THE BALL BONDING CAPILLARY - A BRIEF HISTORY

Formed from heat-drawn glass, the earliest capillaries were used for the compression bonding of gold wire (Compression Bonding). The next advancement was the addition of heat which enhanced the inner-metallic adhesion of the bond (Thermo-Compression Bonding). Capillary material advancements, initially tungsten carbide, lead to more robust and dimensionally consistent capillaries. With the invention of the ultrasonic transducer, ultrasonic energy was introduced into the equation, greatly improving wire bond strengths and bondability (Thermo-Sonic and Ultrasonic Bonding).

The **first** *ceramic* capillary was manufactured by, and most notably *invented* by, Gaiser Tool Company in 1970. Shortly thereafter, the ceramic capillary and the advent of electronic flame-off (EFO), helped advance wire bonding capability from a pioneer technology to the proven and automated processes that exist today.

Compression Bonding: Generally consists of gold-to-gold bonding; force, time, surface area, metallization quality and cleanliness are the key variables.

Thermo-Compression Bonding: Heat is added in addition to compression in the form of tool-heat, stage-heat, or both. The capillary or device may be heated. A capillary is generally heated by a radiant coil and the device to be bonded is usually clamped to a heated stage.

Thermo-Sonic Bonding: Ultrasonic energy is applied in the application to the capillary through an ultrasonic transducer. Ultrasonic energy provides a mechanical scrubbing action, which consequently generates frictional heat, to the thermo-compression bonding process.

Ultrasonic Bonding: Ultrasonic energy is applied in the application to the capillary through an ultrasonic transducer. The Ultrasonic energy provides a mechanical scrubbing action which generates frictional heat. Heat in the form of a heated tool or device may or may not be available.

BASIC REQUIREMENTS FOR SUCCESSFUL BALL BONDING

Following are the basic requirements for successful ball bonding:

1. A maintained ball bonder and a knowledge of its operation
2. An appropriate part number capillary in functional condition
3. Quality wire, stored and properly handled, correct hardness and elongation
4. Optimized tuning of the bonder (time, force, and ultrasonic power)
5. Heat - a heated stage or tool, if applicable
6. Good metallization
7. Clean metallization
8. A securely clamped and leveled work piece

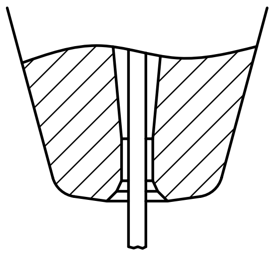
Factors such as bond pad size, bond pad pitch, wire diameter, bonding surfaces, metallization, loop height, loop length, bonder speed and accuracy, and package design will effect the capillary chosen for a wire bonding application. Gaiser Tool Company offers a number of standard industry capillary designs as well as the ability to customize part numbers for individual applications.

THE BALL BONDING PROCESS

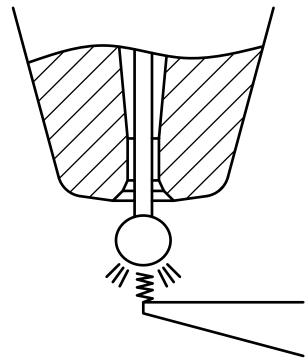
The following page contains a typical step by step overview of the wire bonding process showing the formation of the free air ball, ball bond, stitch bond, and concluding with reformation of the next free air ball.

GAISER TOOL COMPANY
High Precision Micro Tools Since 1967

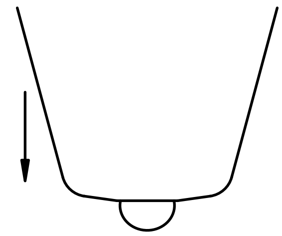
CAPILLARIES
THE BALL BONDING PROCESS



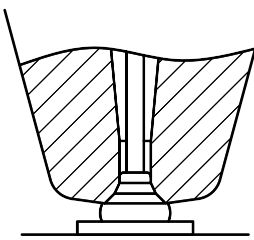
1. The bonding process begins with a threaded capillary.



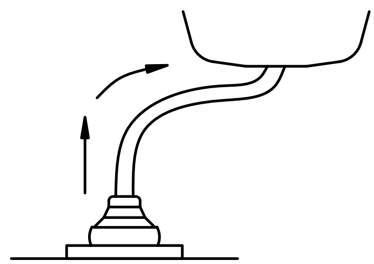
2. Electrical Flame Off (EFO) forms the free air ball.



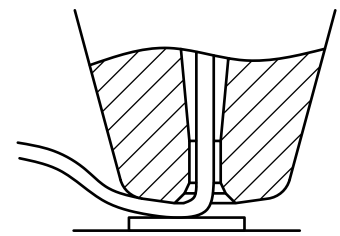
3. The capillary captures the Free Air Ball in the Chamfer Diameter and descends to the Bond Site.



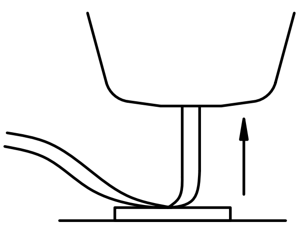
4. Force and Ultrasonic Energy are applied over Time and the Ball Bond is made.



