Laboratory 2
Processing of Electronic Packaging

ME/MSE 487 AA/AB Autumn 2007
Electronic Packaging Laboratory

Objective

To understand the processing steps in second level packaging we will manufacture a simple plastic encapsulated dual inline hybrid package and solder it to a simple printed circuit board (PCB). The cross section of this package is shown schematically in Figure 1.

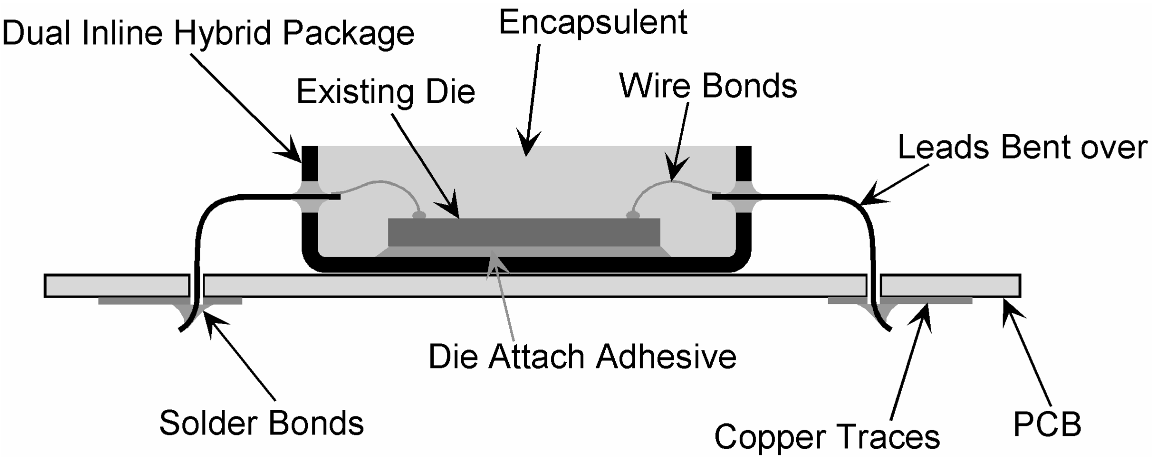

Figure 1: Cross Section of Our Simple Package.

Introduction

Depending on the package type and application, first level electronic packages are manufactured by various processing methods. For this laboratory, we will focus on the plastic encapsulation method. Typical processing steps involved in the manufacturing of plastic encapsulated packaging are shown in Figure 2. This includes die fabrication, die attachment, wire bonding, encapsulation, plating, lead finish, and marking.

For testing purposes we will then take our package one step further and solder mount our plastic encapsulated first level package to a simple PCB. We will then have produced a second level package.

The die or integrated circuit fabrication is preformed on a Silicon (Si) wafer by repeating the following steps: oxidation, photolithography, etching, diffusion, evaporation or sputtering, chemical vapor deposition, ion implantation, and epitaxy. After the desired architecture is obtained, the wafer is sliced into small squares by the use of a diamond saw. The small squares are now considered dies or integrated circuits (IC).

