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NASA TECH BRIEF
Ames Research Center

Nondestructive Testing of Microtab Welds

The problem:

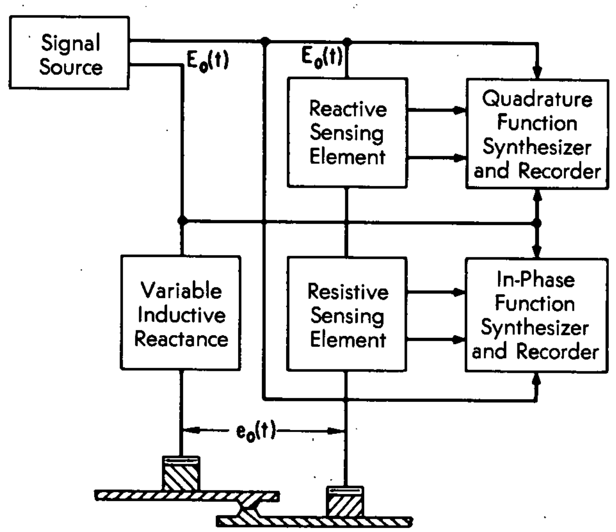
Integrated circuits are generally mounted on a sealed header which supports leads for attachment to other components. As a rule, the interconnection tabs of a group of integrated circuits are spot welded to each other to provide high reliability connections and to maintain low weight and small size. Present methods of assessing the reliability of spot welds involve the destructive testing of sample welds, but a large number of welds must be tested to achieve an acceptable confidence level in quality control; since the testing procedure involves loss of considerable time and material, a nondestructive method for testing microtab welds was desired.

The solution:

Introduce a sinusoidal signal across the welded tabs, and sweep the signal frequency through the resonant frequencies of the weld. The in-phase frequencies and quadrature (±90° phase shift) frequency functions are used to evaluate weld reliability.

How it's done:

Each weld specimen or type exhibits a unique property of the in-phase frequencies or quadrature frequency functions over a certain range of signal frequencies; thus a weld has a complex series of signatures which is related to weld-parameter combinations (pressure, current, and time). Once the center frequency of the complex series of signatures has been located, the range of swept-frequency has to be established so that individual signatures corresponding to each point in the weld schedule can be generated. Often, it will be necessary to exclude part of the total frequency response so that fine structure can be resolved in a small range not necessarily around resonance.



The changes in the characteristics of the individual signatures as a function of weld pressure and current-pulse duration are gradual. The nondestructive inspection procedure depends upon the ability to discern changes in weld parameters from point to point in the weld schedule; in preliminary work, individual signatures are recorded for variations of each point in the weld schedule and classified as a function of weld integrity. During production inspection, the complex series of signatures for each weld are noted and compared against the range of individual signatures established for point-to-point differences in

(continued overleaf)

weld schedules. If all the individual signatures fall within acceptable ranges, the weld is approved.

The nondestructive method of testing welds described above is not sensitive to ohmic contact resistance between probe leads and welded tabs. In the system shown in the block diagram, contact resistance is avoided by capacitative coupling of the signal to the welded junction. This approach eliminates random error associated with metal-to-metal contacts since a surface potential barrier does not form and irregularities in the metallic surfaces are averaged over the normal surface of the probe. A negligible voltage drop will be developed across the contact capacitances at microwave frequencies, and the contact has a predictable reactance at radio frequencies. A capacitative contact is more stable and repeatable than an ohmic contact since capacitance stems from an integrable average over the contact surface. For greater precision in narrow-band applications, the variable inductive reactance shown in the diagram can be used to neutralize a contact capacitance, but it need not be used when broad-band signatures are obtained. The test-system geometry must be recorded as part of the signature analysis; an important parameter in the geometry of the test system is the separation distance between the capacitive contacts shown in the diagram. The dimensions of the weld, probe separation, and tab-width depths must be small compared to the signal free-space wavelength, because it is desired to operate with lumped elements in order to minimize the skin-depth problems associated with traveling waves. Signal current must pass through the circumference of the weld. Skin-depth effects will limit current penetration into the weld if the weld is good, but a poor weld will lead to greater penetration and this will be readily detected by its effect on the sweep-frequency signature.

The testing technique is uniquely adaptable to the inspection of micro-circuit tab welds where the inspection signal frequency is in the radio-frequency to microwave range, and the inspection test circuitry is formed of ultraminiature lumped elements. The center frequency and probe diameter which can be used in such tests are interrelated because the reactance of the capacitors formed by the probe tips and the weld must be small in comparison to the significant reactive or resistive elements within the weld; alternatively, the capacitance can be neutralized or kept constant from test to test.

Notes:

1. As experience with this technique of weld inspection increases, it may be possible to eliminate the need for correlating admittance with weld schedules for each job. There should be a range of admittance which is characteristic of a good weld for each tab geometry in some frequency range. The type of test circuitry used to establish these weld signatures will be determined by the center signal frequency.
2. Requests for further information may be directed to:

   Technology Utilization Officer
   Ames Research Center
   Moffett Field, California 94035
   Reference: TSP 72-10296

Patent status:

Inquiries concerning rights for the commercial use of this invention should be addressed to:

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