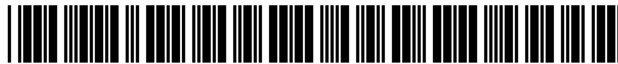
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Crippa

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(54) **PROBE HEAD FOR ELECTRONIC DEVICES AND CORRESPONDING PROBE CARD**

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(30) **Foreign Application Priority Data**

Aug. 7, 2019 (IT) 102019000014208

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G01R 1/073 (2006.01)
G01R 1/067 (2006.01)

(52) **U.S. Cl.**
CPC ***G01R 1/07357*** (2013.01); ***G01R 1/06738*** (2013.01); ***G01R 1/07378*** (2013.01)

(58) **Field of Classification Search**
CPC G01R 1/07357; G01R 1/06738; G01R 1/07378; G01R 1/07371; G01R 31/2886; G01R 1/07314; G01R 31/2808
See application file for complete search history.

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(57) **ABSTRACT**

A probe head for a test equipment of electronic devices comprises a plurality of contact probes inserted in guide holes provided in at least one upper guide and one lower guide, a bending area for the contact probes being defined between the upper and lower guides, each contact probe having at least one first terminal portion which protrudes of a first length from the lower guide and ends with a contact tip (**22**A) adapted to abut onto a respective contact pad of a device to be tested, as well as a second terminal portion which protrudes of a second length from the upper guide and ends with a contact head adapted to abut onto a contact pad of a board for connecting or interfacing with the test equipment, suitably comprising at least one protection structure projecting from the upper guide in direction of a longitudinal development axis of the contact probes towards the board, the protection structure thus extending in correspondence of the contact heads of the contact probes.

9 Claims, 14 Drawing Sheets

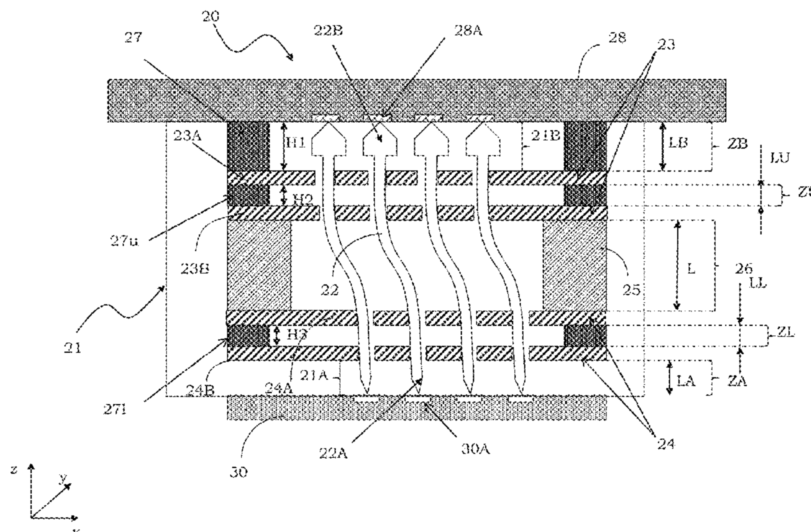

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FIG. 1
PRIOR ART

1 2 2A 2B 2C 3 3A 4 4A 5 6 7 7A 8 8A 9 10 Dshift π x y z

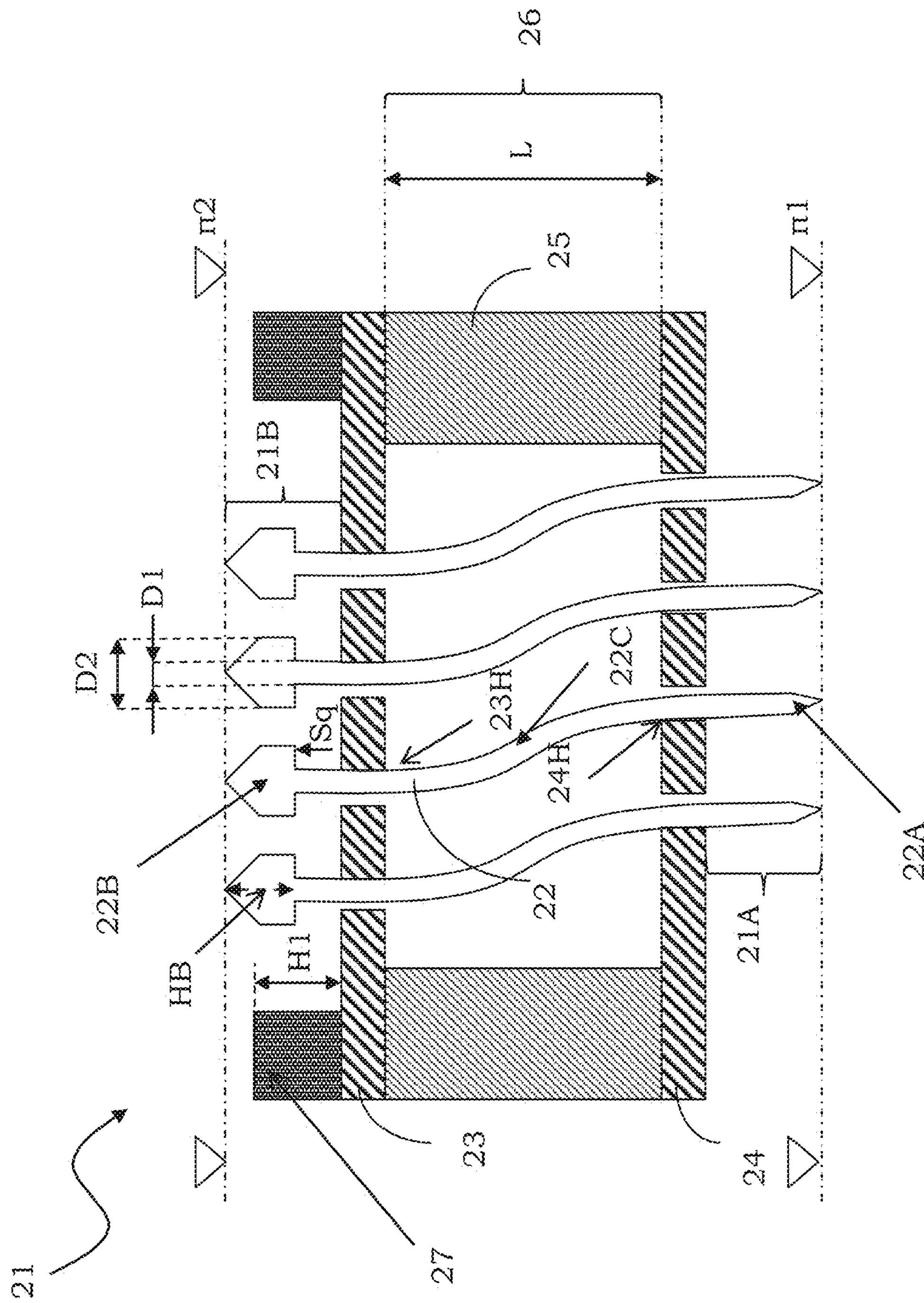

FIG. 2

FIG. 3A

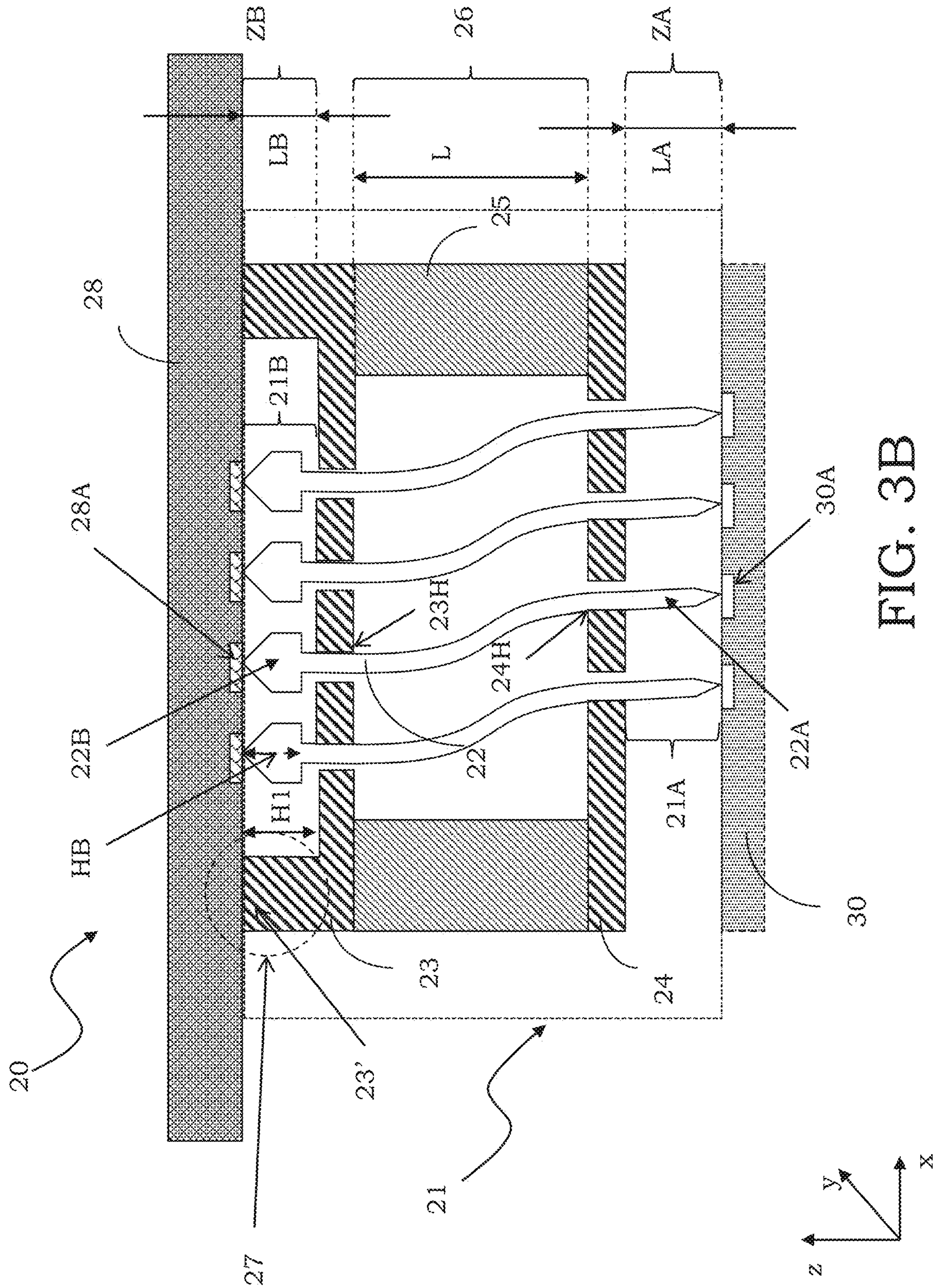

FIG. 3B

ZB
26
ZA
LB
L
LA
25
28
21B
28A
30A
23H
24H
22B
22A
22
HB
H1
21A
30
20
27a
27b
27c
27
27d
23
24
21
y
x
z

