

# **CANTILEVER-TYPE PROBE MECHANISM AND METHOD OF MAKING CANTILEVER-TYPE PROBE CARD**

## **BACKGROUND OF THE INVENTION**

### **5 1. Field of the Invention**

The present invention relates generally to cantilever-type probe cards and more particularly, to a cantilever-type probe mechanism used in a probe card for transmission of high frequency signal and a method of making a cantilever-type probe card using the same.

### **10 2. Description of the Related Art**

FIG. 1 shows a cantilever-type probe card 1 according to a design of prior art. According to this design, the cantilever-type probe card 1 comprises a circuit board 10, a plurality of coaxial transmission lines 11, a probe holder 12, and a plurality of probes 13. The circuit board 10 has a plurality of top solder pads 101 on the top side near the  
15 border for receiving test signal from the test machine. The coaxial transmission lines 11 are electrically connected to the soldered pads 101 and the probes 13 to transmit test signal from the test machine to the probes 13 for conducting wafer-level testing.

The probe holder 12 has a grounding surface 121, a holder body 122, and a plurality of fastening members 123. The grounding surface 121 is electrically  
20 connected to the ground potential of the cantilever-type probe card 1. The probes 13 are mounted on the probe holder 12. The fastening members 123 secure the body of each of the probes 13 to the probe holder 12 in such a manner that the rear parts 132 of the probes 13 are respectively connected to the bottom solder pads 102 on the bottom side of the circuit board 10 near the center area of the circuit board 10, and the front  
25 parts 131 of the probes 13 between the respective probing tips 130 and the associated

fastening members 123 are suspending below the probe holder 12 to serve as elastic lever arms for buffering the reaction force fed back from the probing tips 130 when the probing tips 130 are probing the test sites on the wafer.

Further, a metal conducting shell 111 is provided in each of the coaxial transmission lines 11 and electrically connected to the grounding surface 121 to maintain the characteristic impedance of the coaxial transmission line 11 in transmission of high frequency signal. However, because the probes 13 are simply formed of a conducting metal without having a similar design like the coaxial transmission lines 11, the parasitic capacitor induced by the dielectric surrounding around each of the probes 13 may cause dielectric loss during transmission of high frequency signal through the probes 13, thus lowering the reliability of the high frequency testing.

FIG 2 shows an improved design of cantilever-type probe card 2 according to the prior art. According to this design, coaxial probes 20 having coaxial transmission line characteristics are used to substitute the foresaid single conducting metal type probes 13, and the body 122 of the probe holder 12 is made of a metal conducting material. Each coaxial probe 20 comprises a metal pin 21, which has a front part 201 defined between the respective probing tip and the associated fastening member 123 and suspending below the probe holder 12, and a rear part 202 between the associated fastening member 123 and the circuit board 10, a dielectric material 22 wrapped about the rear part 202 of the metal pin 21, and a conducting layer 23 surrounding the dielectric material 22 and electrically connected with the metal body 122 to the grounding potential of the cantilever-type probe card 2 so that the rear part 202 of each coaxial probe 20 can maintain the characteristic impedance in transmission of high frequency signal. However, because the front part 201 of each coaxial probe 20 is

adapted to offer an elastic lever arm for buffering the reaction force when the probing tip is probing the test site, it is necessary to maintain its weight and keep clear from outer materials as the conducting layer 23 that is electrically connected to the body 122 of the probe pin holder 12. Therefore, the characteristic impedance is maintained at the rear part 202 of the metal pin 21 of each coaxial probe 20, but mismatched at the front part 201. Also the parasitic capacitor that is produced subject to the dielectric surrounding around the front part 201 of the coaxial probes 20 may cause dielectric loss during transmission of high frequency signal.

Therefore, it is desirable to provide a cantilever-type probe card that can maintain the characteristic impedance for transmission of high frequency signals.

#### **SUMMARY OF THE INVENTION**

The present invention has been accomplished under the circumstances in view. It is therefore one objective of the present invention to provide a cantilever-type probe mechanism adapted to be used in a probe card, which can maintain the characteristic impedance of the high frequency signal transmission.

