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(54) **METHOD FOR INSERTING A WIRE INTO A GROOVE OF A SEMICONDUCTOR CHIP**

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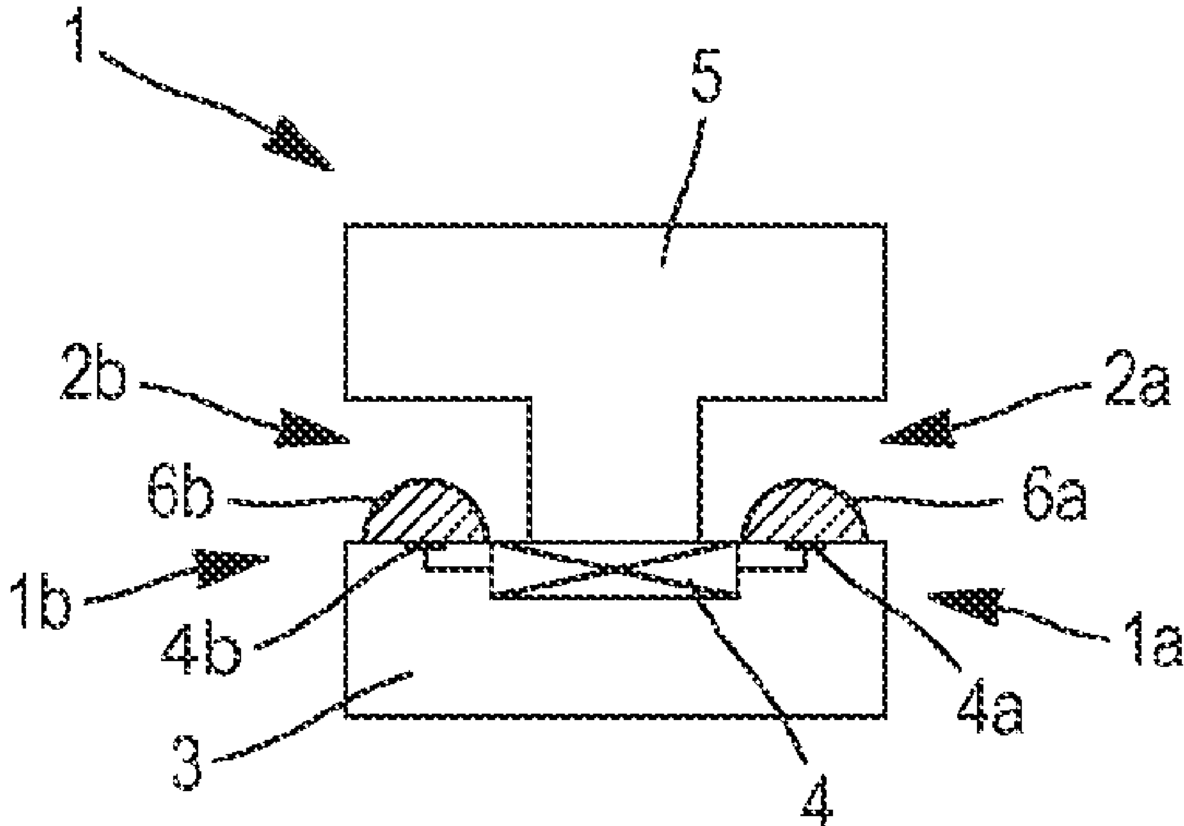
(57) **ABSTRACT**

A method for inserting a wire into a longitudinal groove of a semiconductor chip for the assembly thereof, the groove containing a pad made of a bonding material having a set melting point, comprises: in a positioning step, placing a longitudinal section of the wire along the groove, in forced abutment against the pad; and, in an insertion step, exposing a zone containing at least one portion of the pad to a processing temperature higher than the melting point of the bonding material and for a sufficient time to make the pad at least partially melt, and causing the wire to be inserted into the groove. The present disclosure also relates to a piece of equipment allowing the insertion method to be implemented.



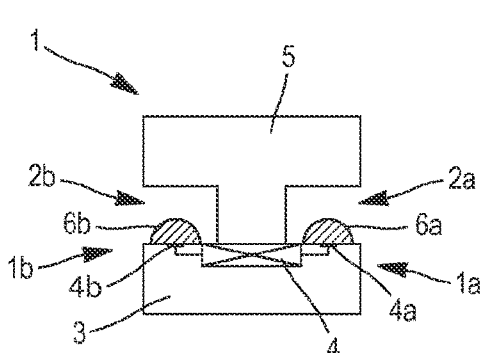


FIG. 1b

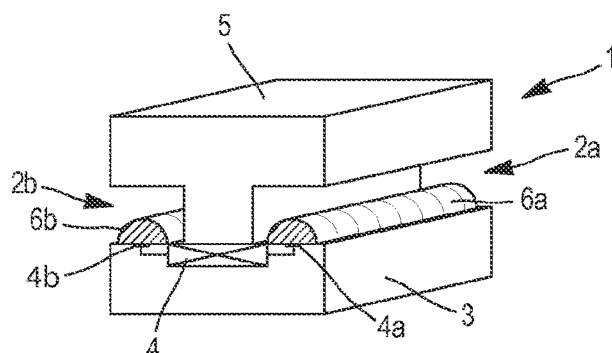


FIG. 1a

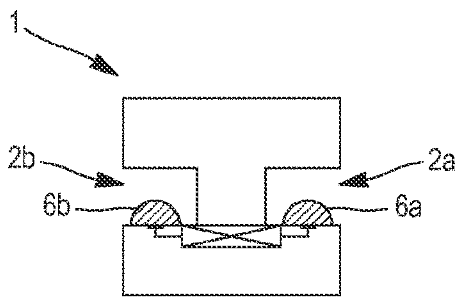


FIG. 2a

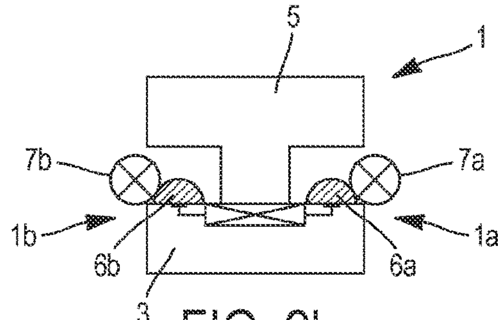


FIG. 2b

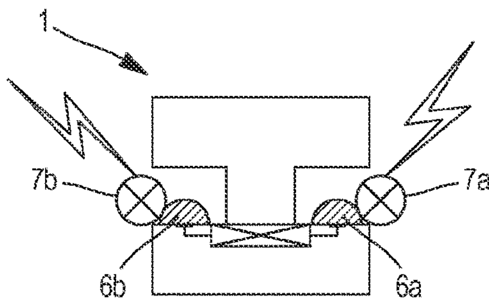


FIG. 2d

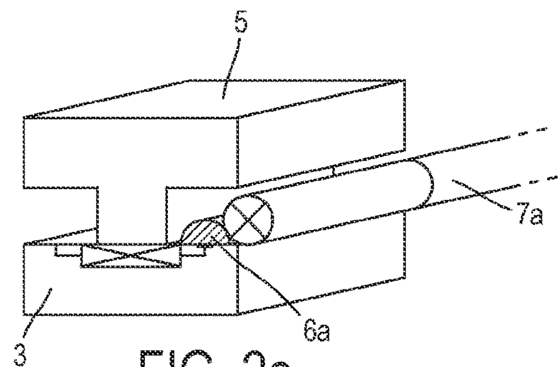
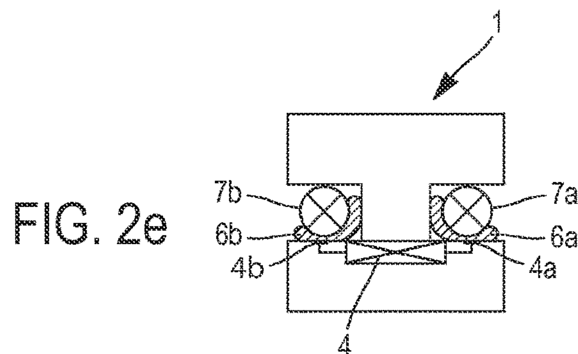


