

Title: Interface element for a testing apparatus of electronic devices and corresponding manufacturing method

DESCRIPTION

Technical Field

5 The present invention refers to an interface element for a testing apparatus of electronic devices integrated on a semiconductor wafer and the following description is made with reference to this field of application with the sole aim of simplifying the description thereof.

Background Art

10 As it is well known, a probe card is an electronic device adapted to electrically connect a plurality of contact pads of a microstructure, such as a device integrated on a semiconductor wafer, with corresponding channels of a testing machine that performs the functionality testing thereof, in particular the electric testing, or the test, generically.

15 The test, which is performed on integrated devices, is particularly useful in detecting and isolating defective devices as early as in the manufacturing phase. Normally probe cards are therefore employed for the electric test of devices integrated on wafers before cutting and assembling them inside a containment package.

20 Generally, a probe card comprises a testing head, including in turn a plurality of contact elements or contact probes held by a pair of guides which are substantially plate-shaped and parallel to each other. Said guides are equipped with suitable guide holes and are arranged at a certain distance from each other in order to leave a free space for the
25 movement and possible deformation of the contact probes, which are slidably housed in said guide holes. The pair of guides comprises in particular an upper guide and a lower guide, both provided with guide holes within which the contact probes axially slide, which are usually formed by wires of special alloys with good electric and mechanical
30 properties.

 Good connection between the contact probes and the contact pads of the device under test is ensured by the pressure of the testing head on the device itself, the contact probes undergoing, during said pressing contact, a bending inside the air gap between the guides and a sliding

inside the corresponding guide holes. Testing heads of this kind are commonly called “testing heads with vertical probes” and indicated with the term “vertical probe head”.

5 Substantially, the vertical probe heads have an air gap in which a bending of the contact probes occurs, said bending can be helped by means of a suitable configuration of the probes themselves or of the guides thereof, as schematically illustrated in figure 1.

10 In particular, figure 1 schematically illustrates a probe card 10 comprising a testing head 1, including in turn an upper guide 2, usually indicated as “upper die”, and a lower guide 3, usually indicated as “lower die”, separated by an air gap 8, having respective guide holes 2a and 3a within which a plurality of contact probes 4 slides, just one probe of the plurality of contact probes being shown for the sake of simplicity in figure 1.

15 Each contact probe 4 has at one end a contact tip 4a intended to abut onto a contact pad 5a of a device under test integrated on a wafer 5, so as to provide the mechanical and electric contact between said device under test and a testing apparatus (not shown), which the testing head 1 forms a terminal element of.

20 The term “contact tip” indicates, here and in the following, an end area or region of a contact probe intended to contact a contact pad of the device under test, said end area or region not being necessarily pointed.

In some cases, the contact probes are fixedly fastened to the testing head at the upper plate-like support: they are referred to as testing heads with “blocked probes”.

25 However, more frequently testing heads having not fixedly fastened probes, but held interfaced to a so-called board, possibly through a microcontacter equipped with a plurality of contact pads, are used: they are referred to as testing heads with “not blocked probes”. The microcontacter is usually called “space transformer” since, in addition to
30 the contact with the probes, it also allows spatially redistributing the contact pads formed thereon with respect to the contact pads of the device under test, in particular through a loosening of the distance constraints between the centers of the pads themselves.

In this case, as illustrated in figure 1, each contact probe 4 has a further end area or region which ends with a so-called contact head 4b towards a contact pad 6a of a plurality of contact pads of a space transformer 6 comprised in the probe card 10. Good electric contact between probes 4 and space transformer 6 is ensured by pressing the contact heads 4b of the contact probes 4 onto the contact pads 6a of the space transformer 6 analogously to the contact between the contact tips 4a and the contact pads 5a of the device under test integrated on a wafer 5.

Generally, the probe card 10 further comprises a support plate 7 (for instance a PCB card), which is in contact with the space transformer 6 and is adapted to interface said probe card 10 with the testing apparatus.

The correct operation of a probe card is fundamentally linked to two parameters: the vertical movement, or overtravel, of the contact probes and the horizontal movement, or scrub, of the contact tips of said contact probes on the contact pads.

All these features are to be evaluated and calibrated during the manufacturing phase of a probe card, since the good electric connection between probes and device under test should always be ensured.

Equally important is to ensure that the pressing contact of the contact tips of the probes onto the contact pads of the device is not so high as to cause the breakage of the probe or of the pad itself.

This problem is strongly felt in the case of the so-called short probes, namely probes with limited body height, in particular with dimensions less than 5000 μm . Probes of this type are for instance used for high-frequency applications, the reduced length of the probes limiting the related self-inductance phenomenon and increasing the performance of the probe card. In particular, the term "probes for high-frequency applications" indicates probes capable of carrying signals with frequencies greater than 1 GHz.