FIG. 3C

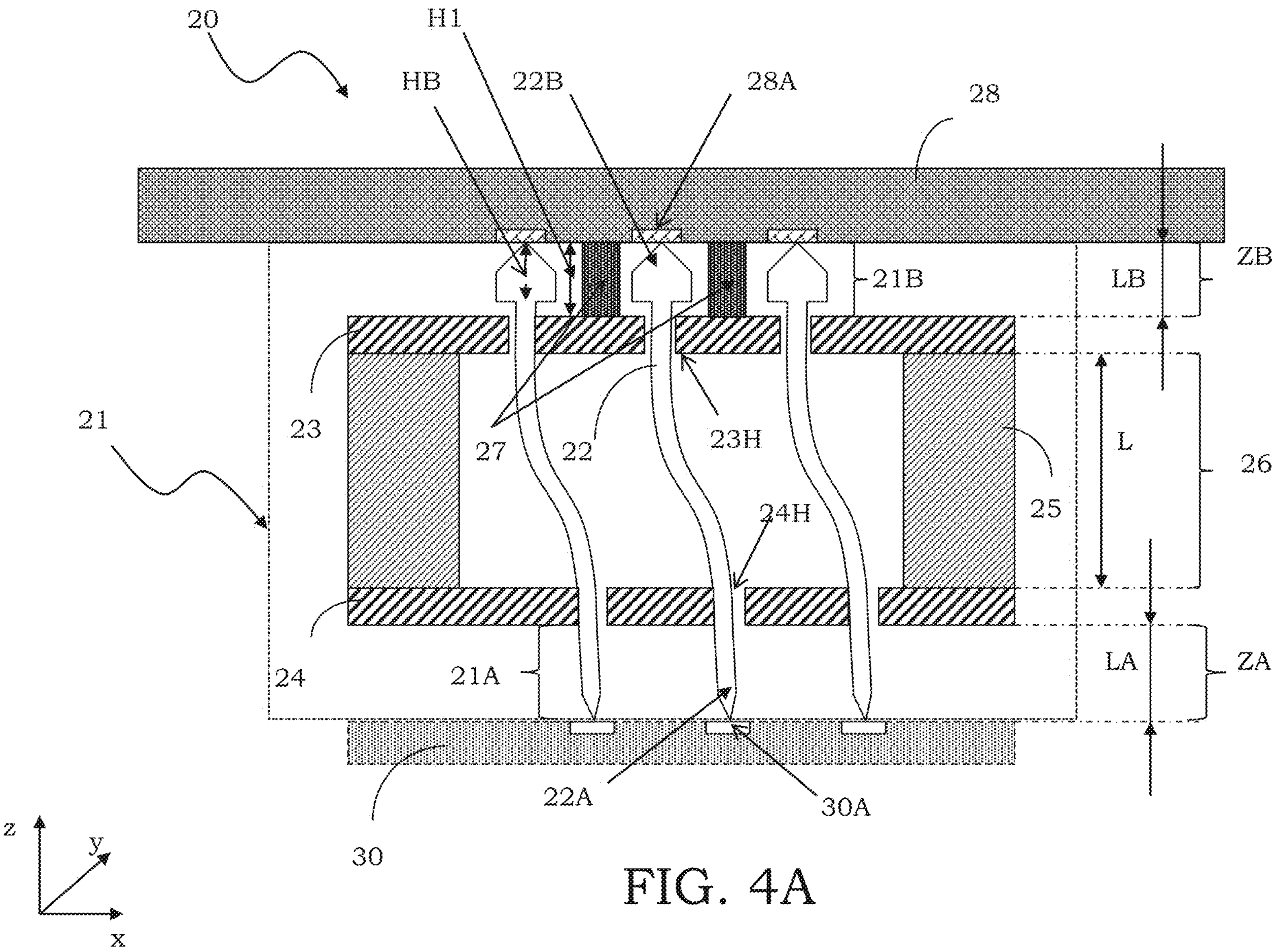

FIG. 4A

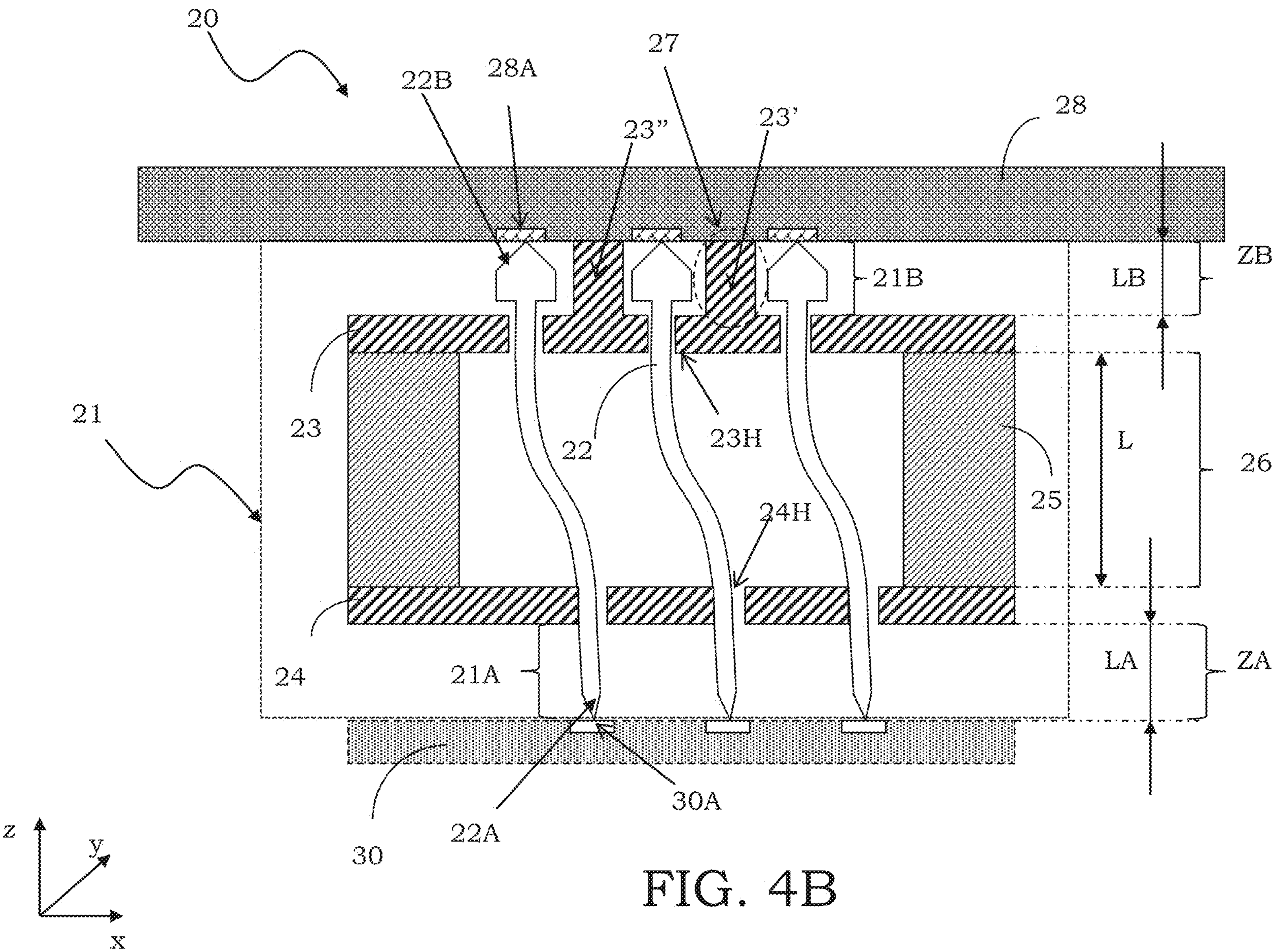

FIG. 4B

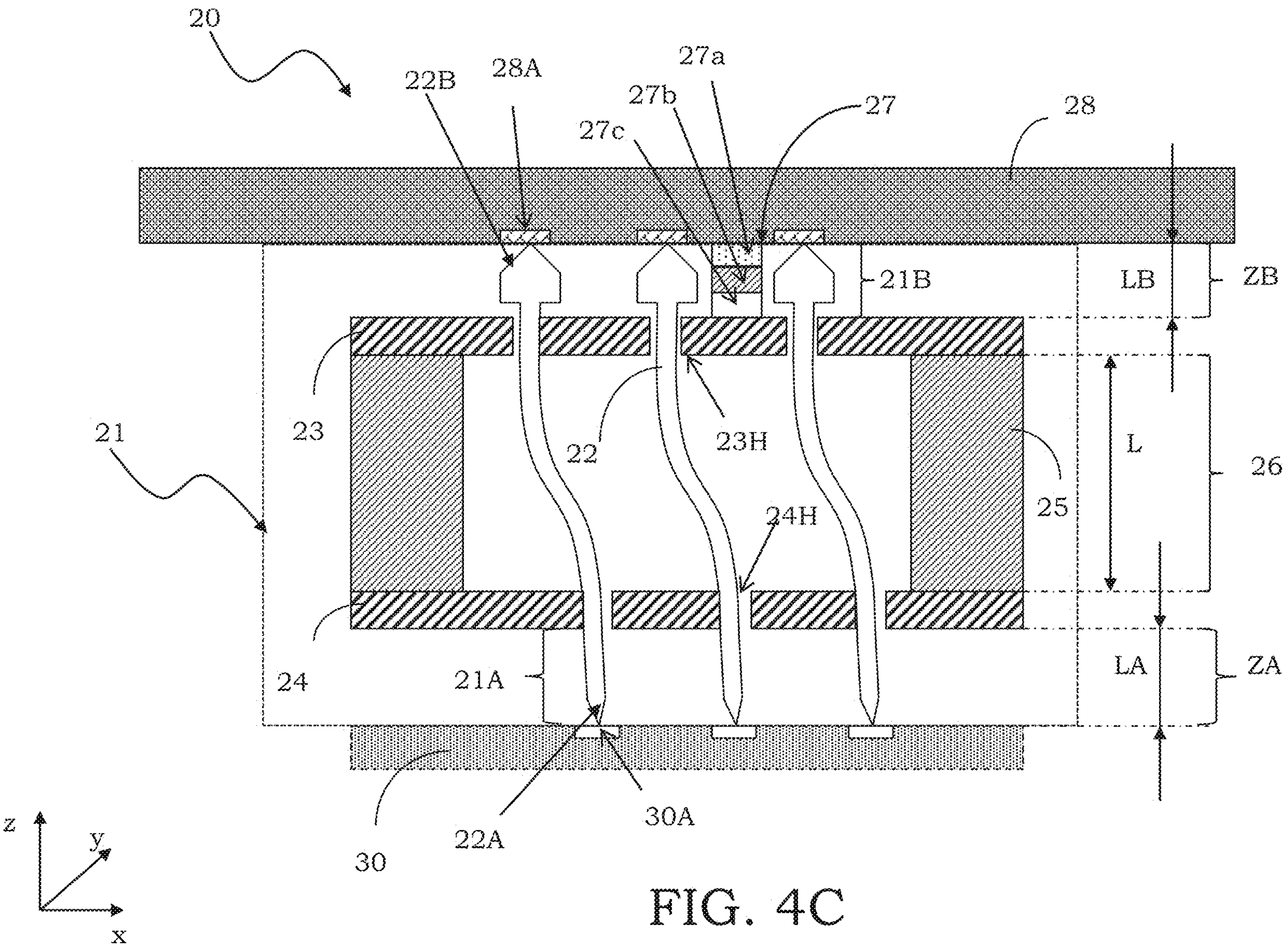

FIG. 4C

FIG. 5A

FIG. 5B

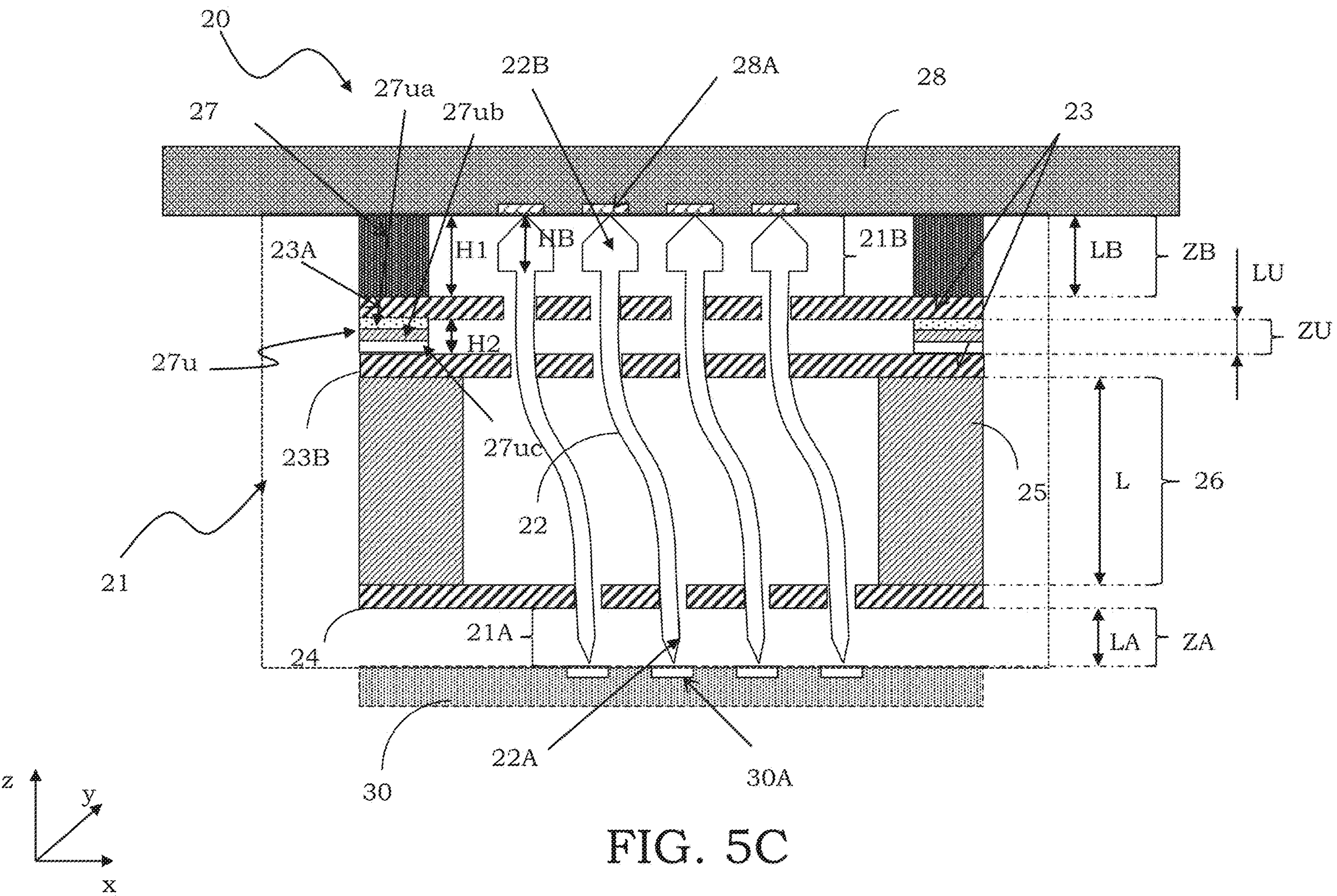

FIG. 5C

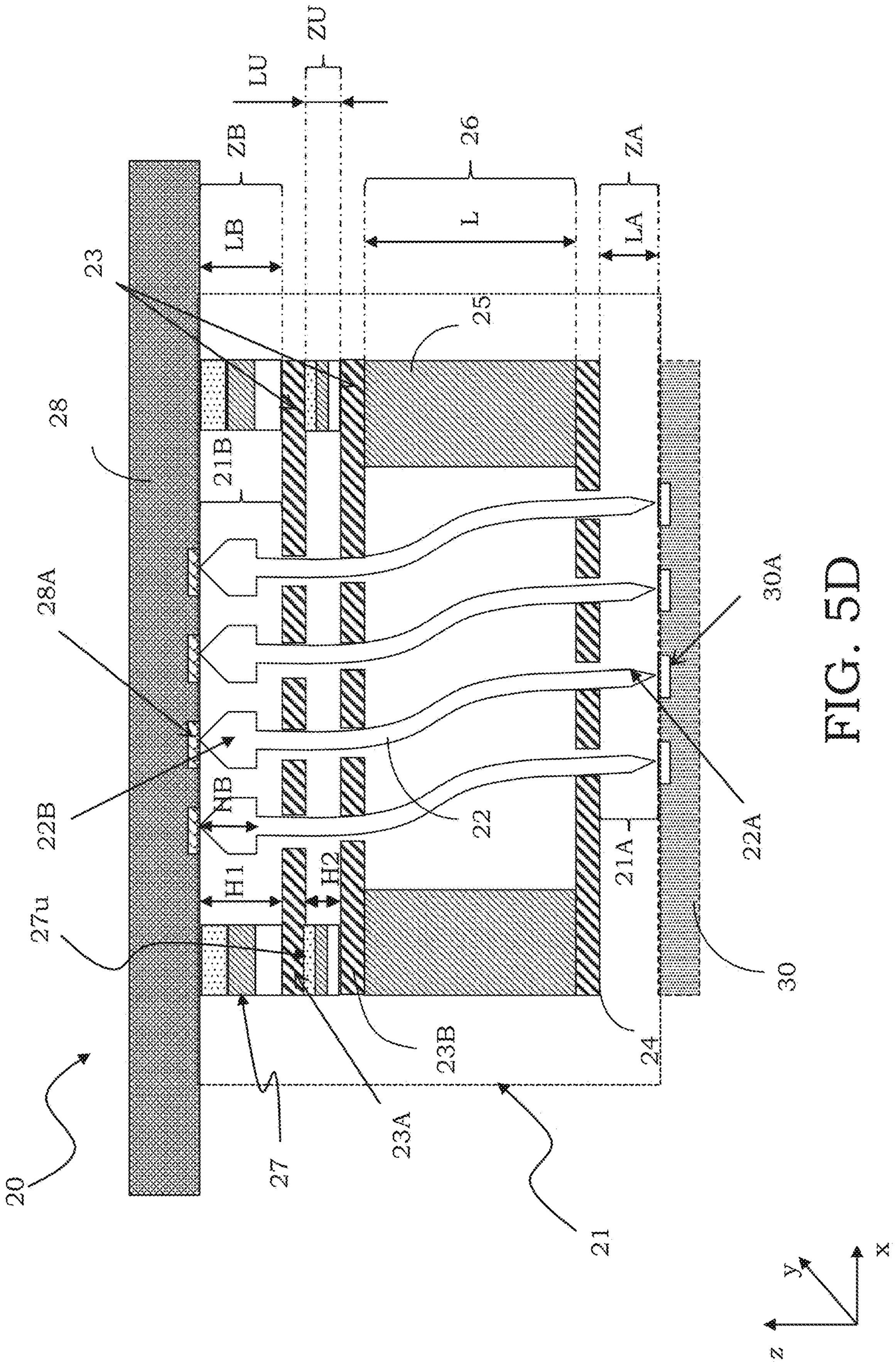

FIG. 5D

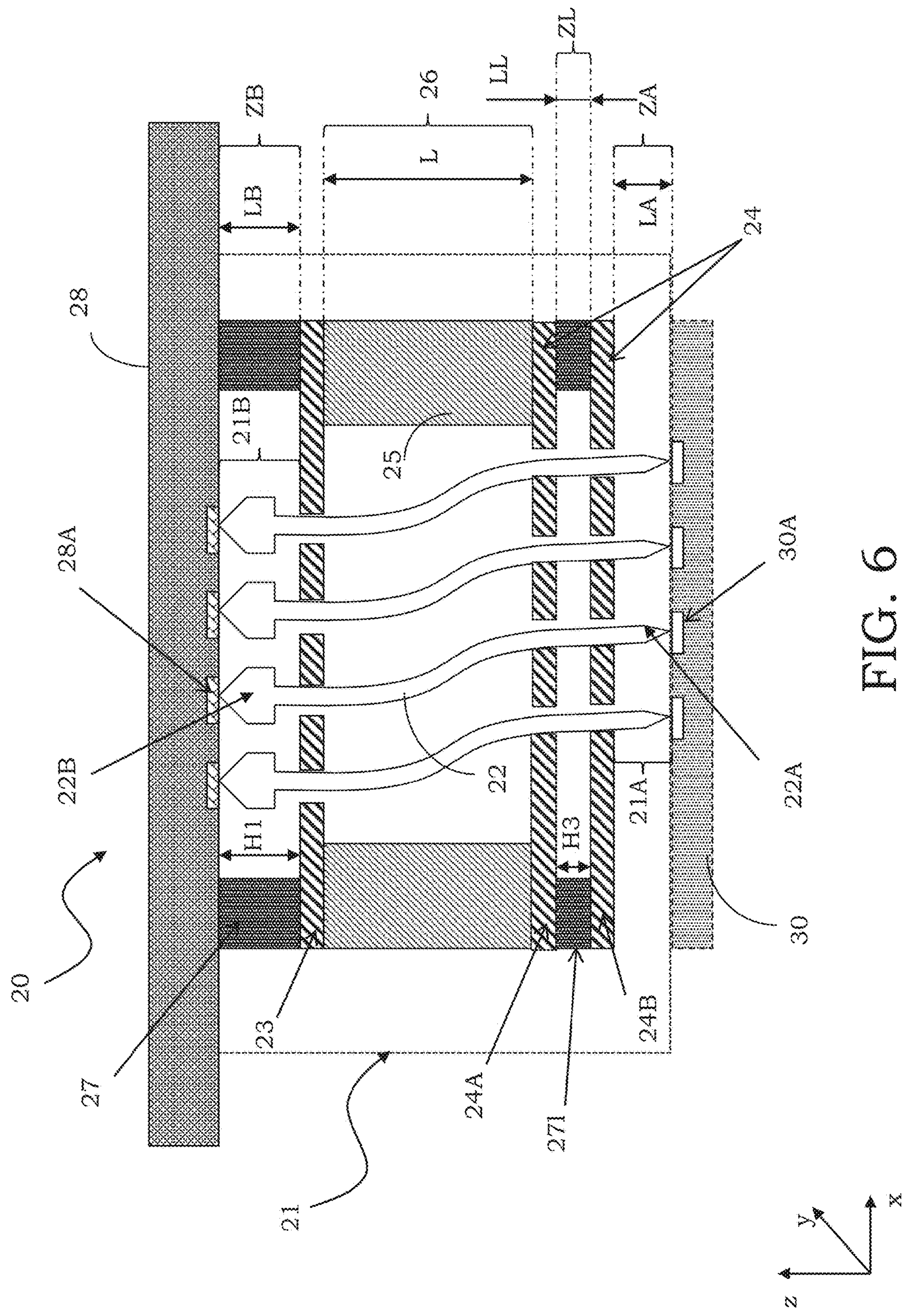

FIG. 6

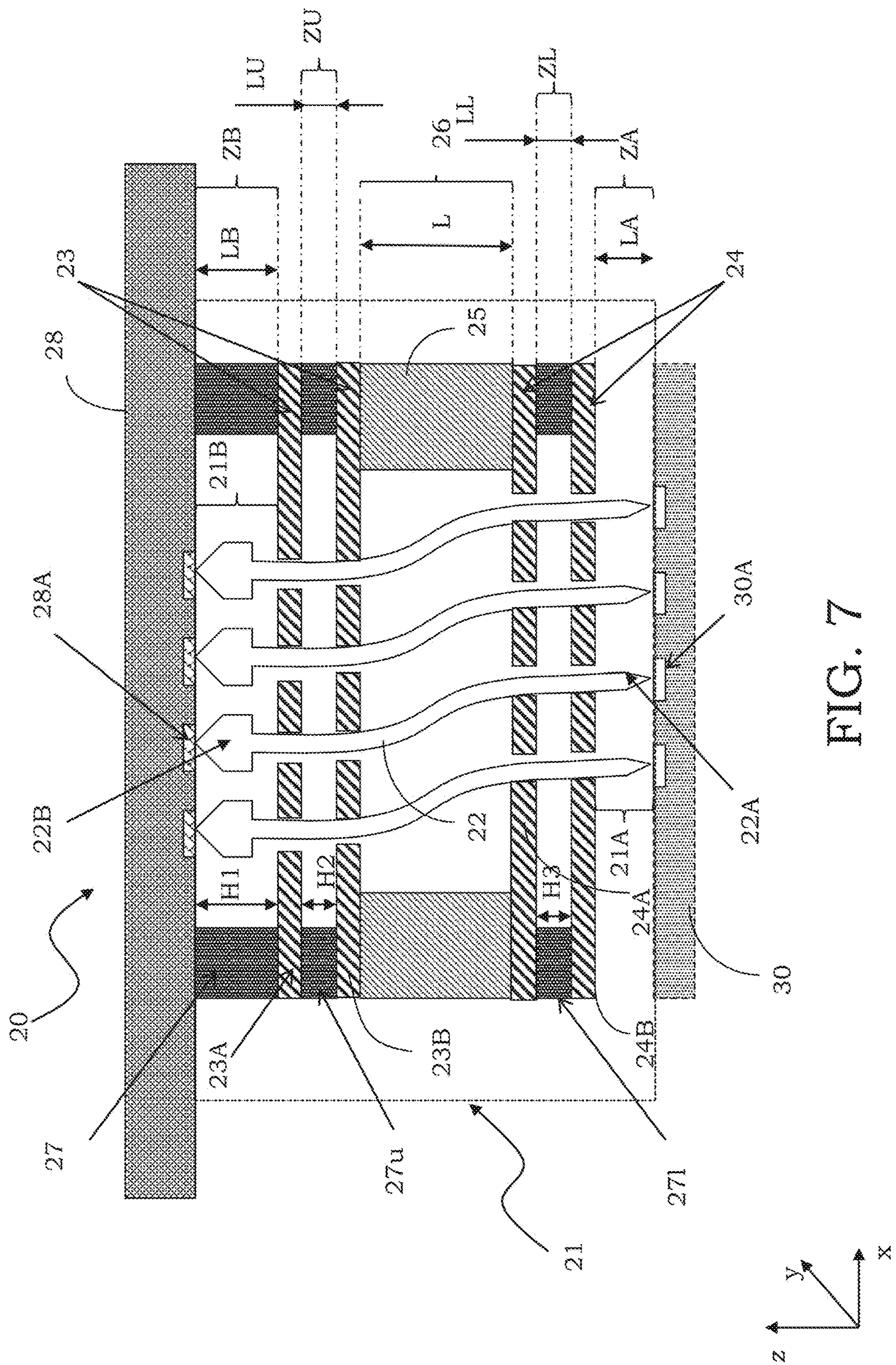

FIG. 7

PROBE HEAD FOR ELECTRONIC DEVICES AND CORRESPONDING PROBE CARD

RELATED APPLICATIONS

The present application is a Continuation-in-Part (CIP) application of Int. Pat. App. No. PCT/EP2020/071893, filed Aug. 4, 2020 and entitled "Probe head for electronic devices and corresponding probe card," which claims priority to Italian Pat. App. No. 102019000014208, filed Aug. 7, 2019, the entire disclosures of which applications are hereby incorporated herein by reference.

TECHNICAL FIELD

The present disclosure refers to a probe head for a test equipment of electronic devices.

The disclosure relates in particular, but not exclusively, to a probe head with vertical probes for testing electronic devices, in particular integrated on a semiconductor wafer and the following description is made with reference to this field of application with the sole purpose of simplifying the presentation thereof.

DESCRIPTION OF THE RELATED ART

As is well known, a probe head is essentially a device adapted to electrically connect a plurality of contact pads of a microstructure, in particular an electronic device integrated on a wafer, with corresponding channels of a test equipment which verifies the functionality thereof, in particular the electrical one.