FIG. 2c

FIG. 2e



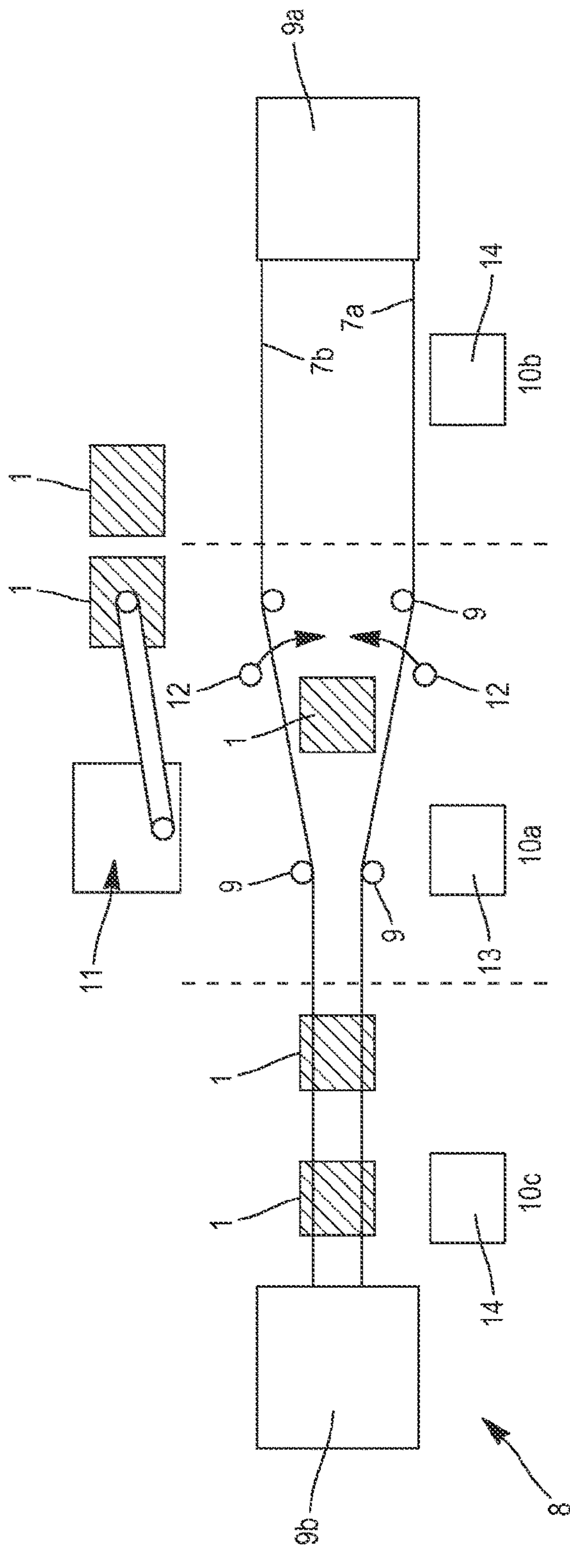


FIG. 3a

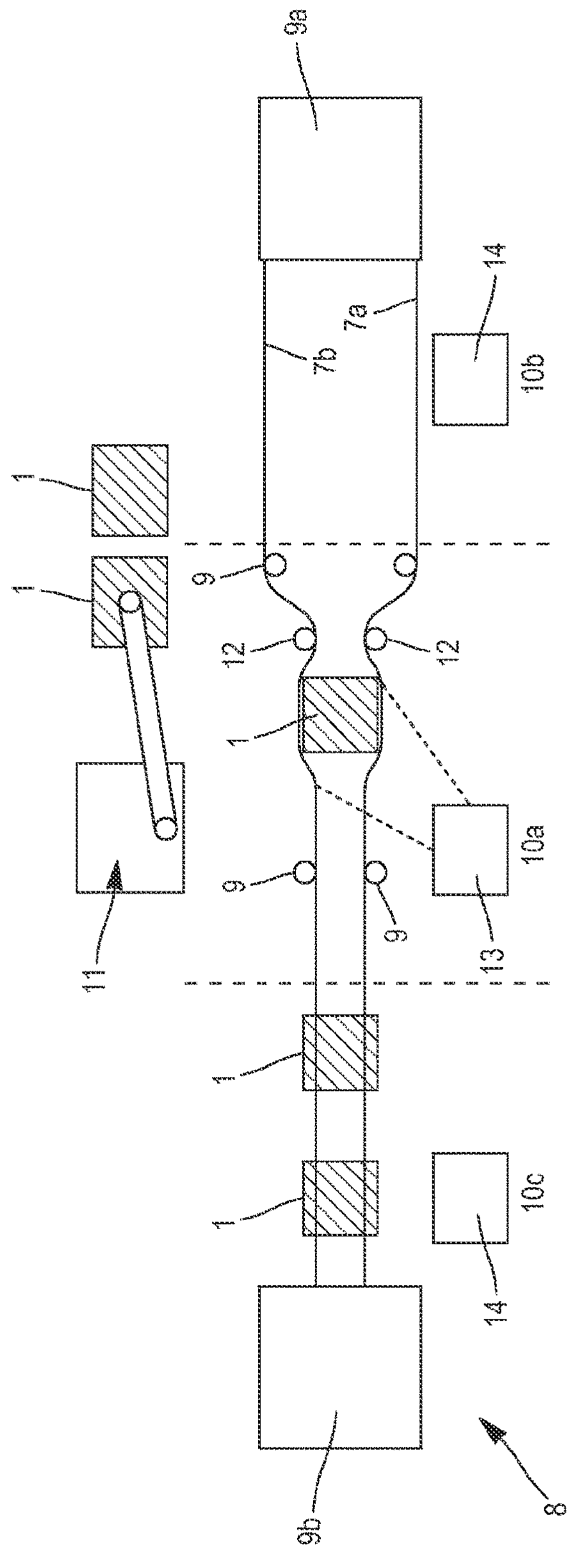


FIG. 3b

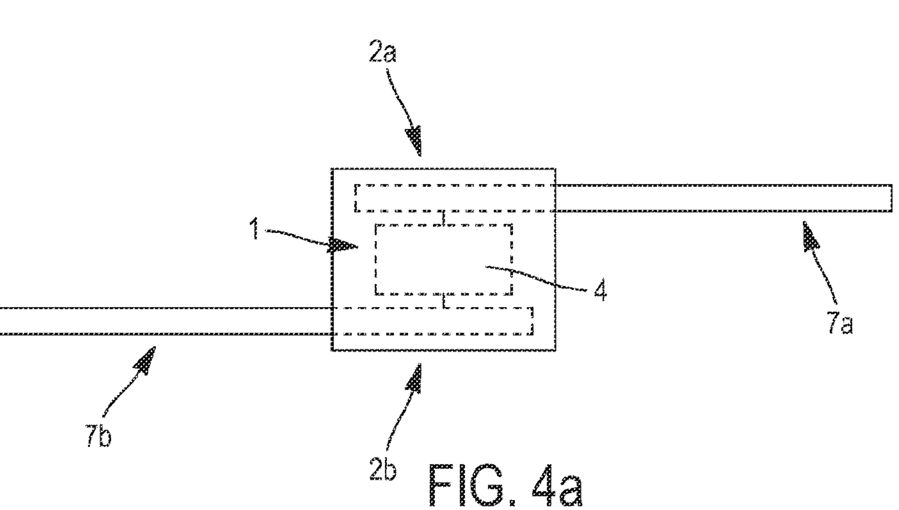


FIG. 4a

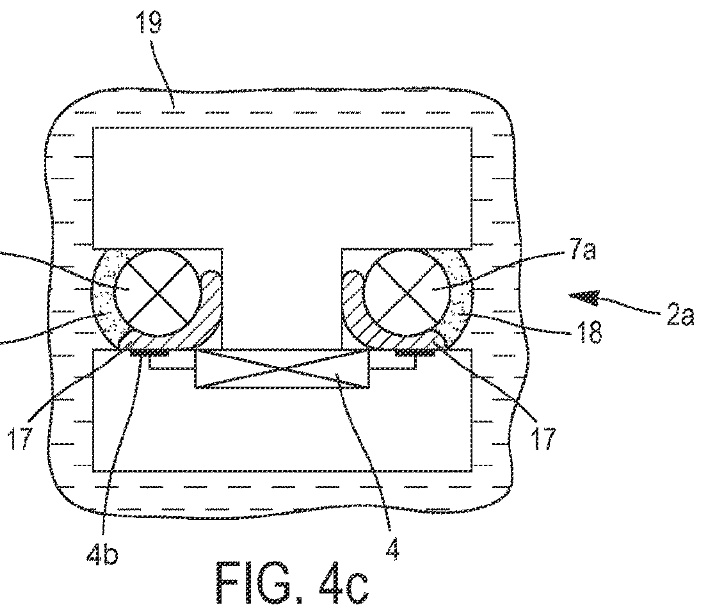


FIG. 4c

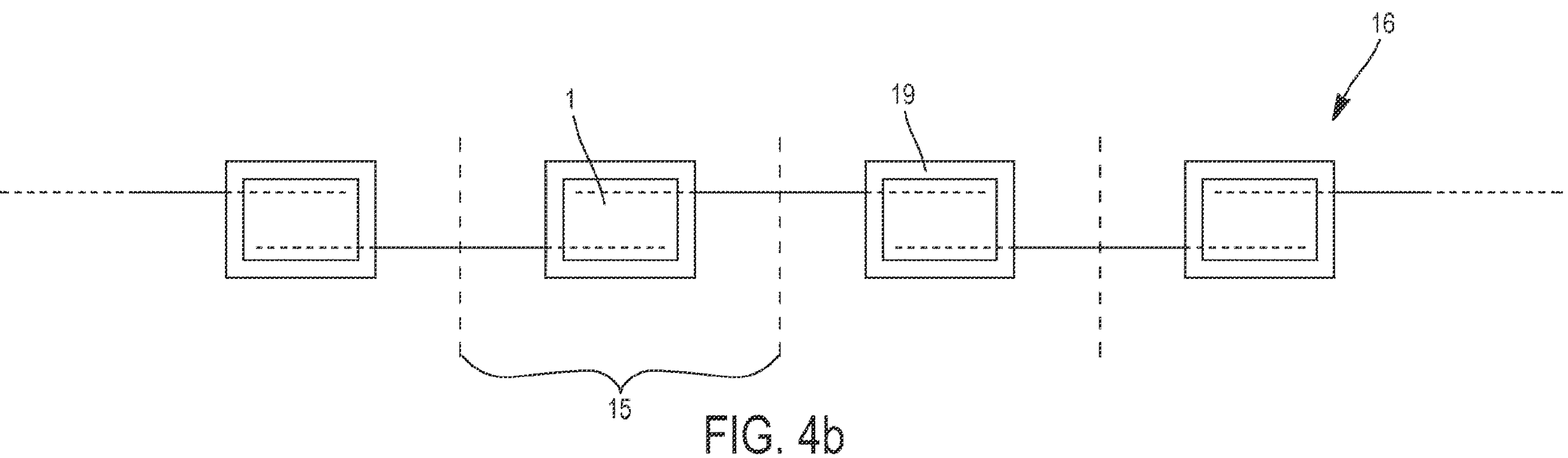


FIG. 4b

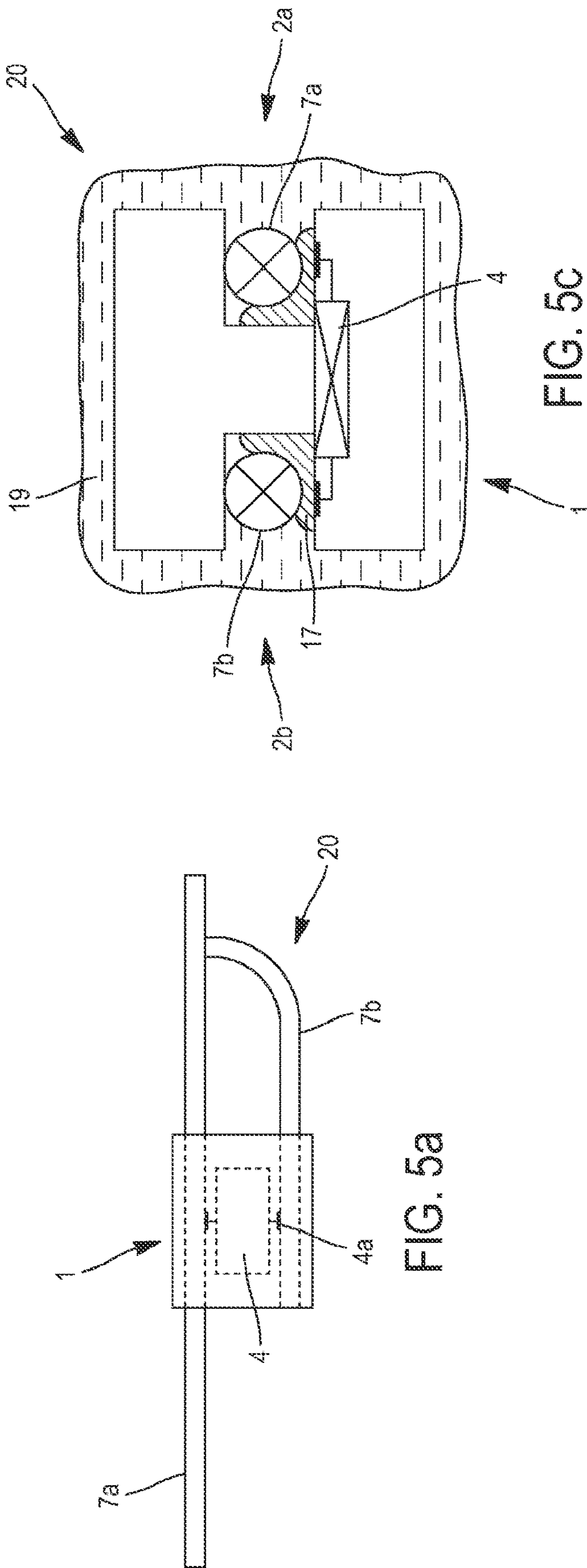


FIG. 5c

FIG. 5a

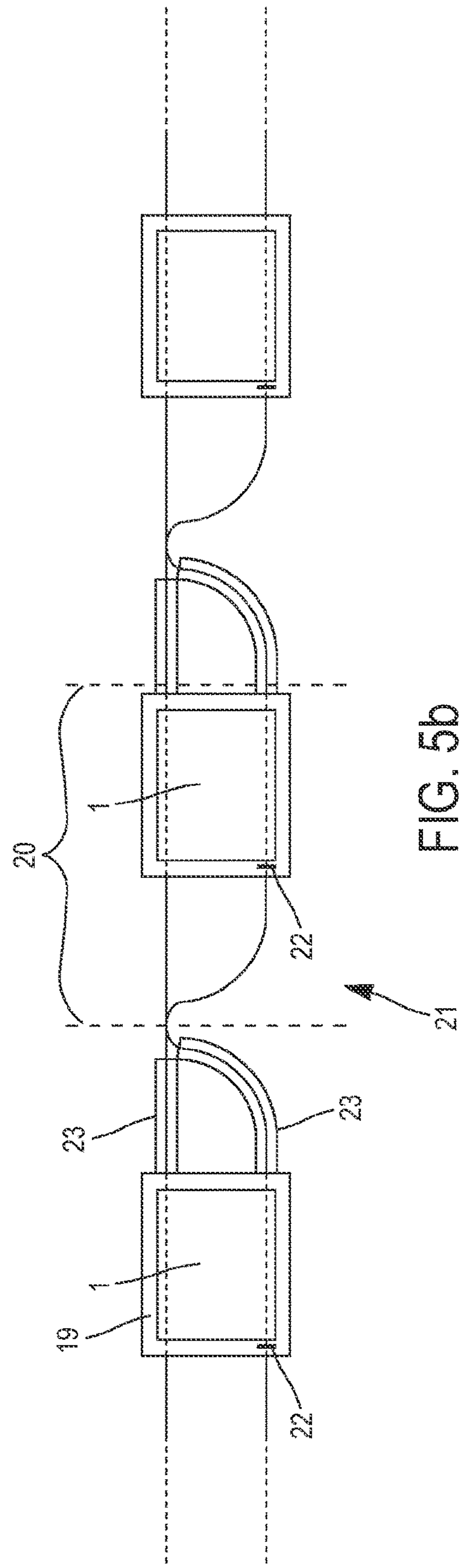


FIG. 5b

METHOD FOR INSERTING A WIRE INTO A GROOVE OF A SEMICONDUCTOR CHIP

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is a divisional of U.S. patent application Ser. No. 16/481,754, filed Jul. 29, 2019, which is a national phase entry under 35 U.S.C. § 371 of International Patent Application PCT/FR2018/050166, filed Jan. 25, 2018, designating the United States of America and published as International Patent Publication WO 2018/138437 A1 on Aug. 2, 2018, which claims the benefit under Article 8 of the Patent Cooperation Treaty to French Patent Application Serial No. 1750728, filed Jan. 30, 2017.

TECHNICAL FIELD

[0002] The present disclosure relates to a method for inserting a wire into a groove of a semiconductor chip for assembly thereof. It also relates to a piece of equipment implementing this insertion method. It finds an exemplary application in the field of RFID electronic tagging ("Radiofrequency Identification") to directly associate an antenna with a transmission reception chip and provide a particularly small radiofrequency device that is simple to manufacture. This device can be integrated into a textile thread and this thread itself can be integrated into a wide variety of objects for the identification, tracking, and administration thereof.

BACKGROUND

[0003] For example, the technology used to assemble a wire and a chip known as E-THREAD™ is known from the documents U.S. Pat. No. 8,471,713, U.S. Pat. No. 8,093,617, U.S. Pat. No. 8,093,617, U.S. Pat. No. 8,723,312, US2015318409, U.S. Pat. No. 8,782,880, U.S. Pat. No. 8,814,054 or US 2015230336.

[0004] With this technology, the chip has a longitudinal groove and a longitudinal section of the wire is inserted into this groove. The assembly can be obtained by embedding the wire in the groove, the dimensions of the wire and of the groove then being sufficiently adjusted to mechanically join the two elements to each other. As disclosed in the documents WO2009112644 and WO2014041107, the groove may in some cases be provided with a pad making it possible to clamp the wire in the groove, so as to hold it there. In addition or alternatively, the assembly can be obtained or reinforced by adding an adhesive material between the wire and the chip, by soldering or brazing the wire and the chip.

[0005] In the document U.S. Pat. No. 8,471,773, the wire is electrically conductive and the semiconductor chip contains a transmission reception circuit. The assembly of the wire and the chip makes it possible to contact the wire and an input-output terminal of the transmission reception circuit to form an operational transmission reception device. The wire is an antenna of this device.