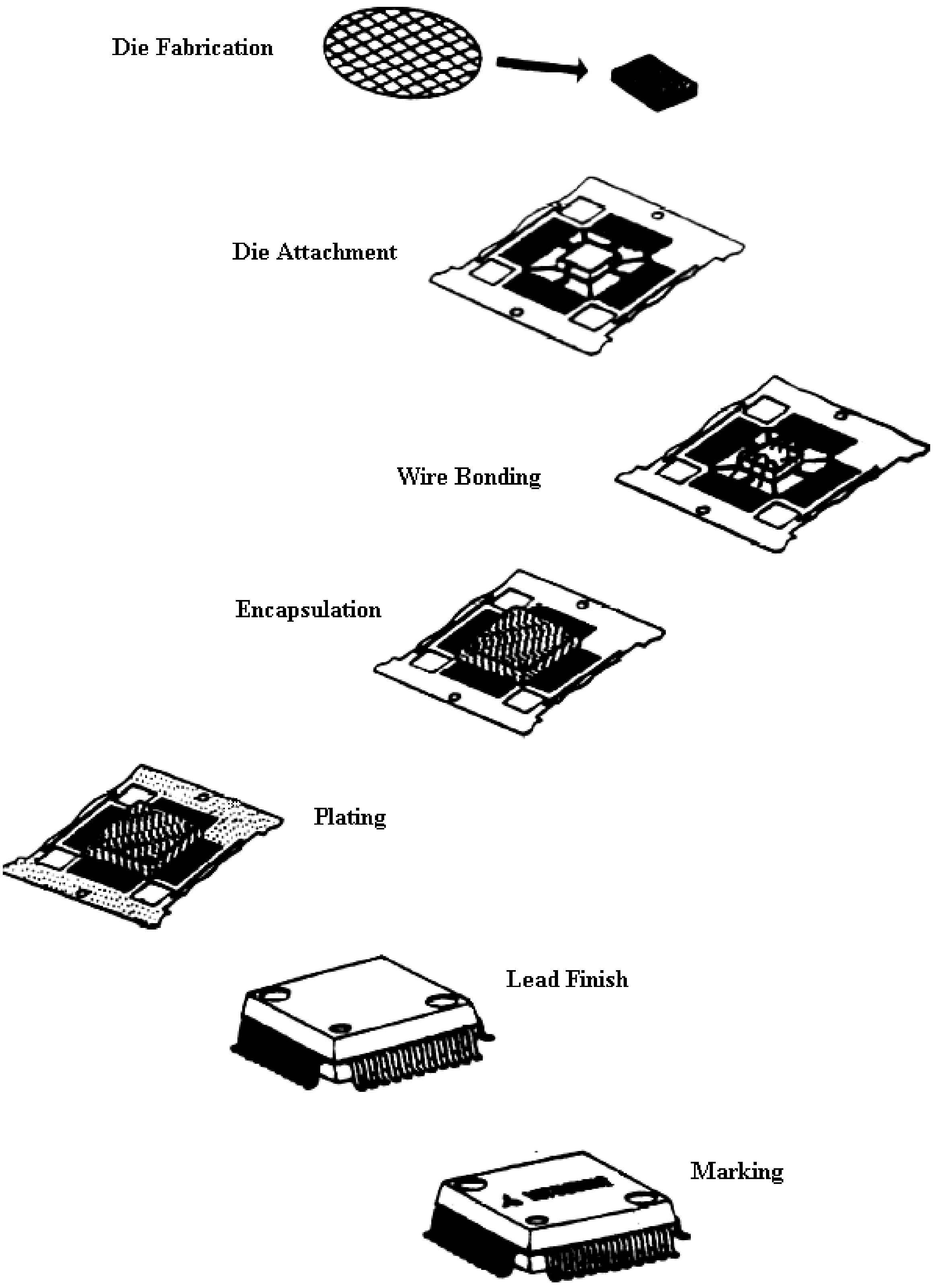

Figure 2 Processing Steps of Typical Plastic Encapsulated Packaging

The IC (die) is mounted on a substrate, leadframe or within the hybrid package using a die attach material. This material must allow for both adequate heat conduction and mechanical stability. Typical types of die attach materials are eutectic bonding (soldering), metal filled polymers, and metal filled glasses. Polymer based adhesives are widely used for die attachment materials due to their cost effectiveness, re-workability, and compliance. Polymeric die attach materials can be dispensed by several different methods including: needle or syringe, stamping, and screen-printing. Once the die attach material is dispensed onto the die paddle, the die is placed on the die attach using a suitable pickup tool. This assembly is then cured according to a set cure profiles provided by the manufacture of the die attach material.

After the above assembly is cured, wire bonding is then used to electrically interconnect Aluminum (Al) or Gold (Au) bonding pads on the die to the lead fingers of the lead frame or hybrid package. Wire bonding is preformed using Thermocompression (high heat and high pressure), UltraSonic (vibration and high pressure) or Thermosonic (vibration, high heat, and high pressure) bonding. Due to the ease of ball formation and oxidation resistance, Au wire is used for Thermocompression and Thermosonic bonding, while Al wire is for Ultrasonic bonding. The diameters of wire vary between 0.2 to 20 mills and are either Gold (Au) or Al depending on the type of bonding process.

Thermocompression bonding uses pressure and temperature to weld a wire between the bonding pad on the die and the lead finger. It is also called ball bonding since a small hydrogen torch is applied at the end of the Au wire to form a ball. Ultrasonic bonding uses an Al wire and high pressure and ultrasonic vibration (20 to 60 kHz) are used to create a wire bond. The Thermosonic bonding process, as shown in Figure 3, uses both ball bonding and wedge bonding to form the interconnect.

