World Applied Sciences Journal 9 (Special Issue of Nanotechnology): 40-42, 2010
ISSN 1818-4952

Mechanical Properties of QFN Semiconductor Package Using Flexural Test

[1,2]M.F.M. Yunoh, [1,2]S. Abdullah and [2]A. Jalar

[1]Department of Mechanical and Materials Engineering, Engineering and Built Environment Faculty, Universiti Kebangsaan Malaysia, 43600 UKM Bangi, Selangor, Malaysia
[2]ASPAC Laboratory, Institute of Microengineering and Nanoelectronic, Universiti Kebangsaan Malaysia, 43600 UKM Bangi, Selangor, Malaysia

Abstract: This paper discusses some of issues in micromechanical property of a newly developed Quad Flat No-lead (QFN) package using three point bending test method. The test method was used for observing the flexural stress, strain, maximum load and deflection of the package. Most commonly the specimens lies on a support span and the load is applied to the center by the loading nose producing three point bending at a specified rate. The tool for an applied load was moved down until the mold compound of the package was broke. This result is important in order to set the parameters of load, stress and strain when proceed to the three point cyclic bending test on the QFN stacked die package in future work.

Key words: Deflection · QFN. Stress · Strain · Three point bending test

INTRODUCTION

3D Quad Flat No-lead (QFN) stacked die has become the package of choice due to its good thermal performance, flexibility in matching any leaded footprint, fast turn-around time and low tooling up cost. A stacked die is typically categorized into two basic configurations which are pyramid and tower stacked die [1]. The 3D staked die package offers an attractive way to reduce transmission delays, since its configuration provides much shorter access to several surrounding chips [2].

In a normal practice, QFN packages are encapsulated with the epoxy mold compound (EMC) in order to reduce significant the stresses. EMC makes the reliability of QFN packages much higher in order to prevent problems associated with manufacturability, package stress, package cracking and interfacial delaminations. According to the EMC selection, delamination may occur during Thermal Cycle Test (TCTs) that may lead to failure of the package [3]. In an early stage of the QFN development, a more effective test method is desirable, because the TCTs are time consuming. TCTs usually require one or two months because one of cycle-time is about one hour. Abdullah *et al* [4] performed a new fatigue method test to observe the epoxy effect in single die QFN packages, namely the three points cyclic bending test method. From this test, the delamination effecf were caused due to the cycle load and the failure parts coincide with those in the case of mechanical load.

Some of micromechanical properties of the QFN stacked die package must be considered for setting the parameter for the three point cyclic bending test. This study is performed to characterize several micromechanical properties of a QFN stacked die package i.e maximum load, flexural strength, flexural strain and deflection. For the further study, the cyclic bending test will then be performed in order to observe the durability affects of the QFN stacked die package.

MATERIALS AND METHODS

For a QFN package, the stress-strain behaviour is not usually ascertained by a tensile test. This is because of the difficulty to prepare the test specimens with the required geometry and grip them without fracturing it. Therefore, a more suitable transverse bending test is most frequently employed, in which the specimen is bent until fracture condition using a three-point loading technique.

In this test, a sample of QFN stacked die package as in Figure 1 was used. This package was developed by ASPAC Research Group, Universiti Kebangsaan Malaysia. Samples of 3D stacked die package was

Corresponding Author: M.F.M. Yunoh, Department of Mechanical and Materials Engineering, Engineering and Built Environment Faculty, Universiti Kebangsaan Malaysia, 43600 UKM Bangi, Selangor, Malaysia
E-mail: faridz_yunus@yahoo.com