[0006] Inserting the wire into the chip groove is a particularly delicate operation, especially in an industrial context where it is necessary to be able to maintain a high production rate.

[0007] Document U.S. Pat. No. 8,782,880 discloses a piece of insertion equipment adapted to maintain this rate. Large wires are supplied in the piece of equipment in the form of coils and the chips stored in a tank. Two wires are unwound from the coils to be supplied, parallel to each other, to a clamping zone of the piece of equipment. It is also configured to successively bring the chips from the tank to this clamping zone, between the two wires, and embed a longitudinal section of each wire in a longitudinal groove of the chip. Alternatively, this document provides for the welding of the wire and a metal pad placed in the groove to each other to secure the chip and the wire at the outlet of the insertion piece of equipment. A chain is thus formed that consists of a plurality of chips connected by large wires. The chip chain can be wound on a support to form a storage reel. Segments of this chain can be removed from the storage reel by cutting the wires according to a desired cutting pattern.

[0008] The insertion technology provided for in this piece of equipment requires the application of relatively significant efforts on the wires to embed them in the grooves. This "forced" insertion of the wire into the groove can lead to weakening or breaking during or after the insertion. In addition, this insertion technology is particularly sensitive to the correct adjustment of the groove and the wire dimensions. A wrong adjustment may lead to an insufficiently robust assembly, or on the contrary, require excessive force that may lead to the breakage of, or damage to the wire.

[0009] It would be advantageous to have an insertion technique that does not require the application of as much effort as the state of the art. It would also be advantageous to be able to insert and assemble the wire and the chip in the same step, without excessive effort.

BRIEF SUMMARY

[0010] With a view to achieving at least one of these purposes, the subject matter of the present disclosure proposes, according to a first aspect, a method for inserting a wire into a longitudinal groove of a semiconductor chip for the assembly thereof, the groove containing a pad made of a bonding material having a set melting point, the method comprising:

- **[0011]** in a positioning step, placing a longitudinal section of the wire along the groove, in forced abutment against the pad; and
- **[0012]** in an insertion step, exposing a zone containing at least one portion of the pad to a processing temperature higher than the melting point of the bonding material and for a sufficient time to make the pad at least partially melt, and causing the wire to be inserted into the groove.

