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GUIDELINES FOR NONDESTRUCTIVE PULL TESTING

OF

WIRE BONDS ON HYBRID DEVICES

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GUIDELINES FOR NONDESTRUCTIVE PULL TESTING OF WIRE BONDS ON HYBRID DEVICES

1.0 SCOPE

This document establishes basic guidelines for preparing working documents which specify performing nondestructive pull tests of wire bonds on particular devices. It is not intended that these guidelines evolve into an enforcing document.

Nondestructive pull testing (NDPT) of flying lead wire bonds is utilized to detect weak or zero strength bonds without degrading acceptable bonds. The method may be applied as a pre-cap lot acceptance or 100% screening test. It can also serve as a referee test for bonds which are disputed when visually inspected.

This test may not be applicable if the distribution of bond pull strengths is not approximately normal.

2.0 DEFINITIONS

Nondestructive Test - A test which evaluates a device feature without degrading the device function or strength although the appearance may be altered.

Mean ($\overline{X}$) - the normal mean:

$$\overline{X} = 1 \sum_{1=1}^{n} X_i$$

Standard deviation (σ) - calculated by some form of:

2.0 DEFINITIONS (continued)

$$\sigma = \left[\frac{1}{n} \sum_{i=1}^{n} (X_i - \overline{X})^2 \right]^{1/2}$$

3.0 APPARATUS

The equipment for this test shall be capable of applying the specified stress to the wire loop or completed bonds without degrading either the wire or the acceptable bonds. Equipment should be accurate within $\pm$ 10% of the specified stress and capable of calibration. The rate of force application should also be controllable to prevent stress transients when the hook engages the wire loop. The duration of the stress must be sufficient to provide a constant stress after the wire loop has been reshaped by the hook.

4.0 PROCEDURE

4.1 Sampling

Nondestructive pull testing (NDPT) can be implemented as 100% screen or as a lot acceptance sample criterion. In the latter case sample selection should consider both design and process-related pattern failures.

When the number of bonding wires on each device is prohibitively high, the test may be applied to a fraction of the wires on each device in the random lot sample. In such a case, the wires should be pulled in a sequential manner so that all bonding sites are eventually checked.

4.2 Stress Strength

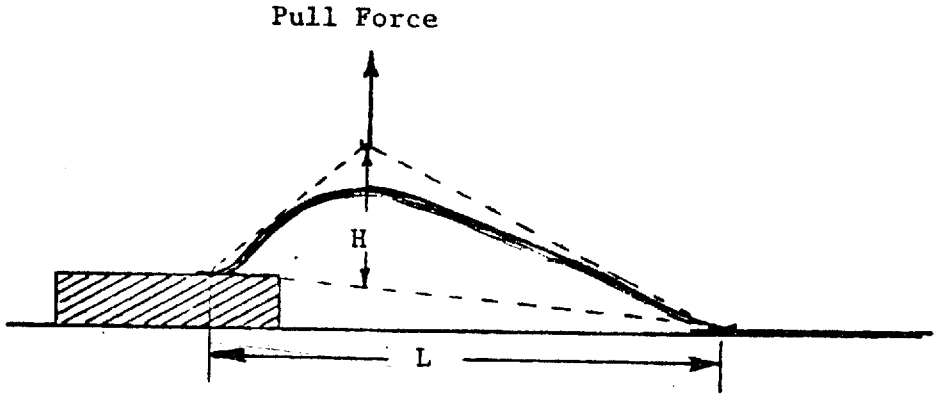
An evaluation of the nominal device geometry, wire size and wire material should be made prior to the initiation of NDPT as a means of establishing the proper test stress. Immediately after any machine adjustments or material changes and periodically thereafter (usually once per shift) a destructive pull test should be conducted to establish the mean bond strength ($\overline{X}$) and the standard deviation σ for each group of similar bonds.

4.2 Stress Strength (continued)

Bonding groups are normally based on nominal geometries and materials so that destructive pull test data on properly grounded bonds will show low σ values. The destructive sample should consist of at least 20 loops from each bonding group. Proper operation of the equipment is indicated when a σ is $<.25\overline{X}$. The sampling should be customized for each hybrid type to provide the desired statistical significance level.

4.2.1 Fixed Stress

Bonds made with wire having a diameter less than .005 .in., elongation less than 3%, bond deformation no greater than allowed by Method 2017, MIL-STD-883, paragraphs 3.1.6.1, 3.1.6.2, and a loop height (H) $\geq$ 25% of the bond-to-bond spacing (L) may be pulled to a fixed stress level.



When the above conditions are met and the periodic destructive bond pull test produces $\overline{X} \geq \frac{B}{4}$ and $\sigma < 0.2X$, the nondestructive bond pull force may be set at .1B, where B is the average breaking force of the wire used when pulled in pure tension.

4.2.1 Fixed Stress (continued)

For example, if the average breaking force B = 13 grams force and the destructive pull test on a sample of bonds of a particular configuration (e.g., 1mil aluminum wire with 1% silicon ultrasonically bonded between a Au thick film substrate metallization and a chip's aluminum bonding pad with a 7 mil height differential where the span is 20 mils and the loop height (H) is always more than 5 mils) yields the following values:

Destructive Test

Bond Pull Strengths ($_{gf}$)

6.6	5.8	6.0	6.4
7.2	7.0	7.2	6.6
7.0	5.6	6.4	5.6
7.2	7.6	5.8	6.0
6.0	6.4	6.2	6.8

then $\overline{X}$ = 6.47 and σ = 0.58. The bond pull strength can then be set at .1B = 1.3 grams force since $\overline{X}$ = 6.47gf $> \frac{B}{4}$ and σ = 0.58 gf $< 0.2\overline{X}$ in this example.

4.2.2 Parametric Stress

All bonding groups not meeting the necessary conditions for the fixed stress level NDPT should be pulled to a limit which is statistically established to prevent damage to good bonds and residual wire strain. The pull test force should be equal to:

$$\frac{\overline{X} - 3\sigma}{2}$$

where $\overline{X}$ and σ are determined from destructive bond pull tests conducted on samples from the same machine and production run.

4.3 Precautions

When the pull-force value is based on the wire breaking force, the NDPT must be conducted on the as-made bonds prior to any thermal exposures which could anneal the wire.

The force application during destructive and nondestructive testing should be applied at the highest point or at mid-span when no high point is evident and should be in a direction perpendicular to the substrate.

The frequency of the destructive test should be determined by the reliability assurance levels required. High reliability programs necessitate that the destructive sample be taken daily and the limit adjusted accordingly. Some production may require a destructive sample as seldom as weekly. Whenever the destructive test indicates $\overline{X}$ and σ conditions are not being met, the preceding NDPT test lot may have degraded bonds due to the elasticity limits being exceeded. Any change in wire size, composition or machine hardware is cause for an additional destructive pull test. Any time the results of the NDPT indicate an abnormal number of bond failures a destructive sample should be taken to assure that the NDPT limit is not above $\frac{\overline{X} - 3\sigma}{2}$ and that $\sigma < .25\overline{X}$.

5.0 DETAILED SPECIFICATION

The controlling documentation should contain the following details:

a. Sampling plan or 100% screening requirement
b. Minimum frequency of destructive sampling.

6.0 REFERENCE

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