To achieve the above-mentioned objective of the present invention, a cantilever-type probe mechanism provided by the present invention for transmitting high frequency signal comprises a probe pin holder, a transmission line, at least one metal signal pin and at least one metal grounding pin. The transmission line has at least one metal core and a metal layer coaxially and spacedly surrounding the at least one metal core and electrically connected to grounding potential. The at least one metal signal pin has a mounting portion mounted to the probe pin holder and electrically connected with the at least one metal core of the transmission line, a probing tip for probing an electronic component on a wafer, and a front arm integrally extending from the mounting portion to the probing tip. The at least one metal grounding pin has a

mounting portion mounted to the probe pin holder and electrically connected with the metal layer of the transmission line, a probing tip, and a front arm integrally extending from the mounting portion of the metal grounding pin to the probing tip of the grounding pin and adjacent to and spaced from the front arm of the at least one metal  
5 signal pin for maintaining the characteristic impedance of the metal signal pin upon transmitting high frequency test signal.

It is another objective of the present invention to provide a cantilever-type probe card using the aforesaid cantilever-type probe mechanism, which reduces the probe pin manufacturing cost and improves test signal transmission quality for a  
10 wafer-level testing.

To achieve the above-mentioned objective, the cantilever-type probe card comprises a circuit board, a probe pin holder, a plurality of transmission lines, and a plurality of metal probe pins. The circuit board has arranged thereon a plurality of signal lines and grounding lines respectively electrically connected to the transmission  
15 lines for transmitting test signals from a test machine to the metal probe pins. The metal probe pins each comprise a mounting portion, a probing tip, and a front arm integrally extending from the mounting portion to the probing tip. The mounting portions of the metal probe pins are fastened to the probe pin holder. The probing tips of the metal probe pins are adapted to probe a semiconductor wafer. The metal probe  
20 pins include signal pins and grounding pins. Each grounding pin is disposed adjacent to one respective grounding pin. The mounting portions of the signal pins are respectively connected to the metal cores of the transmission lines. The mounting portions of the grounding pins are respectively connected to the metal layers of the transmission lines. Therefore, the signal pins can transmit high frequency test signals  
25 from the test machine to the electronic components of the wafer under test. Further, the

front arm of each grounding pin is kept spaced from the front arm of the adjacent signal pin at a predetermined distance to maintain the characteristic impedance in the adjacent signal pin during transmission of a high frequency test signal.

The present invention also provides a method of making a high-frequency  
5 cantilever-type probe card, which comprising the steps of:

a) preparing a circuit board defining a top surface, a bottom surface opposite to the top surface, an inner probing zone, and outer testing zone surrounding the inner probing zone, the inner probing zone on the top surface being electrically connected to a test machine for transmitting test signals from the test machine to the inner probing  
10 zone;

b) mounting a probe pin holder on the bottom surface of the circuit board around the inner probing zone;

c) arranging a plurality of transmission lines around the probe pin holder, the transmission lines each comprising at least one metal core for transmitting the test  
15 signals from the test machine, and a metal layer coaxially and spacedly surrounding the at least one metal core and electrically connected to grounding potential;

d) preparing a plurality of metal pins having a length about equal to the distance between a center of the circuit board and the probe pin holder, the metal pins each having a mounting portion at one end thereof and mounted to the probe pin holder  
20 and a probing tip bent at the other end thereof;

e) connecting each metal core of each of the transmission lines to the mounting portion of one respective metal pin of the metal pins so that the associated metal pin forms a signal pin; and

f) defining the metal pin adjacent to each said signal pin to be a grounding  
25 pin and electrically connecting the mounting portion of each said grounding pin to the

metal layer.

Further scope of applicability of the present invention will become apparent from the detailed description given hereinafter. However, it should be understood that the detailed description and specific examples, while indicating preferred embodiments  
5 of the invention, are given by way of illustration only, since various changes and modifications within the spirit and scope of the invention will become apparent to those skilled in the art from this detailed description.