[0013] According to other advantageous and unrestrictive characteristics of the present disclosure, taken alone or in any technically feasible combination:

- **[0014]** the method comprises, upon completion of the insertion step, solidifying the bonding material to assemble the wire and the chip;
- **[0015]** the wire is maintained in a state of tension opposite the groove and the positioning step consists in pressing the wire against the pad;
- **[0016]** the pad is brought to the induction processing temperature by exposing the zone to a hot air flow or a light flow;
- **[0017]** the method comprises, before or during the positioning step, a step of preparing the longitudinal section of the wire intended to be inserted into the groove;
- **[0018]** the preparation step comprises the deposition of a coating layer on the longitudinal section of the wire;

[0019] the preparation step includes a step of cleaning and/or deoxidation of the longitudinal section of the wire;

[0020] the insertion step is followed by a reinforcing step comprising dispensing an adhesive in the groove and on the longitudinal section of the wire exposed in the groove;

[0021] the insertion step is followed by a step of encapsulating the chip and/or wires;

[0022] the wire is electrically conductive; and

[0023] the method comprises repeating the positioning and inserting steps so as to insert a plurality of chips onto the wire and form a chain **16**, **21**.

[0024] In another aspect, the present disclosure also proposes a piece of equipment for inserting a wire into at least one chip, the chip having a groove to receive a longitudinal section of the wire and the groove containing a pad made of a bonding material having a set melting point, the piece of equipment comprising:

[0025] positioning members for deploying and moving a length of the wire between a first and a second end of a workspace;

[0026] a device for handling the chip capable of placing the chip in an insertion position in which the groove is placed opposite the wire;

[0027] a positioning member for arranging the longitudinal section of the wire along the groove, in forced abutment against the pad; and

[0028] a heating member for raising to a processing temperature a zone comprising the pad when the chip is placed in the insertion position.

[0029] According to other advantageous and unrestrictive characteristics of the present disclosure, taken alone or in any technically feasible combination:

[0030] the positioning members are configured to deploy two parallel wires between the first and the second ends, and wherein the insertion position is located between the two wires;

[0031] the insertion equipment has at least one additional member arranged in the workspace, downstream or upstream of the chip insertion position; and

[0032] the additional member and the positioning member are positioned and configured in the workspace so that the processing performed by these components can be conducted simultaneously.