Indeed, the recent need is well known of producing probe cards capable of carrying signals at ever higher frequencies up to radiofrequencies, with the consequent need of a drastic reduction in length of the contact probes to allow such high-frequency signals to be

carried without adding noise, for instance due to the above-mentioned self-inductance phenomenon.

However, in this case, the reduced length of the body of the probes dramatically increases the stiffness of the probe itself, which implies an increase in the force applied by the corresponding contact tip onto the contact pads of a device under test, which can also lead to the breakage of said pads, with an irreparable damage to the device under test, a situation which obviously should be avoided. Even more dangerously, the increase in the stiffness of the contact probe due to the reduction in the length of its body also increases the risk of breakage of the probes themselves.

Therefore, the technical problem of the present invention is to provide an interface element for a testing apparatus of electronic devices having structural and functional features such as to allow overcoming the limitations and drawbacks which still nowadays affect the known solutions, in particular able to interface in a simple manner with a probe card, thus allowing the test of high-frequency electronic devices without adding noise to the carried signals and eliminating the risk of breakage of its contact elements and of the contact pads of the electronic devices under test.

A further object of the present invention is to provide an interface element of the above indicated type through a simple and quick manufacturing process.

Disclosure of Invention

The solution idea underlying the present invention is to provide an interface element for a probe card filling a plurality of through-openings formed in a support thereof with a conductive elastomer, whose end portions are adapted to contact contact pads of a device under test and/or of components of the probe card which said interface element is associated with, the pressure of said conductive elastomer onto said contact pads allowing the desired mechanical and electric connection.

Based on this solution idea, the above technical problem is solved by an interface element for a testing apparatus of electronic devices, said interface element comprising at least one support equipped with a

plurality of through-openings which house respective interconnection elements extending between a first end and a second end, the interface element being characterized in that the interconnection elements are made of a conductive elastomer that fills the openings of the support,
5 each of said interconnection elements forming a conductive channel between different and opposing faces of said support.

More particularly, the invention comprises the following additional and optional features, taken singularly or in combination if needed.

10 According to an aspect of the present invention, at least one of the first end and the second end of the interconnection elements may protrude from the openings.

According to another aspect of the present invention, the end protruding from the openings can have a section that is less than a section of a portion of the interconnection elements housed inside the
15 openings.

Furthermore, a terminal portion of the end protruding from the openings may comprise a coating metal portion.

20 According to another aspect of the present invention, at least one of the ends of the interconnection elements may comprise a conductive contact element, a first end portion of said conductive contact element being inserted in said at least one of said ends and a second end portion, opposite the first end portion, of said conductive contact element protruding from said at least one of said ends.

25 In particular, the interconnection elements may have a length comprised between 100 μm and 300 μm , said length being measured along a longitudinal axis of the interconnection elements.

Furthermore, the conductive elastomer forming the interconnection elements may comprise an elastomeric material including in turn micro or nano particles of conductive material.

30 According to an aspect of the present invention, at least one portion of the walls of the openings may be coated by a conductive portion.

According to another aspect of the present invention, one of the ends of the interconnection elements may be adapted to contact contact pads of a device under test and the other end of said interconnection elements

may be adapted to contact contact pads of a space transformer associated with the interface element.

Alternatively, the ends of the interconnection elements may be adapted to contact contact pads of components associated with the interface element and between which said interface element is arranged, said interface element providing the mechanical and electric connection among said components.

The present invention also refers to a probe card for a testing apparatus of electronic devices, characterized by comprising at least one interface element of the above described type, said at least one interface element being adapted to perform the contact with contact pads of a device under test by means of the interconnection elements and/or by acting as an electric and mechanical connection element among different components of the probe card.

In particular, the interface element can be arranged between a space transformer and a testing head that comprises a plurality of contact probes extending between a tip portion adapted to contact the contact pads of the device under test and a head portion and are housed in guide holes of at least one guide, said head portion of the contact probes being associated with the first end of the interconnection elements.

According to an aspect of the present invention, the contact probes may be T-shaped, wherein the head of the T corresponds to the head portion of the contact probes and is adapted to abut onto the first protruding end of the interconnection elements.

The present invention also refers to a method for manufacturing an interface element for a testing apparatus of electronic devices, said method comprising at least the steps of:

- providing a substantially plate-like support;
- forming a plurality of through-openings in the support; and
- filling the openings by means of a conductive elastomer, thus forming a plurality of interconnection elements housed in said openings, said interconnection elements extending between a first end and a second end, wherein each of the interconnection elements forms a conductive channel between different and opposing faces of the support.