The test carried out on integrated devices is used to detect and isolate defective devices already in the production phase. Normally, the probe heads are then used for the electrical test of the devices integrated on the wafer before cutting and mounting them inside a chip containment package.

A probe head comprises a plurality of movable contact elements or contact probes held by at least one plate, usually a pair of plates or guides that are substantially plate-like and parallel to each other and placed at a certain distance between them so as to leave a free area or air area for the movement and possible deformation of the contact probes. The pair of guides includes in particular an upper guide, usually indicated with the term "upper die", and a lower guide, usually indicated with the term "lower die", the adjectives "upper" and "lower" being used in the sector with reference to a probe head during its operation and corresponding to the illustrations of the figures, the head being positioned between the test equipment (above) and the semiconductor wafer comprising the devices to be tested (below). In other words, the upper guide is the one that is positioned the closest to the test equipment and the lower guide is the one that is positioned the closest to the wafer of devices to be tested.

The guides are both provided with guide holes in which the contact probes slide axially, normally formed by special alloy wires with good electrical and mechanical properties.

The probe head is also completed by a case arranged between the upper and lower guides, normally made of ceramic and adapted to contain and protect the probes.

The good connection between the contact probes and respective contact pads of the device to be tested is ensured by the pressure of the probe head on the device itself, that is on the wafer that comprises it, the contact probes, movable within the guide holes made in the upper and lower guides, undergoing in case of said pressing contact a bending inside the air area between the guides and a sliding inside the guide holes.

Probe heads of this type are commonly indicated with the term "vertical probe head".

The vertical probe heads essentially have an air area in which a bending of the contact probes takes place, and is therefore also indicated as a bending area; furthermore, the bending of the contact probes can be assisted through a suitable configuration of the probes themselves and/or thanks to a suitable relative positioning or phase shift of the guides.

In some cases, the contact probes are connected to the probe head at the upper guide in a fixed manner, for example by welding or bonding: they are called probe heads with blocked probes.

More frequently, however, probe heads are used with probes not connected in a fixed manner, but kept interfaced with a spatial transformation board, commonly referred to as a "space transformer" which is part of a probe card including the probe head and connected to the test equipment: they are called probe heads with non-blocked probes. In general, the probe head is however interfaced and connected to a PCB of the probe card which comprises it, so as to interface with the test equipment of which the probe card is a terminal element.

A probe card comprising a probe head with non-blocked vertical probes is schematically in FIG. **1**, where for simplicity's sake of illustration only one contact probe of the plurality of probes normally included in such a probe head has been shown.

In particular, the probe card **10** comprises the probe head **1** and a PCB for connecting and interfacing with the test equipment, such as a space transformer **8**; the probe head in turn includes at least an upper guide **3** and a lower guide **4**, made by substantially flat and parallel plate-like supports and having respective upper guide holes **3**A and lower guide holes **4**A within which respective contact probes **2** slide. In FIG. **1**, the probe card **10** is illustrated in operating conditions, with the probe head **1** resting on a wafer comprising at least one device to be tested **7**.

The probe head **1** also comprises a case **4**, which also acts as a stiffener, arranged between the upper and lower guides, **3** and **4**, so as to contain and protect the contact probes **2**. The case **4** extends in particular at an air or bending area **6** between said guides.

Each contact probe **2** has a substantially rod-like body **2**C and at least one contact end or tip **2**A. The term end or tip indicates herein and in the following a portion of the end, not necessarily pointed. In particular, the contact tip **2**A abuts onto a contact pad **7**A of the device to be tested **7**, making the mechanical and electrical contact between said device and a test equipment (not shown) of which the probe card **10** is a terminal element.

In the example illustrated in FIG. **1**, the contact probe **2** has a further contact end, usually indicated as contact head **2**B, towards a plurality of contact pads **8**A of the space transformer **8**. The good electrical contact between probes and space transformer is ensured in a similar way to the contact with the device to be tested by pressure of the end portions, in particular of the head, of the contact probes onto the respective contact pads.

More generally, as indicated above, the contact pads with the contact heads of the probes can be made on a PCB for connecting or interfacing with the test equipment used for the connection with the probe card which comprises the probe head, the considerations made previously being valid also for said PCB.

The upper guide **3** and the lower guide **4** are suitably spaced from the air or bending area **6** which allows the deformation of the contact probes **2**, the upper guide holes **3**A and the lower guide holes **4**A being sized so as to allow a sliding of a respective contact probe inside them. A further area **9**, called the floating area, is defined between the upper guide **3** and the space transformer **8**; said floating area **9** is established so that a movement of the contact heads **2**B in case of the pressing contact of the probe head **1** and therefore of the contact probes **2** on the device to be tested **7** is guaranteed, that is of the contact tips **2**A on the relative contact pads **7**A, ensuring in any case the contact of the contact heads **2**B with the contact pads **8**A of the space transformer **8**.

In the case of a probe head made with the so-called "shifted plate" technology, the upper guide **3** and the lower guide **4** are also offset or shifted in a direction Dshift, being parallel to their development plane, indicated in the figure with π, and the contact probes **2**, also referred to as the "buckling beam", therefore have a suitably deformed probe body, in a substantially central position, as illustrated in FIG. **1**, so as to allow the correct holding of the probe in the guide holes of the upper and lower guides and forcing a privileged bending direction of the same, substantially corresponding to the direction Dshift.

It should be remembered that the correct operation of a probe head and therefore of the probe card which comprises it is fundamentally linked to two parameters: the vertical displacement, or overtravel, of the contact probes and the horizontal displacement, or scrub, of the respective contact ends, in particular the contact tips **2**A, on the contact pads **7**A of the device to be tested **7**, capable of obtaining a surface "cleaning" of said pads, thus improving the contact made by the probe head **1**, that is by its contact probes **2**, for its entire useful life.

It is also important to ensure that the floating area **9** of the contact heads **2**B of the contact probes **2** is sized so as to ensure the correct housing of said contact heads **2**B in the probe head, in addition to the correct mechanical and electrical contact of the same on the contact pads **8**A of the space transformer **8**.

All these characteristics are to be evaluated and calibrated during the realization of a probe head, the good electrical connection between probes, device to be tested and test equipment, always having to be guaranteed.

The ends of the contact probes, in particular the tips contacting the pads of the devices to be tested, are subject to accumulation of material, generally referred to as dirt, during use, which decreases the performance thereof and risks compromising the correct contact of the probes with the device to be tested, when the scrub of said tips is not however able to ensure the electrical contact with the pads.

It is therefore known to perform periodic cleaning operations of the probe heads, in particular of the contact tips of their probes by means of abrasive cloths.

Said cleaning operations however involve the consumption of a part of the end portion of the probes, in particular of the contact tip, and are therefore limited in number precisely by the length of said tip, which is shortened with each cleaning. Any subsequent abrasion of the end portion of contact tip must in particular be limited to the portion of the tapered probe which protrudes from the lower guide, which precisely provides the contact tip.

The number of cleaning operations of the probe head actually determines its useful life and consequently the useful life of the probe card that contains it.

It is known from the international patent application (PCT) published on 16 Oct. 2014 with No. WO 2014/167410 in the name of the same Applicant, the use of a spacer element, interposed in a removable manner between the containment element and one of the upper and lower guides, so as to adjust the length of the end portions of the contact probes, in particular, at the contact points.

Said probe head, although advantageous in various respects, has a drawback linked to the fact that the variation in length of the end portions effected by removing the spacer or a layer thereof inevitably also changes the air or bending area of the contact probes thus modifying the contact dynamics and introducing problems in terms of force exerted by the probes on the contact pads and also of scrub that can be provided on them, in addition to modifying the deformation suffered by the probes in said air area, with the risk of permanent deformations or interlocking of said probes in the respective guide holes.

It is also immediate verifiable how measures aimed at modifying the length of the contact probe that projects from the probe head, in particular at its tip end portion towards the device to be tested, often also involve undesired changes in the floating area at the head end portion of the probes, compromising their connection with the PCB towards the test equipment, even bringing an incorrect operation of the probe head as a whole.

BRIEF SUMMARY

The probe head of electronic devices integrated on a wafer is able to guarantee a correct housing of the contact probes inside it also following cleaning operations of the contact probes without functional loss, overcoming the limitations and drawbacks that still afflict the probe heads made according to the prior art, in particular ensuring an adequate protection and correct holding of the contact heads of the probes within the floating area, a correct sliding of the probes in the respective guide holes and essential scrub mechanisms for a correct contact between probes and contact pad of the device to be tested and the PCB connected to the test equipment throughout the life of the probe head and the probe card which comprises it, even after a plurality of cleaning operations.

According to an aspect of the disclosure suitable protection structures within the probe head for the contact head portions of its probes are provided, such protection structures being also positioned so as not to interfere with the normal operation of the probe head and being preferably removable, possibly provided by means of individually removable layers so as to modify the extension of the floating area and consequently the length of the probes protruding from the probe head towards the device to be tested after cleaning operations that have reduced the length thereof at the contact tip portion, without however changing the length of the bending area of the probes.

The probe head for a test equipment of electronic devices comprises a plurality of contact probes inserted in guide holes provided in at least one upper guide and one lower guide, a bending area for the contact probes being defined between the upper and lower guides, each of said contact probes having at least one first terminal portion which protrudes of a first length from the lower guide and ends with a contact tip adapted to abut onto a respective contact pad of a device to be tested, as well as a second terminal portion which protrudes of a second length from the upper guide and ends with a contact head adapted to abut onto a contact pad of a PCB for connecting or interfacing with the

test equipment, characterized in that it comprises at least one protection structure projecting from said upper guide in direction of a longitudinal development axis of the contact probes towards the PCB, said protection structure thus extending at the contact heads of the contact probes.

According to another aspect of the disclosure, the protection structure can be fastened, possibly in a removable way, to the upper guide.

In particular, the protection structure can be fastened to the upper guide by means of an adhesive glue layer, a welding or fastening means selected from screws or clips, which at least partially cross the protection surface and the upper guide.

