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Mechanical Tenacity Analysis of Moisture Barrier Bags for Semiconductor Packages

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Abstract: We have been using Moisture Barrier Bags for dry packing of semiconductor packages to prevent moisture from absorbing during shipping. Moisture barrier bag material is required to be waterproof, vapor proof and offer superior ESD (Electro-static discharge) and EMI shielding. Also, the bag should be formed easily to the shape of products for vacuum packing while providing excellent puncture resistance and offer very low gas & moisture permeation. There are some problems like pinholes and punctured bags after sealing and before the surface mount process. This failure may easily result in package pop corn crack during board mounting. The bags should be developed to meet the requirements of excellent electrical and physical properties by means of optimization of their raw material composition and their thickness. This study investigates the performance of moisture barrier bags by characterization of their mechanical endurance, tensile strength and through thermal analysis. By this study, we arrived at a robust material composition (polyester/Aluminate) for better packing.

Keywords: Moisture barrier bag, Mechanical tenacity, Puncture, Pin hole, Dry packing, Drop test

Introduction

Moisture induced cracking in susceptible surface-mount packages is a serious reliability problem that can cause device failures. As a solution to moisture induced cracking, the susceptible surface-mount packages are dry packed with desiccant, in moisture barrier bags that are virtually impermeable to water. This packing procedure allows the surface-mount packages to remain dry when placed in inventory or during shipping, and offers the printed circuit board manufacturer the flexibility to mount these packages within a specific time period without having to perform a drying operation. Moisture barrier bags (MBBs) are made from high-performance barrier materials, specially designed for "dry packaging" of moisture absorbing electronic components. MBBs are required to be water proof, vapor proof and offer superior ESD (Electro-static discharage) and EMI shelding. Also, the bags should be formed easily to the shape of products for vacuum packaging, while providing excellent puncture resistance and providing very low gas and moisture permeation.

In general, MBBs are composed of several layers (a static dissipative, nylon, adhesive, aluminum foil, polyethylene and another static dissipative layer) of polymer (Fig. 1).

The bags are designed for particle and contamination free (containing no anions such as Cl-, F-, and Br-) electronic devices that are produced in clean rooms and assembled into an electronic package.

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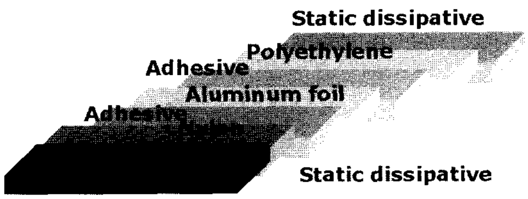


Fig. 1. The structure, for example, of moisture barrier bag.

Puncture and pin hole failures of MBBs may result in package cracking later during the board assembly reflow process, resulting from moisture penetration of the bag and moisture absorption of the composit materials (such as epoxy mold compound & die attach materials) in the electronic package[1-2]. These packaging materials absorb moisture easily from the ambient environment. Surface-mount devices, including semiconductor packages, are mounted to printed circuit boards by reheating solder on the pads (reflow process). Absorbed moisture in the package may cause "pop corn" failures during reflow, so named because of the popping sound made during the cracking of these componenets as the moisture vapor pressure delaminates & cracks the plastic within the package during high temperature reflow. In case of plastic packaging, delamination at various interfaces is a key issue for package reliability.[3]

To resolve this issue, moisture barrier bag material should provide better puncture resistance through optimization of material composition and its thickness control.

Experiment

Mechanical edurance analysis of the moisture barrier bag is done by means of drop and vacuum seal testing using tensile strength measurements of sealed bags to define their optimum material composition and thickness.

In this evaluation the mechanical properties were measured by DMA and UTM equipment. Firstly, the modulus data measured by DMA is helpful to understand the mechanical performance or elasticity of the material. In addition, drop testing and visual inspection after the vacuum packing of trays is used to define the mechanical resistance for puncture or pin hole failures. The detailed experiments are described as follows.

Table 1. Sample information

Sample	Remark
Sample 1	Nylon + Aluminate
Sample 2	Nylon + Al foil
Sample 3	Polyester + Al foil
Sample 4	Polyester + Aluminate

Dynamic Mechanical Analyzer, DMA

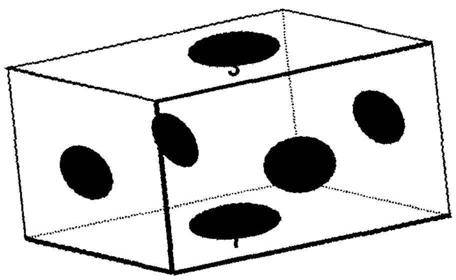
DMA was used to measure the modulus of the MBBs. The modulus is measured by the DMA instrument, as a function of temperature, time, stress, amplitude, frequency and static force. The storage modulus (E) is then calculated by the software. The test was done according to the following test conditions. Tensile on mode, static force:110mN, tension: 120%, dynamic force: 100mN, dynamic force control amplitude: 10um.