According to an aspect of the present invention, the step of filling the openings may be preceded by a step of arranging a mask onto at least one of the faces of the support, said mask being provided with openings at said openings of said support.

5 According to another aspect of the present invention, the method may comprise a step of selecting a thickness of the mask in order to select a length of the protruding ends, and/or of selecting a diameter of the openings of said mask in order to select a section of said protruding ends.

10 Furthermore, the step of filling the openings of the support may be performed through a polymerization process. In particular, the polymerization process may be performed by means of thermal cycles.

Finally, the method may further comprise a step of depositing a conductive portion onto at least one portion of the walls of the openings of the support.

15 The features and advantages of the interface element and of the method according to the invention will be apparent from the following description of an embodiment thereof, given by non-limiting example, with reference to the accompanying drawings.

Brief Description of Drawings

20 In these drawings:

- figure 1 schematically shows a probe card realised according to the prior art;

- figure 2 schematically shows in section an interface element realised according to the present invention;

25 - figures 3A and 3B schematically show a detail of the interface element according to a preferred embodiment of the present invention, in a rest condition and in a pressing condition onto contact pads of a device under test, respectively;

30 - figures 4A and 4B schematically show a detail of an interconnection element of the interface element of the present invention in a rest condition and in a pressing condition onto contact pads of a device under test, respectively;

- figures 5A and 5B schematically show an interface element according to alternative embodiments of the present invention;

- figure 6 schematically shows in section a probe card comprising the interface element according to the present invention;
- figures 7A and 7B schematically show probe cards according to alternative embodiments of the present invention;
- 5 - figures 8A-8F schematically show steps of a manufacturing method of the interface element according to the present invention; and
- figures 9A-9C schematically show steps of a manufacturing method according to an embodiment of the present invention.

Modes for Carrying Out the Invention

10 With reference to said figures, and in particular to figure 2, reference number 20 globally and schematically indicates an interface element for a testing apparatus of electronic devices integrated on a semiconductor wafer realised according to the present invention.

15 It is worth noticing that the figures represent schematic views and are not drawn to scale, instead they are drawn so as to enhance the important features of the invention. Furthermore, in the figures, the different elements are shown schematically, since their shape may vary according to the desired application. It should also be noticed that in the figures identical reference numbers refer to elements identical in shape or function. Finally, particular expedients described in connection with
20 an embodiment illustrated in a figure can also be used for the other embodiments illustrated in the other figures.

 As shown in figure 2, the interface element 20 comprises at least one support or substrate 21 that is substantially plate-like and equipped with
25 a plurality of through-openings 22 formed between different and opposing faces of said support 21, in particular between two opposing faces thereof, Fa and Fb, face Fa being a lower face and face Fb being an upper face according to the local reference of the figures.

 The support 21 is made of a ceramic material or alternatively of a
30 polyamide material, such as for instance Kapton or Mylar, even if other suitable materials are obviously possible, the present invention not being limited to a determined kind of material for the support 21.

 The openings 22 of the support 21 are adapted to house a respective plurality of interconnection elements, which are all indicated in the

present description with reference number 23.

Even if figure 2 only shows six interconnection elements 23 for the sake of simplicity, it is apparent that the interface element 20 may comprise a number of interconnection elements 23 which varies
5 according to the needs and/or circumstances, the figures being provided just by way of non-limiting example of the present invention.

As shown in figure 2, in a preferred embodiment of the present invention, the interconnection elements 23 of the interface element 20 are adapted to contact contact pads 24 of a device under test integrated
10 on a semiconductor wafer 25, thus ensuring the electric connection of said contact pads 24 with contact pads 26 of a space transformer 27. In other terms, the interface element 20 acts as a testing head to ensure the contact with the device under test, the interconnection elements 23 having opposite ends adapted to contact the contact pads 24 of the device
15 under test and the contact pads 26 of the space transformer 27, as it will be illustrated in greater detail in the following.

However, it is pointed out that the present invention is not limited to the above exposed application, since the interface element 20 can also be used in a probe card as an electric and mechanical connection element
20 among different components between which it is arranged. Consequently, the interface element 20 can also be adapted to contact contact pads of additional components of a probe card which it is associated with (for instance interposed).

In any case, though not limited to a particular application and
25 arrangement, the interface element 20 of the present invention will be illustrated in the following mainly in connection with the preferred application thereof, wherein the interconnection elements 23 are adapted to contact the contact pads 24 of the device under test.

Advantageously according to the present invention, the
30 interconnection elements 23 are made of a conductive elastomer that fills the openings 22 of the support 21. In other terms, the interconnection elements 23 are formed by filling the openings 22 of the support 21, for instance by depositing an elastomeric material into said openings 22, in accordance with a method that will be illustrated later.

