Wedge Bonding Tool Selection

Selecting an Appropriate Wedge Bonding Tool for Fine Pitch Application

Increasing I/O numbers, device complexity, and product miniaturization requires high precision bonding tools, and sophisticated equipment. Careful consideration should be given to wedge geometry while selecting the tool for a fine pitch wire bonding application. Wire bonding is a process that creates an electrical connection between a die and a substrate or lead typically using gold or aluminum wire. Wedge bonding is a specific type of wire bonding that uses a wedge shaped tool to create the welds. The design of the wedge tool has changed very little over the past decade. The wire is fed at an angle through the back of the wedge. This angle is typically 30 to 60 degrees and is application dependent. Some applications require a higher feed angle due to package clearance issues. Some deep access applications require a 90 degree feed angle. In this configuration, the wire is fed through a hole in the shank of the wedge tool. Wire feed is shown in Figure 1.

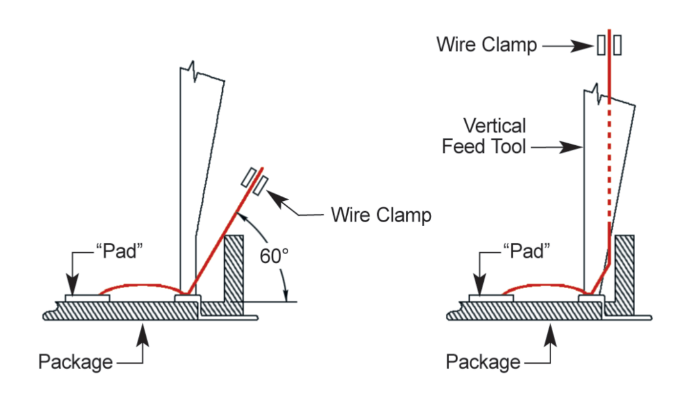

Figure 1: Wire feed angles of 60° and 90°.

A wedge has a number of features which contribute to the quality and consistency of the wire bonds and loops. A thorough understanding of the wedge geometry is required for selecting a suitable wedge for any application. Figure 2 shows a detailed view of some of the critical features of a wedge bonding tool.

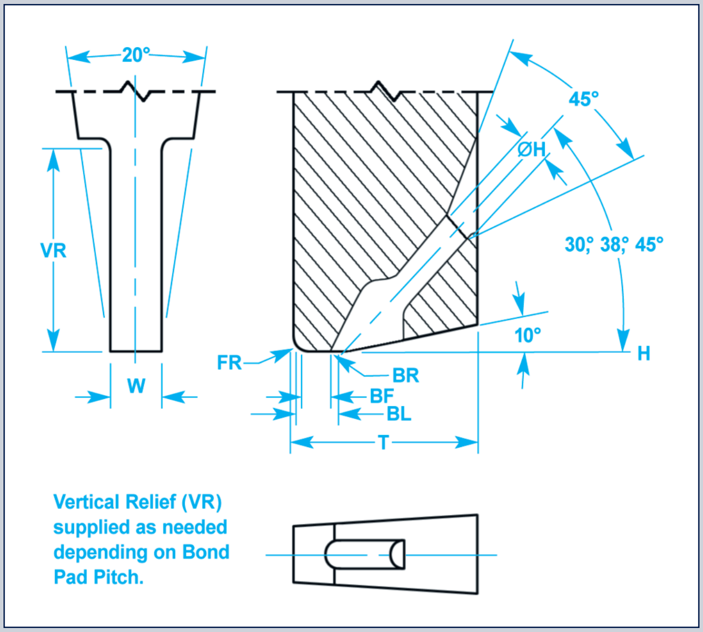

Figure 2: Critical areas of a wedge.

Where:

FR = Front Radius
BR = Back Radius
W = Width of the Wedge
ØH = Hole Diameter
H = Wire Feed Angle (30° through 90°)
BF = Bond Foot Length
BL = Bond Length
VR = Vertical Relief
T = Total Length of the Wedge

The bond length is calculated using the formula:

$$BL = 2/3FR + BF + 2/3BR$$

Special considerations should be taken before selecting a wedge tool for an application. Here are some of the critical wedge design features which drive the wedge selection.

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1. Wedge Material.