Drop and visual test

We put the vacuum sealed sample (vacuum sealed trays inside the subject moisture barrier bag) loose, inside a cardboard box. And then, we drop the box six times from a height of approximately one meter and leave the box from 5 to 10 minutes before checking for pin holes. Tests were done with variations of several trays, i.e. (2, 4, 6, 8 & 10). And testing was done by dropping the box on each of its flat sides.

Vacuum sealing test

An auto-machine was used for vacuum sealing. Various time & pressure conditions for sealing were applied. And then the MBBs were checked for pin holes or punctures.



Drop Test Box

Fig. 2. Drop method, drop height; 36inch, 6 drop points as illustrated by the colored circles.

Univesal test machine, UTM

Tensile strength and elongation for MBB materials is measured by UTM. The samples were made according to the ASTM(American Society for testing and materials) test method and placed in the UTM instrument with a tensile test jig set to tensile test mode at room temperature.

Differential Scanning Calorimeter, DSC

The DSC instrument (TA model) was used to measure heat flow into or out of moisture barrier bag material. The sample was put into an aluminum DSC sample pan. Then, the sample was put into the DSC cell at 5°C/min heating rate from room temperature to 300°C. The temperature profile was then obtained after the DSC experiment, to determine the melting temperature of each polymer for each of the MBBs.

Results and discussion

Vacuum sealing performance(visual test)

Mechanical endurance test analysis was done by performing vacuum seal of each bag by various applied conditions for vacuum time and pressure for various tray stacks, i.e. 2, 4, 6, 8 & 10 trays were used for this test, respectively. The greater number of trays means the more severe the condition. Vacuum times of 5 and 10 seconds were applied and then inspeciton was performed for pin hole and/or puncture failures.

There were torn pin hole failures after vacuum sealing in the case of samples 2 and 3. Sample 3 showed various punctures like the one shown in figure 3, at the edge of the tray bundle for 2 & 10 tray stacks, immediately after vacuum sealing. Sample 2 also experienced a tear after vacuum sealing for 10sec. This represents that the bag did not have the endurance to withstand the combination of both inner and outer vacuum pressure.

Drop test

The drop test was done to test the mechanical endurance of MBB materials. Four samples were evaluated, which had different layer combinations of nylon, polyester, aluminum foil and aluminum laminate. Again, tray stacks of 2, 4, 6, 8 & 10 trays were vacuum sealed for this test, and again the larger number of trays indicates a more severe condition.

Based on drop test result, sample 4 showed the best quality compared with the other samples. For the 10 tray stacked bundle of sample 1, the bag was punctured. Sample 3, had the worst result with all tray stack combinations exhibiting punctures, after

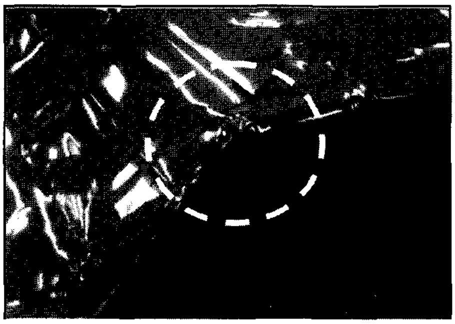


Fig. 3. Puncture failure of sample 3 with 10 tray stacking after vacuum sealing.

Table 2. The result of vacuum sealing performance. Fail indicates a puncture failure, and p indicates passing.

		Sample 1		Sample 2		Sample 3		Sample 4	
Tray #	Vacuum Time	5 sec	10 sec	5 sec	10 sec	5 sec	10sec	5 sec	10sec
2		P	P	P	Fail	P	Fail	P	P
4		P	P	P	P	P	P	P	P
6		P	P	P	P	P	P	P	P
8		P	P	P	P	P	P	P	P
10		P	P	P	P	P	Fail	P	P

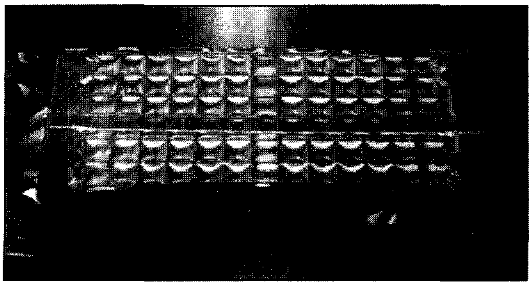


Fig. 4. Visual quality of sample 1 with 10 trays was normal before the drop test.

the drop test. But, leg 4 showed good performance even though one bag with 10 stacked trays was torn. Leg 4 (Polyester + Al laminate) and leg 1 (Nylon + Al foil) showed better performances than all others from the perspective of appearance after sealing, mechanical endurance and resistance to the drop test.

