Air-Insulated Beam-Lead Crossovers for Integrated Circuits

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Air-insulated crossovers for integrated circuit interconnections have been developed which feature low capacitance and dual dielectrics for high yield and reliability. This type of crossover is fabricated using beam lead technology and is applicable to integrated circuit chips as well as substrates.

The cross section drawing in Fig. 1 shows a crossover with dual dielectric insulation consisting of a 5 micron air gap in series with a 2000 Å layer of ZrO_2. Fig. 2 is a plan view photograph of a typical pattern. The dual dielectric crossover will not fail under mechanical load even if the top conductor is deflected until it touches the bottom level, since the ZrO_2 has a breakdown strength by itself of approximately 100 volts. (See Fig. 3.) Any pinholes in the solid dielectric will not lead to short circuits either, as they would if the top level metallizing were applied by deposition. When the external force is released, the top beam lead will elastically return to its original position, and the air gap will once again sustain over 200 volts.

The fabrication procedure is as follows. A Ti-Pt lower level contact pattern is formed according to methods previously described.[1] A layer of Zr-Cu is then deposited, and feed-through holes etched where contact to the lower level is desired. The top layer, a gold beam lead, is electroformed using the copper as a base, and the copper is etched away. Thermal oxidation of the Zr layer to ZrO_2 completes the structure: two levels of metallization separated by a ZrO_2-air dielectric.

The use of a thick air gap as one of two dielectrics between two

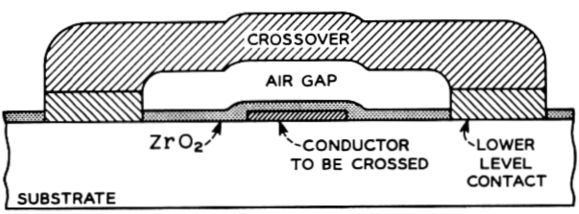

Fig. 1 — Cross section of crossover.

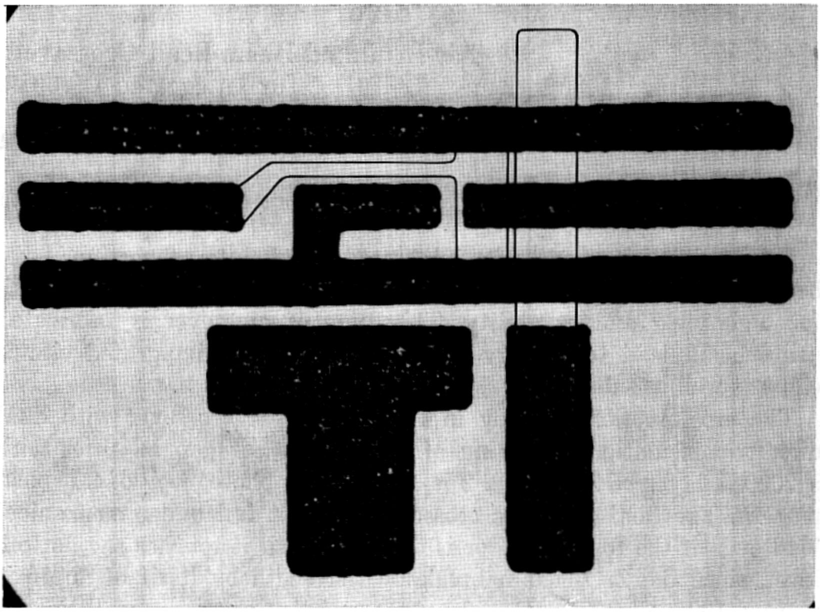

Fig. 2 — Plan view of crossover pattern on integrated circuit chip (narrowest line is 0.4 mil).

crossing conductors leads to a system where pinhole shorts are nearly impossible, thermal stresses are minimal, and parasitic capacitance is low (~0.001 pf/mil²). Conventional crossovers consisting of evaporated metals over and under a deposited dielectric (for example, SiO_2) are prone to pinhole shorts, conductor opens, and high thermal stresses owing to the mismatches involved. Diffused crossunders are limited to use in chips only, and use large areas of silicon because of their high sheet resistances.

The beam lead crossover system has been successfully applied to integrated circuit chips as well as complex substrates (see Fig. 4).

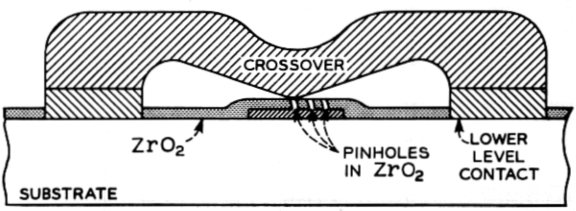

Fig. 3 — Cross section of loaded crossover.

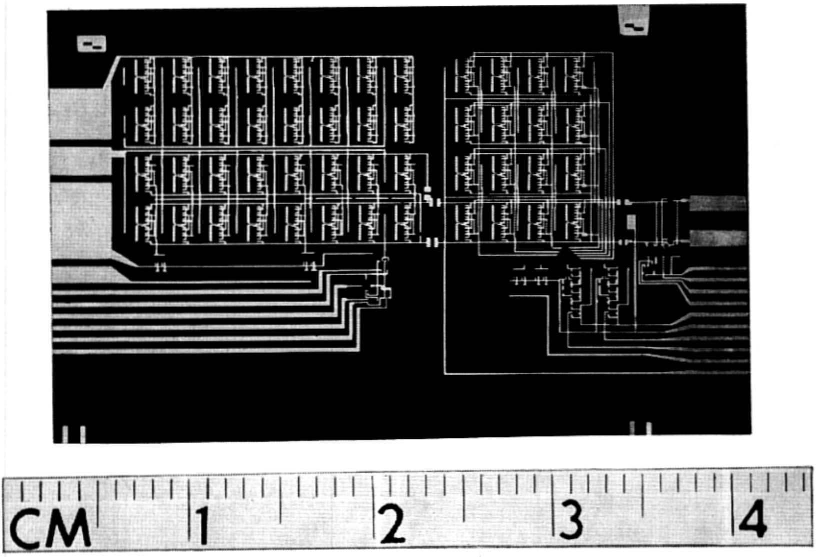

Fig. 4 — Photograph of integrated circuit memory substrate.

In addition to the high initial yields, aging of hundreds of crossovers in room air at 350°C for over 1000 hours has shown no apparent change, nor is any envisaged. The metallurgical system has been stringently tested on beam lead transistors and found to be very rugged. It is therefore believed that these crossovers will be generally useful in many integrated circuit applications.

REFERENCE

1. M. P. Lepselter, "Beam-Lead Technology," B.S.T.J., *45,* No. 2 (February 1966), pp. 233–253.