Encapsulant is an electrically insulating plastic used to protect semiconductor devices during handling, storage, and operation. Epoxies are traditionally chosen as the encapsulant material because of their high reliability, excellent adhesion, and cost effectiveness. Other choices include silicones, polyamides, polyesters and polyurethanes. In general, the encapsulant resin material must provide adequate mechanical strength, adhesion to package components, manufacturing and environmental chemical resistance, electrical resistance, matched coefficient of thermal expansions and thigh thermal and moisture resistance.

Processes commonly used for encapsulating electronic packages include transfer molding, injection molding and reaction-injection molding. A process called deflashing removes any excessive molding compound present on the package either mechanically or chemically. Package leads are then trimmed, finished and formed and the package is marked with a part number, lot number and date code. The package is now ready for surface mount applications.

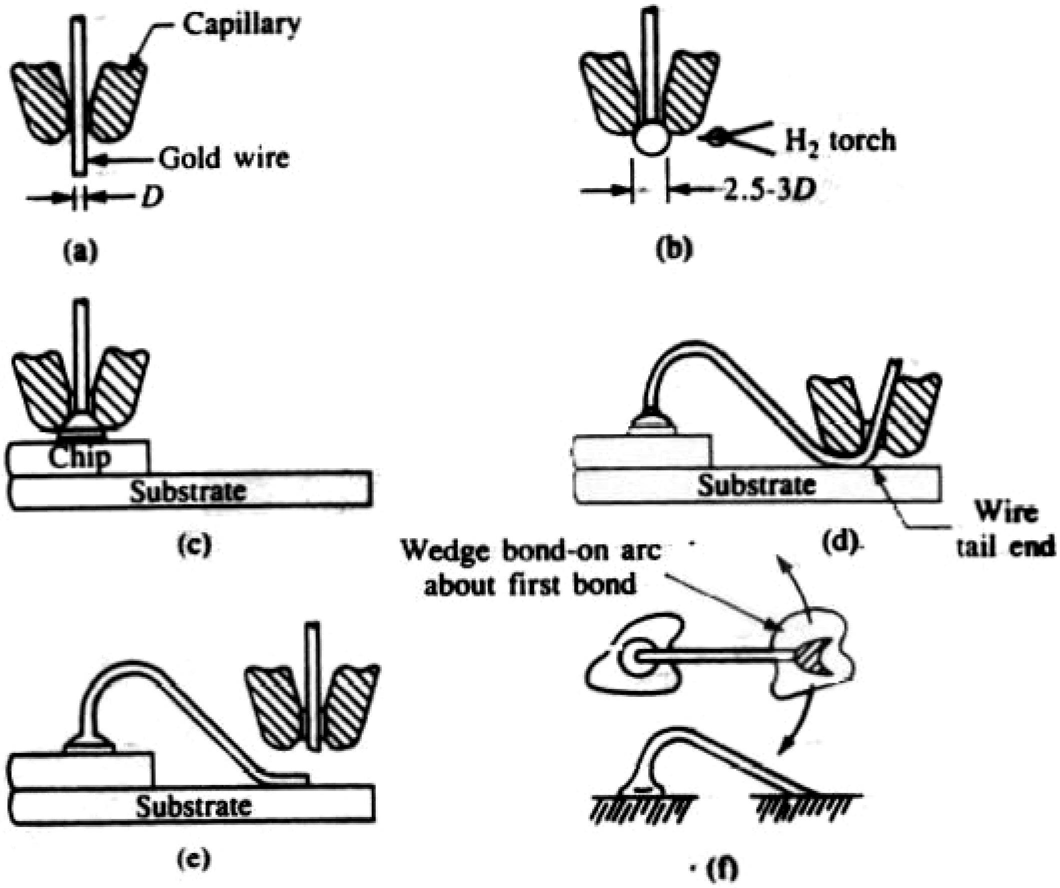

Figure 3 Thermosonic Ball-Wedge Bonding of a Gold Wire

(a) Gold wire in a capillary; (b) ball formation; (c) bonding accomplished by simultaneously applying a vertical load on the ball while ultrasonically exciting the wire (the chip and substrate are heated to about 150 °C); (d) a wire loop and a wedge bond ready to be formed; (e) the wire is broken at the wedge bond; (f) the geometry of the ball-wedge bond [4].