In this way, each of the interconnection elements 23 forms a conductive channel between different and opposing faces of the support 21, in particular between the two opposing faces Fa and Fb.

Specifically, the interconnection elements 23 extend between a first end 23a and a second end 23b, opposite the first end 23a, which are intended to contact the contact pads 24 with the device under test and the contact pads 26 of the space transformer 27, respectively. In the example of the figures, the first end 23a is the end at the face Fa of the support 21, whereas the second end 23b is the end at the face Fb of the support 21.

The ends 23a and 23b of the interconnection elements 23 are free ends, the term “free ends” meaning here and in the following an end (be it a body portion of the interconnection elements 23 or a single face thereof) not in contact with the walls of the openings 22 of the support 21.

The ends 23a and 23b of the interconnection elements 23 preferably protrude from the openings 22 of the support 21, so as to ensure the contact of said interconnection elements 23 with the contact pads 24 of the device under test and with the contact pads 26 of the space transformer 27. Consequently, in order to ensure the desired mechanical and electric connection, the interconnection elements 23 comprise at least one end protruding from the openings 22, preferably both the ends protruding from the openings 22.

In the example of figure 2, the ends 23a and 23b are the end portions of a body 23' of the interconnection elements 23 extending therebetween along a longitudinal axis, indicated in the figure as axis H-H, even if other configurations are obviously possible.

In a preferred embodiment of the present invention, illustrated in figures 3A and 3B, the protruding ends 23a and 23b (the end 23a in the example of the figure, which only shows a portion of the interface element 20) have a section S1 that is less than a section S2 of the portion of the interconnection elements 23 that is housed inside the openings 22. In other terms, the ends 23a and 23b of the interconnection elements 23 are shaped so as to have a section S1 that is less than the section S2 of

the body 23' of the interconnection elements 23. It is noticed that, in the present description, the term "section" means a dimension of the interconnection elements 23 measured in a transversal direction, i.e. a direction orthogonal to the longitudinal axis H-H of said interconnection elements 23.

This embodiment is particularly advantageous since, on occasion of the pressing of the interface element 20, in particular of the ends 23a and 23b, onto the contact pads of a device under test and of the space transformer, said protruding ends 23a and 23b deform, in particular they have a bulging, as shown in greater detail in figure 3B, and therefore they greatly increase their transversal section. If the ends 23a and 23b were not provided with a section S1 less than the section S2 of the body 23' of the interconnection elements 23, further measures should be adopted to prevent their bulging from causing a short-circuit between adjacent interconnection elements 23, in particular spacing apart said interconnection elements 23 from each other, which is not optimal in case of applications in which low-pitch devices are tested (for instance less than 150 μm). Instead, the reduced section S1 of the ends 23a and 23b in a rest condition allows a deformation thereof such as there is no electric connection between adjacent interconnection elements 23 while pressing onto the contact pads 24 of the device under test, even with low-pitch, said pressing being indicated in the figures with the arrow F.

It is further noticed that at least one portion of the walls of the openings 22 is coated by a conductive portion 22w. Preferably, the entire wall of the openings 22 is metallized through the conductive portion 22w. Suitably, the metallized wall ensures a proper electric conductivity of the conductive channel formed by the interconnection elements 23 between the faces of the support 21. It is in fact noticed that the electric conductivity of the interconnection elements 23 varies according to their compression, said compression being more limited for the portion of the interconnection elements 23 inside the openings 22 compared to the one suffered by the protruding ends 23a and 23b thereof.

In fact, the conductive elastomer forming the interconnection elements 23 comprises an elastomeric material, including in turn micro

or nano particles of conductive material 23p, as illustrated in figures 4A and 4B. By way of example, the elastomeric material can be a silicone, which is filled with micro or nano particles of silver, even if other material can obviously be used.

5 In the above illustrated case, in which an elastomer charged with micro or nano particles of conductive material 23p is used, during the pressing of the interconnection elements 23, said particles 23p move from their rest position and contact the nearby particles. Furthermore, the peripheral particles 23p which are nearer to the contact pads 24 to be
10 contacted exert, during pressing, a slight abrasive mechanical action onto the pad itself, so as to allow providing the desired electric contact. As illustrated in figures 4A and 4B, passing from a rest condition to a pressing condition of the interconnection elements 23, the peripheral particles 23p thus exert an abrasive action onto the contact pads 24,
15 moving thereon as indicated by the arrow F'.