The wire material plays an important role in determining the wedge. A tungsten carbide wedge is used for aluminum wire and a titanium carbide wedge is used for gold wire. Selection of the wrong material will cause premature wear of the wedge tool resulting in poor welds. The latest developments in bonding tools for fine pitch application focus on implementation of new materials such as cermets, void-free carbides, and ceramics to increase long term stability and to avoid interactions with wire and pad materials.

2. Bond Pad Pitch.

Pad size and pad pitch play a significant role in selecting the wedge. Typically 100% of the bond is required to be on the pad. Bond width, bond length, and pad pitch should be considered before selecting the wedge. Bond pad pitch less than 50µms is considered as fine pitch.

3. Wire Feed Angle.

Loop consistency is critical, especially in stacked die applications which have inner and outer loops. Lower wire feed angles give better loop control while higher feed angles give less loop consistency. Figure 3 shows the importance of wire looping to avoid shorting. Higher wire feed angles are preferred for deep access application.

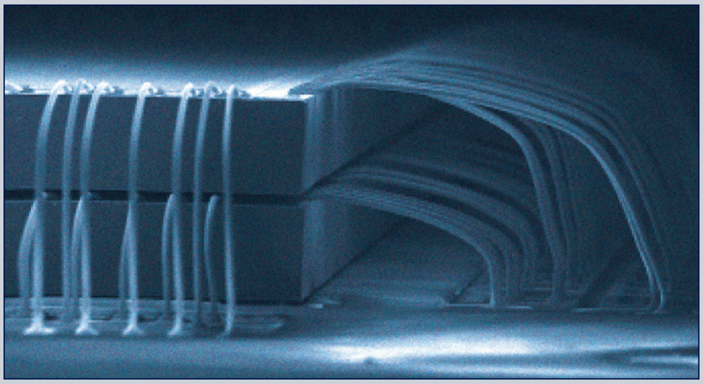

Figure 3: Consistent wire loops.

4. Back Radius.

For applications where tail consistency is critical, a sharper back radius is required. However, sharper back radii can result in heel cracking. A trade off in the back radius is critical for achieving uniform tailing and avoiding heel stress after the first bond. A normal back radius will range between 50%-100% of the wire diameter.

5. Front Radius.

The front radius and the bond length chiefly define the strength of the second bond. The front radius assures a gentle transition from the wire into the weldment of the second bond.

6. Wire Hole Diameter.

The wire hole diameter plays an important role in applications that require high placement accuracy. A typical guide for selecting the hole diameter is two times the wire diameter. If the hole is too large, the wire will tend to move under the foot of the wedge. This will result is poor accuracy (and poor looping). If the wire hole diameter is too small, the wire can scrape along the sides of the hole as the wire is fed through the wedge. This will result in wire slivers which can cause shorts and reduce reliability. Wire slivers can be prevented by requesting wedges with polished holes to remove any metal burrs.

7. Vertical Radius.

Vertical radius is also referred to as vertical side relief (VSR). High-frequency devices can have large numbers of input/output (I/O) pads placed as close to each other as possible, or very small individual bond pads. Wedge bonding can achieve finer pad pitch geometries than ball bonding with the same wire diameter because of the smaller amount of bond "squash" or wire deformation. Wedge bonding squash is typically 1.3 times the wire diameter as compared to two times the wire diameter for ball bonding. A thinner vertical radius allows wedge bonding to smaller bond pads without the need to decrease wire diameter.

8. Tool Face Geometry.

Cross groove tools increase the ultrasonic coupling and are recommended for hard gold wire bonding. Soft materials like aluminum wire are not recommended for use with a cross groove tool because of the possibility of aluminum build up of in the groove. Flat or concave tools are usually used when bonding with aluminum wire.

ACI Technologies' Power Packaging Lab has capabilities for bonding fine pitch applications using fine round wire (Al and Au wire – 0.7mil to 2.4mil diameter), ribbon wire (Al and Au ribbon 0.25mil x 1.4mil up to 1.0 x 10.0mil) and heavy wire (Al wire 10.0mil up to 30.0mil diameters). Wire pull and ball shear capabilities are also available at ACI Technologies.

ACI Technologies, Inc.

ACI Technologies, Inc. 1 International Plaza, Suite 600 Philadelphia, PA 19113 *phone:* 610.362.1200 *web:* www.aciusa.org

Training Center *phone:* 610.362.1295 *email:* registrar@aciusa.org

Helpline *phone:* 610.362.1320 *email:* helpline@aciusa.org