

INTERCONNECTION HIGH DENSITY TEST CONNECTOR
PARTICULARLY MEANT FOR THE VERIFICATION OF INTEGRATED
CIRCUITS

5 The current invention concerns the area of test equipment for high-density integrated circuits.

10 In the current technical situation, we know that some connectors enable us to apply a great number of points on the surface of the integrated circuit to be checked. Such connectors show a dense network of spindles with mobile ends to be able to adapt to the defects in the planeness of the circuits to be checked and to the defects of the handling equipment. These spindles are electronically linked to a cable bundle that permits the connection to a control-equipment.

15 We know, for example, the European patent EP 68270 that describes a set of electrical tests comprising a multiplicity of elongated test elements made up of conductive and flexible material and some spaced out lower and higher support elements with openings through which the ends of the said test elements go. The lower support element maintains those test elements according to a generally parallel position, within a configuration that
20 corresponds to the one of the contacts to connect.

25 We also know the European patent EP735372 that describes an assembly of spindles crossing a perforated plate and comprising spring elements to exercise a pressure on the contact surface. The European patent EP 528608 describes a connector to test a set of integrated circuits mounted on the surface of a printed circuit card and shows a roughly rectangular configuration that includes a higher surface, a lower surface and four lateral edges. A series of electrical conductors spreads from at least one of the said lateral edges. The connector comprises:

- 30 - A connector box that includes a roughly rectangular hollow space that can be adjusted above the integrated circuit set;

A minimum of one comb made of insulating material and fitted with a series of teeth that spread laterally toward the inside of the said hollow space for the said connector box with a pre-specified space between each pair of adjacent teeth, with the said teeth being capable of being inserted in a detachable way between the said conductors when the said connector box is adjusted above the said set of integrated circuit;

- An assembly of conductor frames joined to the said connector box inside the said hollow space;
- A flexible cable that includes a series of conductors spreading in parallel fashion from the said connector box toward a second connector capable of carrying out the electrical connections with an external test equipment; and
- A series of conductive spindles mounted in the said openings fitted with a coating of the said insulating layer capable of carrying out interconnections.

The problem posed by the connectors of the preceding item is the problem of the density of the spindles and the miniaturization of the contacts. This density is limited by the distortion of the spindle during the application on the surface of the integrated circuit to be checked, and by the need to avoid at all cost any contact between the adjacent spindles. A second problem is the one concerning the control of the travel-force function. The object of the exercise is to work in the part of the movement-force curve that corresponds to saturation in order to ensure that there is practically a constant force of support whatever the expansion of the ends of the spindle. This characteristic enables us to ensure a support force identical for all the spindles, even when the surface of contact shows defects in planeness.

The invention aims at reaching this objective by way of a high density

interconnection test connector meant in particular to verify the integrated circuits comprising a plate that supports a multiplicity of conductive spindles with one of the ends forming a contact zone with the electronic circuit to be tested, and the other end forming a contact zone with a link plate with a mean of connection with the test equipment, the conductive spindles having a form capable of ensuring a flexibility consisting of a longitudinal component, characterized by the spindles showing a succession of at least three sections curved on both sides by mobile straight segments according to a degree of freedom in axial translation, with the spindles inserted in frontal plates.

According to a favourite mode of operation, the spindles have a succession of three curved sections.

According to a variation, the curved segments have a growing length from the tip toward the connection plate.

According to a favourite mode of operation, the first curved segment has a length L_1 , the second segment has a length of about $1.5 L_1$ and the third segment has a length of about $2.1 L_1$.

According to a particular mode of operation, the first curved segment has a length $L_1 = 480$ micrometers, the second segment has a length of about 700 micrometers and the third segment has a length of about 1000 micrometers.