 According to an embodiment of the present invention, illustrated in figure 5A, a terminal portion of the protruding ends 23a and 23b also comprises a coating metal portion 28. In this way, the terminal portion of the ends 23a and 23b in contact with the contact pads of the device under
20 test or of the space transformer is metallized, thus ensuring an improved electric connection of the interconnection elements 23 with said contact pads.

 Furthermore, according to another embodiment of the present invention, illustrated in figure 5B, at least one of the ends 23a or 23b of
25 the interconnection elements 23 comprises a conductive contact element 29 (such as for instance a contact probe or a conductive foil) therein inserted. In particular, a first end portion of the conductive contact element 29 is inserted in the end 23a and/or 23b, whereas a second end portion, opposite said first end portion, of the conductive contact element
30 29 protrudes from said end 23a and/or 23b, said ends 23a and 23b not necessarily protruding from the openings 22 in this embodiment. By way of example, the conductive contact elements 29 can be contact probes equipped with a body extending between their first end portion and their second end portion, along a longitudinal axis parallel to the axis H-H. The

ends 23a and 23b of the interconnection elements 23 may comprise suitable housing seats for housing the conductive contact elements 29. Alternatively, the conductive contact elements 29 may be forcibly inserted into the ends 23a and 23b of the interconnection elements 23.

5 The protruding end portion of the conductive contact elements 29 is adapted to contact the contact pads 24 of the device under test. Consequently, in this embodiment, the end 23a and/or 23b of the interconnection elements 23 contacts the contact pads 24 of the device under test through the conductive contact element 29 therein inserted.

10 The presence of the conductive contact element 29, which is completely conductive, further improves the electric contact with the contact pads 24 of the device under test, with respect to the coating metal portion 28 of figure 5A.

15 The conductive contact element 29 have a length, measured along the longitudinal axis H-H, comprised between 100 μm and 500 μm , whereas the interconnection elements 23 generally have a length comprised between 100 μm and 300 μm . It is thus evident that, also in the presence of the conductive contact elements 29, the interface element 20 of the present invention is particularly suitable for performing the test
20 of high-frequency electronic devices.

It is once again noticed that, advantageously according to the present invention, one of the ends 23a or 23b of the interconnection elements 23 is adapted to contact the contact pads 24 of the device under test and the other end 23b or 23a is adapted to contact the contact pads
25 26 of the space transformer 27 associated with the interface element 20, which has a pitch between the interconnection elements 23 that cannot be obtained through the known solutions.

Obviously, the ends 23a and 23b of the interconnection elements 23 can also be adapted to contact contact pads of other components
30 associated with the interface element 20 and between which said interface element 20 is arranged, thus providing the mechanical and electric connection between said components.

In general, the interface element 20 of the present invention is particularly versatile and can be associated simply and effectively with a

probe card.

Figure 6 illustrates a probe card 40 for a testing apparatus of electronic devices realised according to a preferred embodiment of the present invention. In particular, the probe card 40 comprises the interface element 20 previously described and the space transformer 27. Furthermore, the probe card 40 comprises a PCB 30 adapted to interface with the testing apparatus, said PCB card 30 being associated with a stiffener 31 adapted to hold the probe card 40 in position. In this embodiment, the interface element 20 is suitably supported by a support element 32 connected to the support 21.

In figure 6 a preferred embodiment is illustrated, in which the interface element 20 is adapted to perform the contact with the contact pads 24 of the device under test integrated on the semiconductor wafer 25 through the interconnection elements 23, in particular through the first end 23a, and with the contact pads 26 of the space transformer 27 through the second end 23b. Obviously, as previously described, in an embodiment not illustrated in the figures, the interface element 20 may also act as an electric and mechanical connection element among different components of the probe card 40, for instance it may be arranged between the PCB 30 and the space transformer 27, if required by the circumstances.

Furthermore, the embodiment of figure 5B can be generalized by providing a probe card 40 in which the interface element 20 is associated with a traditional vertical-probe testing head 35, in particular arranged between the testing head 35 and the space transformer 27, as illustrated in figure 7A.

The testing head 35 comprises a plurality of contact probes 36, in particular probes having a length less than at least 1 mm (for instance between 200 μm and 500 μm) for testing high-frequency devices, said contact probes 36 being housed in respective guide holes 37h formed in at least one guide 37. The contact probes 36 extend between a pitch portion 36a, which is adapted to contact the contact pads 24 of the device under test, and a head portion 36b, which is generally adapted to contact contact pads of a space transformer.

In the example of figure 7A, provided by way of non-limiting example of the scope of the present invention, the contact probes 36 are free-body probes held in the guide holes 37h of the guide 37 at the head portion 36b thereof, which protrudes superiorly from said guide 37. Suitably, it is possible to associate said protruding head portion 36b with the first end 23a of the interconnection elements 23 of the interface element 20.