According to another aspect of the disclosure, the protection structure can be provided by projecting portions of the upper guide in the direction of the longitudinal development axis of the contact probes towards the PCB.

According to yet another aspect of the disclosure, the protection structure can comprise a plurality of individually detachable layers which are stacked one upon another between the PCB and the upper guide.

In particular, the protection structure can comprise an adhesive material, preferably a glue with low seal, or removable coupling means adapted to make the layers integral with each other.

According to another aspect of the disclosure, the protection structure can have a shape selected from a frame, pairs of half-frames, single projecting elements such as pillars.

Furthermore, according to another aspect of the disclosure, the protection structure and possibly layers thereof can be provided so as to protrude with respect to the upper guide and/or the PCB.

The protection structure and possibly layers thereof can also be made of transparent or semitransparent plastic material, or ceramic material, or metallic material or organic material or silicon, preferably of Kapton®.

According to another aspect of the disclosure, the probe head can comprise an upper guide and/or a lower guide including a pair of elementary supports and provided with a spacer structure positioned between the elementary supports.

According to said aspect of the disclosure, the spacer structure can be fastened, possibly in a removable manner, to one of the elementary supports, or it is provided by projecting portions thereof, or it comprises a plurality of overlapping and individually removable layers.

According to another aspect of the disclosure, the protection structure can have a height equal or preferably greater than one of the greatest among all heights of enlarged portions of the contact heads of the contact probes.

Alternatively, the protection structure can have a height equal or preferably greater than one of the greatest among all heights of tapered portions of the contact heads of the contact probes.

The technical problem is also solved by a probe card for a test equipment of electronic devices comprising at least one probe head and at least one PCB for connecting and interfacing with the test equipment, the probe head being provided with a plurality of contact probes adapted to abut onto a plurality of contact pad of the space transformer, characterized in that the probe head is provided as indicated above.

According to another aspect of the disclosure, the probe card can further comprise holding means adapted to make the guides and/or elementary supports of the probe head, the protection structure and/or the spacer structures, being provided with suitable housing seats for the holding means, integral.

The characteristics and advantages of the probe head according to the disclosure will become clear from the description, made below, of an example of its embodiment given by way of non-limiting example with reference to the attached drawings.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

FIG. **1**: schematically shows a probe card of electronic devices, in particular integrated on wafer, provided according to the prior art;

FIG. **2**: schematically shows a section view of a probe head, provided according to an embodiment of the disclosure; and

FIGS. **3**A-**3**C, **4**A-**4**C, **5**A-**5**D, **6** and **7**: schematically show in respective section views a probe card comprising alternative embodiments of the probe head of the disclosure.

DETAILED DESCRIPTION

With reference to these figures, and in particular to FIG. **2**, a probe head according to the disclosure is globally indicated with **21**.

It should be noted that the figures represent schematic views and are not drawn to scale, but are instead drawn in such a way as to emphasize the important features of the disclosure. It is further pointed out that measures shown with reference to a particular embodiment can obviously be used in combination with other embodiments. Finally, the same numeral references are used in the different figures to indicate structurally and functionally corresponding elements.

The probe head **21** includes a plurality of contact probes **22** housed in suitable guide holes of respective supports or an upper guide **23** and a lower guide **24**, that are plate-like and parallel. The probe head **21** also comprises a containment element or case **25** extended between the upper guide **23** and the lower guide **24**, at an air area or bending area **26**, having a height indicated with L, where the contact probes **22** can be further deformed in case of the pressing contact of the probes on a device to be tested, usually contained in a semiconductor wafer, onto which the probe head **21** abuts, at a first plane indicated in the figure with **π1**.

In particular, the probe head **21** illustrated in FIG. **2** is of the non-blocked vertical probe type and the contact probes **22** each have respective terminal portions **21**A and **21**B adapted to make a mechanical and electrical contact with respective contact pads; in particular a first terminal portion **21**A ends with a contact tip **22**A adapted to abut onto a contact pad of the device to be tested at the first plane **π1**, whereas a second terminal portion **21**B ends with a contact head **22**B adapted to abut onto a further contact pad of a connection element towards a test equipment, such as a layer of spatial transformation or space transformer or a generic connection or interface PCB, at a second plane indicated in the figure with **72**. In this way, the contact probes **22** provide for the mechanical and electrical contact between the device to be tested and a test equipment (not shown) of which the probe head **21** is a terminal element. The contact probes **22** also have a substantially rod-like probe body **22**C extended between said first and second end portions, **21**A and **21**B.

The term "terminal portion" means a part of the contact probes **22** which protrudes with respect to the guides and

therefore to the case **25**, in particular in the direction of the device to be tested or of the PCB of the probe card which comprises the probe head **21**, respectively. Furthermore, like previously pointed out, the term tip indicates an end portion, not necessarily pointed.

In particular, the first terminal portion **21**A of the contact probes **22** at the contact tip **22**A extends below the lower guide **24** of the probe head **21**, in the direction opposite to the longitudinal development axis of the probe indicated with z in the local reference of the figure. Likewise, the second terminal portion **21**B of the contact probes **22** at the contact head **22**A extends above the upper guide **23** of the probe head **21**, in the direction of the longitudinal development axis z.

As previously described, the contact probes **22** have a first terminal portion **21**A comprising the contact tip **22**A having a tapered shape so as to make a substantially point-like contact on the contact pads of the device to be tested. Furthermore, the contact probes **22** have a second terminal portion **21**B comprising the contact head **22**B provided with at least one enlarged portion, that is, having a transverse diameter D**2** of greater dimensions than a transverse diameter D**1** of the rest of the second terminal portion **21**B and in general of the probe body **22**C, whereby diameter refers to a maximum transverse dimension of a section of said portion orthogonal to a longitudinal development axis z of the contact probe **22**; the contact head **22**B is further tapered so as to make a substantially point-like contact on the pads of the PCB of the probe card which comprises the probe head **21**. The contact head **22**B, thanks to its enlarged portion, also has respective undercut walls adapted to rest on the upper guide **23**, realizing the desired holding of the contact probe **22** inside the probe head **21** even in the event of no contact of said probe head **21** with a device to be tested.

Precisely the presence of such an enlarged portion at the contact head **22**B of the contact probes **22** increases the problems tied to the correct containment and freedom of movement of the contact probes **22** inside the probe head **21**. As already explained, during the operation of said probe head **21**, i.e. in case of a test operation of a device integrated on a semiconductor wafer, the contact probes **22** undergo a bending and a deformation when their contact tips **22**A abuts onto the pads of the device to be tested and their contact heads **22**B abut onto corresponding contact pads of a PCB or of a space transformer of the probe card which comprises said probe head **21**; during said contact, the contact probes **22** but also the entire probe head **21** are substantially pushed up, that is towards the test equipment, according to the direction of the longitudinal development axis z in the figure.

Suitably, the probe head **21** according to an embodiment of the present disclosure therefore comprises at least one protection structure **27** projecting from the upper guide **23** in the direction of the test equipment, that is in the direction of the longitudinal development axis z indicated in the figure. The protection structure **27** therefore extends at the contact heads **22**B, which protrude from the upper guide **23** precisely according to the direction of the longitudinal development axis z.

In particular, the protection structure **27** has a height H**1** equal or preferably greater than a corresponding height HB (H**1**≥HB) of the contact heads **22**B starting from their enlarged portions up to the substantially point-like end of real contact. More specifically, the height HB of each individual contact head **22**B is measured from the undercut walls Sq, i.e. from the section of maximum diameter, to the tapered end that forms the real contact area, i.e. the section of minimum diameter, substantially point-like. Furthermore, the height H**1** of the protection structure **27** is selected so as to be equal or preferably greater than the greatest among all heights of the contact heads **22**B of the contact probes **22**; in this way the protection structure **27** is able to correctly protect all the contact heads **22**B of the contact probes **22** of the probe head **21**.

It is pointed out that, although not illustrated in the figures, the probe head **21** can also comprise contact probes **22** with second terminal portions **21**B provided with non-enlarged contact heads **22**B. In this case, the protection structure **27** is used to avoid an excessive approach of the contact heads **22**B, in particular of the real area of contact with the upper guide **23**, which approach might cause an interlocking of the contact heads **22**B in the respective upper guide holes **23**H, with consequent malfunction of the probe head **21** as a whole, in particular due to the lack of contact with the PCB for connecting and interfacing with the test equipment. In this case, the height H**1** of the protection structure **27** is selected so as to be greater than a tapered portion of the second terminal portion **21**B which forms the contact head **22**B or in any case such as to avoid an interlocking of the contact head **22**B in the corresponding upper guide hole **23**H which houses it in the upper guide **23**; also in this case, the height H**1** of the protection structure **27** is determined so as to be equal or preferably greater than one of the greatest among all heights of tapered portions of the contact heads **22**B of the contact probes **22**.

The protection structure **27** is fastened in a more or less removable manner to the upper guide **23**, for example by means of an adhesive glue layer, by welding or with fastening means such as screws or clips, which at least partially cross the protection surface **27** and the upper guide **23**.

Such a protection structure **27** can be substantially shaped as a frame or comprise one or more portions, at areas of the upper guide **23** not crossed by guide holes and therefore by the contact probes **22**, all projecting from the upper guide **23** in the direction of the longitudinal development axis z.

FIG. **3**A shows the probe head **21** mounted on a probe card **20**, which also comprises a space transformer or generally a PCB **28** for connecting and interfacing with a test equipment (not illustrated). In particular, the PCB **28** comprises a plurality of contact pads **28**A onto which the contact heads **22**B of the contact probes **22** abut. The probe card **20** is adapted to abut with its probe head **21** onto a device to be tested **30**, in particular integrated on a semiconductor wafer **30'**, and provided with a corresponding plurality of contact pads **30**A onto which the contact tips **22**A of the contact probes **22** abut.