Preferably, the first curved segment has a form defined by the following function:

$$Y_1(x) = b_1 \left(1 - \frac{2}{1 + e^{\left(\frac{\left(\frac{L_1}{2} \right)^2 - x^2}{\sigma_1^2} \right)}} \right)$$

With

b_1 approximately equal to 500

a_1 approximately equal to 300

5

L_1 approximately equal to 480 micrometers

For favourable results, the second curved segment has a form defined by the following function:

10

$$Y_2(x) = b_2 \cdot \left(1 - \frac{2}{1 + e^{\left(\frac{\left(\frac{x}{L_2} \right)^2 - 1\right)}} \right)$$

15

With

B_2 approximately equal to 300

A_2 approximately equal to 300

L_2 approximately equal to 700 micrometers

20

Preferably, the third curved segment has a form defined by the following function:

$$Y_3(x) = b_3 \cdot x \cdot \left(\frac{1}{e^{a_3 x}} - \frac{1}{e^{a_3 L_3}} \right)$$

25

With

B_3 approximately equal to 1

A_3 approximately equal to 0.005

L_3 approximately equal to 1000 micrometers

30

According to a particular mode of operation, the straight segment is guided over

a length of about 300 micrometers, and starts at a distance of about 100 micrometers from the third curved segment.

5 The invention also covers a process of manufacturing a spindle for a connector characterized by the fact that we prepare a SOI-type substrate formed of two silicon substrates merged with a silicon oxide interface, by the fact that we manufacture according to a mask by way of deep dry engraving, by the fact that we then proceed with the engraving of the silicon oxide layer, by the fact that we proceed with a metallic deposit by way of cathodic spray and/or chemical deposit
10 and by the fact that we then free the elements.

According to a variation, the spindle is made by way of direct chemical engraving in a metallic plate made of tungsten, palladium, copper or similar material.

15 The invention also covers test equipment for integrated circuits characterized by the fact that it comprises a connector in compliance with the invention.

The invention will be better understood after reading the following description that refers to a non-restrictive example of operation and to the diagrams in the
20 appendix where:

Diagram 1 represents a front view of the spindle according to the invention;

25 Diagram 2 represents a side view of the spindle according to the invention;

Diagram 3 represents an enlarged view of the contact end of the spindle;

Diagram 4 to 6 represent a section view of the spindle according to the section plan AA, BB, and CC.
30

The spindle according to the invention has a contact end (1) provided for at the

end of a straight segment (2), the median axis of which is merged with the median axis of the straight segment (3) that form the opposite end of the spindle.

The spindle has, between these two straight segments:

- A first curved segment (4);
- A second curved segment (5);
- A third curved segment (6).

At rest, the first curved segment shows a belly. It joins the second segment (5) through a link gradient with an angle of about 45° with the longitudinal axis (7). The link with the straight segment (2) takes place with a sharp variation of the gradient. The tangent at the end of the first curved segment (4) forms an angle of about 45° with the median axis of the straight segment (2).

The second curved segment (5) also forms a belly, in the opposite direction in relation to the belly of the first curved segment. The third segment has a belly with amplitude, in the same direction as the first belly. The link with the straight segment (3) takes place by way of a gently curved zone (8).

The contact end (1) has a trapezoid shape as shown in enlarged view in diagram 3. The gradient of the sides is about 60° . The flat frontal part has a square shape.

The straight segment (2) has a rectangular section as shown in diagram 4.

The curved part has a square section as shown in diagram 5.

The straight part (3) has a rectangular section as shown in diagram 6.

The straight segment before (2) shows, near the zone of connection with the first

curved segment (4), an escarpment (10) with a thickness of about 0.015 mm. This escarpment enables us to exert a pre-pressure on the spindle when it is introduced between the two perforated plates that form the connector.

5 The spindles thus made are inserted in a known manner between two plates with a network of punched holes to carry out the guiding of the straight ends (2, 3) in the image of the contacts of the integrated circuit to be checked. If necessary, only the back segment (3) could be guided since the front segment (2) is free. The network thread can reach 50 micrometers with the spindles according to the
10 invention.

They can be mounted in a pre-pressured manner. They are then positioned between two plates with a gap slightly smaller between the escarpments of the spindle, so as to exert an axial pressure at rest on the spindles.

15 The spindles can be manufactured by way of SOI-type substrate cutting technique (Silicon on Insulator) formed by a support N or P of a type [100] boosted so as to have the lowest resistance and a thickness of a few dozen micrometers.

