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YOUR MONTHLY LOOK INSIDE SEMICONDUCTOR TECHNOLOGY

Transfer Molding

By Christopher Henderson

In this month's Feature Article, we continue our series on Transfer Molding. Transfer Molding is one of the more common steps in semiconductor packaging, and provides protection for the sensitive semiconductor components and packaging interconnect. In this article, we will discuss the storage and handling of mold compounds.

First, let's discuss shelf life. The reaction in an epoxy resin mold compound polymer system is exponential with temperature, so storing the material at a lower temperature helps to slow the reaction or curing rate. If one needs to store the mold compound materials for a significant amount of time, even a slow reaction rate can lead to partial curing of the material. Therefore, storage below 5ºC helps to prevent polymerization. We show the degradation in the spiral flow values, which corresponds to an increase in viscosity, in Figure 1. Notice that the sample stored at 4ºC shows very little polymerization after more than 3 months, while a sample stored at 23ºC shows a significant amount of polymerization after just a few days. Generally, a 10% retention or degradation of the original spiral flow is considered to be acceptable. Moisture can play a role in this process, so normally, epoxy resin mold compound comes in a sealed container that contains a desiccant to remove moisture.

WHAT'S INSIDE?

01 Feature Article

04 Technical Tidbit

05 Ask The Experts

06 Course Spotlight

Want to take control of your learning? See page 5

Upcoming Courses:

- Failure and Yield Analysis

See page 9 for more details

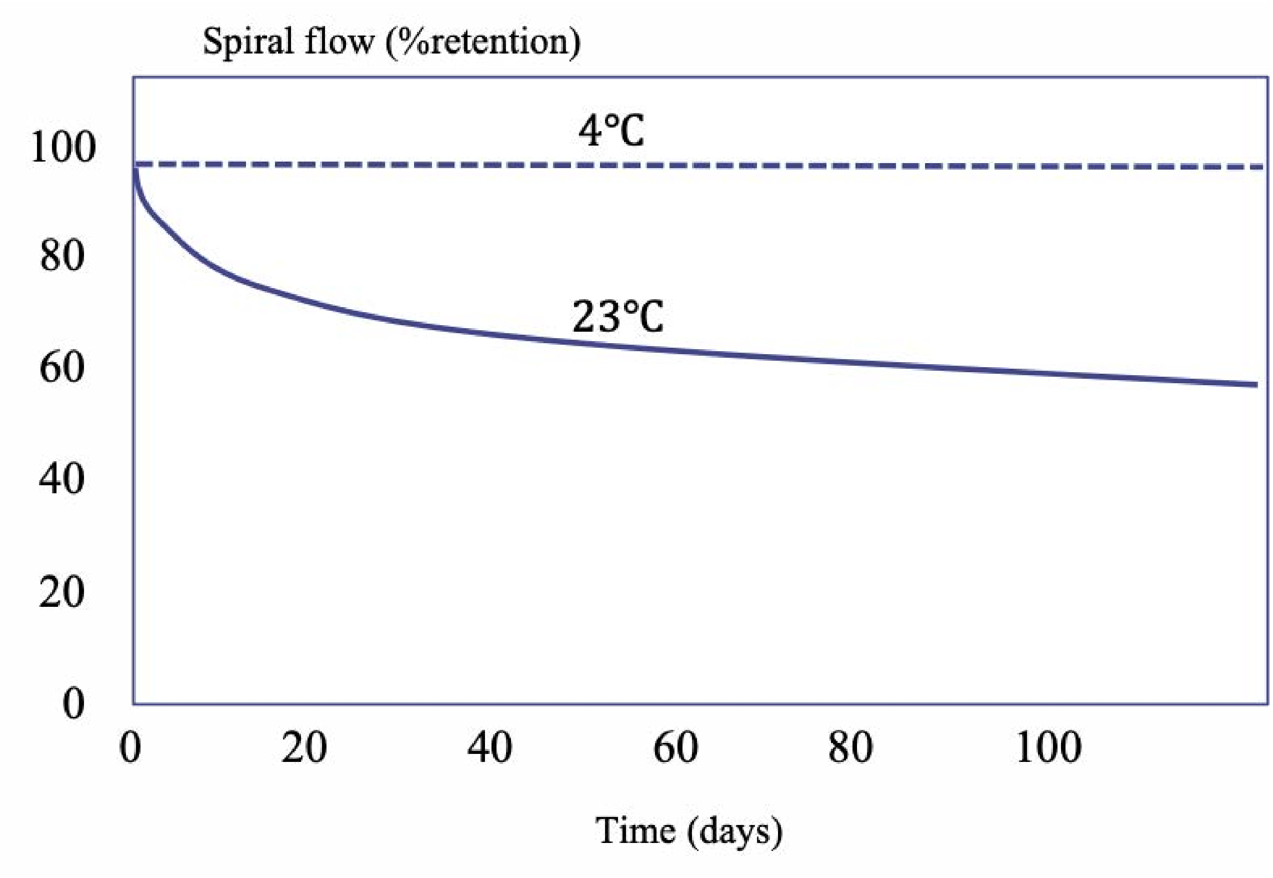

Figure 1- Change in spiral flow at two different temperatures as a function of storage time.

