DUKE UNIVERSITY
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Wire Bonder Theoretical & Practical Training

Basic Wire Bonding Theory
Parameter Development
Practical Applications

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Outline & Schedule

- Definitions and Terminology
- Materials
- Bonding Process
- Parameter Guidelines
- Small Group Hands On Application
- Homework

Definitions & Terminology

- Wire Bond

  The process of intermetalically connecting Au or Al wire or ribbon to a microelectronic device

- Ultrasonic

  High frequency motion used to "scrub" the wire or ribbon into the desired surface to create a wire bond

- Thermocompression

  A combination of heat and pressure used to force the wire or ribbon into the desired surface to create a wire bond

- Thermosonic

  Combination of both Ultrasonic and Thermocompression bonding

Definitions & Terminology

- Transducer

  The ferrite horn that transfers the ultrasonic oscillation from the crystal oscillators to the bonding tool

- Wire Clamps

  Mechanical method for gripping the wire for terminations and wire feed

- Bonding Tool

  Wedge or Capillary used to attach the wire or ribbon at the desired site

- Wire Despooler

  Device which holds the spool and helps regulate the back tension in the wire

- Manipulator

  Hand Controller to position the bond tool at the desired site to place the bond

Definitions & Terminology

- **Ball-Crescent Bonding**

  A bonding method using an electronic torch to form a ball of Au as the basis for the first bond and using the edge of the capillary to form the second "terminating" bond

- **Wedge-Wedge Bonding**

  A bonding method using a rear feeding bonding wedge to form all bonds with the flat of the tool.

- **Tab Bonding**

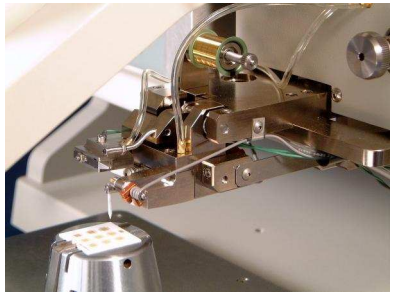
  Using thermosonic bonding to attach the leads or "tabs" of a prepackaged device

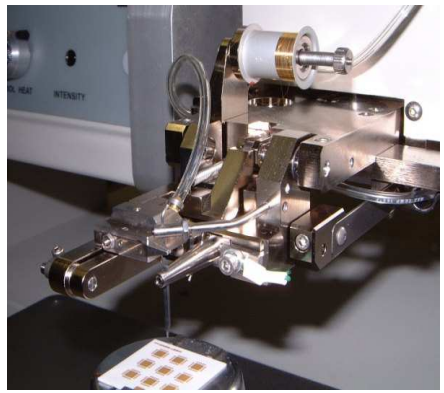
- **Eutectic Die Attach**

  Using Solder preforms to attach devices to a substrate

- **Epoxy Die Attach**

  Using glue or adhesive to attach devices to a substrate





Definitions & Terminology

- Force

  The contact pressure created by the downward motion of the bond tool, capturing and compressing the wire against the desired surface

- Stage Heat

  Heat applied to the assembly held in the work holder to assist in the bonding process

- Tool Heat

  Heat applied to the bonding tool thru the radient heater coil to precondition the Au wire and soften its grain structure

- Ultrasonic Power

  The amplitude of the Ultrasonic motion

- Ultrasonic Time

  The duration of the Ultrasonic motion measured in milliseconds

Ball-Bonding Definitions

- Capillary

  Bonding Tool usually made of ceramic

- Ball Bond

  The compression of the formed ball to make the first bond forming a bell shape

- Free Air Ball

  The ball formed by the torch below the tool prior to bonding

- Inside Chamfer

  The inside dimensions of the capillary which concentrates the forces used to form the bond

- Crescent Bond

  Termination bond formed by the outside radius of the capillary

Wedge Bonding Definitions

- Wedge

  Bonding tool with rear feed to position wire directly under the active area of the tool

- Toe

  The front most part of the bond formed by the front radius of the wedge

- Foot

  The portion of the bond created by the largest contact area of the tool. This is where your bond strength is.

