Designation: F 459 – 84 (Reapproved 2001)

Standard Test Methods for Measuring Pull Strength of Microelectronic Wire Bonds [1]

This standard is issued under the fixed designation F 459; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope

1.1 These test methods cover tests to determine the pull strength of a series of wire bonds. Instructions are provided to modify the methods for use as a referee method. The methods can be used for wire bonds made with wire having a diameter of from 0.0007 to 0.003 in. (18 to 76 µm).

NOTE 1—Common usage at the present time considers the term "wire bond" to include the entire interconnection: both welds and the intervening wire span.

1.2 These test methods can be used only when the loop height of the wire bond is large enough to allow a suitable hook for pulling (see Fig. 1) to be placed under the wire.

1.3 The precision of these methods has been evaluated for aluminum ultra-sonic wedge bonds; however, these methods can be used for aluminum ball bonds and gold wedge or ball bonds, as aluminum wedge bonds are the most sensitive to manufacturing variations (such as bond deformation) of any wire-bond type. [2]

1.4 These methods are destructive. They are appropriate for use in process development or, with a proper sampling plan, for process control or quality assurance.

1.5 A nondestructive procedure is described in Practice F 458.

1.6 The values stated in inch-pound units are to be regarded as the standard. The values given in parentheses are for information only.

1.7 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*

F 458 Practice for Nondestructive Pull Testing of Wire Bonds [3]

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 For the purposes of these test methods the following failure points are defined:

3.1.2 *bond-wire junction failure*—a rupture in the wire within two wire diameters of the bond and in which more than 25 % of the bonded area is left on the pad after the pull test has been applied.

3.1.3 *weld interface failure*—a rupture in which less than 25 % of the bonded area is left on the pad after the pull test has been applied.

3.1.4 *wire span failure*—a rupture in the wire other than *(1)* at a point within two wire diameters of either bond, or *(2)* at the point at which the hook contacted the wire.

4. Summary of Test Methods

4.1 The microelectronic device with the wire bond to be tested is held firmly in an appropriate fixture. A hook is positioned under the wire midway between the two bonds. The hook is then raised until the wire bond breaks. The force applied to the hook in order to cause failure of the wire bond is recorded. The point of failure is observed and recorded. In the referee method, the force in the wire on breaking is calculated.

5. Significance and Use

5.1 Failure of microelectronic devices is often due to failure of an interconnection bond. A common type of interconnection bond is a wire bond. These methods can assist in maintaining control of the process of making wire bonds. They can be used to distinguish between weak, nonadherent wire bonds and acceptably strong wire bonds. The methods are destructive.

5.2 These test methods are appropriate for on-line use for process control, for purchase specifications, and for research in support of improved yield or reliability. The referee method should be used for quantitative comparison of pull strengths of wire bonds.

[1] These test methods are under the jurisdiction of ASTM Committee F-1 on Electronics and are the direct responsibility of Subcommittee F01.07 on Wire Bonding.

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[2] Harman, G. G., "Microelectronic Ultrasonic Bonding," *NBS Special Publication* 400-2, pp. 94–95.

[3] *Annual Book of ASTM Standards*, Vol 10.04.

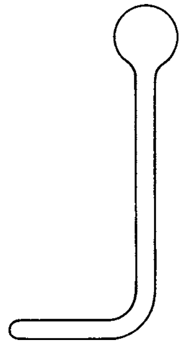

FIG. 1 Suggested Configuration for a Pulling Hook

6. Interferences

6.1 Failure to center the hook along the loop between the two bonds or pulling in a direction not lying in the plane containing the undisturbed loop may invalidate the test since an unbalanced distribution of forces between the two bonds may result.

6.2 Slippage of the hook along the wire span during pulling may invalidate the test because an unbalanced distribution of forces between the two bonds may result.

6.3 Careless insertion of the hook may damage either bond or wire and thus invalidate the test.

6.4 The presence of vibration or mechanical shock may cause the application of an extraneous force and thus invalidate the test.

6.5 Measured bond-pull force is strongly dependent on the height of the loop ($H + h$, as defined in 11.1.1) and the bond-to-bond spacing (d, as defined in 11.1.1).

7. Apparatus

7.1 *Bond-Pulling Machine*—Apparatus for measuring wire-bond pull strength with the following components:

7.1.1 *Hook*—Pulling hook made from rigid wire such as tungsten. The diameter of that part of the hook that contacts the wire loop should be approximately 2.5 times the diameter of the wire used to make the wire bond. A suggested hook configuration is shown in Fig. 1. The hook should appear under visual inspection to have a smooth polished surface with no sharp edges in any part of the hook that contacts the wire loop. The hook should be rigidly mounted in the pulling apparatus.

7.1.2 *Lifting-and-Gaging Mechanism*—Mechanism for applying a measured vertical force to the hook. The mechanism shall incorporate a means for recording the maximum force applied and shall be capable of applying force at a rate constant to within 2 gf/s (20 mN/s) in the range from 1 to 30 gf/s (10 to 290 mN/s) inclusive. A mechanism with a single fixed scale shall have a maximum scale reading no greater than three times the nominal bond pull strength anticipated.

NOTE 2—Mechanisms of the dynamometer type known as "gram gages" have been found satisfactory.

7.1.3 *Microscope with Light Source*—Zoom microscope with light source with a magnification range of approximately 14× to 60× with the eyepiece not to exceed 10×, for viewing the device under test.

7.1.4 *Device Holder*—Mechanism for holding the device under test *(1)* in a horizontal position, for Method A, or *(2)* in either a horizontal or a tipped position so that both bonds are in the same horizontal plane, for Method B. For the referee Method C, the device holder should provide a measurement, to within 2°, of the angle from the horizontal (which may be zero) through which the device has been tipped.

7.1.5 *Calibration Masses*—At least five masses (weights) with mass values known to within 0.5 % sized to cover the lifting-and-gaging mechanism range of force measurement, and suitably configured so that they may be supported by the pulling mechanism for calibration.

8. Sampling

8.1 Since the pull-test method is destructive, it shall be performed on a sampling basis. The sample selected should be representative of the wire bonds of interest. The size of the sample and the method of selection shall be agreed upon by the parties to the test.

9. Calibration

9.1 Calibrate the bond-pulling machine at the beginning of each series of tests, or daily if a series spans more than one day.

9.2 Assemble the bond-pulling machine in the same configuration to be used to perform the wire-bond pull test.

9.3 Calibrate the lifting-and-gaging mechanism.

9.3.1 For mechanisms incorporating a calibration adjustment, either calibrate the mechanism in accordance with the manufacturer's instructions or in accordance with the procedure of 9.3.2.

9.3.2 For mechanisms without a calibration adjustment, use the following procedure:

9.3.2.1 Select masses that will provide at least five calibration points over the mechanism range.

9.3.2.2 Attach a selected calibration mass to the lifting-and-gaging mechanism. If a lever-arm mechanism (dynamometer or gram gage) is used, rotate the body of the gage in a manner that maintains the arm (carrying the hook) in a horizontal orientation.

9.3.2.3 Observe and record the measured force in grams-force (millinewtons).

9.3.2.4 Repeat 9.3.2.2 and 9.3.2.3 for each calibration mass selected.

9.3.2.5 Plot the measured force values as a function of the forces applied by the masses. Use these results to construct a calibration curve.