The next item associated with storage and handling is floor life. This is also important for the same reasons as shelf life. As a reminder, the reaction in an epoxy resin mold compound polymer system is exponential with temperature, so time spent at room temperature increases the reaction rate. First, just prior to the use of the mold compound, it needs to be brought up to room temperature, or run through a thawing process. Second, because moisture affects the polymerization, the seal on the mold compound should be maintained until just prior to processing. The manufacturer normally provides the floor life information, but it is usually up to the process technician to determine if the floor life has been exceeded. When the mold compound package is opened, it should not be exposed to high humidity, for the reason we cited above. As is the case with storage, we can use the Spiral Flow technique to determine the floor life. Again, in general, a 10% retention or degradation of the original spiral flow is considered to be acceptable.

Figure 1 not only applies to shelf life but also applies to floor life as well. Again in Figure 1, notice that the sample stored at 4ºC shows very little polymerization after more than 3 months, while a sample stored at 23ºC shows a significant amount of polymerization after just a few days. As such, the floor life is typically 24 hours or less.

In next month's Feature Article, we will continue our discussion of transfer molding by discussing mold compound properties.

Technical Tidbit: Wire for Wire Bonding

This month's Technical Tidbit covers the materials used for the wire in the wire bonding process. The material for wire bonding is important. We need to select a wire based on the interface to the die, which involves the materials on the bond pad and immediately below the bond pad; the leadframe materials and platings; and the properties of the wire material itself. Also important is the cost of the wire.

Based on the die materials; leadframe or substrate materials; and the application needs, we can then choose a wire type. There are 5 major wire types used in the industry: palladium coated copper, or PCC; copper; aluminum; gold; and silver wire. For reference, see Figure 1 for images and short descriptions of the different wire types. For all wire types, the wire should be smooth so that it will not snag in the bonding machine. Aluminum wiring is typically 99% aluminum and 1% silicon and must be homogenous in order to bond consistently. Gold wire provides better current-carrying capabilities than aluminum, and works well in plastic packages, but suffers from a problem known as Kirkendall voiding, which can lead to open bond connections when the bond is exposed to high temperatures for long periods of time. Copper wire is becoming more popular, as it costs less than gold. Copper also has a lower resistance than gold and can be made thinner than gold for an equivalent resistance. Copper does suffer from problems with oxidation, so copper wire is sometimes palladium-coated to improve the lifetime and bonding characteristics. Silver is the most conductive of the materials and does not suffer from an electrical effect known as the skin effect, whereas, aluminum, gold and copper do, so it works well for high frequency applications, but it does suffer from sulfur contamination.

Figure 1- Images and brief descriptions of the five major bond wire types: Palladium Coated Copper (PCC), bare copper, aluminum, gold, and silver.

Ask The Experts

Q: How critical is viscosity drop due to shear rate during injection with these molding compounds? I hear this is extremely important with injection molding of thermoplastics.

A: First, as a background comment, when a mold compound experiences an increase in shear rate, its viscosity will drop, meaning the material becomes easier to flow; this phenomenon is commonly referred to as "shear thinning" and is particularly relevant in injection molding processes where high shear rates are present during mold filling. The physical reason why this occurs is that when a mold compound is subjected to high shear, the polymer chains within the material tend to align themselves parallel to the flow direction, reducing resistance and lowering viscosity. The advantage of this is that higher shear rates during injection molding can facilitate better mold filling, especially in complex geometries, due to the decrease in viscosity. The disadvantage of this property is that excessive shear rate can lead to issues like polymer chain degradation, which could affect the mechanical properties of the final molded part. Now is this critical? This is likely to be dependent on the application, and the environment to which the component will be exposed.

Course Spotlight: FAILURE AND YIELD ANALYSIS

OVERVIEW

Failure and Yield Analysis is an increasingly difficult and complex process. Today, engineers are required to locate defects on complex integrated circuits. In many ways, this is akin to locating a needle in a haystack, where the needles get smaller and the haystack gets bigger every year. Engineers are required to understand a variety of disciplines in order to effectively perform failure analysis. This requires knowledge of subjects like: design, testing, technology, processing, materials science, chemistry, and even optics! Failed devices and low yields can lead to customer returns and idle manufacturing lines that can cost a company millions of dollars a day. Your industry needs competent analysts to help solve these problems. ***Failure and Yield Analysis*** is a 4-day course that offers detailed instruction on a variety of effective tools, as well as the overall process flow for locating and characterizing the defect responsible for the failure. This course is designed for every manager, engineer, and technician working in the semiconductor field, using semiconductor components or supplying tools to the industry.

By focusing on a ***Do It Right the First Time*** approach to the analysis, participants will learn the appropriate methodology to successfully locate defects, characterize them, and determine the root cause of failure.