Experimental Equipment

- **Die:** fully n-doped Si chip with 4 Au bond pads and Ti-W transmission lines
- **Substrate:** Dual Inline Hybrid Package
- **PCB:** General purpose IC PC Board from Radio Shack
- **Die attachment material:** Conductive Silver Filled Die Attach Paste, # EC1030, (manufactured and Donated by HoneyWell, Electronic Materials-Advanced Polymers Group)
- **Wire:** 99.99% Au, 0.001 in diameter, elongation 5-8%, break strength 8 gm
- **Encapsulant**: CicuitSAF ME 455 Cavity Fill Encapsulant (manufactured and donated by Thermoset Advanced Electronic Materials Division of LORD Chemical Products)
- **Solder:** Standard 60/40 .032" diameter rosin core solder
- **PCB:** General Purpose DIP IC PC Board

Wire bonder (West Bond 7700C, Thermosonic)
Dispensers (EFD 1500DX)
Oven
Soldering iron and soldering accessories
Acetone, Wipers, Gloves, Glass dishes, Spatulas and tweezers
Digital Multimeter

Experimental Procedures

Week 1: Die Attachment

1. Measure and record the resistance of the Ti-W transmission lines on the die using the digital multimeter.
2. Clean the die and substrate with Acetone.
3. Find Lead 1 on the Dual Inline Hybrid Package (This lead has **GREEN** potting and is in a corner). Determine the proper orientation and position of the die in the cavity (the top edge should be in line with leads 5 and 22) as in Figure 4B.

4. Dispense die attach onto the substrate in the shape of an “X” as instructed by the TA (refer to Figure 4A). Use the air dispenser set at 30 psi for 10 seconds. ***Caution: Only a small amount of die attach is needed!***
5. Place the cleaned die on the die attach “X” with air pen. Then apply light pressure with 6 to 8 glass slides and spacers as provided by the TA. This will ensure good bonding between die and substrate.
6. Place in a dish with your name.
7. Take dish and place in pre-heated oven for 1 hour at 150°C.

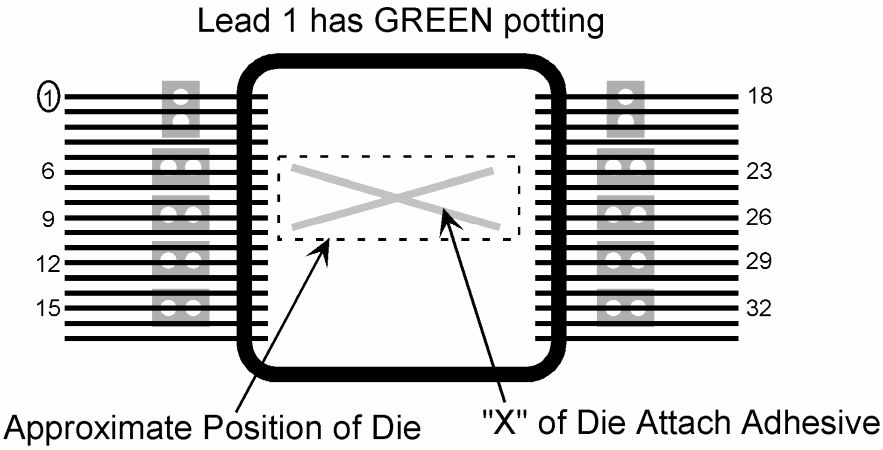

Figure 4A: Placement of the “X” for die attachment.

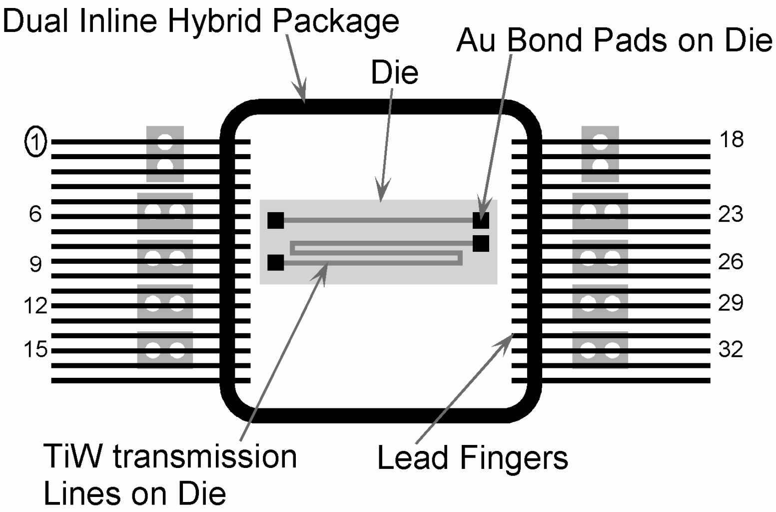

Figure 4B: Proper position and orientation of die in the cavity.

