



AEROSPACE STANDARD

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Revised

THERMOCOMPRESSION WIRE BONDING

1. INTRODUCTION

- 1.1 Purpose: To insure the formation of reliable electrical interconnections to semiconductor devices by the use of thermocompression bonded wires.
- 1.2 Scope: This standard specifies the materials, design considerations, equipment, process, conditions, inspection and testing of thermocompression wire bonded interconnection on semiconductor devices. It is intended for use in whole or in part 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.

2. TYPES OF BONDS

The bond type may be ball and stitch, stitch, or wedge, as dictated by the wire material, part design and bonding equipment to be used as mutually agreed. Bond geometries should conform to the descriptions in Section 8.

3. MATERIALS

- 3.1 Substrate and device materials (basic) silicon, germanium, ceramic, glass, Kovar, H-film, or other materials as specified.
- 3.2 Metallization:
- 3.2.1 Device: Aluminum, silver, platinum, gold, multilayer (i.e., Pt-Au, Ti-Au, etc.), minimum total metal thickness 6,000 angstroms.
- 3.2.2 Substrate/package: Aluminum, silver, platinum, gold, or fired thick films such as Au-Pt, Au-Pd, etc. Underlying metallization to be nickel, Mo-Mn, etc. Minimum top layer thickness in bonding area to be 75 microinches.
- 3.3 Wire:
- 3.3.1 Size: As specified, with $\pm 10\%$ tolerance.
- 3.3.2 Elongation: Within range specified for wire material selected.
- 3.3.3 Minimum tensile strength: Gold: 15,000 psi; Aluminum: 10,000 psi; Aluminum alloy: 30,000 psi; Other: as specified.
- 3.3.4 Purity: 99.975% to 99.999%, base material, plus required alloy. (e.g., 1% Si.)
- 3.3.5 Spooling: Wire should be used directly from spool supplied by wire manufacturer, not rewound. Spool design should be compatible with bonder (see 5.5). Spool should be of metal chosen for thermal expansion match with wire used. Edges and winding surfaces should be clean and free from burrs. Each layer of wire should be free of underwinds (overlapping strands).

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3.3.6 Packing: Wire must be packaged to allow inspection of wire at 50X, without removing spool of wire from container. Package must be capable of protecting the wire from dust, dirt, and other contaminants; shipping damage, despooling, etc. Each spool of wire, or its container, shall be labeled with the following:

- (a) Diameter and length of wire
- (b) Type and purity of material
- (c) Percent elongation
- (d) Minimum tensile strength
- (e) Vendors melt number

3.3.7 Storage:

- (a) Wire shall be stored in manufacturer's containers, under normal room conditions, with temperature extremes between 60 F and 90 F.
- (b) Spool axis should be horizontal.

3.4 Material Compatibility: Metallization and wire should be selected for compatibility within the processing and environmental conditions intended, as specified by the applicable procurement document.

Note: After bonding, devices with Au wire to Al thin film bonds shall not be subjected to temperatures in excess of 175 C, except for normal processing steps such as subsequent bonding and/or sealing operation. (Bake cycles should not exceed 175 C.)

4. DESIGN PARAMETERS

4.1 Chip Pad Size and Location:

- 4.1.1 For ball bonding, pad size shall be a minimum of four times the wire diameter for expanded contact devices, and a minimum of three times the wire diameter for non-expanded contact devices. For wedge bonds, the pad must be a minimum of 2-1/2 times the wire diameter.
- 4.1.2 Location of pads shall be such that lead lengths are kept to a minimum and to prevent the crossing of wires. Lead patterns between bonding pad and edge of chip should be avoided if possible.
- 4.1.3 Space from pad to pad shall be a minimum of 2 wire diameters and from pad to an adjacent interconnect shall be a minimum of 1 wire diameter.

4.2 Substrate/Package Lead Bonding Area: The package lead bonding area shall be a minimum of 0.010 in. diameter, and glass free within the 0.010 in. circle, and shall be parallel to the package base to within 15 degrees.

4.3 Wire Length: The wire length of bonded leads shall not exceed 80 wire diameters between any two of their contact points for gold wire or 200 wire diameters for aluminum wire.

4.4 Height of Substrate/Package Bonding Areas: The posts or leads shall be no more than 0.010 in. below the level of the top surface of the chip and shall be coplanar with each other to within ± 0.010 inch.

4.5 Wire Diameter: Wire diameter shall be as required by device geometry and electrical environmental stresses.

5. EQUIPMENT

Design and construction of equipment used should meet the following requirements.

5.1 Workstage:

- 5.1.1^{*} Be constructed of material capable of being heated for prolonged periods at temperatures up to 400 C, without adverse effects. Example: Stainless steel, Inconel.
- 5.1.2 Firmly hold piece part without damage. Example: Magnets, mechanical clamp or vacuum.
- 5.1.3 Permit accurate X-Y and movements for positioning, yet remain fixed during bond formation (unless positioning movements are provided by bonding tool (see 5.5)). Example: Micro-manipulators, grease plates, teflon bearings, vacuum plates or chessman movements.
- 5.1.4 Be capable of accurately maintaining piece part at desired temperature (see Section 6) by conduction, hot gas, or other suitable means.
- 5.1.5 Be able to envelope piece part with inert gas atmosphere, if materials involved are susceptible to oxidation at bonding temperature.

5.2 Bonding Tool:

- 5.2.1 Be constructed of materials capable of prolonged temperatures of 400 C and of sufficient strength to withstand the pressures and forces exerted during bonding operation (e.g., tungsten carbide).
- 5.2.2 Be designed to fit into bonding area, permit sufficient alignment vision and impose proper deformation to the wire during the bonding cycle. (See Section 8 for illustrations of proper bond deformation.)
- 5.2.3 Edges should be relieved by chamfers or radii equal to approximately 0.2 wire diameter.
- 5.2.4 Bonding face should be clean and free from cracks, chips or breaks.

5.3 Optics:

- 5.3.1 Focal length should permit adequate working space between objective and piece parts.
- 5.3.2 Sufficient magnification to define necessary area, usually 10X to 40X, depending on device geometry.
- 5.3.3 Binocular optics of sufficient quality to assure precise, clear focus and freedom from fatigue.
- 5.3.4 Located at a comfortable height and angle above work table, usually 12 in. to 20 in. and 30 to 70 deg angle.

5.4 Temperature Controllers (Substrate and Bonding Tool):

- 5.4.1 Furnish power source and controlling circuitry capable of heating a bonding tool and/or work stage to the required temperature (Section 6).
- 5.4.2 Accurate within $\pm 2\%$ of set condition.
- 5.4.3 Contain a continuous, visual temperature monitor system. Example: IC or CA thermocouple or voltage and current meters.

5.5 Bond Tool Assembly:

- 5.5.1 Provide accurate Z motion in addition to X and Y if these motions are not provided by work stage.
- 5.5.2 Provide variable force, adjustable within range required by bond configuration geometry, accurate to $\pm 3\%$ of set condition. (Total force should include mass and drag of bonding tool.)