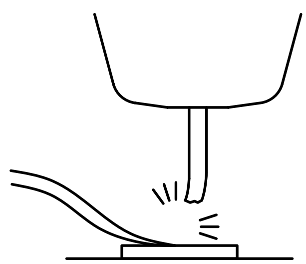
5. The Looping Sequence



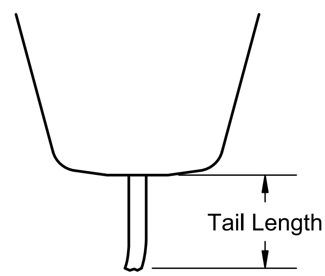
6. Force and Ultrasonic Energy are applied over Time to make the Stitch Bond.



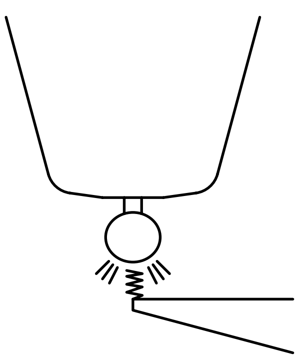
7. The capillary rises with the Wire Clamps off for a specific distance.



8. The Wire Clamps are applied and the wire breaks away from the 2nd Bond leaving a specific tail length.



9. The Tail Length after breaking away from the 2nd Bond.



10. The EFO forms the next Free Air Ball and the cycle begins again.

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BASIC CAPILLARY DESIGN DIMENSIONS

Capillaries have two basic sets of industry standard dimensional characteristics: large geometry and small geometry. Large geometry dimensions generally refer to the shank, back hole, and cone. Small geometry dimensions refer to the tip details.

Virtually all capillaries in use today are 1/16 inch diameter (0.0625 in./1.58mm). The most common capillary length is 0.437 in./11.1mm, followed by the 0.375 in./9.52mm length. Also available for the longer lengths are 0.625 in./15.88mm and 0.750 in./19.05mm.

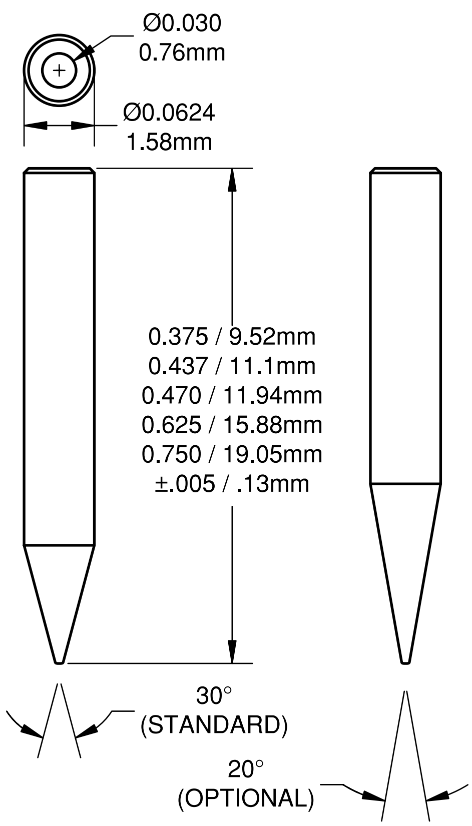

Figure 1. Large geometry dimensions

Industry standard large geometry dimensions:

1. Shank Diameter (SD)
2. Tool Length (L)
3. Cone Angle or Main Taper Angle
4. Back Hole

The industry standard cone angle is 30° with 20° and 15° being optional. A 20° cone angle is becoming increasing popular for an all purpose capillary with today's shrinking packages. Sharper cone angles provide additional clearance in tight packages. Use of a 15° cone angle may result in some loss of ultrasonic energy transfer.

For fine pitch applications, an angle bottleneck tip design may be required. Most angle bottlenecks have a 10° or 5° angle and are normally 0.006 in./150µm to 0.015 in./380µm high. The angle bottleneck height and angle are driven mainly by the bond pad pitch and loop height of the application. See the fine pitch section for more information.

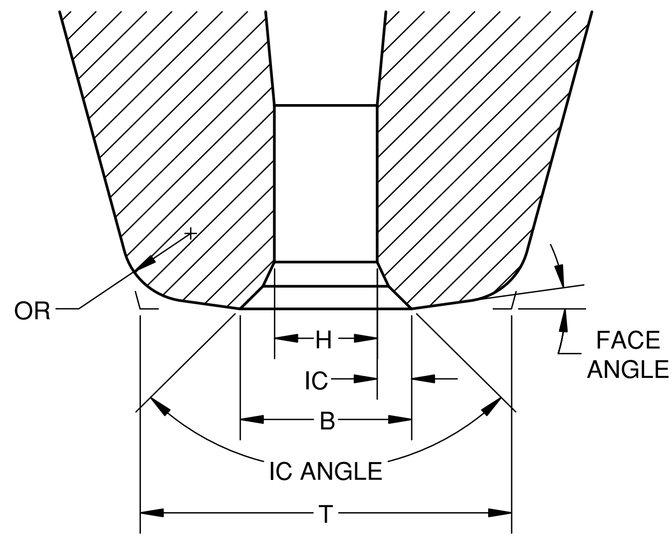

Figure 2. Small (tip) geometry dimensions

Industry standard small geometry dimensions:

1. Tip Diameter (T)
2. Hole Diameter or Size (H)
3. Chamfer Diameter (CD or B)
4. Inside Chamfer (IC)
5. Inside Chamfer Angle (IC Angle)
6. Face Angle (Note: may be flat, 0°)
7. Outside Radius (OR)