- Heel

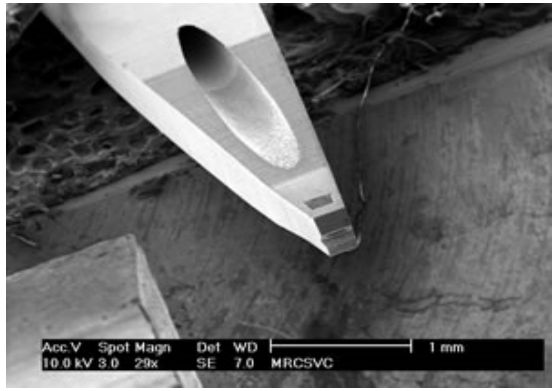
  The portion of the bond formed by the back radius of the wedge. This is the weakest area of the bond

- Stitch

  Making two or more connected loops to connect parallel circuits

- Deep Access

  Method used to bond inside walled packages, using a hollow centerline tool



Bond Failure Definitions

- Bond Strength

  The amount of force needed to cause a completed bond to fail

- Bond Lift

  The deformed wire at the bond site separates from the material it was to be attached to

- Metallization Lift

  The bond adheres to the targeted area but the metallization under the bond separates from the device

- Cratering

  The bond sticks, appears to be good but the crystal structure under the bond collapses and causes an open area under the bond

- Bond Peel

  Heel of the bond starts to lift but does not fully separate from the bond

Bond "Failure" Definitions

- Wire Break

  A break in the midspan of a bonded wire providing the break point is above the minimum standard for that size and type of material is the best failure you could get. It is an ideal strength bond pull.

Die Attach Definitions

- Eutectic Die Attach

  The attachment of discrete devices into an assembly using solder usually in preforms

- Epoxy Die Attach

  The attachment of discrete devices to an assembly making use of glue or adhesive materials

Materials
Crystal and Active Components

- GaAs

  Relatively delicate crystal used for high speed and frequencies, Very thin (4-8 mils) Subject to fracturing under either excessive force or ultrasonics "Low and Slow"

- Silicon

  Robust crystal used for less critical applications Higher threshold for force and ultrasonics

- Chip Capacitors

  Ceramic based components. Very robust, but often dirty

- Resistors

  Usually ceramic based with thin film surfaces, subject to metallization lifts

Materials
Substrates and Carriers

- Ceramic

  Alumina, typical substrate used for insulating properties, circuits usually have Au top layer for bonding

- Duroid

  Usually Cu impregnated polymer used for its dielectric range. Very heat sensitive and reactive to ultrasonics "high and hard"

- Kovar

  Metal alloy, always plated, simple to bond due to stability under almost all conditions

- FR4

  Standard PCB material, used for Chip on Board. Handles some heat and ultrasonics but drawback is often its large dimensions

Bonding Process

The bonding process is the following sources of energy combined to cause the material from the wire or ribbon to join to the target material in an intermetallic joint.

Force

Tool Heat

Stage Heat

Ultrasonic Power

Ultrasonic time

Bonding Process

- A combination of all five will give you the greatest flexibility for success and is generally referred to as Thermosonic Bonding. You will need to consider limiting factors such as temperature constraints and ultrasonic sensitivity.

U/S Power + U/S Time + Stage Heat + Tool Heat + Force =

Your Best Possible Bond

Bonding Parameters

- Almost every current West Bond wire bonder includes a LCD display which allows for the programming and viewing of every bond characteristic except bond force. That is set mechanically.

Bonding Parameters

- These machines will display the current settings as well as displaying the recommended settings. These setting are based on the following;

Bond Parameters

- .001 Au wire

  .8 – 2 % elongation for wedge bonding

  4 – 6 % elongation for ball bonding
- Ceramic substrate with thick or thin film Au
- 100* C Stage heat
- 80*-100* Tool heat
- Known good bonding wedge or capillary

Bonder Baseline Setting

- With A Series Bonders the recommended baseline settings are based on the same materials as above but since there is no digital control, these are set manually
- Ultrasonic Power Bond 1 300
- Ultrasonic Time Bond 1 30 ms
- Ultrasonic Power Bond 2 325
- Ultrasonic Time Bond 2 35 ms
- Forces for Wedge Bonding are 30H/20L
- Forces for Ball Bonding are 40H/20L

Bonding Process

Remember

- Ball Bonding is omni-directional
- Wedge Bonding is always straight line front to back directly into the machine

Conclusion

- You will need to develop a feel for how adjusting one of these starting points will affect the others.
- If you need to reduce stage heat, where will you compensate?
- If your part does not like high ultrasonics power, can you increase ultrasonic time?

Finally

- DO NOT HESITATE TO CONTACT ME!!
- When you have a new material application come up call me. I have probably seen it before.

Thank You for Your Time

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