#### **BRIEF DESCRIPTION OF THE DRAWINGS**

The present invention will become more fully understood from the detailed  
10 description given herein below and the accompanying drawings which are given by way of illustration only, and thus are not limitative of the present invention, and wherein:

FIG. 1 is a schematic sectional view of a cantilever-type probe card according to a design of prior art;

15 FIG. 2 is schematic sectional view of a cantilever-type probe card according to another design of prior art;

FIG. 3 is a top view of a cantilever-type probe card in accordance with a first embodiment of the present invention;

FIG. 4 is a schematic side view of the cantilever-type probe card according to  
20 the first embodiment of the present invention;

FIG. 5 is a bottom view of the probing zone of the cantilever-type probe card according to the first embodiment of the present invention;

FIG. 6 is an enlarged view of a part of FIG. 5;

FIG. 7 is a schematic side view of a cantilever-type probe card in accordance  
25 with a second embodiment of the present invention;

FIG. 8 is a bottom view of the probing zone of the cantilever-type probe card according to the second embodiment of the present invention;

FIG. 9 is an enlarged view of a part of FIG. 8;

FIG. 10 is a bottom view of a part of a cantilever-type probe card in accordance with a third embodiment of the present invention;

FIG. 11 is an enlarged view of a part of FIG. 10.

#### **DETAILED DESCRIPTION OF THE INVENTION**

As shown in FIGS. 3-5, a cantilever-type probe card 3 for testing semiconductor wafers or the like in accordance with a first embodiment of the present invention comprises a circuit board 30, a probe pin holder 40, a plurality of transmission lines 50, a plurality of metal probe pins 60.

Referring to FIGS. 3 and 4 again, the circuit board 30 defines a top surface 301, a bottom surface 302 opposite to the top surface 301, an inner probing zone 303, and an outer testing zone 304. The testing zone 304 at the top surface 301 is to be electrically connected to a test machine (not shown) that is controllable to output high frequency test signals to the cantilever-type probe card 3, enabling high frequency test signals to be transmitted to the inner probing zone 303. The circuit board 30 has arranged thereon electronic circuits, comprising multiple signal lines 31 and grounding lines 32 that extend from the top surface 301 to the bottom surface 302 and respectively electrically connected to the transmission lines 50. The signal lines 31 are adapted to transmit the aforesaid high frequency test signals. Further, the grounding lines 32 are respectively arranged adjacent to the signal lines 31. The grounding lines 32 may be directly or indirectly connected to the grounding potential of the test machine to maintain the characteristic impedance of the signal lines 31 in transmission of the aforesaid high frequency test signals.

Referring to FIGS. 4 and 5 again, the probe pin holder 40 is made by an electrically insulative material, for example, epoxy resin, and mounted on the bottom surface 302 of the circuit board 30 around the probing zone 303, and adapted to hold the metal probe pins 60 and to keep the metal probe pins 60 electrically insulated from one another.

The transmission lines 50 are arranged around the probe pin holder 40, each having one end connected to the circuit board 30 and the other end respectively connected to the metal probe pins 60. The transmission lines 50 are coaxial lines, each having a metal core 51, a dielectric layer 52 surrounding the metal core 51, a tubular metal layer 53 surrounding the dielectric layer 52, and a protective layer 54 surrounding the tubular metal layer 53. The metal cores 51 of the transmission lines 50 are respectively electrically connected to the signal lines 31 for transmitting the aforesaid high frequency test signals. The tubular metal layers 53 of the transmission lines 50 are respectively electrically connected to the grounding lines 32 to maintain the characteristic impedance of the metal cores 51 in transmission of high frequency test signals.