As already indicated, during the testing operations carried out by the probe card **20**, i.e. when the probe head **21** is in pressing contact onto the device to be tested **30** and onto the PCB **28**, the contact probes **22** bend at the bending area **26**, which extends between the upper guide **23** and the lower guide **24** and has a length L, corresponding to the height of the case **25**.

The first terminal portion **21**A of the contact probes **22** at the contact tip **22**A extends in a first area ZA between the lower guide **24** and the device to be tested **30**; in particular, the contact tip **22**A protrudes of a suitable first length LA with respect to the lower guide **24** of the probe head **21**, with reference to a plane π**1** determined by the wafer **20'** of the device to be tested **30** in pressing contact with said probe head **21**, corresponding to the length of the first area ZA. Said first area ZA allows a movement of the contact tips **22**A of the contact probes **22** on the contact pads **30**A of the

device to be tested **30** during the operation of the probe head **21** and of the probe card **20** which comprises it and is therefore indicated as scrub area ZA.

Likewise, the second terminal portion **21**B of the contact probes **22** at the contact head **22**B extends in a second area ZB between the upper guide **23** of the probe head **21** and the PCB **28**; in particular, the contact head **21**B protrudes of a suitable second length LB with respect to said upper guide **23**, with reference to a plane π**2** of the PCB **28** in pressing contact with the probe head **21**, in a similar way to the device to be tested **30**, corresponding to the length of the second area ZB. Said second area ZB allows a movement of the contact heads **22**B of the contact probes **22** during the operation of the probe head **21** and of the probe card **20** which comprises it and is therefore indicated as the floating area ZB.

Substantially, FIG. **3**A shows the probe head **21** in operating conditions, i.e. during a test phase of the device to be tested **30** integrated in the wafer **30'**, when the contact probes **22** contained therein each have the contact tip **22**A in pressing contact with a contact pad **30**A of said device to be tested **30** and the contact head **22**B in pressing contact with a contact pad **28**A of the PCB **28**; in the example of the figure, the protection structure **27** is in turn in contact with the PCB **28**.

It is pointed out that the protection structure **27** of the probe head **21** therefore allows the length LB of the floating area ZB to be kept constant, essentially acting as a spacer element between the contact heads **22**B of the contact probes **22** and the PCB **28**, so as to ensure a constant and correct contact with said PCB **28** and therefore with the test equipment of which the probe card **20** constitutes a terminal element, a contact made precisely by the contact heads **22**B abutting onto the contact pads **28**A of the PCB **28**. Said protection structure **27** is also able to prevent contact probes **22**, even without enlarged contact heads **22**B, from interlocking in the upper guide holes **23**H provided in the upper guide **23** and adapted to house them. Corresponding lower guide holes **24**H are provided in the lower guide **24** to house the contact probes **22**.

It is also possible to make the protection structure **27** by means of a suitable configuration of the upper guide **23**, in particular by providing the same with projecting portions **23'** in the direction of the PCB **28**, said projecting portions **23'** being able, for example, to be in the form of a frame or edge of the upper guide **23**, extended outside an area of said upper guide **23** provided with the upper guide holes **23**H and therefore adapted to house the contact probes **22** so as to guarantee the correct operation of the probe head **21** and of the probe card **20** which comprises it, as schematically illustrated in FIG. **3**B. In this case, the protection structure **27** is made in one piece with the upper guide **23**.

As illustrated in FIG. **3**C, the protection structure **27** can also be made by means of a plurality of layers **27**_a_, **27**_b_, **27**_c_, **27**_d_, suitably stacked one upon another between the PCB **28** and the upper guide **23**, individually detachable or peelable, so as to provide a protection structure **27** having a height H**1** that can be modified. Said layers **27**_a_, **27**_b_, **27**_c_, **27**_d_ are possibly made integral with each other by means of an adhesive material, such as a glue, with low seal, so as to easily allow the separation of the same from each other.

The protection structure **27** illustrated in FIG. **3**C comprises four layers, by way of non-limiting example only, said structure being able to comprise any number of layers, possibly even just one, with equal or different thickness.

Such an embodiment proves to be particularly convenient. In fact, it is well known that the first terminal portion **21**A reduces its length LA as the probe head **21** is used, by virtue of the passages of its contact tips **22**A on the abrasive cloth, as explained above. Basically, the first terminal portion **21**A wears out during each cleaning operation of the corresponding contact tip **22**A, reducing the length LA of the scrub area ZA, until the probe head **21** can no longer work correctly.

Suitably according to the present embodiment, the protection structure **27** can be reduced in height by eliminating one or more layers **27**_a_, **27**_b_, **27**_c_, **27**_d_, which reduces the length LB of the floating area ZB, thus allowing a displacement towards the other of the assembly upper guide **23**-lower guide **24**-case **25**, that is of the probe head **21**, allowing the contact probes **22** housed therein to protrude more from the lower guide **24** and consequently increasing the length LA of the scrub area ZA.

The protection structure **27**, in particular the number or height of its layers **27**_a_, **27**_b_, **27**_c_, **27**_d_ is sized so as to have a height H**1** that is sufficiently greater than the height HB of the contact head **22**B, so as to be able to guarantee the correct containment of the contact heads **22**B and in particular a sufficient length LB of the floating area ZB, even after the elimination of one or more of the layers **27**_a_, **27**_b_, **27**_c_, **27**_d_ of the protection structure **27**.

According to an alternative embodiment, not illustrated in the figures, the protection structure **27** comprises at least a fixed portion with a height equal or greater than the height HB of the contact heads **22**B and a further portion with individually removable layers. In this way, it is ensured that the height H**1** of the protection structure **27** is always greater than or equal to the height HB of the contact heads **22**B even after the elimination of all the removable layers.

The protection structure **27** and layers **27**_a_-**27**_d_ thereof, if any, are made of transparent or semitransparent plastic material, or ceramic material, or metallic material or organic material or silicon, preferably of Kapton®. Furthermore, the layers can be made integral with each other, for example by means of a layer of adhesive material, preferably with low seal, or by means of further removable coupling means, such as screws or clips.

In the embodiment illustrated in FIG. **3**C, again by way of example, the protection structure **27** and the individual layers thereof **27**_a_-**27**_d_ are made in the form of a frame. It is also possible to make the protection structure **27** in the form of pairs of half-frames, extended substantially along opposite and parallel sides of the probe head **21** and of the upper guide **23**.

Although not illustrated in the figures, it is pointed out that the protection structure **27** and layers **27**_a_-**27**_d_, if any, thereof can also be made so as to protrude with respect to the upper guide **23** and/or the PCB **28**.

The protection structure **27** can also take on a totally different shape, such as for example one or more individual pillars positioned on the upper guide **23** also within the housing area of the contact probes **22**, in areas without the corresponding upper guide holes **23**H, as schematically illustrated in FIG. **4**A. In the example of the figure, the protection structure **27** comprises a pair of pillars which extend between the upper guide **23** and the PCB **28** in areas not occupied by the contact probes **22**.

Also in this case, the protection structure **27** projects from the upper guide **23** in the direction of the test equipment and is fastened to said guide in a more or less removable manner, for example by means of a layer of adhesive glue, by welding or by fastening means such as screws or clips which cross at least partially the protection structure **27** and the upper guide **23**. Furthermore, like previously, the protection structure **27** has a height H**1** equal to or preferably greater

than a corresponding height HB (H1≥MB) corresponding to the overall volume of the contact heads **22**B with their enlarged portions, always intended as the greatest among the heights of the individual contact heads **22**B of the contact probes **22** housed in the probe head **21**. Alternatively, the height H**1** of the protection structure **27** is established in such a way as to avoid an interlocking of the contact head **22**B in the corresponding upper guide holes **23**H of the upper guide **23**, in particular when an enlarged portion is not present.

Like previously, it is also possible to make said protection structures **27** by means of a suitable configuration of the upper guide **23**, in particular by providing it with projecting portions **23'** in the direction of the PCB **28**, as schematically illustrated in FIG. **4**B, or by means of a plurality of individually detachable or peelable layers **27***a*, **27***b*, **27***c*, suitably stacked one upon another between the PCB **28** and the upper guide **23**, as illustrated in FIG. **4**C, where the protection structure **27** comprises a single pillar formed by three layers only by way of example.

It is also well known that in vertical probe heads of the "buckling beam" type, as illustrated in the figures, the contact probes **22** show significant problems of friction inside the respective guide holes, which can make the sliding of the probes inside them difficult or even prevent it.

The shortening of the first terminal portion **21**A of the contact probes **22** due to the cleaning operations increases the chances of the probes getting interlocked in the corresponding lower guide holes; in a similar way, an approach of the upper guide **23** to the PCB **28** and therefore a decrease in the length LB of the floating area ZB increases the risk of the contact probes **22** of getting interlocked in the upper guide holes **23**H, in particular when there are no enlarged contact head **22**B.

Suitably it is possible to obtain a decrease in said sliding friction of the probes thanks to the use of a plurality of elementary supports, preferably two, parallel to each other to form at least one of the upper and/or lower guides of the probe head, as schematically illustrated in the FIGS. **5**A-**5**D.

For example, as in the embodiment illustrated in FIG. **5**A, the probe head **21** can comprise an upper guide **23** formed by a pair of elementary supports, an upper elementary support **23**A and a lower elementary support **23**B, that are plate-like and parallel, separated by at least one upper air area ZU having a length LU.

The probe head **21** also comprises in this case a protection structure **27** projecting from the upper guide **23**, in particular from its upper elementary support **23**A in the direction of the PCB **28**, while the bending area **26**, where the contact probes **22** may further deform, in case of the pressing contact of the probes onto the device to be tested **30**, is defined between the lower elementary support **23**B and the lower guide **24**.

Suitably, the probe head **21** also comprises an upper spacer structure **27***u* with height H**2** positioned between the elementary supports of the upper guide **23**, thus ensuring that the distances between them and therefore the length LU of the upper air area ZU, as schematically illustrated in FIG. **5**A, is maintained.