Participants will learn to develop the skills to determine what tools and techniques should be applied, and when they should be applied. This skill-building series is divided into three segments:

1. **The Process of Failure and Yield Analysis.** Participants will learn to recognize correct philosophical principles that lead to a successful analysis. This includes concepts like destructive vs. non-destructive techniques, fast techniques vs. brute force techniques, and correct verification.

2. **The Tools and Techniques.** Participants will learn the strengths and weaknesses of a variety of tools used for analysis, including electrical testing techniques, package analysis tools, light emission, electron beam tools, optical beam tools, decapping and sample preparation, and surface science tools.

3. **Case Histories.** Participants will identify how to use their knowledge through the case histories. They will learn to identify key pieces of information that allow them to determine the possible cause of failure and how to proceed.

COURSE OBJECTIVES

1. This course will provide participants with an in-depth understanding of the tools, techniques and processes used in failure and yield analysis.

2. Participants will be able to determine how to proceed with a submitted request for analysis, ensuring that the analysis is done with the greatest probability of success.

3. This course will identify the advantages and disadvantages of a wide variety of tools and techniques that are used for failure and yield analysis.

4. This course will offer a wide variety of video demonstrations of analysis techniques, so the analyst can get an understanding of the types of results they might expect to see with their equipment.

5. Participants will be able to identify basic technology features on semiconductor devices.

6. Participants will be able to identify a variety of different failure mechanisms and how they manifest themselves.

7. Participants will be able to identify appropriate tools to purchase when starting or expanding a laboratory.

COURSE OUTLINE

DAY 1

1. Introduction

2. Failure Analysis Principles/Procedures
   a. Philosophy of Failure Analysis
   b. Flowcharts

3. Gathering Information

4. Package Level Testing
   a. Optical Microscopy
   b. Acoustic Microscopy
   c. X-Ray Radiography
   d. Hermetic Seal Testing
   e. Residual Gas Analysis

5. Electrical Testing
   a. Basics of Circuit Operation
   b. Curve Tracer/Parameter Analyzer Operation
   c. Quiescent Power Supply Current
   d. Parametric Tests (Input Leakage, Output voltage levels, Output current levels, etc.)
   e. Timing Tests (Propagation Delay, Rise/Fall Times, etc.)
   f. Automatic Test Equipment
   g. Basics of Digital Circuit Troubleshooting
   h. Basics of Analog Circuit Troubleshooting

DAY 2

6. Decapsulation/Backside Sample Preparation
   a. Mechanical Delidding Techniques
   b. Chemical Delidding Techniques
   c. Backside Sample Preparation Techniques

7. Die Inspection
   a. Optical Microscopy
   b. Scanning Electron Microscopy

8. Photon Emission Microscopy
   a. Mechanisms for Photon Emission
   b. Instrumentation
   c. Frontside
   d. Backside
   e. Interpretation

9. Electron Beam Tools
   a. Voltage Contrast
      i. Passive Voltage Contrast
      ii. Static Voltage Contrast
      iii. Capacitive Coupled Voltage Contrast
      iv. Introduction to Electron Beam Probing
   b. Electron Beam Induced Current
   c. Resistive Contrast Imaging
   d. Charge-Induced Voltage Alteration

DAY 3

10. Optical Beam Tools
   a. Optical Beam Induced Current
   b. Light-Induced Voltage Alteration
   c. Thermally-Induced Voltage Alteration
   d. Seebeck Effect Imaging
   e. Electro-optical Probing

11. Thermal Detection Techniques
   a. Infrared Thermal Imaging
   b. Liquid Crystal Hot Spot Detection
   c. Fluorescent Microthermal Imaging

12. Chemical Unlayering
   a. Wet Chemical Etching
   b. Reactive Ion Etching
   c. Parallel Polishing

DAY 4

13. Analytical Techniques
   a. TEM
   b. SIMS
   c. Auger
   d. ESCA/XPS

14. Focused Ion Beam Technology
   a. Physics of Operation
   b. Instrumentation
   c. Examples
   d. Gas-Assisted Etching
   e. Insulator Deposition
   f. Electrical Circuit Effects

15. Case Histories

Upcoming Courses:

Public Course Schedule:

Failure and Yield Analysis - March 3-6, 2025 (Mon.-Thurs.) | Phoenix, AZ - $2,195

Failure and Yield Analysis - March 25-28, 2025 (Tues.-Fri.) | San Jose, CA - $2,095 until Tues. Mar. 4

Have an idea for a course? If you have a suggestion or a comment regarding our courses, online training, discussion forums, or reference materials, or if you wish to suggest a new course or location, please email us at info@semitracks.com

To submit questions to the Q&A section, inquire about an article, or suggest a topic you would like to see covered, please contact Jeremy Henderson at jeremy.henderson@semitracks.com

We are always looking for ways to enhance our courses and educational materials and look forward to hearing from you!