BRIEF DESCRIPTION OF THE DRAWINGS

[0033] Other characteristics and advantages of the present disclosure will emerge from the detailed description of the present disclosure that follows with reference to the appended figures on which:

[0034] FIGS. **1***a* and **1***b* represent, in perspective and in cross-section, a chip compatible with an insertion method according to the present disclosure;

[0035] FIGS. **2***a* to **2***e* show the steps of a method according to the present disclosure;

[0036] FIGS. **3***a* and **3***b* show a piece of equipment configured to implement a method according to the present disclosure at two particular times during its operation;

[0037] FIGS. **4***a* to **4***c* show an exemplary application of the method to the manufacturing of a first reception transmission device; and

[0038] FIGS. **5***a* to **5***c* show an exemplary application of the method of the present disclosure to the manufacturing of a second transmission reception device.

DETAILED DESCRIPTION

[0039] FIG. **1***a* shows, in perspective, an electronic component, referred to as a "semiconductor chip" **1**, or more simply a "chip" in the following description, compatible with an insertion method according to the present disclosure. FIG. **1** is a cross-sectional view of such a chip **1**.

[0040] The chip **1** has two longitudinal grooves **2***a*, **2***b*, parallel to each other and respectively formed on two side faces **1***a*, **1***b* of the chip **1**, opposite each other. This configuration makes it possible to keep all its generality to the description that follows, but the present disclosure is by no means limited to this number and this arrangement of grooves, and the chip **1** can quite well be provided with a single or any number of groove(s), each arranged in any orientation on any one of the faces of the chip **1**, without leaving the scope of the present disclosure. These longitudinal grooves **2***a*, **2***b* are provided each to receive and accommodate a longitudinal section of a wire (not shown in these FIGS. **1***a* and **1***b*). To facilitate the insertion of the wire, each groove **2***a*, **2***b* extends, on the face of the chip that it is placed on, from one side to the other of the chip **1**. In the following, the portion of the wire that is or will be accommodated in a groove of the chip, depending on its length, is referred to as the "longitudinal section of the wire."

[0041] According to the present disclosure, the height and depth dimensions of the grooves **2***a*, **2***b* are chosen large enough, or the wire cross-section is chosen small enough, so that each wire can be accommodated in a groove **2***a*, **2***b* without mechanically forcing its embedding. To promote the connection of the wire to the chip **1**, it is generally preferable, for the longitudinal section of the wires to be able to be fully accommodated in the grooves, i.e., the accommodated portion of each wire does not extend beyond the face of the chip that the groove is formed on. When the chip **1** has a plurality of grooves **2***a*, **2***b* as in FIGS. **1***a* and **1***b*, they are not necessarily of the same size. Similarly, the wires that are to be accommodated in the grooves are not necessarily of the same nature and do not necessarily have identical cross-sections.

[0042] The chip **1** comprises a substrate **3** having a functional circuit **4**, such as a transmission reception circuit, a calculation device, a sensor, a LED or any other form of integrated circuit provided on the substrate **3**, for example, using techniques known in the semiconductor field. The functional circuit **4** can be electrically connected to one or more connection terminal(s) **4***a*, **4***b* leading into either one of the grooves **2***a*, **2***b* using conductive tracks or vias formed on or in the substrate **3**. At least one of the wires can then be brought into electrical contact when it is inserted into one of the grooves **2***a*, **2***b* with the functional circuit **4**. In this case, the wire assembled to the chip **1** is not a simple mechanical support for the chip **1**, but can contribute to the operation thereof, for example, by forming an antenna, or by electrically connecting the chip to a power supply, or still by distributing a signal to another chip that would also be connected thereto. In this case, of course, the wire is made of, or includes an electrically conductive material. If the wire is provided with an insulating sheath, it may be necessary to strip the wire at its longitudinal section to be

accommodated in the groove in order to enable an electrical contact with a connection terminal. But the present disclosure is by no means limited to an electrical conductive wire connected to a connection terminal located in a groove of the chip **1**. It can be envisaged that the wire will be made of a non-conductive material that forms a mechanical support for this chip. Alternatively, the chip may be provided with a plurality of wires arranged in grooves, at least one wire being a metal conductor electrically connected to the chip **1**, at least another wire being an electrical insulator and being used only as a support.

[0043] In the description of FIGS. **1***a* and **1***b*, the chip **1** also includes a cover **5**, with a T-shaped section, the base of the T being assembled with a main face of the substrate **3**. In this way, the two longitudinal grooves **2***a*, **2***b* are formed between the T-bar of the cover **5** and the main surface of assembly with the substrate **3**. Like the substrate **3**, the cover **5** can also be provided with a functional circuit, connection terminals and/or conductive tracks or vias. These elements can be electrically and functionally connected to the functional circuit **4**.

[0044] Other configurations of the chip **1** than the one shown in the figures below and FIG. **1***b* are possible. For example, the chip **1** may consist of a single flat support having the functional circuit **4**, the longitudinal grooves **2***a*, **2***b* being formed, for example, by etching, on two opposite lateral faces of this support, or on one and/or the other of the main faces of this support. According to another configuration, the chip **1** can consist of two flat supports of identical or similar dimensions, each having a functional circuit. The flat supports are each assembled to the two opposite sides of a smaller spacer to define the two longitudinal grooves **2***a*, **2***b* of the chip **1**. The spacer can consist of a part made up of a sufficiently thick layer of adhesive.

[0045] Whatever the configuration chosen, a chip **1** compatible with an insertion method according to the present disclosure shall have at least one longitudinal groove **2***a*, **2***b* for receiving and accommodating a longitudinal section of a wire.

[0046] Also according to the present disclosure, the groove **2***a*, **2***b* contains at least one pad **6***a*, **6***b* made of a bonding material. In the example shown in FIGS. **1***a*, **1***b* the pads **6***a*, **6***b* are arranged in the grooves **2***a*, **2***b* on the face of the cover **5** forming one of the walls of the grooves **2***a*, **2***b*, and over their whole length. Alternatively, the pads **6***a*, **6***b* could be placed on another wall forming the grooves **2***a*, **2***b*, for example, on the cover **5** side. Alternatively, each pad **6***a*, **6***b* of a plurality of elementary pads, distinct from each other, arranged in a groove over a reduced length, could be chosen. Whatever the shape, volume or arrangement of the pads **6***a*, **6***b* in the grooves **2***a*, **2***b*, they are so large that it is not possible to perfectly accommodate the wires in the grooves **2***a*, **2***b* in their presence. As will be made explicit in the following description, each pad **6***a*, **6***b* forms a reserve of a bonding material that will allow the assembly and good mechanical strength of the wire accommodated in each of the grooves **2***a*, **2***b*.

[0047] The material constituting each pad **6***a*, **6***b* is chosen so that its melting point is relatively low. This melting point is lower than the maximum temperature that the functional circuit **4** of the chip **1** can be exposed to without damage. If, for example, this maximum temperature is 350° C., the material of the pads **6***a*, **6***b* should be chosen so that its melting point is lower than 350° C., for example, 300° C. Advantageously, for reasons of simplicity of the insertion method described below, this material is chosen so that its melting point is between 80° C. and 100° C. or 150° C., or 250° C. The material constituting each pad **6***a*, **6***b* may include a plurality of elemental compounds. For example, it may be an alloy of metals, such as tin, silver and copper. It should be noted that the chip **1** is intended to be handled at atmospheric pressure, and therefore the mentioned melting point is determined at this pressure. In addition, it is not necessary for all the pads **6***a*, **6***b* or elementary pads to be made of the same material.

[0048] Advantageously, especially when a pad **6***a*, **6***b* is used to electrically connect a wire to a connection terminal of the chip **1**, it is made of an electrically conductive material. But, as noted above, this is not compulsory.

[0049] The chip **1** can be mass-produced, using technologies of the semiconductor integrated circuits field, as taught in the mentioned state-of-the-art documents. The pads **6***a*, **6***b* can be advantageously manufactured during the manufacture of the chip **1**, for example, by forming them by deposition on the substrate **3** before the assembly thereof with the cover **5** or, more generally before the formation of the cover **5**. It is also possible to consider forming the pads **6***a*, **6***b* in the longitudinal grooves **2***a*, **2***b* after manufacturing the chip **1**, for example, by dispensing the bonding material forming these pads **6***a*, **6***b* in a liquid form, at a temperature above its melting point, directly into the grooves **2***a*, **2***b*.

