Wirebond Process Improvement through Silicon Die Polyimide Removal

Anthony R. Moreno¹, Jonalyn E. Jaylo¹, Frederick Ray I. Gomez¹ and Edwin M. Graycochea Jr.¹

¹New Product Development and Introduction, STMicroelectronics, Inc., Calamba City, 4027, Laguna, Philippines.

Authors’ contributions

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

ABSTRACT

This study aims to develop polyimide etching process on the silicon die after decapsulation to resolve the wire shear issue during ball shear data gatherings. The shear strength of the ball is affected by the presence of polyimide insulator during ball shearing process, due to the polyimide layer of the silicon die being coplanar with the ball height of the wire. Experimentation and statistical analysis were done on units with and without polyimide coating, with Sodium Hydroxide (NaOH) used to remove the excess polyimide. Results revealed that silicon dice without polyimide coating resulted to better reading in terms of ball shear.

Keywords: Sodium hydroxide; semiconductor; polyimide; silicon die; ball shear.

1. INTRODUCTION

Semiconductor companies have emerged to another milestone on creating new technologies like emerging of polyimide. The polyimide coating in semiconductor die provides a reliable insulation when subjected to various types of environmental stresses with high temperature stability of the material [1-2]. It is also used as heat insulator from the heat of die to prevent

*Corresponding author: Email: anthony.moreno@st.com;
delamination on molding compound. However, the presence of polyimide affects the ball shear data during the destructive test of ball shear affects as it hinders the full contact of the bonded ball as illustrated in Fig. 1. The ideal situation is to have reliable ball shear result. When polyimide is used as sacrificial layer, isotropic etching is used in order to release the top functional layer [3-4]. Polyimide is also very often used as dielectric layer, or as substrate material for flexible applications. In this case, different types of etching are required for the fabrication of electrical bias running through the polyimide layer [5]. Several studies have been published on the characterization of polyimide dry etching using different plasma chemistries, etching methods, and parameters [6-8]. However, the capability and availability of plasma machine in semiconductor is a factor but this was not become an excuse to have a reliable ball shear data during evaluation of the device.

2. LITERATURE REVIEW AND PROBLEM IDENTIFICATION

The assembly process flow of the package is shown in Fig. 2. Pre-assembly process wherein the bare wafer is prepared and cut into its preferred die sizes of the silicon dies. Next process is the die attach responsible in attaching the silicon dies into a substrate or a carrier. Wirebond is the process of serving electrical connections into silicon dies and lead finger of the substrate or a carrier. Mold process where the units is already encapsulated by a molding compound either compression or a transfer molding. Deflash is a type of wet process to remove excessive flash on bottom part of the carrier. Laser marking process where the units is serialized by marking identification. Last process is singulation, wherein the units is cut into pieces and ready to deliver to end customer. Worthy to note that assembly process flow varies with the product and the technology [9-12].

One major problem encountered during ball shear data gathering in wirebond process is the polyimide on the silicon die blocking the bonded ball with a break mode of wire shear. This also results to ball remain on the bond pad as shown in Fig. 3. An actual scanning electron microscope (SEM) photo of the unit is shown in Fig. 4. Note that criteria for rejects are governed by assembly design rules and work instructions [10, 13-14].
3. PROCESS DEVELOPMENT SOLUTION AND DISCUSSION OF RESULTS

An improved polyimide removal is discussed on this study by using Sodium Hydroxide (NaOH) dissolves in DI water. A SEM photo of actual unit with removed polyimide is shown in Fig. 5. Furthermore, by removing the polyimide in the silicon die, the ball shear test data gathering would easily be performed and the data response is now reliable. The new improved polyimide removal on the actual unit is a big impact during data gatherings and to know whether the bonded ball is totally stuck or bonded on the bond pad after wire bonding process.

Statistical analysis in Fig. 6 compares the ball shear reading with polyimide and remove polyimide. Using the sodium hydroxide to remove
the polyimide on the silicon die has a significant difference compared with polyimide and it has a big impact on the ball shear data gathered.

4. CONCLUSION

The paper presented a process improvement using NaOH which significantly removed polyimide on the silicon die and removed the occurrence of wire shear during data gathering of ball shear in wirebond process. Statistical results showed that the silicon die without polyimide insulation has better ball shear data reading compared to die with polyimide coating. Worth noting is that continuous process and design improvement at every step of assembly manufacturing is important to foster and sustain high quality performance of semiconductor products.

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.

ACKNOWLEDGEMENT

The authors would like to express gratitude to the New Product Development & Introduction (NPD-I) team and the Management Team for the usual great support to make this study a success.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Bryant R. Polyimides. Ullmann’s Encyclopedia of Industrial Chemistry. Wiley-VCH Verlag GmbH & Co., Germany; 2014.
2. Constantin C, Afiori M, Damian R, Rusu R. Biocompatibility of polyimides: A mini-review. Materials. 2019;12(19).
3. Bagolini A, Pakula L, Scholtes TLM, Pham HTM, French PJ, Sarro PM. Polyimide sacrificial layer and novel materials for post processing surface micromachining. Journal of Micromechanics and Microengineering. 2002;12(4).
4. Fernandez-Bolaños M, Abele N, Pott V, Bouvet D, Racine GA, Quero JM, Ionescu AM. Polyimide sacrificial layer for SOI SG-MOSFET pressure sensor. Microelectronic Engineering. 2006;83(4-9):1185-1188.
5. Aggarwal A, Raj PM, Tummala R. Metal–polymer composite interconnections for ultra fine-pitch wafer level packaging. IEEE Transactions on Advanced Packaging. 2007;30(3).

6. Buder U, von Klitzing JP, Obermeier E. Reactive ion etching for bulk structuring of polyimide. Sensors and Actuators A: Physical. 2006;132(1):393-399.

7. Mimoun B. Residue-free plasma etching of polyimide coatings for small pitch vias with improved step coverage. Journal of Vacuum Science & Technology B. 2013;31(2).

8. Puliyalil H, Cvelbar U. Selective plasma etching of polymeric substrates for advanced applications. Nanomaterials. 2016;6(6).

9. May GS, Spanos CJ. Fundamentals of semiconductor manufacturing and process control. 1st ed., Wiley-IEEE Press, USA; 2006.

10. STMicroelectronics. Package and process maturity management in back-end manufacturing. rev. 7; 2018.

11. Nenni D, McLellan P. Fabless: The transformation of the semiconductor industry. CreateSpace Independent Publishing Platform, USA; 2014.

12. Geng H. Semiconductor manufacturing handbook. 2nd ed., McGraw-Hill Education, USA; 2017.

13. STMicroelectronics. Visual criteria for sawed wafers and dice. rev. 26; 2019.

14. STMicroelectronics. Gold wire bonding in process control ball wedge technology. rev. 33; 2019.