For instance, it is possible to insert the head portion 36b of the contact probes 36 into the first end 23a of the interconnection elements 23, or, preferably, said head portion 36b may rest on said first end 23a. Even more preferably, the head portion 36b may comprise a portion protruding superiorly to be inserted into the first end 23a of the interconnection elements 23, the rest of said head portion 36b resting on said first end 23a, thus ensuring a better connection.

Thanks to the association between contact probes 36 and interconnection elements 23, it is possible to solve the problem of stiffness of the contact probes 36 thanks to the presence of the interface element 20 arranged between the testing head 35 and the space transformer 27, whose contact pads 26 are in contact with the second end 23b of the conductive interconnection elements 23, the reduced length of said interconnection elements 23 not adding noise to the signals carried by the contact probes 36. Such an embodiment further prevents an undesired breakage of the contact pads 26 of the space transformer 27 as well, the interface element 20 suitably damping the contact of the contact probes 36 thanks to the elasticity of the interconnection elements 23.

Furthermore, in an embodiment shown in figure 7B, the contact probes 36 of the testing head 35 are T-shaped (or mushroom-shaped), in which the head of the T is adapted to abut onto the first end 23a, which is protruding, of the interconnection elements 23. In other terms, the head of the T of the contact probes 36 corresponds to the head portion 36b associated with the interconnection elements 23. In this embodiment, the pressing of the contact probes 36 in the overdrive step determines the compression of the first end 23a of the interconnection elements 23, the head of the contact probes 36 ensuring an extensive

abutting area onto said first end 23a, so as not to penetrate thereinto.

Now with reference to figures 8A-8F, a method for manufacturing an interface element 20 for a testing apparatus of electronic devices is hereinafter described.

5 In particular, as illustrated in figure 8A, the method comprises a preliminary step of providing a substantially plate-like support 21, which is preferably made of a ceramic material or of a polyamide material, such as for instance Kapton or Mylar, even if other suitable materials are obviously possible.

10 As illustrated in figure 8B, the method thus comprises a step of forming a plurality of through-openings 22 in the support 21.

Suitably, the step of forming the openings 22 is followed by a step of filling said openings 22 through a conductive elastomer, thus forming a plurality of interconnection elements 23 housed therein, each of said
15 interconnection elements 23 forming a conductive channel between different and opposing faces Fa and Fb of the support 21, the face Fa being a lower face and the face Fb, opposite the face Fa, being an upper face according to the local reference of the figures.

The interconnection elements 23 thus comprise a first end 23a and
20 a second end 23b for contacting contact pads of a device under test and/or contact pads of further components associated with the interface element 20 thus formed.

According to an embodiment of the present invention, the step of filling the openings 22 is preceded by a step of depositing a conductive
25 portion 22w onto at least one portion of the walls of said openings 22 of the support 21, preferably along the entire wall, as illustrated in figure 8C.

It is worth noticing that said metallization of the walls of the openings 22 is advantageous since it contributes improving the electric
30 conductivity of the conductive channel formed by the interconnection elements 23.

As illustrated in figure 8D, the step of filling the openings 22 of the support 21 is preceded by a step of arranging a mask 33 onto at least one of faces Fa and Fb of said support 21, so as to be able to shape at will the

ends 23a and 23b of the interconnection elements 23, in particular in terms of dimensioning of their heights and sections. To this end, the mask 33 is equipped with openings 22m at the openings 22 of the support 21.

5 Once the openings 22 of the support 21 and the openings 22m of the mask 33 have been filled with a conductive elastomer 34, as illustrated in figure 8E, the exceeding conductive elastomer is removed and afterwards the mask 33 is also removed, forming the interface element 20 equipped with the plurality of interconnection elements 23
10 made of conductive elastomer, as shown in figure 8F.

 Suitably, by modifying a thickness 33t of the mask 33 and a diameter of its openings 22m, it is possible to obtain ends 23a and 23b, protruding from the openings 22, of the interconnection elements 23 shaped at will according to the needs and/or necessity.

15 To this end, as illustrated in figures 9A-9C, the method of the present invention comprises a step of selecting the thickness 33t of the mask 33 in order to select the length of the ends 23a and 23b of the interconnection elements 23 protruding from the openings 22. Analogously, a step of selecting the diameter of the openings 22m of the
20 mask 33 is also provided, in order to select a section S1 of the protruding ends 23a and 23b, forming in particular the ends 23a and 23b with a reduced section with respect to the body of the interconnection elements 23, so as to avoid an undesired electric connection between said ends while the interface element 20 presses for instance onto contact pads of
25 a device under test.