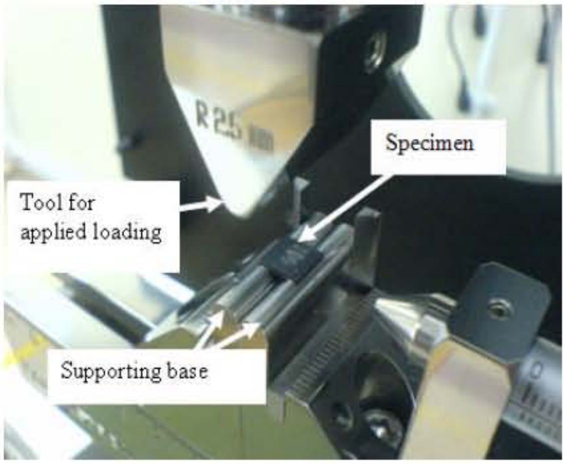

Fig. 1: Position of QFN Stacked die on flexural test bench

prepared using the daisy chain die with the overall package dimensions was 7 mm x 7 mm x 0.85 mm with 48 leads. The bottom die size was designed at the dimensions of 5 mm x 5 mm and the top die size was 3.3 mm x 3.3 mm, where the thickness for both dies were 0.15 mm. The epoxy thickness between the die and the leadframe was 0.0251 mm. For the normal flexural test, the Dynamic Micro tester machine was used for the three point bending test. A series of experiment were used at the loading speed of 0.5 min^{-1}. This value was chosen based on the study by Geng *et al* [5], which they set the loading speed on three point bending test for Ball Grid Array (BGA) is between 0.1 to 10 min^{-1}.

RESULTS AND DISCUSSION

In many brittle materials, the normal tensile test cannot easily be performed because of the presence of flaws at the surface. In any three point bending test, the concentrated load could be given directly at the center of the package [6]. Fig. 2 shows the example flexural stress-strain curve obtained from the three point bending test in room temperature of this paper with the amount of 335.65MPa flexural stress at the break and also 8.39 % of it flexural strain value. Using this method, the shear stress range was proportional to the range of load at the center of specimen. For the whole test, the flexural strain maintains with the increment of the applied stress before the fracture of the package mold compound. This fracture was started when it reaches the ultimate stress of 375.35 MPa and the stress was slightly decreased until the QFN package stacked die failed at 335.65 MPa. From this mechanism, the failure strength of the QFN stacked die package is the maximum stress at the moment of breakage.

Fig. 3 shows the example plot of load versus deflection of QFN staked die package under three point bending test. The package deflection is referring to the loading span displacement from zero deflection position. From the graph, it shows the maximum deflection of the QFN stacked die package was 0.41 mm and the maximum load was 251.52 N before the failure occurred. The graph also indicates the flexural load was linearly increased with the deflection.

