



AEROSPACE STANDARD

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THERMOCOMPRESSION BONDING OF GOLD BEAM LEADS

1. INTRODUCTION

- 1.1 Purpose: This standard disseminates basic information for thermocompression bonding of beam lead semiconductor devices to facilitate reliable electrical interconnections.
- 1.2 Scope: This standard specifies the materials, design considerations, equipment, process, inspection, repair, and testing of thermocompression bonded interconnections on beam lead semiconductor devices. It is intended for use in whole or in parts as mutually agreed upon by customer and vendor, and may be supplemented by other related specifications as desired (e.g., Mil. Std. 883, for a more comprehensive coverage of reliability evaluation) and by other specific requirements peculiar to a given contract. No attempt has been made to describe environmental tests intended for evaluation of complete device reliability.

This standard is written with the intent for use in bonding gold beam leads to gold-based thin or thick film metallization. The bonding method is assumed to be capable of bonding all the beam leads on a device in a single process step.

- 1.3 Definitions: Pertinent definitions of terminology employed for the purposes of this standard only are given in conjunction with Fig. 1, 2, and 3.

1.3.1 Beam Lead Length: On an unbonded device, the distance from the edge of the dielectric layer to the outer edge of the beam lead, dimension "a", Fig. 1.

1.3.2 Beam Lead Width: The width of an unbonded (undeformed) beam lead, dimension "g", Fig. 3.

1.3.3 Beam Lead Thickness: The thickness of an unbonded (undeformed) beam lead, dimension "b", Fig. 1.

1.3.4 Bond Length: On a bonded device, the distance from the outer edge of the bonded beam lead to the apparent inner edge of the bonded area, dimension "c", Figs. 2 and 3.

1.3.5 Unbonded Beam Lead Length: On a bonded device, the distance from the edge of the dielectric layer to the apparent inner edge of the bonded area, dimension "e", Fig. 2.

1.3.6 Apparent Bond Width: On a bonded device, the maximum width of the beam lead in the bonded area, dimension "i", Fig. 3. The apparent bond width is also called the "squash dimension."

1.3.7 True Bond Width: On a bonded device, the maximum width of the beam lead in the bonded area directly over the conductor film metallization, dimension "j", Fig. 3.

1.3.8 Deformed Beam Lead Thickness: On a bonded device, the mean thickness of the beam lead in the bonded area, dimension "f", Fig. 2.

1.3.9 Device Lift: On a bonded device, the vertical distance from the conductor film metallization to the dielectric surface of the semiconductor device, dimension "d", Fig. 2. The device lift is also called the "bugging distance."

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- 1.3.10 Beam Lead Bond Misalignment: On a bonded device, that portion of the unbonded beam lead width not over the conductor film metallization, dimension "h", Fig. 3.
- 1.3.11 Film Edge - Bond Spacing: For a bonded device, the distance from the end of the substrate conductor film metallization to the closest edge of the bonded area, dimension "k", Fig. 3.
- 1.3.12 Anchor Bond: That portion of the beam lead which adheres to the device dielectric layer and has the required beam lead thickness (see Fig. 1).
- 1.3.13 Thick Film Metallization: Conductive metallization applied to an insulating substrate by either: (1) silk screening an admixture of finely divided gold powder and base metal oxides which are suspended in an organic vehicle and firing in air to produce adherence, or (2) silk screening an admixture of finely divided base metal powder and base metal oxides which are suspended in an organic vehicle, firing in a controlled atmosphere to produce adherence, and electroplating a gold overlayer.
- 1.3.14 Thin Film Metallization: Conductive metallization applied to an insulating substrate by evaporating, sputtering, or plating metallic layers, or by an equivalent process.
- 1.3.15 Beam Lead As-Plated Surface: That surface of a beam lead which is plated last and is bonded to the conductor film metallization during the bonding operation (see Fig. 1).
- 1.3.16 Beam Lead Platinum-Titanium Surface: That surface of a beam lead which is contacted by the bonding tool during the bonding operation (see Fig. 1).