DSC result

The polymer layer in each of the moisture barrier

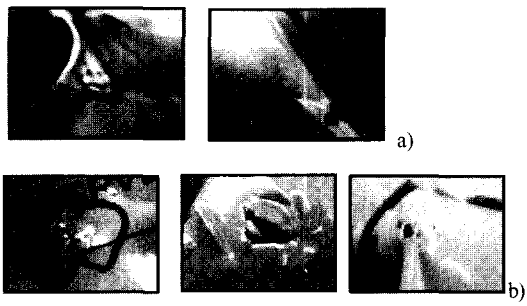


Fig. 5. Image of failures after the drop test. a) puncture failures of sample 2, b) pucture failures of sample 3.

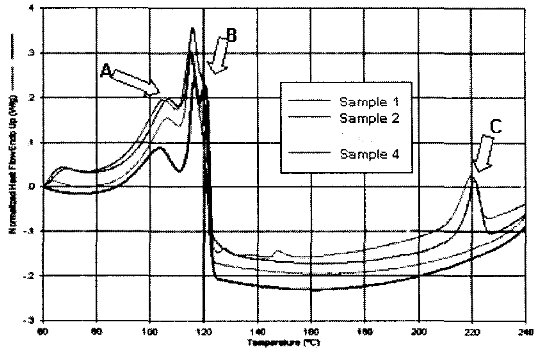


Fig. 6. DSC curve for MBB materials. Peaks indicate: A; polyethylene(LDPE), B; polyester, C; Nylon.

bags was analyzed by its melt temperature in the DSC experiment. The index of melt temperatures of polymers in the polymer library or handbook was used to help characterize each polymer analyzed. Figure 6 shows the analysis of the DSC melt temperature peaks. From this information shown in the DSC curve, samples 1 and 2 were nylon materials, while samples 3 and 4 were polyester materials. Additionally, polyethylene materials are analyzed for all samples.

Modulus result

The Modulus was measured by DMA at room temperature. There was no significant difference of modulus values between MBB materials. Sample 2 with Nylon+Al laminate showed a lower modulus value compared with sample 3 with polyester + Al foil.

The result of tensile strength and elongation

The tensile strength and elongation of MBB materi-

Table 3. Drop test result: Fail indicates a puncture failure, and p indicates passing.

		Sample 1		Sample 2		Sample 3		Sample 4	
Tray #	Vacuum Time	5 sec	10 sec	5 sec	10 sec	5 sec	10sec	5 sec	10sec
2		P	P	P	P	Fail	Fail	P	P
4		P	Fail	Fail	Fail	Fail	P	P	P
6		P	P	Fail	Fail	Fail	Fail	P	P
8		P	P	Fail	Fail	Fail	Fail	P	P
10		P	Fail	P	Fail	Fail	Fail	Fail	P

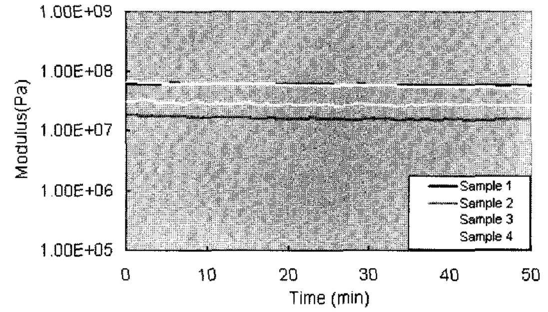


Fig. 7. Modulus data of MBB material.

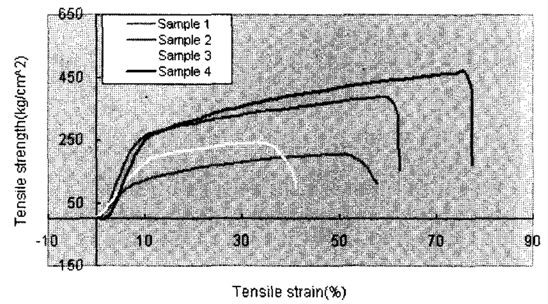


Fig. 8. Curve of tensile strength vs strain for MBB materials.

als was measured by the UTM. Sample 4 with polyester + Aluminum laminate appears to have a higher tensile strength and longer elongation than that of the other bags. Sample 1 appears to have a lower tensile strength value, while sample 3 shows a lower elongation compared with others. Generally, material that has a higher tensile strength and elongation will also have a greater toughness.

Conclusion

This report describes the characterization of four types of moisture barrier bags, each composed of different polymer layers, thickness and structure, by means of thermal analysis and mechanical endurance testing. There was no significant difference in properties, like ESD & EMI shielding. Based on the test results, sample 4, which is composed of polyester and aluminum laminate as main polymer components, shows better puncture resistance performance, as well as greater tensile strength and elongation by tensile testing. As a result, sample 4 seems to have better toughness when compared to the other samples. Additionally, sample 4 conforms better to the tray stacks for a tight vacuum seal. You might say, the suitability of sample 4 to the application of vacuum sealing various tray stacks, conforms to its good material characterization for the application. In conclusion, the moisture barrier bag is required to be water proof, vapor proof and offer ESD & EMI shielding. It should be formed easily to the shape of products for vacuum packing, while providing excellent puncture resistance. These properties will be achieved by optimization of material composition and thickness control through material characterization.

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