The metal probe pins 60 each have a mounting portion 601, a probing tip 602, and a front arm 603 integrally and axially extending from the mounting portion 601 to the probing tip 602. The mounting portions 601 of the metal probe pins 60 are respectively fastened to the probe pin holder 40. The probing tips 602 of the metal probe pins 60 are adapted to probe on pads 71 under test of a semiconductor wafer. Further, these metal probe pins 60 are arranged in pairs each including one signal probe pin 61 and one grounding probe pin 62. The mounting portion 601 of each signal probe pin 61 is electrically connected to the metal core 51 of the associated transmission line 50 for transmitting high frequency test signal to the electronic

component that is connected to the pad 71 under test. The mounting portion 601 of each grounding probe pin 62 is electrically connected to the tubular metal layer 53 of the associated transmission line 50 so that the associated probing tip 602 can probe on one grounding pad 72 that is connected to the grounding potential of the respective  
5 electronic component.

As stated above, the cantilever-type probe card 3 uses the combination of the metal probe pins 60 and the transmission lines 50 to substitute for the conventional probe mechanism, so that a grounding potential is provided near every transmission path of high frequency test signal to obtain the optimal effect of characteristic  
10 impedance matching, thereby maintaining the high frequency signal transmission quality and effectively solve the drawbacks of the conventional probe mechanism of the probe card. Further, because the metal probe pins 60 design with a length approximately equal to the distance between the center of the probe card 3 and the probe pin holder 40, the invention save much probe pin manufacturing cost (about one  
15 half of the conventional design).

FIGS. 7 and 8 show a cantilever-type probe card 4 in accordance with a second embodiment of the present invention. According to this embodiment, the probe pin holder 50 comprises a grounding surface 41 made of an electrically conductive metal material. The tubular metal layers 53 of the transmission lines 50 and the  
20 mounting portions 601 of grounding probe pins 62 are respectively electrically connected to the grounding surface 41, therefore, referring also to FIG. 9, the grounding surface 41 provides the electronic circuits in the probe card 4 with an equipotential for grounding, maintaining the common grounding potential in the circuits of the probe card. Further, setting one grounding probe pin 62 between each  
25 two adjacent signal probe pins 61 is sufficient to maintain the characteristic impedance

in each signal probe pin 61 when transmitting high frequency test signal. Therefore, this embodiment greatly reduces the number of the probe pins 62 for probing the circuits of a semiconductor wafer having a relative less number of grounding pads.

The high frequency test signal transmission structure of the present invention is not limited to the arrangement of the coaxial transmission lines 50 with the metal probe pins 60. FIGS. 10 and 11 show a cantilever-type probe card 5 in accordance with a third embodiment of the present invention. This embodiment is adapted to probe driver ICs applied for display panel with high frequency transmission of differential signal-pairs. This embodiment uses differential signal-pair transmission lines 80 to substitute for the aforesaid coaxial transmission lines 50 for transmitting high frequency differential signals. The differential signal-pair transmission lines 80 are in the form of spaced dual cores. Each differential signal-pair transmission line 80 comprises two metal cores 81, two dielectric layers 82 respectively surrounding the metal cores 81 to hold the metal cores 81 in parallel and to keep the metal cores 81 electrically insulative from each other, a tubular metal layer 83 surrounding the dielectric layers 82, and a protective layer 84 surrounding the tubular metal layer 83. The metal cores 81 are respectively electrically connected to one respective signal probe pin 61. The tubular metal layer 83 is electrically connected to at least one grounding probe pin 62. By means of the tubular metal layer 83 and the associated grounding probe pin(s) 62, the characteristic impedance is maintained when the cantilever-type probe card 5 transmits differential signal-pairs of high frequency testing.

The invention being thus described, it will be obvious that the same may be varied in many ways. Such variations are not to be regarded as a departure from the spirit and scope of the invention, and all such modifications as would be obvious to

one skilled in the art are intended to be included within the scope of the following claims.

