Effecting aging time of epoxy molding compound to molding process for integrated circuit packaging

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Abstract. This research studied about effecting aging time of epoxy molding compound (EMC) that effect to reliability performance of integrated circuit (IC) package in molding process. Molding process is so important of IC packaging process for protecting IC chip (or die) from temperature and humidity environment using encapsulated EMC. For general molding process, EMC are stored in the frozen at 5°C and left at room temperature at 25 °C for aging time on self before molding of die onto lead frame is 24 hours. The aging time effect to reliability performance of IC package due to different temperature and humidity inside the package. In experiment, aging time of EMC were varied from 0 to 24 hours for molding process of SOIC-8L packages. For analysis, these packages were tested by x-ray and scanning acoustic microscope to analyze properties of EMC with an aging time and also analyzed delamination, internal void, and wire sweep inside the packages with different aging time. The results revealed that different aging time of EMC effect to properties and reliability performance of molding process.

1. Introduction

Encapsulation of epoxy molding compound (EMC) for molding process is a popular method for integrated circuit (IC) packaging manufacturing. Molding is the process for protecting die or chip of IC package form external environment for chemical reaction and mechanical damage by shaping EMC continuing with the formation of a gelatin with complete cross linked network and leading finally to the fully cured thermoset. EMC is thermostetting polymer which is materials with cross linked polymer chains and no melting temperature after they are cured. EMC is a mixture of an epoxy resin, a filler (silica, SiO2), a hardener, and other additives. The important part of EMC which is epoxy resin functions as an adhesive and binder. For silica filler part, this part is the largest portion of EMC provides excellent mechanical strength and a thermal dispersion. Properties of these components effect to reliability performance of IC package. From normal manufacturing process, the EMC is stored in the frozen at 5 °C and aging at around room temperature before molding process. The EMC aging effect to its properties and reliability performance of IC package.

Therefore, this research interested in studying effecting of aging time to epoxy molding compound (EMC) in term of reliability performance for integrated circuit (IC) package in range from 0 hour to 24 hours and analyze properties of EMC with aging time and also study about quality and reliability
performance of molding process. Next section describes methodology of inspection effect to epoxy molding compound aging time to reliability performance for IC package. Section 3 presents results and discussion. Finally, section 4 concludes this paper.

2. Methodology and Methods

This section, we describe methodology for inspection EMC properties with difference of aging time before molding process, mold ability, and reliability performance. The SOIC 8L package were observed with different aging time of EMC for analyzing. In experiment, EMC were varied aging time from 0 hours to 24 hours with step 3 hours for analysis as shown in Table 1. And diagram of methodology to observe mold ability and reliability performance of 8L SOIC package is shown in figure 1.

| EMC A | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|-------|---|---|---|---|---|---|---|---|
| Aging time (hours) | 3 | 5 | 7 | 9 | 11 | 13 | 15 | 24 |

**Figure 1** Diagram of methodology to observe mold ability and reliability performance of 8L SOIC package.
The EMC for SOIC 8L package were measured the relationship between temperature and humidity by thermocouple during aging compound which result as shown in Figure 2.

![Figure 2](image-url)  
*Figure 2* The relationship between temperature and humidity.

For analysis, the samples were observed moldability with x-ray for inspection wire sweep and incomplete mold. For reliability testing, the sample was performed with humidity sensitivity testing as shown in table 2 and table 3.

![Figure 3](image-url)  
*Figure 3* The procedure for humidity sensitivity level test (MSL).
Table 2 Standard of humidity sensitivity level.

| Level | Time       | Conditions   |
|-------|------------|--------------|
| 1     | Unlimited  | ≤30 °C/85% RH|
| 2     | 1year      | ≤30 °C/60% RH|
| 3     | 4weeks     | ≤30 °C/60% RH|
| 4     | 168 hours  | ≤30 °C/60% RH|
| 5     | 72 hours   | ≤30 °C/60% RH|
| 6     | 48 hours   | ≤30 °C/60% RH|
| 7     | 24 hours   | ≤30 °C/60% RH|

Table 3 Standard of humidity sensitivity level for soaking requirement.

| Soak requirements | Standard | Accelerated equivalent |
|-------------------|----------|------------------------|
|                   | Time (hours) | Conditions   | Time (hours) | Conditions   |
|                   | 168       | 85 °C/85% RH          | 120          | 60 °C/60% RH          |
|                   | +5/-0     |                        |              |                |
|                   | 168       | 85 °C/60% RH          | 40           | 60 °C/60% RH          |
|                   | +5/-0     |                        |              |                |
|                   | 696²      | 30 °C/60% RH          | 20           | 60 °C/60% RH          |
|                   | +5/-0     |                        |              |                |
|                   | 192²      | 30 °C/60% RH          | 15           | 60 °C/60% RH          |
|                   | +2/-0     |                        |              |                |
|                   | 96²       | 30 °C/60% RH          | 10           | 60 °C/60% RH          |
|                   | +2/-0     |                        |              |                |
|                   | 72²       | 30 °C/60% RH          | 10           | 60 °C/60% RH          |
|                   | +2/-0     |                        |              |                |
|                   | 48²       | 30 °C/60% RH          | 10           | 60 °C/60% RH          |
|                   | +2/-0     |                        |              |                |