It is also possible to provide the upper spacer structure **27***u* by means of a suitable configuration of the lower elementary support **23**B of the upper guide **23**, in particular by providing it with projecting portions **23**B' in the direction of the upper elementary support **23**A and therefore of the PCB **28**, as schematically illustrated in FIG. **5**B, or by means of a plurality of individually detachable or peelable layers, suitably stacked one upon another between the upper elementary support **23**A and the lower elementary support **23**B, as illustrated in FIG. **5**C, where the upper spacer structure **27***u* comprises three layers only by way of example and has a height such as to guarantee the desired length LU for the upper air area ZU.

Suitably, the upper spacer structure **27***u* made by means of a plurality of individually peelable layers can be used, as previously explained for the layered protection structure **27**, to adjust the lengths of the floating area ZB and of the scrub area ZA, without modifying the length L of the bending area **26** defined between the lower elementary support **23**B of the upper guide **23** and the lower guide **24**.

In a preferred embodiment, schematically illustrated in FIG. **5**D, the probe head **21** can comprise both a protection structure **27** and an upper spacer structure **27***u* made by means of a plurality of individually and independently removable or peelable layers.

The considerations just made can also be applied if the lower guide **24** is formed by a pair of elementary supports, **24**A and **24**B, separated by a lower spacer structure **27**I with height H**3**, which defines a lower air area ZL having a length LL, as schematically illustrated in FIG. **6**, and in case both guides are, the probe head therefore comprising two pairs of elementary supports **23**A, **23**B and **24**A, **24**B and two spacer structures **27***u* and **27**I with respective heights H**2** and H**3**, in addition to a protection structure **27** of the contact heads **22**B of the contact probes **22**, as schematically illustrated in FIG. **7**.

Also for said alternative embodiments, it is possible to provide one or more of the structures as described above, combining the solutions with each other according to the application needs of the probe head **21** and of the probe card **20** which comprises it.

It is pointed out that the different layers of the protection structures **27** and of the spacer structures **27***u* and/or **27**I can be made so as to have portions protruding from the probe head **21**, preferably with different lengths, so as to facilitate the correct removal thereof. Suitably, said protruding portions have equal lengths for corresponding layers of the different structures, for example the protruding portion of the layer that is the closest to the PCB **28** has the same minor length as the one of the subsequent layers, gradually closer to the guide or support positioned below said structure, considering the local reference of the figures. It is also possible to provide for a numbering for said layers, for example with numbering gradually increasing, said numbering being applied in the protruding portion of the layer so as to be visible and to make it possible to verify that all the structures comprise the desired number of layers simply by reading said numbering on all the protruding portions of the layers.

Asymmetrical removals of said layers can also allow to modify the relative distances between the supports and/or the guides, in particular causing an inclination of the same so as to compensate for any production or assembly inaccuracies of the supports and guides.

The probe card **20** also comprises respective holding means (not illustrated), adapted to integrate the various components of said board, in particular the elementary guides and/or supports, as well as the protection structures **27** and the spacer structures **27***u* and **27**I, provided for said purpose with suitable housing seats for holding means. Said holding means can also be used to make the PCB **28**, that is a space transformer, and the case **25** integral with each other.

It is pointed out that all the illustrated embodiments of the probe head and of the probe card according to the present disclosure allow an adjustment of the length of the terminal portion of the contact probes comprising the contact tips and

therefore subject to consumption without modifying the length of the bending area of the probes themselves and therefore the movement dynamics of the same, in particular in terms of scrub as well as ensuring the constant maintenance of the floating area for the contact heads of the contact probes, so as to ensure a constant and correct contact with the PCB or the space transformer and therefore the test equipment, said floating area being maintained with a constant and unchanged length in case of the length of the contact tips of the contact probes being adjusted.

Furthermore, the presence of the protection structures allows to maintain a suitable distance between the upper guide and the PCB associated with the probe head, so as to guarantee the protection and correct holding of the contact probes and in particular of their contact heads possibly provided with enlarged portions.

In conclusion, the probe head according to the embodiments of the disclosure has a longer duration, since it is possible to provide for a large number of cleaning operations of the corresponding tip with a subsequent adjustment of the length of the terminal portions of the contact probes which protrude with respect to the lower guide so that it is equal to or greater than a length corresponding to a correct operation of the probe head, always ensuring the correct containment of the further terminal portions comprising the contact heads. In this way, the useful life of the probe card comprising such a head is also extended.

Suitably, the protection structure of said contact heads can be made in such a way as to extend over limited areas, even if severely limited, with respect to the extension of the guides, thus being positionable at will, both in number and position.

Furthermore, it is possible to make further adjustments to the length of the terminal portions of the contact probes at different times in the life of the probe head which includes them, in particular whenever said terminal portions comprising the contact tips have shortened due to use and cleaning and have a length smaller than a length corresponding to a correct operation of the probe head, also allowing to modify the length of the terminal portions in a different way for different contact probes in case of a misalignment of the respective contact tips due to the tolerances of the process for making the probes themselves.

Obviously, a person skilled in the art can make numerous modifications and variations to the probe head described above in order to satisfy contingent and specific needs, all included in the scope of protection of the disclosure as defined by the following claims.

In particular, it is obviously possible to consider geometric shapes other than those illustrated by way of example in the figures.

Furthermore, it is possible to provide the contact probes of the probe head according to the embodiments of the present disclosure with further measures, such as particular conformations for the tip portion, such as offsets or elongated portions, as well as for the body, like stoppers projecting therefrom.

Finally, the contact probes can be made by means of multilayer combinations of conductive, semiconductive or insulating materials, both in planar overlap and in concentric or coaxial manner; multilayer solutions are also possible in order to provide the guides and/or supports included in the probe head according to the embodiments of the present disclosure.

From the foregoing it will be appreciated that, although specific embodiments of the disclosure have been described herein for purposes of illustration, various modifications may be made without deviating from the spirit and scope of the disclosure.

The various embodiments described above can be combined to provide further embodiments. These and other changes can be made to the embodiments in light of the above-detailed description. In general, in the following claims, the terms used should not be construed to limit the claims to the specific embodiments disclosed in the specification and the claims, but should be construed to include all possible embodiments along with the full scope of equivalents to which such claims are entitled. Accordingly, the claims are not limited by the disclosure.

What is claimed is:

1. A probe head for a test equipment of electronic devices, able to test the devices provided with a plurality of contact pads by connecting them with corresponding contact pads of a board for connecting or interfacing with the test equipment, the probe head comprising:

- at least one upper guide and one lower guide, provided with respective guide holes;
- a plurality of contact probes developed along a longitudinal development axis and inserted in the guide holes of the upper guide and the lower guides; and
- a bending area for the contact probes defined between the upper guide and the lower guide;
- wherein each of the contact probes has:
  - at least one first terminal portion which protrudes of a first length from the lower guide and ends with a contact tip adapted to abut onto a respective contact pad of the device to be tested; and
  - a second terminal portion which protrudes of a second length from the upper guide and ends with a contact head adapted to abut onto a contact pad of the board for connecting or interfacing with said test equipment; and
- wherein the probe head further comprises at least one protection structure comprising projecting portions of the upper guide in direction of the longitudinal development axis of the contact probes towards said board and a plurality of individually detachable layers which are stacked one upon another between the projecting portions of the upper guide and the board; and
- wherein the protection structure is a spacer element between the contact heads of the contact probes and the board and is configured to keep a length of a floating area between the upper guide and the board and to avoid an excessive approach of the contact heads, the second terminal portion extending in the floating area.

2. The probe head according to claim **1**, wherein the protection structure comprises an adhesive material or removable coupling means adapted to make the layers integral with each other.

3. The probe head according to claim **2**, wherein the protection structure comprises a glue with low seal as adhesive material.

4. The probe head according to claim **1**, wherein the protection structure has a shape selected from a frame, pairs of half-frames, single projecting elements such as pillars.

5. The probe head according to claim **1**, wherein the protection structure and the plurality of individually detachable layers thereof are made of transparent or semitransparent plastic material, or ceramic material, or metallic material or organic material or silicon.

6. The probe head according to claim **1**, wherein the protection structure has a height equal to or greater than one

of the greatest among all heights of enlarged portions of the contact heads of the contact probes.

7. The probe head according to claim **1**, wherein the protection structure has a height equal to or greater than one of the greatest among all heights of tapered portions of the contact heads of the contact probes.

8. A probe card for a test equipment of electronic devices, able to test the devices provided with a plurality of contact pads by connecting them with corresponding contact pads of a board for connecting or interfacing with the test equipment, comprising:

at least one probe head comprising:

at least one upper guide and one lower guide, provided with respective guide holes;

a plurality of contact probes developed along a longitudinal development axis and inserted in the guide holes of the upper guide and the lower guide; and

a bending area for the contact probes defined between the upper guide and the lower guide; and

at least one board for connecting and interfacing with the test equipment;

wherein each of the contact probes has:

at least one first terminal portion which protrudes of a first length from the lower guide and ends with a contact tip adapted to abut onto a respective contact pad of the device to be tested, and

a second terminal portion which protrudes of a second length from the upper guide and ends with a contact head adapted to abut onto a contact pad of the board for connecting or interfacing with said test equipment;

wherein the probe head further comprises at least one protection structure comprising projecting portions of the upper guide in direction of the longitudinal development axis of the contact probes towards said board, and a plurality of individually detachable layers which are stacked one upon another between the projecting portions of the upper guide and the board; and

wherein the protection structure is a spacer element between the contact heads of the contact probes and the board and is configured to keep a length of a floating area between the upper guide and the board and to avoid an excessive approach of the contact heads, the second terminal portion extending in the floating area.

9. The probe card according to claim **8**, further comprising holding means adapted to make integral the guides of the probe head, the protection structure being provided with suitable housing seats for the holding means.

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