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BDX-613-1081

AUTOMATIC TESTING AND HANDLING
OF BEAM LEAD TRANSISTORS AND DIODES

Technological Spinoff Report

Prepared by:
L. W. Smith and
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Published March 1974

Prepared for the
United States Atomic Energy Commission
Under Contract Number AT(29-1)-613 USAEC

**Kansas City
Division**

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AUTOMATIC TESTING AND HANDLING OF BEAM LEAD TRANSISTORS AND DIODES

BDX-613-1081, UNCLASSIFIED Technological Spinoff Report,
Published March 1974

Prepared by L. W. Smith, D/863, and B. G. Wilson, D/144

A Bendix-designed system electrical-tests all devices received in an as-etched array, moves the good devices into an expanded array, and facilitates visual inspection. The system allows economical 100-percent testing and has greatly increased quality levels in next assemblies.

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THE BENDIX CORPORATION

KANSAS CITY DIVISION

KANSAS CITY, MISSOURI

A prime contractor for the
Atomic Energy Commission
Contract Number AT(29-1)-613 USAEC

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INTRODUCTION

Manual handling of miniature beam lead semiconductor devices is difficult and can result in damage to or loss of many devices. A unique, custom-built system has been developed for automated probing, testing, and array expansion of high-reliability beam lead transistors and diodes used in hybrid microcircuits. The system is illustrated in Figure 1.

BEAM LEAD DEVICES

Failure of wire bonds has long been a predominant failure mode for monolithic integrated circuits, hybrid microcircuits, and discrete semiconductors. The development of beam lead, sealed-junction technology has established a new semiconductor device which increases the reliability of interconnections to the using circuitry.* In addition, this technology provides a device which is virtually hermetically sealed without external packaging.

In the beam lead device (BLD) structure, comparatively thick (typically 0.5 mil [13 μ m]) gold leads extend beyond the edges of the semiconductor die to provide electrical contact and structural support for the device itself. A cross section drawing of a typical BLD is shown in Figure 2. The BLD, which is ideally suited for hybrid circuit applications, has all leads in the same plane, can be bonded to the using circuitry in a single operation, and is encapsulated in its own hermetic package. The sealed junctions protect the circuit from deleterious surface contamination without external encapsulation. A typical beam lead transistor (0.5 mm square with leads 0.13 mm long) is shown in Figure 3.

DEVICE SHIPMENT AND TESTING CONFIGURATION

BLD's are procured from the vendor in as-etched arrays on 1.5 or 3.0 inch (3.8 or 7.6 cm) diameter sapphire or glass discs. The sapphire or glass has a thin film of wax as a holding medium applied before the vendor's final etch separation operation. These as-etched arrays contain both electrically good and bad devices maintained in a precise matrix with leads interdigitated. A typical array contains from 600 to the 4500 BLD's shown in Figure 4.

*Bell Telephone Laboratories, 1964

Figure 1. Incoming Beam Lead Device Inspection

Figure 2. Cross Section of a Typical Beam Lead Transistor

Figure 3. Typical Beam Lead Transistor

Figure 4. Typical As-Etched Array

TEST METHODS

Incoming BLD's are 100-percent room temperature tested upon receipt. An automatic chip prober interfaced to a computer controlled semiconductor test system is used to index, contact, and electrically test each device in the array. The array is always placed on the prober so that the notched leads of the devices are pointed toward the operator. A particular device is then selected by the operator, and its coordinates establish the reference point from which the locations of all other devices in the array are measured.

Either fixed probe cards or adjustable probes are used to contact the beam leads of the device for electrical test (Figure 5). Peripheral equipment generates a punched paper tape which contains "pass," "fail," or parameter sort information, plus the XY coordinates of each device in the array with respect to the reference device. Rejected devices are inked either simultaneously with the probing operation or as a separate operation to make certain that none will be used in hybrid circuits. The punched tape may be used to generate a map of the array showing the location of all good devices, all bad devices, or devices which meet one or a combination of electrical requirements.

EXPANSION AND VISUAL INSPECTION OPERATION

Once the devices have been electrically tested, the next operation is array expansion. The purpose of the expansion operation is to transfer only electrically good devices from the dense as-etched array to an expanded array for further visual inspection and to enable pickup by the bonding tool in subsequent hybrid circuit bonding. The punched paper tape generated during electrical testing is used to direct automatic device handling equipment which was custom-built to Kansas City Division specifications (Figure 6). This equipment automatically selects, picks up, and transfers electrically good devices to an expanded array. The holding wax is heated during this operation to soften the wax to just below the temperature at which device migration would occur.

The tape generated during the test operation is used to locate the appropriate device within the array; the heated vacuum collet then contacts the device, extracts it from the dense as-etched array, and relocates it in a precise expanded array. The selected device is removed without disturbing adjacent units and may be presented to visual inspection optics prior to its relocation.

A glass slide approximately 2.5 by 3.0 inches (6.4 by 7.6 cm) is used as a carrier for the expanded array (Figure 7). Each

Figure 5. Fixed Probe Card Contacting the Leads on a BLD

Figure 6. Automatic Beam Lead Device Handling Equipment

Figure 7. Expanded Array Containing Visually Inspected Beam Lead Devices

device is held in place by residual wax. Uniform lead orientation is maintained and devices are accurately located, permitting electrical reprobng using adjustable probes and reducing next assembly beam lead bonder search and pick-up time. The expanded array contains only units which have been 100-percent electrically tested and accepted by both the vendor and the user.

A closed-circuit TV system is used to perform detailed front and backside visual inspection on each device in the expanded array, and failing devices are removed. The array is uniquely identified with a color code for each different device type, the device nomenclature, the lot number, and the diffusion run. After completion of the visual inspection operation, the expanded arrays are stored in a nitrogen atmosphere prior to shipment to the hybrid microcircuit assembly line.

TEST RESULTS

The High-Reliability Beam Lead Device Inspection Area has been in operation for approximately one year, and over 150,000 devices have been supplied to the hybrid microcircuit production area. Results from the first year of operation indicate that approximately 20 percent of the devices received from the vendor as electrically good are rejected during beam lead inspection processing. Visual rejects account for approximately one-half of the failures. Since 100-percent visual inspection is not required of the semiconductor vendor, this figure is not considered excessive. In addition, a cost analysis indicated that it was more economical to perform the visual inspection in-house and absorb the cost of the rejects than to have the beam lead manufacturer perform this service. Rejected devices are used to certify next assembly thermo-compression bonders.

CONCLUSION

An automatic testing and handling system has been developed to supply high-reliability beam lead devices for hybrid microcircuit applications. This unique system allows economical, 100-percent inspection of purchased devices and has processed over 150,000 transistors and diodes. Results from the first year of hybrid microcircuit production indicate that acceptable quality levels are being maintained on all using assemblies and that the beam lead sealed junction technology can greatly lower failure rates.

ACKNOWLEDGEMENT

The authors acknowledge the support and cooperation of Sandia Laboratories, Albuquerque, New Mexico, in the establishment of the High Reliability Beam Lead Device Inspection Facility.