20 The layer of silicon oxide has a thickness of a few micrometers. The base is of an N type or P type [100] and has a thickness of 350 to 500 micrometers.

We manufacture that substrate according to a mask by way of a deep silicon engraving, using a high density plasma with inductive coupling that enables us
25 to reach a high engraving speed, important selectivity and vertical engraving independent of the substrate crystal angle. This process enables us to ensure the square section of the spindles.

We then proceed with the engraving of the oxide layer with fluorhydric acid in
30 order to free the spindles from the support. We then proceed with a metallic deposit by way of a cathode spray or PVD (plasma vapour deposition) or CVD

(chemical vapour deposition) before proceeding with cutting the spindles to separate the adjacent elements.

5

10

15



CLAIMS

1. Interconnection high-density test connector particularly meant for the verification of integrated circuits, comprising a plate that supports a multiplicity of conductive spindles, one end of which forms a contact zone with the electronic circuit to be tested and the other end of which forms a contact zone with a linking plate with a means of connection with a test equipment; the conductive spindles have a form capable of ensuring a flexibility that includes a longitudinal component, characterized by the fact that the spindles have a succession of at least three curved sections (4, 5, 6) in alternate directions extended in both sides by mobile straight segments according to a degree of freedom in axial translation, with the spindles inserted in the frontal plates.
2. Interconnection high-density test connector according to the preceding claim characterized by the fact that the spindles have a succession of three curved sections.
3. Interconnection high-density test connector according to anyone of the preceding claims characterized by the fact that the curved segments have a growing length from the tip towards the connection plate.
4. Interconnection high-density test connector according to one of the preceding claims characterized by the fact that the first curved segment (4) has a length L_1 , the second curved segment (5) has a length of about $1.5 L_1$ and the third segment has a length of about $2.1 L_1$.



5. Interconnection high-density test connector according to anyone of the preceding claims characterized by the fact that the first curved segment (4) has a form defined by the function:

5

$$Y_1(x) = b_1 \cdot \left(1 - \frac{2}{1 + e^{\left(\frac{\left(\frac{x}{a_1} \right)^2 - x^2}{a_1^2} \right)}} \right)$$

10

6. Interconnection high-density test connector according to anyone of the preceding claims characterized by the fact that the second curved segment (5) has a form defined by the function:

15

$$Y_2(x) = b_2 \cdot \left(1 - \frac{2}{1 + e^{\left(\frac{\left(\frac{x}{a_2} \right)^2 - x^2}{a_2^2} \right)}} \right)$$

20

7. Interconnection high-density test connector according to anyone of the preceding claims characterized by the fact that the third curved segment (6) has a form defined by the function:

25

$$Y_3(x) = b_3 \cdot x \cdot \left(\frac{1}{e^{a_3 x}} - \frac{1}{e^{a_3 L_3}} \right)$$

30

8. Interconnection high-density test connector according to anyone of the preceding claims characterized by the fact that straight segment is guided over a length of about 300 micrometers, and starts at a distance of about 100 micrometers from the third curved segment (6).



9. Interconnection high-density test connector according to the claim 1 characterized by the fact the spindles are pre-pressured.
- 5 10. Process of manufacturing a spindle for a connector in compliance with at least one of the preceding claims characterized by the fact that we prepare a SOI-type substrate, in the fact that we manufacture according to a mask by way of deep dry engraving, in the fact that we then proceed with the engraving of the silicon oxide layer, in the fact that we proceed with a metallic deposit and in the fact that we then cut the
- 10 elements.
11. Process of manufacturing a spindle for a connector comprising spindles with a succession of at least three curved sections (4, 5, 6) in alternate directions extended on both sides with mobile straight segments according to a degree of freedom in axial translation; the spindles are inserted in the frontal plates characterized by the fact that
- 15 the spindles are chemically engraved in a metallic plate.
12. Test equipment for integrated circuits characterized by the fact that it includes a connector comprising spindles with a succession of at least three curved sections (4,
- 20 5, 6) in alternate directions extended on both sides with straight mobile segments according to a degree of freedom in axial translation, the spindles being inserted in the frontal plates.
- 25
- 30