[0050] The present disclosure takes advantage of the characteristics of the chip **1** to propose a particularly clever method for inserting at least one wire into at least one groove **2***a*, **2***b* of the chip **1** that does not require a forced embedding of this wire, and therefore limits the forces applied to the wire during its insertion. This method is described while referring to FIGS. **2***a* to **2***e*.

[0051] First of all, it should be noted that the wire can be of any kind as long as it is sufficiently resistant to the mechanical and chemical treatments that will be disclosed. Advantageously, the wire is a conductive electrical wire, for example, made of stainless steel, a copper-based alloy or copper, and the insertion method allows this wire to be electrically connected to a terminal **4***a*, **4***b* of the functional circuit **4** of the chip **1**.

[0052] FIG. **2***a* shows a chip **1** as described above.

[0053] During a positioning step, a longitudinal section of two wires **7***a*, **7***b* is laid out along two grooves **2***a*, **2***b*. The pad **6***a*, **6***b* occupies a sufficient portion of the groove **2***a*, **2***b* to prevent the wire from being fully accommodated therein. During the positioning step, limited efforts are made on the wire **7***a*, **7***b* to press it against the pad **6***a*, **6***b* and put it in forced abutment against it. FIGS. **2***b* and **2***c* show the chip **1** and two wires **7***a*, **7***b* upon completion of the positioning step. The wires **7***a*, **7***b* are in contact with the pads **6***a*, **6***b*, they can also be in contact with one of the edges of the substrate **3** and/or the cover **5** defining the contours of the grooves **2***a*, **2***b* on the side faces **1***a*, **1***b* of the chip **1**. In the case where a pad **6***a*, **6***b* does not extend over the full length of a groove **2***a*, **2***b*, a portion of the longitudinal section of a wire may be partially accommodated therein.

[0054] It should be remembered that the diameter of the wires is chosen to be smaller than the height of the grooves, so that in the absence of the pads **6***a*, **6***b*, the wires can be inserted without any particular embedding effort and be accommodated in the grooves **2***a*, **2***b*.

[0055] As shown in FIGS. **2***d* and **2***d*, the method of the present disclosure also includes an insertion step, subsequent to the positioning step. During this insertion step, a zone at least partially comprising the pads **6***a*, **6***b* is exposed to a processing temperature above the melting point of the bonding material they contain, and for a sufficient time to melt it. The change to the liquid state of the bonding material, combined with the modest forces exerted on the wires **7***a*, **7***b*, leads to the insertion of the latter into the grooves **2***a*, **2***b* as shown in FIG. **2***e*. It is not necessary for the bonding material of the pads **6***a*, **6***b* to pass in its entirety to the liquid state to cause the insertion of the wires **7***a*, **7***b*. It is sufficient that only a portion of the material liquefies to clear a sufficient passage to allow the wires **7***a*, **7***b* to be engaged and accommodated in the grooves **2***a*, **2***b*. The zone exposed to the processing temperature includes all the pads **6***a*, **6***b*, but only a portion of these pads **6***a*, **6***b* may directly be exposed to the processing temperature that can be caused by heat conduction.

[0056] When the chip **1** has several grooves **2***a*, **2***b* to accommodate several wires **7***a*, **7***b*, as shown in the example shown in FIGS. **2***a* to **2***e*, the insertion step can be performed successively or simultaneously for each of the wires. The zone exposed to the processing temperature may be large enough to at least partially include all the pads **6***a*, **6***b*. Alternatively, the insertion step may include the simultaneous or successive exposure of several distinct zones, each encompassing at least a portion of the pads **6***a*, **6***b*.

[0057] The insertion step can be carried out with a heating member, for example, a generator of a flow of air or another heated fluid, by induction, or by light irradiation such as laser irradiation or ultraviolet radiation, leading to the generation of a heat flow defining the heated zone at the chip **1**. The flow is maintained for long enough and has a sufficient temperature, higher than the melting point of the bonding material the pad **6***a*, **6***b* is made of, to cause it to melt. Of course, the heating can be global, for example, by placing the chip **1** in a heated enclosure, but this approach could be a little more complex to implement industrially.

[0058] As shown in FIG. **2***e*, the bonding material constituting the pads **6***a*, **6***b*, once in the liquid state, tends to embed itself around the wire **7***a*, **7***b*, and flow over the walls defining the grooves **2***a*, **2***b*. Some of the bonding material can be absorbed by the longitudinal section of the wire and contributes to reinforcing the mechanical strength of the wire **7***a*, **7***b* in the grooves **2***a*, **2***b*.

[0059] When the wires **7***a*, **7***b* are inserted into the grooves **2***a*, **2***b*, the heat treatment of the bonding material can be interrupted either by deactivating the heating member or by moving the chip **1** and/or the member so as to extract the chip **1** from the zone exposed to the heat flow. The interruption of the heat treatment in the zone restores a temperature lower than the melting point of the bonding material, typically at room temperature, which leads to a solid constitution and to the wire being joined to the chip. When the bonding material and the wires are electrical conductors, it is thus possible to electrically connect the wires **7***a*, **7***b* to terminals **4***a*, **4***b* of the functional circuit **4**. It should therefore be noted that the method makes it possible, in a combined way, to insert the wire and secure it to the chip **1** without the need for major embedding efforts. The pad **6***a*, **6***b* forms a kind of reservation of an assembly material, prepositioned in the grooves.

[0060] Before or during the positioning step, the method of the present disclosure may provide for a step of preparing the wires **7***a*, **7***b*. This step may include removing an insulating sheath surrounding a conductive core, when the wires **7***a*, **7***b* are so formed, so that an electrically conductive assembly can be formed with the chip **1**. Alternatively, or in addition, a cleaning or deoxidation processing of the wires **7***a*, **7***b* can be provided to improve the formation of this contact and/or the adhesion of the pads **6***a*, **6***b* bonding material. In some alternative solutions, the preparation step may include tinning the wires or, more generally, coating them with a material that promotes electrical contact or adhesion of the bonding material. These treatments can be carried out, for example, by projecting or spraying liquid fluids or liquefied liquids depending on the desired processing (acid, cleaning solution, liquid metal alloy, etc.).

[0061] The method according to the present disclosure may also include additional steps, after the wires **7***a*, **7***b* have been inserted into the grooves **2***a*, **2***b*, during or after the assembly thereof on the chip **1** by solidifying the bonding material. Thus, the method can include a step of reinforcing the assembly of the wires **7***a*, **7***b* on the chip **1**. This step is particularly useful when unbalanced forces are applied to a plurality of wires **7***a*, **7***b* leading to the formation of shear stresses in their assemblies with the chip **1**. The reinforcing step may include dispensing an adhesive into the grooves **2***a*, **2***b* and on at least a portion of the longitudinal section of the wires **7***a*, **7***b* exposed in the grooves. Dispensing the adhesive can be supplemented by the exposure thereof, for example, by UV treatment, and can be very short, of the order of one second or a few seconds, to stiffen the adhesive and promote the attachment thereof to the elements that it is in contact with.

[0062] The method may also include, as a complementary step, a step of encapsulating the chip **1** in a sufficiently rigid and waterproof material, such as resin, to protect it from mechanical or chemical stresses in its final application. Preferably, this encapsulation is such that all the faces of the chip **1**, and particularly where the faces which the grooves **2***a*, **2***b* have been formed on, are in fact coated with the encapsulating material.

[0063] In some cases, especially when the chip **1** is associated with several conductive wires **7***a*, **7***b*, it may be necessary to electrically isolate the wires **7***a*, **7***b* from each other. The present disclosure may therefore provide for a complementary step aimed at providing electrical insulation on or between the wires **7***a*, **7***b*. The insulant can be made of a liquid material placed on and between the conductive wires **7***a*, **7***b*, or even on the chip **1** itself, before being made solid. Preferably, the electrical insulating material is not excessively rigid in order to keep the wires **7***a*, **7***b* deformable, and may be of particular interest depending on the application concerned.

