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Semiconductor Chip Processing

By A. V. Grimm

Published July 1980

Final Report

Prepared for the United States Department of Energy
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**Kansas City
Division**

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SEMICONDUCTOR CHIP PROCESSING

✓ By A. V. Grimm

Published July 1980

Final Report
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The processes necessary to assemble metal-oxide semiconductor devices in hermetic ceramic packages were developed. The assembly techniques developed were gold-silicon die attachment, 25.4- μ m aluminum wire interconnection, and gold-tin cover attachment.

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SUMMARY

The processes necessary to assemble metal-oxide semiconductor devices in hermetic ceramic packages were developed. These processes included the use of a gold-silicon braze material to attach the semiconductor die to the ceramic package, to attach 25.4- μm aluminum wires between the semiconductor die and the package leads, and to attach the gold-plated Kovar cover using gold-tin braze material. The assemblies were tested to determine the acceptability of each process.

DISCUSSION

SCOPE AND PURPOSE

The purpose of this activity was to develop the processes necessary to assemble a semiconductor die into a hermetic ceramic package. The processes investigated were the use of a gold-silicon die-attach material, the use of a 25.4- μ m aluminum wire for die-to-package electrical interconnection, and the use of a gold-tin cover braze to the ceramic package.

ACTIVITY

Pieceparts

The pieceparts and criteria used to build metal-oxide semiconductor-large scale integrated circuit (MOS-LSI) sequencer were selected to demonstrate the acceptability of the assembly process. The ceramic flatpack package has 64 leads and measures 22.9 mm on a side. The semiconductor die measures 5.309 by 5.004 by 0.254 mm and has a gold-plated back surface. The die-attachment to the package is made of 98 percent gold-2 percent silicon braze alloy measuring 3.81 by 3.81 by 0.051 mm. The electrical interconnection between the die and the package is made with 25.4- μ m, 99 percent aluminum and 1 percent silicon wire. The cover, measuring 12.827 by 12.827 by 0.254 mm, is brazed to the package using an 80 percent gold-20 percent tin alloy.

Die Attachment

The die and packages were cleaned using room temperature Freon TF for 5 minutes minimum. The parts were then suspended in boiling Freon TF vapors for 5 minutes minimum. Finally, the parts were blown dry with nitrogen and stored in a dry nitrogen environment until ready for use. The attachment of the die was accomplished as follows. The package was placed on a work holder heated to a temperature of 430°C. Two gold-silicon preforms were placed in the gold-plated well in the package. After the preforms had melted, the die was picked up with a heated collet (275°C) and then manually scrubbed into the attachment material until thorough wetting was observed. Next, the assembly was removed from the heated tool, allowed to cool, and then was stored in a dry nitrogen environment until ready for the wire attachment operation.

Wire Attachment

An ultrasonic wire bonder was used to attach 56 wires to the die and package. The following bonder parameters were used: a clamping force of 65 grams for 40 ms with a 0.5 V input to the transducer.

Package Sealing

The first attempts to seal gold-plated covers to the 64-lead, LSI flatpack package resulted in a high seal integrity failure rate. X-ray analysis revealed a large number of voids in the gold-tin cover braze material. To evaluate if the package or the cover was causing the voids, several devices were sealed after being cleaned in a 10 percent hydrogen peroxide (H_2O_2) solution or a tantalum-etch solution consisting of 3 parts HF, 1 part HNO_3 , and 10 parts CH_3COOH by volume.

To determine what contaminants were present on the seal ring of the package, a surface analysis was performed. The package that had not been cleaned was found to have small traces of copper-oxide in the seal ring area. The package that had been cleaned in boiling hydrogen peroxide showed traces of nickel-oxide. A third package, that had been cleaned in the tantalum-etch for 5 seconds and then rinsed in deionized (DI) water, had traces of silver on the sealing surface.

Subsequent sealing efforts indicated much better solder wetting on the packages cleaned with tantalum-etch than observed on packages as-received or cleaned in hydrogen peroxide.

Ninety-three LSI packages were sealed for final evaluation. These packages were cleaned as follows.

- Empty packages were dipped in tantalum-etch solution for 15 seconds and then rinsed in flowing DI water for 2 minutes, minimum.
- The surface water was removed with a vacuum pencil, and then the packages were suspended in boiling Freon TA vapors for a minimum of 2 minutes.
- The covers with solder preform attached (combo) were cleaned by suspending them in Freon TA vapors for 2 minutes, minimum.

After die attachment and wire-bonding, the packages were vacuum-baked at $150^\circ C$ in less than $20\text{ }\mu m$ vacuum for 2 hours. The combo covers were not vacuum baked. The packages were moved directly from the vacuum oven into the glove box, where they were sealed in a dry nitrogen environment. The moisture level in the glove box during sealing was 75 ppm.

The packages and covers were loaded into the sealer chamber and then were sealed using the following procedure:

- Close sealer chamber and evacuate,
- Backfill chamber with dry nitrogen,
- Evacuate chamber for 52 seconds while heating cover/preform to approximately 200°C,
- Backfill chamber with dry nitrogen,
- Raise temperature to 385°C within 45 seconds,
- Dwell at 385°C for 30 seconds,
- Cool down to approximately 200°C in 15 seconds, and
- Open sealer chamber and remove sealed package.

Test Results

The 93 completed packages were subjected to the following tests: hermetic seal, stabilization bake, temperature cycling, centrifuge, cover seal X-ray, and burn-in. A sample of 10 devices was selected and was subjected to thermal shock, mechanical shock, and vibration. The covers were removed from a second sample of 10 devices, and each of the aluminum wires was subjected to a pull strength test; the die was subjected to a shear test. The only failures observed were two fine leak rejects.

ACCOMPLISHMENTS

All original objectives of this project were satisfied: the semiconductor die can be attached easily to ceramic packages using gold-silicon braze materials, the 25.4- μ m aluminum wire can be attached to the die and package, and the cover can be attached hermetically to the package.

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