2. BEAM LEAD CHIP

2.1 Beam Lead Material Properties:

- 2.1.1 Composition: The beam lead composition shall be 99.9% gold by weight, minimum. The concentration of iron, nickel, or cobalt shall not exceed 0.03% by weight, individually, and 0.05% by weight, totally. The individual concentration of any other impurity shall be less than 0.1% by weight.
- 2.1.2 Hardness: Measurements of microhardness of gold beam leads shall be made on a specified sample lot. The microhardness measurements must be taken on the as-plated surface of the beam leads with a Vickers diamond pyramid indenter at a load of 0.022 lb (10 gm). The mean gold microhardness shall not be less than $DPH_{10} = 30$ or exceed $DPH_{10} = 70$.
- 2.2 Beam Lead Dimensions: The beam lead length, width, and thickness will be as specified in the applicable EIA Committee JC-11 Outline Series on mechanical standardization for uncased chips (JC-11.4-1 and following outlines). The specified dimensions will be for unbonded (undeformed) beam leads.
- 2.3 Beam Lead Surface Contamination: The beam lead bonding surface shall be substantially free of contaminants, including adsorbed protein compounds, oils, plating residues, and adherent particulate matter, such as loose gold particles, dust, or lint fibers. Freedom from particulate matter may be checked visually under at least 100X magnification.
- 2.4 Lead-Device Anchor Bond: The bond between the semiconductor device body and the beam lead shall have sufficient strength to withstand the bonding process. To insure this, mechanical tests of the lead-device anchor bond shall be performed on a specified sample lot of unbonded (undeformed) devices. Both the bend test described in 2.4.1 of this standard and the peel test described in 2.4.2 shall be employed. These tests are destructive.

2.4.1 Bend Test: The bend test shall be performed in the following manner:

- 2.4.1.1 The semiconductor body of an unbonded (undeformed) device to be tested shall be held in or mounted on a suitable holder to withstand the applied testing force. The semiconductor body shall be positioned such that the beam leads to be tested project out beyond the holder. More than one lead may be bend tested simultaneously.

- 2.4.1.2 A suitably-sized flat push tool must be employed for this test. The push tool shall be brought into contact with the titanium-platinum side of the beam leads at a midpoint along the beam lead length. The push tool shall be forced against the leads at a constant rate not exceeding 0.1 in./min (2.54 mm/min), bending the leads to an approximate 90 degree angle with the plane of the device dielectric layer (see Fig. 4).
- 2.4.1.3 None of the beam leads tested shall show evidence, when visually examined under low-power (30 - 60X) magnification, of separation, cracks, or fissures between the lead and the dielectric layer in the anchor bond area.
- 2.4.2 Peel Test: The peel test shall be performed in the following manner:
 - 2.4.2.1 The semiconductor body of an unbonded (undeformed) device to be tested shall be held in or mounted on a suitable holder to withstand the applied testing force. The semiconductor body shall be positioned to permit access to the active side of the device.
 - 2.4.2.2 With an appropriate tool, the beam leads to be tested shall be carefully bent without twisting to an angle of approximately 90 degrees to the plane of the dielectric layer (see Fig. 4).
 - 2.4.2.3 Each lead shall be peel tested individually at a constant strain rate not exceeding 0.05 in./min (1.27 mm/min) with a suitable apparatus capable of indicating the testing force applied. The maximum force at the point of failure shall be recorded.
 - 2.4.2.4 For each lead tested, the peel load shall not be less than 1.1 lb/in. (19.7 gm/mm) of maximum beam lead width in the anchor bond area.

3. SUBSTRATE AND METALLIZATION

3.1 Substrate:

3.1.1 Material and Properties: The substrate material is not specified except that it shall meet the following:

- 3.1.1.1 It must be capable, without degradation, of withstanding the bonding force and temperature prescribed in 4.1.1 and 4.1.2.
- 3.1.1.2 It must be capable, during the bonding operation, of meeting the flatness criterion prescribed in 3.1.2.
- 3.1.1.3 It must be capable of being so metallized to meet the requirements of 3.2.1 or 3.2.2, particularly 3.2.1.5 or 3.2.2.5.

3.1.2 Deviation from Flatness: During the bonding operation, concave or convex warpage of the metallized substrate shall not exceed 1 unit, measured perpendicularly to the substrate, in 250 units, measured along the substrate edge or diagonal, or in any other direction across the substrate. The measurements can be made with appropriately-spaced parallel flats or an equivalent technique.

3.2 Conductor Film Metallization: Gold metallization shall be applied to the substrate in the beam lead bonding areas and must be capable of meeting all requirements contained herein for producing satisfactory bonds. Multiple layers of both thin and thick films have demonstrated a capability of satisfactory performance for beam lead device bonding. Sections 3.2.1 and 3.2.2 of this standard provide minimum requirements for thin and thick film metallization, respectively. Within the specifications of this standard, the metallization system and its related requirements shall be mutually agreed upon between customer and vendor as outlined in 1.2.

3.2.1 Thin Film:

3.2.1.1 Material: The thin film conductor metallization shall be substantially gold (99. % gold by weight, minimum). If necessary, other metallization may be employed underneath the gold layer. There are no requirements relating to these other layers, if used, except that the entire layered metallization shall be capable of meeting the adherence test prescribed in 3.2.1.3.