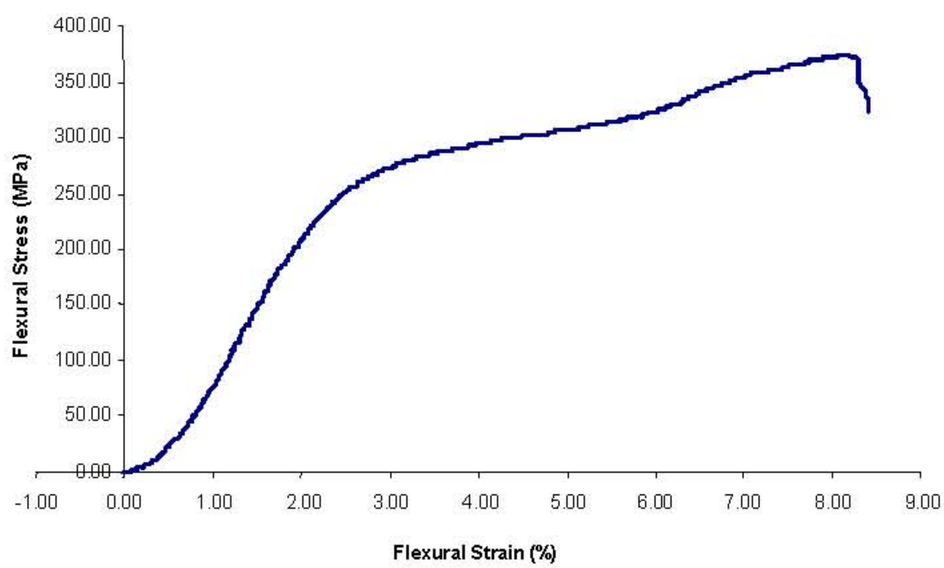

Fig. 2: Plot of flexural stress- strain relationship at room temperature

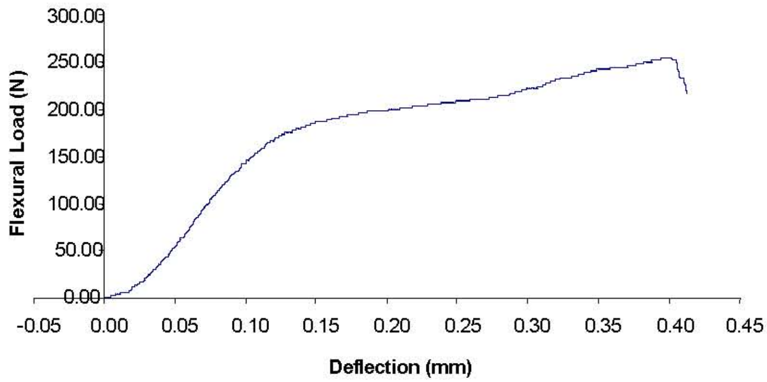

Fig. 3: Plot of the flexural load versus the package deflection at room temperature

When the load reach at 173.70 N, the deflection was slowly increased until the QFN stacked die broke at the maximum load of 251.52 N. From this finding, it shows that the deflection was influence with the applied load, as the load increased with the increment of the package deflection.

CONCLUSION

The micromechanical properties such as flexural strength, strain and maximum load gave an important influence for the failure of QFN stacked die. In this study, the specimens were supported at the three points and the tool for load was moved down until the mold compound of the package broke. The fracture was started when it reaches the ultimate stress at 375.35 MPa. The stress was then slightly decreased until the QFN package failed at 335.65 MPa. The maximum load of the QFN stacked die package was defined at 251.52 N. From this finding, the QFN stacked die package clearly failure dependent on the maximum load that can be supported before it brokes. This result is important in order to set the parameters for the further test of those durability tests of the newly developed QFN package, i.e. the cyclic test. This particular test has been found to be suitable replacement to the TCTs method.

ACKNOWLEDGEMENT

The authors would like to express their gratitude to Universiti Kebangsaan Malaysia (Research funding: UKM-GUP-NBT-08-25-087) for supporting this research.

REFERENCES

1. Jalar, A., S.A. Radzi, A. Abdullah, M.F.M Yunoh and M.F. Rosle, 2008. Effect of mechanical properties of gold wire on looping behavior and pull strength for QFN Stacked Die Package. Proceedings of the 4th WSEAS International Conference on Applied and Theoretical Mechanics (Mechanics '08)Cairo, Egypt. pp: 118-112.
2. Heikkila, R., J. Tanskanen and E.O. Restolainen, 2002. Reliability Study of 3D Stacked Structures, Proc. Electronic Components and Technology Conference. pp: 1449-1453.
3. Doi, K., N. Hirano, T. Okada, Y. Hiruta, T. Sudo and M.Mukai, 1995. Prediction of thermal fatigue life for encapsulated flip chip interconnection in Proc. ISHM'95 Conf., pp: 247-252.
4. Abdullah, S., M.F. Abdullah and A.K. Arifin, 2007. Fatigue Test Method for Observing the Delamination Effect in a QFN Package, 2007 9th Electronics Packaging Technology Conference. pp: 670-674.
5. Geng, P., P. Chen and Y. Ling, 2002. Effect of Strain Rate on Solder Joint Failure under Mechanical Load, Electronic Component and Technology Conference. pp: 974-978.
6. Hirohata, K., N. Kawamura, M. Mukai, T. Kawakami, H. Aoki and K. Takahashi, 2002. Mechanical Fatigue Test Method for Chip/Underfill Delamination in Flip-ChipPackages, IEEE Transction on Electronics Packaging Manufac., 25(3): 217-222.
7. Rizvi, M.J., Y.C. Chan, C. Bailey and H. Lu, 2005. Study of anisotropic conductive adhesive joint behaviour under 3-point bending, Microelectronics Reliability. 45: 589-596.
8. Skipor A. and L. Leicht, 2001. Mechanical Bending Fatigue Reliability and Its Application to Area Array Packaging, Electronic Components and Technology Conference.