Week 2: Wire Bonding

1. Clean the surface of the die with Acetone to ensure good wire bonding.

2. Next place on a pre-heated work holder at 150 °C.
3. Thermosonic wire bond with 0.001” Au wire (Fig 3 & Fig 5 & Fig 6). When wire bonding, be sure to form ball bond (1st bond) on Au bond pads of the die then wedge bond (2nd bond) to lead fingers of the Dual Hybrid Inline Package. When bonding to the Dual Hybrid Inline Package, it is important to form the wedge bond near the free ends of the lead fingers as shown in Figure 6.

   IMPORTANT: <u>You must wire bond the indicated pad on the die to the indicated lead (6, 9, 23, 26) as shown in Figure 6.</u>
4. Inspect wire bonding with a microscope.
5. Measure and record resistance with digital multimeter as instructed by your TA.

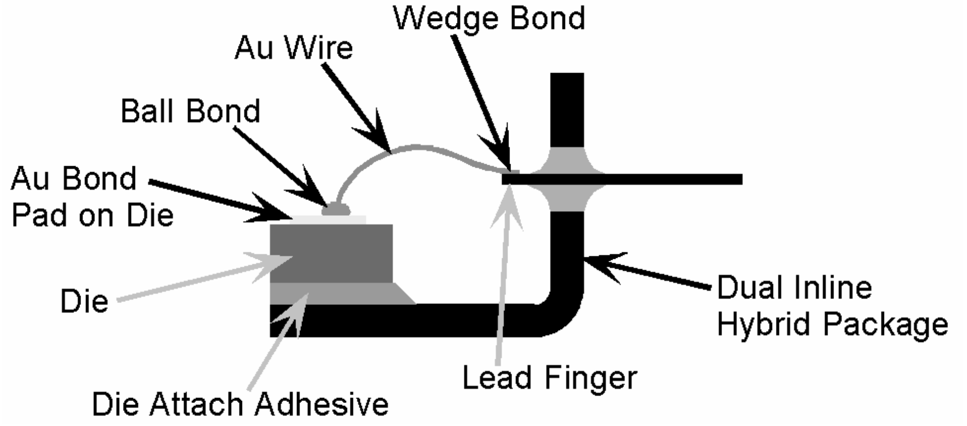

Figure 5: Ball-wedge wire bonding to an Au bonding pad and a lead finger.

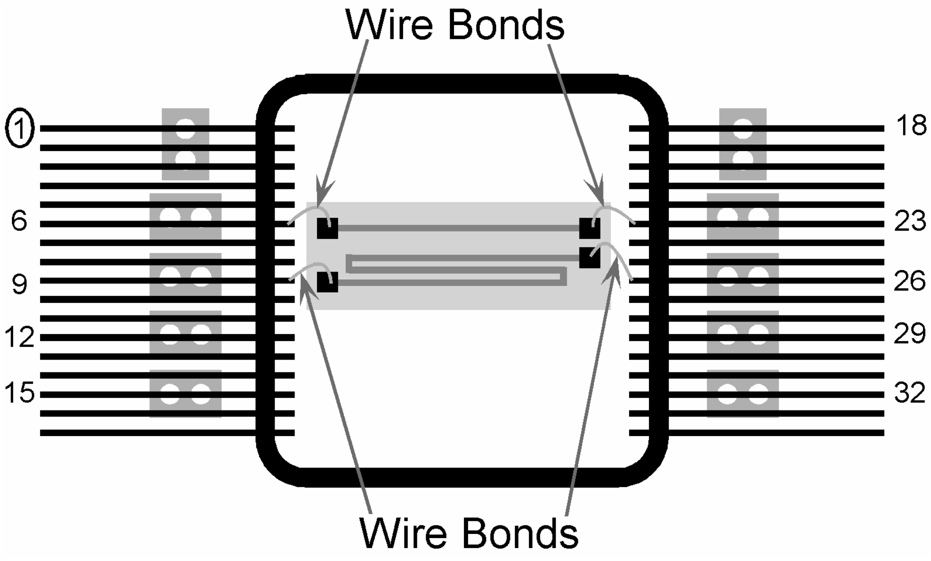

Figure 6: Wire bonding between die and Dual Inline Hybrid Package.