 In particular, it is thus possible to choose different thicknesses and diameters of the openings at faces Fa and Fb, as illustrated in figures 9A-9C. In other terms, through the morphology of the mask 33 it is possible to obtain protruding ends 23a and 23b calibrated with different
30 geometries and different dimensions according to the needs and/or necessity.

 In the example of figures 9A-9C, the end having reduced section is end 23b, even if the same shape may obviously be chosen for end 23a.

 The step of filling the openings 22 of the support 21 is performed

through a polymerization process. In particular, according to a preferred embodiment of the present invention, a polymer/catalyst in the liquid state poured onto the area of interest is used, in particular into the openings 22 of the support 21 and into the openings 22m of the mask 33.

The polymerization process varies according to the elastomeric material being used, for instance it may be performed by means of thermal cycles, UV exposition or in any other suitable way.

By way of example, the elastomeric material may be a silicone, which is filled with micro or nano particles of silver, even if other materials may obviously be used.

It is thus clear that the method of the present invention allows forming an interface element 20 comprising a high number of interconnection elements 23 in a very short time, said interconnection elements 23 being formed simultaneously by means of the above method, turning out to be correctly positioned and distanced apart thanks to the provision of the openings 22 where desired.

In conclusion, the present invention provides an interface element wherein a plurality of through-openings formed in a support thereof is filled with a conductive elastomer, whose end portions are adapted to contact contact pads of a device under test and/or of components of a probe card which said interface element is associated with, the pressing of said conductive elastomer onto said contact pads allowing the desired mechanical and electric connection.

Advantageously according to the present invention, it is possible to form an interface element whose contact elements are the interconnection elements made of elastomeric material, the length of which is such as to allow an effective working even at radio frequencies without adding noise to the carried signals.

In fact, it is pointed out that, according to the present invention, the interconnection elements of the interface element have a length less than at least 300 μm .

The interconnection elements further have an elasticity able to ensure a correct damping of the contact with the contact pads of a device

under test or of a space transformer, overcoming the problem of stiffness and of the high probability of breakage of the prior art short probes, meanwhile ensuring a proper reduction of the pressure onto said contact pads, thus avoiding a breakage thereof.

5 Consequently, the interface element of the present invention on the one hand allows testing the electronic devices for high-frequency applications, on the other hand it allows avoiding the breakage of the contacts elements thereof and/or of the contact pads of the devices under test or of the space transformer, the elasticity of the interconnection
10 elements ensuring the removal of any tangential and longitudinal stress onto said contact pads, thus solving the technical problem of the present invention.

Also in case the terminal portions of the ends of the interconnection elements are coated with a coating conductive material, the absence of
15 tangential stresses onto the contact pads of the device under test or of the space transformer is in any case always ensured.

The interface element of the present invention, though able to perform the test of electronic devices even with a very low pitch, is in any case very versatile and may be also used as a mechanical and electric
20 connection element among different components of a probe card.

It is also pointed out that the proposed interface element may be easily removed and replaced if required by the circumstances and/or necessity, allowing an easy re-configuration of the probe card which it
25 interfaces with. Consequently, once the interface element has been associated with a probe card, also its removal and replacement is particularly easy and quick.

Furthermore, advantageously according to the present invention, the method described allows an extremely quick and cheap manufacturing of the interface element, since in a short time it is possible
30 to simultaneously form a high number of interconnection elements by depositing an elastomeric material directly into the openings of the support, without needing to proceed to an assembly process of the pick and place type of said interconnection elements, with a consequent reduction of the assembly time.

This method allows forming an interface element in which the pitch between the interconnection elements is greatly reduced. The possibility to reduce the pitch thus allows testing electronic devices directly through the interface element, in which the interconnection elements are adapted to contact the contact pads of said device, said interconnection elements being very short and elastic. The possibility to contact contact pads of a device under test with elastomers is thus a distinctive feature of the present invention, even if the proposed interface element is particularly versatile and may also be used simply as mechanical/electric interface in a probe card, as well as it may also be suitably associated with short probes of a testing head.

Obviously, a person skilled person, in order to satisfy contingent and specific needs, may make numerous modifications and variations to the above described interface element and method, all included in the scope of the invention as defined by the following claims.