[0064] The method may also include, as a complementary step, a step of bringing the wires **7***a*, **7***b* into electrical contact in order to form a loop. This contact can result in the dispensing of a conductive adhesive.

[0065] The method may also include, as a complementary step, a step of cutting one or more wire(s) **7***a*, **7***b*. This may involve taking a segment provided with at least one chip **1** for the integration thereof into an object. It may also involve cutting a portion of a wire to form a dipole antenna connected to the chip **1** as taught in the document U.S. Pat. No. 8,471,773. The cutting of one or more wire(s) **7***a*, **7***b* can be

carried out by any means known per se, for example, by using a mechanical shearing tool or by laser cutting.

[0066] An additional step of testing and/or programming the chip **1** after it has been assembled to the wires **7***a,* **7***b* can also be provided to ensure that the previous steps have not affected its functionality and/or make it fully functional.

[0067] The present disclosure also provides for a piece of equipment **8** for inserting a wire **7***a,* **7***b* into the groove **2***a,* **2***b* of a semiconductor chip **1**, making it possible to implement a method according the one just described. The piece of equipment **8** is particularly suitable for the repeated insertion of a wire into a plurality of chips **1**, to form a chip chain **1**.

[0068] FIGS. **3***a* and **3***b* show such piece of equipment at two particular times of its operation. The piece of equipment **8** shown in these figures is configured to allow the simultaneous insertion of two wires **7***a,* **7***b* into two grooves **2***a,* **2***b* respectively of a chip **1**. But the piece of equipment of the present disclosure is by no means limited to this particular example and the same principles that will be explained may apply for the insertion of a different number of wires.

[0069] The piece of equipment **8** includes positioning members **9**, **9***a,* **9***b* to deploy, under a controlled state of tension, a wire **7***a,* **7***b* between two ends of a workspace. At one end of this space, a wire supply member **9***a,* such as a reel, may be provided to extract the two wires **7***a,* **7***b* from two supply reels. These wires **7***a,* **7***b* are deployed over the entire length of the workspace to reach the second end which a storage member **9***b* such as a reel can be provided on, making it possible to position the chip chain that will be manufactured by the piece of equipment on a storage reel **8**. The wires **7***a,* **7***b* are guided between the two ends by guide members **9** such as wheels or rollers to precisely position and guide the position in the space of the wires **7***a,* **7***b,* especially during the movements thereof. The positioning members **9***a,* **9***b,* **9***b,* **9** can be motorized to allow the wire to be driven, ensuring, as the piece of equipment **8** processes, the transfer of the wires **7***a,* **7***b* from their supply reels to the storage reel.

[0070] The positioning members **9**, **9***a,* **9***b* are also designed to control the tension of each wire **7***a,* **7***b* so that it can be between a minimum tension for which the wires **7***a,* **7***b* are not tensioned and a maximum tension for which the wires are likely to deteriorate or break. When the piece of equipment **8** is designed to deploy a plurality of wires **7***a,* **7***b,* as in the example shown, it may be advantageous to try to maintain the same tension between the two wires. Similarly, when a plurality of wires **7***a,* **7***b* are inserted into at least one chip **1**, it is important that the movement of the wires **7***a,* **7***b* along the workspace during the processing performed by the piece of equipment **8** should be performed simultaneously and with the same speed for each wire **7***a,* **7***b* in order to avoid generating shearing forces on the chips **1**, which could lead to the disassembling of the wires **7***a,* **7***b* from the grooves **2***a,* **2***b*.

[0071] In the example shown, the two wires **7***a,* **7***b* are arranged in the same horizontal plane so that they can be inserted into a chip **1** provided with two grooves **2***a,* **2***b* also arranged in the same plane. Another configuration of the grooves **2***a,* **2***b* on the chip **1** could lead to a different adjustment of the arrangement of the wires **7***a,* **7***b* with respect to each other.

[0072] The work space consists of an intermediate zone **10***a* in which the step of assembling the wires **7***a,* **7***b* and the chip **1** is performed.

[0073] Upstream of the intermediate zone **10***a,* on the side of the first end and the supply member **9***a,* the two wires **7***a,* **7***b* are spaced from each other by more than the distance between the two wires **7***a,* **7***b* when inserted into the grooves **2***a,* **2***b* of the chip **1**. When the distance between the grooves **2***a,* **2***b* of a chip **1** is less than one millimeter, which is usual, the two wires **7***a,* **7***b* can be separated from each other, in the upstream zone **10***b,* by a few millimeters, for example, 3 mm.

[0074] Downstream of the intermediate assembly zone **10***a,* on the second end of the piece of equipment **8** and storage member **9***b* side, the wires **7***a,* **7***b* are inserted into the grooves **2***a,* **2***b* and assembled with the chips **1**. The distance between the two wires **7***a,* **7***b* is therefore imparted by the geometry of the chip **1** and the depth of its grooves. This distance is typically less than 1 mm.

[0075] The guide elements **9** placed in the intermediate zone **10***a,* or directly in the vicinity of this zone, allow the spacing of the wires **7***a,* **7***b* to be guided between the existing spacing in the upstream zone **10***b* and the one existing in the downstream zone **10***c*.

[0076] The piece of equipment shown in FIGS. **3***a*, **3***b* also includes a handling device **11** that allows a chip **1** to be extracted from a chip storage zone and positioned in an insertion position, located in the intermediate zone **10***a* between the wires **7***a,* **7***b*. The insertion position can be materialized by a tray that the chip **1** can be positioned and fixedly held on. When a chip **1** is correctly positioned in the insertion position, the grooves **2***a,* **2***b* of the chip are positioned facing and at the same elevation as the wires **7***a,* **7***b* and in the same plane. The handling device **11** can be an automatic component insertion ("Pick and Place") machine comprising an articulated arm with a suction nozzle making it possible to grasp a chip **1** from the storage area and position same precisely in the insertion position thereof.

[0077] The piece of equipment **8** also includes a member **12** for positioning the wires **7***a,* **7***b*. This member **12** placed in the intermediate insertion zone **10***a* can be supported on the wires **7***a,* **7***b,* according to two configurations. In a first "open" configuration, shown in FIG. **3***a*, the positioning member **12** does not or does not sufficiently rest on the wires **7***a,* **7***b,* leaving a space between these wires **7***a,* **7***b* clear in order to be able to place a chip **1**, therein, in the insertion position. In a second configuration of the positioning member **12**, shown in FIG. **3***b*, the latter is controllably resting to position the wires **7***a,* **7***b* along the grooves **2***a,* **2***b,* pressed against the pads **6***a,* **6***b* placed in these grooves, and therefore in forced abutment against the pads **6***a,* **6***b*.

[0078] According to the present disclosure, the piece of equipment **8** also includes at least one heating member **13** arranged in or near the intermediate zone **10***a,* to raise to a processing temperature a zone comprising at least a portion of the pads **6***a,* **6***b* arranged in the grooves **2***a,* **2***b,* when a chip **1** is placed in the insertion position. As seen in the detailed description of the method of the present disclosure, the heating member **12** allows the temperature of the bonding material forming the pads **6***a,* **6***b* to be raised above its melting point. The member **12** may include a generator of a flow of hot air or any other gaseous fluid, a generator of a light radiation such as UV or laser radiation, a generator of induction heating. The member **12** may include several

generators, each generator exposing a particular zone, located, for example, in each of the grooves **2***a*, **2***b* of a chip **1** when it is placed in the insertion position.

[0079] All the members just described may be connected to a processing device, not shown in the figures, ensuring the sequencing of the operations of moving the wires **7***a*, **7***b*, placing the chip **1** in the insertion position, actuating the insertion members **12**, and the heating member **13** to allow the insertion method of the present disclosure to be carried out at high speed.