Week 2: Encapsulation

1. Fill in the cavity with ME-455 encapsulant to just below the rim of the cavity so that the wire bonds and die are covered as shown in Figures 1 and 7.
2. Place in dish and cure at 150° C for 1 hour in preheated oven.
3. Measure and record the resistance of the package as instructed by TA. Refer to Figure 6 to see which pairs of leads to measure (6/23 and 9/26).

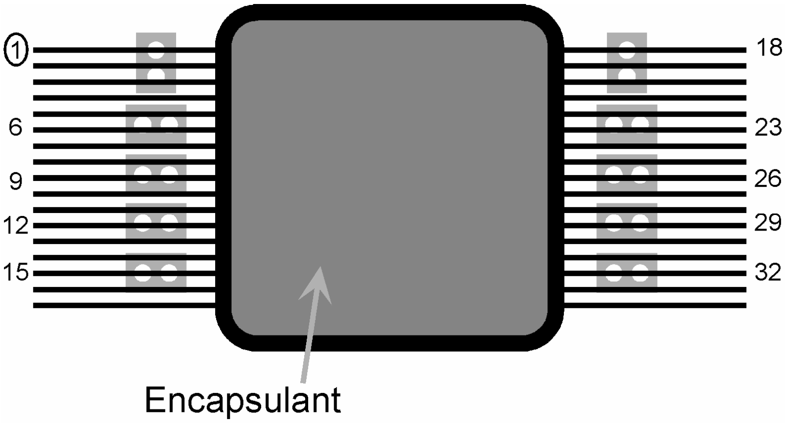

Figure 7: Encapsulation of die (top view)

Week 3: Soldering to the PCB

1. Cut the leads as shown by the TA.
2. Carefully bend over the leads and insert through the holes indicated in Figure 8 and bend over on the backside (the side with the Cu pads) as shown in Figure 1.

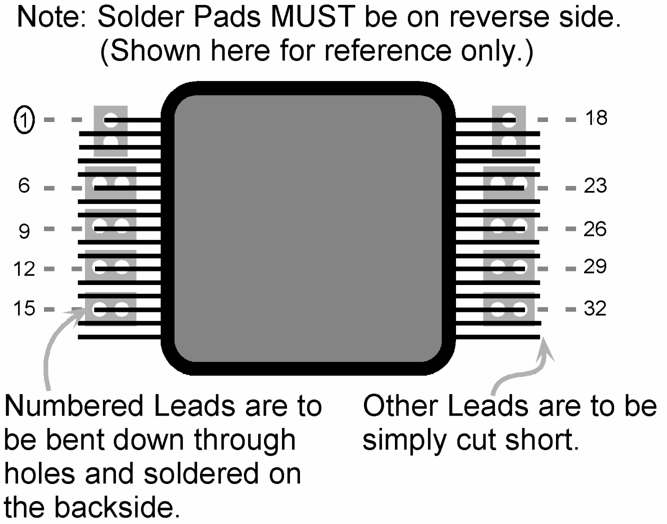

Figure 8: Orientation of Package on PCB for Soldering.

3. Solder the leads to the pads as directed by the TA.

4. Measure and record the resistance of the package as instructed by TA. Refer to Figure 6 to see which pairs of leads to measure (6/23 and 9/26).

Items to be included in discussion

1. Discuss the steps involved in the processing of a COB package.
2. Describe in detail the three types of wire bonding (using your own words). (Ultrasonic, Thermosonic, and Thermocompression)
3. Discuss the common polymeric encapsulants for electronic packages. Meaning what are the advantages vs. disadvantages and properties of each encapsulant.
4. The resistances measured at each stage and explanation of any change observed.

Questions

1. As an electronic packaging engineer where and why would you use a Hybrid package?

References

1. Plastic Encapsulated Microelectronics, M. Pecht, L. Nguyen, and E. Hakim, John Wiley & Sons, Inc., New York, 1995.
2. Physical Architecture of VLSI Systems, R. Hannemann, A. Kraus, and M. Pecht, John Wiley & Sons, Inc., New York, 1994.
3. Handbook of Electronic Package Design, M. Pecht, Marcel Dekker, Inc., New York, 1991.
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