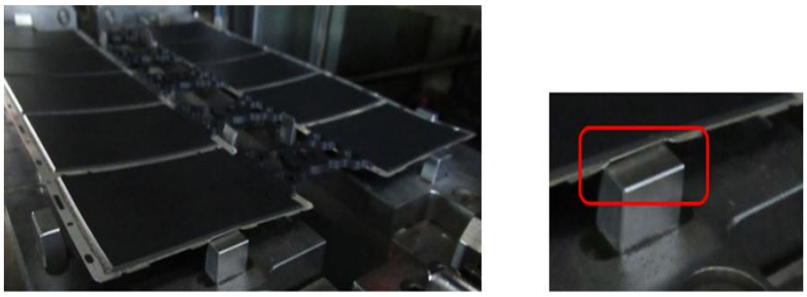

Fig. 5. Molded strips at de-culling module

Table 1. Process mapping for cause and effect of bent rail

Process Mapping for Occurrence of Bent Rail				
	Process	**Bent Side Rail Occurrence**		**Remarks**
		Input	**Output**	
	Strip Loading	PASSED	PASSED	No Issue
	Pre-Heat	PASSED	PASSED	No Issue
Mold	Molding	PASSED	PASSED	No Issue
	De-culling	PASSED	FAILED	No Issue
	Strip Unloading	PASSED	PASSED	No Issue
	Strip Stacking	PASSED	PASSED	No Issue
PMC	Magazine Loading	PASSED	PASSED	No Issue
	Mold Curing	PASSED	PASSED	No Issue
	Magazine Unloading	PASSED	PASSED	No Issue
	Strip Loading	PASSED	PASSED	No Issue
Etching	Etching	PASSED	PASSED	No Issue
	Strip Unloading	PASSED	PASSED	No Issue
	Strip Loading	PASSED	PASSED	No Issue
Marking	Marking	PASSED	PASSED	No Issue
	Strip Unloading	PASSED	PASSED	No Issue
	Strip Loading	PASSED	PASSED	No Issue
	Strip Alignment	FAILED	FAILED	Jig alignment Error
Singulation	Cutting	FAILED	FAILED	Need assistance at jig saw
	Unit Tray Loading	FAILED	FAILED	Need assistance at jig saw
	Tray Unloading	FAILED	FAILED	Need assistance at jig saw

Strips with bent rail have been processed thru post-mold cure and laser marking without error noted. However, jig alignment error was encountered at Singulation. Once jig alignment error occurs, the strip cannot be auto processed at jig saw singulation and will be assisted thru manual strip loading using the manual aligner jig.

4. CONCLUSION AND RECOMMENDATIONS

Thru the results gathered in this study, the authors would like to conclude that the cause of bent side rail in Mold process was due to the misalignment of the position of molded strip during de-culling process. Adjustment to align the strip on the de-culling module was performed to eliminate the occurrence of bent side rails.

The authors also conclude that bent rails induced at mold is validated to have negative effect at singulation where jig alignment errors occur as the strip misaligned on the singulation jig caused by the bent protrusion. Strips encountered with jig alignment error due to bent rail can be assisted thru manual loading of the strip using the aligner jig.

In reference to the conclusion, the authors recommend on including the validation of bent rail as early as set-up buy-off procedure to prevent issues on the downstream process. This activity would help in avoiding the jig alignment error at the singulation auto process. Noted also that cited references [9-13] will be useful for improvement and recommended to apply on similar process to introduce process robustness.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Belalo LJT, Maming, MGR. Capacity Improvement for Transfer Molding Trough Reduction of Mold Curing Time. Journal of Engineering Research and Reports. 2021;20(2):125-141. Available:https://doi.org/10.9734/jerr/2021/v20i217272
2. Jin-wei Chen, Liang He, Bai-ping Xu. "The application of cavity pressure profile in the injection molding process parameters optimization," 2010 International Conference on Mechanic Automation and Control Engineering. 2010; 5350-5353. DOI: 10.1109/MACE.2010.5535917.
3. Gomez FR, Rodriguez R. Specialized lead design of leadframe packages for improved mold adhesion. Journal of Engineering Research and Reports. 2020;14(3):15-19. Available:https://doi.org/10.9734/jerr/2020/v14i317124
4. Alam MR. A Computer-aided process planning for the manufacture of injection molds, PhD Thesis, National University of Singapore (NUS), Singapore; 2003.
5. Mendoza MA, Buera MVS, Gomez FRI, Kumawit AJD. Understanding jig alignment error occurrences for substrate 1-Map Strips. Journal of Engineering Research and Reports. 2021;20(9):113-118. Available:https://doi.org/10.9734/jerr/2021/v20i917380
6. Low MAH, Lee KS. Application of standardization for initial design of plastic injection molds. International Journal of Production Research. 2003; 41:2301-2324.
7. Gablan AG, Gomez FR, Moreno A. Improvement on QFN leadframe design of extended leads to support the mitigation of mold flash occurrence. Journal of Engineering Research and Reports. 2021;20(5):37-40. Available:https://doi.org/10.9734/jerr/2021/v20i517309
8. Zeiler RA. "Molded circuit interconnects: electronic packaging in the third dimension." Fourth IEEE/CHM T European International Electronic Manufacturing Technology Symposium. 1988;85-88. DOI: 10.1109/EEMTS.1988.75961.
9. Tan LT, Lee CH, Teo YY, Lim BH. “Perfect molding challenges and the limitations”, IEEE 19th Electronics Packaging Technology Conference (EPTC).
10. Krishnanramaswami MS, McCluskey G. Pecht M. “Failure mechanisms in encapsulated copper wire-bonded devices”. IEEE 23rd International Symposium on the Physical and Failure Analysis of Integrated Circuits (IPFA); 2016.
11. Padilla ED, Birog EP. Enabling artificial intelligence as input variable control to prevent package thickness related defect in compression molding. Journal of

Engineering Research and Reports. 2020;16(1):9-21.
Available:https://doi.org/10.9734/jerr/2020/v16i117155

12. Muneo Miura. Compression molding solutions for various high-end package and cost savings for standard package applications. International Conference on Electronics Packaging (ICEP). 2016;243-246.
13. Bu Lin, Ding Mian Zhi et al. Design and optimization of molding process for MEMS WLSCP. IEEE 18th Electronics Packaging Technology Conference (EPTC). 2016;370-374.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/88624