CLAIMS

1. An interface element (20) for a testing apparatus of electronic devices, said interface element (20) comprising at least one support (21) provided with a plurality of through openings (22) that house respective
5 interconnection elements (23), which extend between a first end (23a) and a second end (23b), said interface element (20) being characterized in that said interconnection elements (23) are made of a conductive elastomer that fills said openings (22), each of said interconnection elements (23) forming a conductive channel between different and opposing faces (Fa, Fb) of said support (21).
10
2. The interface element (20) according to claim 1, characterized in that at least one of said first end (23a) and said second end (23b) of said interconnection elements (23) protrudes from said openings (22).
3. The interface element (20) according to claim 2, characterized
15 in that said end (23a, 23b) protruding from said openings (22) has a section (S1) that is less than a section (S2) of a portion of said interconnection elements (23) housed inside said openings (22).
4. The interface element (20) according to claim 2 or 3, characterized in that a terminal portion of said end (23a, 23b) protruding
20 from said openings (22) comprises a coating metal portion (28).
5. The interface element (20) according to claim 1, characterized in that at least one of said ends (23a, 23b) of said interconnection elements (23) comprises a conductive contact element (29), a first end portion of said conductive contact element (29) being inserted in said at
25 least one of said ends (23a, 23b), and a second end portion, opposite said first end portion, of said conductive contact element (29) protruding from said at least one of said ends (23a, 23b).
6. The interface element (20) according to any one of the preceding claims, characterized in that said interconnection elements
30 (23) have a length between 100 μm and 300 μm , said length being measured along a longitudinal axis (H-H) of said interconnection elements (23).
7. The interface element (20) according to any one of the preceding claims, characterized in that said conductive elastomer

forming said interconnection elements (23) comprises an elastomeric material in turn including micro or nano particles of conductive material (23p).

5 8. The interface element (20) according to any one of the preceding claims, characterized in that at least one portion of the walls of said openings (22) is coated by a conductive portion (22w).

10 9. The interface element (20) according to any one of the preceding claims, characterized in that one of said ends (23a, 23b) of said interconnection elements (23) is adapted to contact contact pads (24) of a device under test, and the other one of said ends (23b, 23a) of said interconnection elements (23) is adapted to contact contact pads (26) of a space transformer (27) associated with said interface element (20).

15 10. The interface element (20) according to any one of the claims from 1 to 8, characterized in that said ends (23a, 23b) of said interconnection elements (23) are adapted to contact pads of components associated with said interface element (20) and between which said interface element (20) is arranged, said interface element (20) providing the mechanical and electrical connection among said components.

20 11. A probe card (40) for a testing apparatus of electronic devices, characterized in that it comprises at least one interface element (20) according to any one of the preceding claims, said at least one interface element (20) being adapted to perform the contact with contact pads (24) of a device under test by means of said interconnection elements (23) and/or acting as an electrical and mechanical connection element among
25 different components of said probe card (40).

30 12. The probe card (40) according to claim 11, characterized in that said interface element (20) is arranged between a space transformer (27) and a testing head (35) that comprises a plurality of contact probes (36), said contact probes (36) extending between a tip portion (36a) adapted to contact said contact pads (24) and a head portion (36b) and being housed in guide holes (37h) of at least one guide (37), said head portion (36b) of said contact probes (36) being associated with said first end (23a) of said interconnection elements (23).

13. The probe card (40) according to claim 12, characterized in

that said contact probes (36) are T-shaped, wherein the head of the T corresponds to said head portion (36b) of said contact probes (36) and is adapted to abut onto said protruding first end (23a) of said interconnection elements (23).

5 14. A method for manufacturing an interface element (20) for a testing apparatus of electronic devices, said method comprising at least the steps of:

- providing a substantially plate-like support (21);
- forming a plurality of through openings (22) in said support
- 10 (21); and
- filling said openings (22) by means of a conductive elastomer, forming a plurality of interconnection elements (23) housed in said openings (22), said interconnection elements (23) extending between a first end (23a) and a second end (23b),

15 wherein each of said interconnection elements (23) forms a conductive channel between different and opposing faces (Fa, Fb) of said support (21).

15 15. The method according to claim 14, wherein said step of filling said openings (22) is preceded by a step of arranging a mask (33) on at least one of said faces (Fa, Fb) of said support (21), said mask (33) being provided with openings (22m) at said openings (22) of said support (21).

20 16. The method according to claim 15, further comprising a step of selecting a thickness (33t) of said mask (33) in order to select a length of said protruding ends (23a, 23b), and/or a step of selecting a diameter of said openings (22m) of said mask (33) in order to select a section (S1) of said protruding ends (23a, 23b).

25 17. The method according to any one of the claims from 14 to 16, wherein said step of filling said openings (22) of said support (21) is performed by means of a polymerization process.

30 18. The method according to claim 17, wherein said polymerization process is performed by means of thermal cycles.

19. The method according to any one of the claims from 14 to 18, further comprising a step of depositing a conductive portion (22w) onto at least one portion of the walls of said openings (22) of said support (21).