**WHAT IS CLAIMED IS:**

1. A cantilever-type probe mechanism for transmitting high frequency signal, comprising:

a probe pin holder;

5 a transmission line having at least one metal core and a metal layer coaxially and spacedly surrounding the at least one metal core and electrically connected to grounding potential;

at least one metal signal pin having a mounting portion mounted to the probe pin holder and electrically connected with the at least one metal core of the  
10 transmission line, a probing tip, and a front arm integrally extending from the mounting portion to the probing tip; and

at least one metal grounding pin having a mounting portion mounted to the probe pin holder and electrically connected with the metal layer of the transmission line, a probing tip, and a front arm integrally extending from the mounting portion of  
15 the metal grounding pin to the probing tip of the grounding pin and adjacent to and spaced from the front arm of the at least one metal signal pin.

2. The cantilever-type probe mechanism as claimed in claim 1, wherein the metal layer is spaced from the at least one metal core by a dielectric layer surrounding  
20 the metal core.

3. The cantilever-type probe mechanism as claimed in claim 2, wherein the characteristic impedance of the at least one metal core is in match with the characteristic impedance of the at least one metal signal pin during transmission of  
25 electrical signal through the transmission line and the at least one metal signal pin.

4. The cantilever-type probe mechanism as claimed in claim 3, wherein the probe pin holder is made of an electrically insulative material; the mounting portions of the at least one metal signal pin and the at least one metal grounding pin are  
5 respectively adhered to the at least one metal core and the metal layer on the probe pin holder.

5. The cantilever-type probe mechanism as claimed in claim 4, wherein the probe pin holder comprises a grounding surface made of an electrically conductive  
10 metal material; the metal layer of the transmission line and the at least one metal grounding pin are electrically connected to the grounding surface of the probe pin holder.

6. The cantilever-type probe mechanism as claimed in claim 1, wherein the  
15 transmission line has an axial length about equal to the length of the at least one metal signal pin and the at least one metal grounding pin.

7. The cantilever-type probe mechanism as claimed in claim 1, comprising two said metal signal pins; wherein the transmission line comprises two said metal  
20 cores which are spaced from each other, spacedly surrounded by the metal layer and respectively electrically connected with the two metal signal pins.

8. The cantilever-type probe mechanism as claimed in claim 7, wherein the transmission line is used to transmit differential signal-pair.

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9. The cantilever-type probe mechanism as claimed in claim 7, comprising two said metal grounding pins and the two metal grounding pins are spacedly arranged at two sides of the two metal signal pins.

5           10. A method of making a high-frequency cantilever-type probe card, comprising the steps of:

          a) preparing a circuit board defining a top surface, a bottom surface opposite to the top surface, an inner probing zone, and outer testing zone surrounding the inner probing zone, the inner probing zone on the top surface being electrically connected to  
10   a test machine for transmitting test signals from the test machine to the inner probing zone;

          b) mounting a probe pin holder on the bottom surface of the circuit board around the inner probing zone;

          c) arranging a plurality of transmission lines around the probe pin holder, the  
15   transmission lines each comprising at least one metal core for transmitting the test signals from the test machine, and a metal layer coaxially and spacedly surrounding the at least one metal core and electrically connected to grounding potential;

          d) preparing a plurality of metal pins having a length about equal to the distance between a center of the circuit board and the probe pin holder, the metal pins  
20   each having a mounting portion at one end thereof and mounted to the probe pin holder and a probing tip bent at the other end thereof;

          e) connecting each metal core of each of the transmission lines to the mounting portion of one respective metal pin of the metal pins so that the associated metal pin forms a signal pin; and

25           f) defining the metal pin adjacent to each said signal pin to be a grounding

pin and electrically connecting the mounting portion of each said grounding pin to the metal layer.

11. The method as claimed in claim 10, wherein the probe pin holder  
5 includes a metal grounding surface, and the grounding pin is electrically connected to the metal layer through the metal grounding surface in step f).

12. The method as claimed in claim 11, wherein each said grounding pin is arranged between each two adjacent signal pins in step f).

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13. The method as claimed in claim 10, wherein each said transmission line comprises two said metal cores spaced with each other and respectively electrically connected to two said signal pins in step e).