3. Results and Discussion

3.1 Moldability
The results of wire sweep and incomplete mold with different aging time, observe by x-ray and high power microscope as shown in Table 4 and Table 5.
The wire sweep results were observed about displacement and deformation of wire loop inside the packages. The results show that wire sweep values clearly increase from range aging time 0 hours to 24 hours. For standard IC packaging manufacturing. The maximum wire sweep was controlled with 15% from standard values. However, the results of aging time in range 0 hours to 24 Hours don’t found values of wire sweep more than 15% which is maximum stand specification of wire sweep.
Table 4 The wire sweep results for aging time EMC.

| Aging time (Hours) | 3  | 5  | 7  | 9  | 11 | 13 | 15 | 24 |
|--------------------|----|----|----|----|----|----|----|----|
| Max                | 1.68 | 1.84 | 1.59 | 1.81 | 1.70 | 1.87 | 1.49 | 1.56 |
| Min                | 0.05 | 0.15 | 0.12 | 0.36 | 0.27 | 0.35 | 0.14 | 0.46 |
| Average            | 0.85 | 0.95 | 0.95 | 0.95 | 1.06 | 1.07 | 1.06 | 1.13 |

3.2 Incomplete mold
After molding process, the IC package also were observed with visual inspection to observe incomplete molding. The results show that not found incomplete mold for all range aging time of EMC. The result is shown in Table 5.

Table 5 The incomplete mold and surface results for each aging time.

| Aging time (Hours) | 3 | 5 | 7 | 9 | 11 | 13 | 15 | 24 |
|--------------------|---|---|---|---|----|----|----|----|
| Result (units)     | 0/432 | 0/432 | 0/432 | 0/432 | 0/432 | 0/432 | 0/432 | 0/432 |
| Microscope high power 50x |

3.3 Delamination
The results of delamination by C-SAM after molding and post mold cure (PMC) in range aging time of EMC as shown in Table 6.

Table 6 Delamination results for each aging time after post mold cure.

| Aging time (Hours) | 3 | 5 | 7 | 9 | 11 | 13 | 15 | 24 |
|--------------------|---|---|---|---|----|----|----|----|
| Result (units)     | 0/432 | 0/432 | 0/432 | 0/432 | 0/432 | 0/432 | 0/432 | 0/432 |
| C-SAM Top view |
| Bottom view |
3.4 Reliability
After molding and trim and form process, the IC package was tested for MSL testing with 30 units per each aging EMC. The results show about delamination before and after testing in Table 7 Delamination inside the samples were observed in range of 0 to 11 hours of aging time and not found delamination for in range 13 to 24 hours of aging time.

| Delamination | 3  | 5  | 7  | 9  | 11 | 13 | 15 | 24 |
|--------------|----|----|----|----|----|----|----|----|
| Result (units) | 0/30 | 0/30 | 0/30 | 0/30 | 0/30 | 0/30 | 0/30 | 0/30 |
| Before       | ![Top view](image1) | ![Top view](image2) | ![Top view](image3) | ![Top view](image4) | ![Top view](image5) | ![Top view](image6) | ![Top view](image7) | ![Top view](image8) |
|             | ![Bottom view](image9) | ![Bottom view](image10) | ![Bottom view](image11) | ![Bottom view](image12) | ![Bottom view](image13) | ![Bottom view](image14) | ![Bottom view](image15) | ![Bottom view](image16) |
| Result (units) | 13/30 | 19/30 | 15/30 | 19/30 | 6/30 | 0/30 | 0/30 | 0/30 |
| After        | ![Top view](image17) | ![Top view](image18) | ![Top view](image19) | ![Top view](image20) | ![Top view](image21) | ![Top view](image22) | ![Top view](image23) | ![Top view](image24) |
|             | ![Bottom view](image25) | ![Bottom view](image26) | ![Bottom view](image27) | ![Bottom view](image28) | ![Bottom view](image29) | ![Bottom view](image30) | ![Bottom view](image31) | ![Bottom view](image32) |

4. Conclusion
This research studied about effect of epoxy molding compound that different aging time to EMC properties and reliability performance of molding process package SOIC 8L. The properties of EMC are acceptable for standard value of IC packaging manufacturing process. The mold ability also acceptable in part of wire sweep, incomplete mold, molding surface for all range of aging time. However, for part delamination in range aging time 3-11 hours after MSL found delamination a little at lead area of package but in range 13-24 hours don’t found effect of delamination. For surface of package, if used compound while had high humidity continuous maybe affect to surface of package such as void and incomplete due to stain on cavity surface of molding. Therefore, aging time of EMC is not any concern for EMC property, moldability and reliability in range 13 hours to 24 hours for molding process of IC packaging manufacturing.

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References

[1] Junichi SAEKI** and Aizou KANEDA**(1990) “Flow Analysis of an Epoxy Compound for Low-Pressure Transfer Molding in a Circular Cross-Sectional Channel”, Volume 33 pp 486-493

[2] N. Kinjo and Ogata (1989) “Epoxy Molding Compounds as Encapsulation Materials for Microelectronic Devices” Raw Material for Epoxy Molding Compounds. Volume 88 pp 1-48

[3] Chen-Hung Lee, Lu-Fu Lin (2010) “Study on paddle delamination for quad flat no leads package”, IEEE Transactions on Microsystems Packaging Assembly and Circuits Technology Conference

[4] P. Udom (2016) “Effect of Epoxy Molding Compound Floor Life to Reliability Performance for Integrated Circuit (IC) Package”

[5] N. Chokchai (2006) “Parameters Influence on Inflow Pressure Loss in Injection Molding”