[0080] In addition to the members arranged in or near the intermediate assembly zone **10***a* just described, the piece of equipment **8** may also provide, upstream and/or downstream of this zone, other additional members **14** to carry out the steps of preparing the wires **7***a*, **7***b*, and the complementary steps on the assembly formed by the chip **1** and the wires **7***a*, **7***b*. These additional members may include dispensing nozzles for, for example, spraying cleaning, deoxidation, tin plating or adhesive fluids onto the wires **7***a*, **7***b* and/or into the grooves **2***a*, **2***b*. The additional members may also include a laser source for cutting a wire or a UV source for solidifying an adhesive or a resin. It can also be a mechanical device for cutting wires by shearing, or chip testing or programming means. Preferably, these additional members **14** make it possible to process the wires **7***a*, **7***b* or the chip **1** without contacting these elements.

[0081] The additional members **14** are advantageously distributed, in the workspace, along the wires **7***a*, **7***b* on the upstream zone **10***b* side and in the downstream zone **10***c* so that the processes carried out by these members and by those placed in the intermediate zone **10***a*, can all be performed simultaneously. In other words, when the wires **7***a*, **7***b* are driven by the supply, guide and storage members **9***a*, **9** and **9***b*, to be moved by a length portion corresponding to the spacing between two chips, the additional members are positioned opposite a chip (downstream of the intermediate insertion zone) or opposite a longitudinal section of wire (upstream of this zone) that they can process. When all the processes have been carried out by these members, the wires **7***a*, **7***b* can be driven and moved by an additional length portion.

[0082] In an alternative embodiment of the present disclosure, the wires **7***a*, **7***b* can be continuously driven, in order to further increase the working rate. In this case, the chip **1** can be positioned on a plate moving in the wire driving direction and at the same speed so that the chip **1** is substantially stationary relative to the wires **7***a*, **7***b*, and allow the insertion thereof into the grooves **2***a*, **2***b* and the assembly thereof.

FIRST EXAMPLE

[0083] The above described method and piece of equipment **8** can be used to produce a transmission reception device **15** and a chain of such devices, as described in document U.S. Pat. No. 8,471,773.

[0084] Such a transmission reception device **15** is formed by a chip **1** according to the one shown in FIG. **1***a*, comprising two longitudinal grooves **2***a*, **2***b* arranged on opposite sides of the chip **1**. Two conductive wires **7***a*, **7***b* are placed in the grooves **2***a*, **2***b*. These wires extend on either side of the chip **1** to form a dipole-shaped antenna. The wires **7***a*, **7***b* are electrically connected to terminals **4***a*, **4***b* of a transmission reception circuit **4**, positioned, for example, in the substrate **3** of the chip **1**. FIG. **4***a* shows a schematic representation of such a transmission reception device **15**.

[0085] For reasons of mechanical resistance, in particular, to bending, the wire is preferably chosen in stainless steel. In some cases, however, copper-based alloy or copper wires may be preferred.

[0086] To manufacture such a transmission reception device, or a chain of such devices, two wire coils are placed in the unwinders of the positioning members **9***a*, and these wires **7***a*, **7***b* are deployed through the positioning members **9** until they are attached to the storage spool of the reel forming the positioning member **9***b*. Once positioned, the different positioning members are activated to position the wires in a state of tension and in the same plane to prepare the insertion of the wires **7***a*, **7***b* into the chips **1**. Transmission reception chips **1**, for example, RFID chips, are positioned in the chip storage zone and can be successively moved, during the processing sequences, to the insertion position by the handling device **11**. During each new processing sequence, the members that the piece of equipment **8** is made of simultaneously perform the following operations, before moving the wire by a specified length and repeating these operations again.

[0087] In the upstream zone **10***b* of the workspace, at an additional member **14**:

- **[0088]** cleaning, and possibly tin-plating a longitudinal section of the wires **7***a*, **7***b* intended to be accommodated in the grooves **2***a*, **2***b* of a chip **1**.

[0089] In the intermediate zone **10***a*, using the members located in this zone:

- **[0090]** removing a chip **1** from the storage area and positioning this chip **1** in the insertion position;
- **[0091]** inserting the longitudinal sections of the wires **7***a*, **7***b* that have been previously prepared during a previous sequence; and
- **[0092]** assembling the wires **7***a*, **7***b* in the grooves **2***a*, **2***b* by liquefying and solidifying the bonding material initially forming the pads **6***a*, **6***b*.

[0093] In the downstream zone **10***c*, using additional members **14** arranged in this zone opposite a plurality of chips **1** assembled to the wires **7***a*, **7***b* during previous sequences:

- **[0094]** dispensing an adhesive into the grooves **2***a*, **2***b* and on the longitudinal sections of the wires exposed in these grooves and exposure of the adhesive to harden it and reinforce the assembly of the wires **7***a*, **7***b* on the chip **1**;

[0095] cutting one of the two wires **7***a*, **7***b* in order to preform dipole-shaped antennas;

- **[0096]** encapsulating the chip **1** in a protective material such as a rigid resin, allowing it to be mechanically and chemically protected; and
- **[0097]** functional testing of the chip **1**, and programming the chip **1** to assign it a unique identification number.

[0098] It should be noted that dispensing an adhesive into the grooves **2***a*, **2***b* and on the longitudinal sections of the wires can lead to the formation of an adhesive meniscus between the wire and one edge of the chip, perpendicular to the wire. This meniscus helps to make the assembly of the chip and the wires **7***a*, **7***b* particularly resistant to the forces that could be applied to the wires and that would tend to disengage them from the chip.

[0099] Upon completion of the manufacturing process, a storage coil is obtained, comprising a chain **16** of transmission reception devices **15**, as shown schematically in FIG. **4***b*. Segments forming a functional transmission reception device **15** that can be integrated into an object, for example, for identification purposes, can be taken from this chain **16**.

[0100] As shown in FIG. **4***a*, each transmission reception device **15** of the chain **16** comprises a chip **1** having two longitudinal grooves **2***a*, **2***b* parallel to each other and arranged on two opposite sides of the chip **1**. The transmission reception device also includes a functional transmission reception circuit **4**, and two wire segments **7***a*, **7***b* accommodated in the grooves **2***a*, **2***b* and spreading out each from one side of a groove **2***a*, **2***b* to form a dipole-shaped antenna. The wire segments **7***a*, **7***b* are in electrical contact with terminals **4***a*, **4***b* of the functional circuit **4**, arranged in the groove, via a bonding material **17**. The wire segments are also maintained in the grooves **2***a*, **2***b* by one adhesive **18** positioned in these grooves **2***a*, **2***b* and on the exposed side of the wires **7***a*, **7***b*. The chip **1** is also coated and encapsulated in a protective material **19**.

SECOND EXAMPLE

[0101] This second example relates to a transmission reception device **20**, similar to the one of the first example. In this second example, however, shown schematically in FIG. **5***a*, the transmission reception device **20** has an antenna with a loop, formed by electrically connecting one end of one wire **7***b* to the other wire **7***a*. To manufacture this device, a manufacturing process similar to the one of the preceding example is used. During each new processing sequence, the members that the piece of equipment **8** is made of simultaneously perform the following operations, before moving the wire by a set length and repeating these operations again.

[0102] In the upstream zone **10***b* of the workspace, at an additional member **14**:

- **[0103]** cleaning, and possibly tin-plating a longitudinal section of the wires **7***a*, **7***b* intended to be accommodated in the grooves **2***a*, **2***b* of a chip **1**.

[0104] In the intermediate zone **10***a*, using the members located in this zone:

- **[0105]** removing a chip **1** from the storage zone and positioning this chip **1** in the insertion position;
- **[0106]** inserting the longitudinal sections of the wires **7***a*, **7***b* that have been previously prepared during a preceding sequence; and

[0107] assembling the wires **7***a*, **7***b* in the grooves **2***a*, **2***b* by liquefying and solidifying the bonding material initially forming the pads **6***a*, **6***b*.

[0108] In the downstream zone **10***c*, using additional members **14** arranged in this zone opposite a plurality of chips **1** assembled to the wire **7***a*, **7***b* during preceding sequences:

- **[0109]** dispensing an electrically insulating material at least on the two wires **7***a*, **7***b* arranged on one side of the chip to avoid putting them in electrical contact over a set distance. The insulation can also be dispensed on the chip;
- **[0110]** Optionally, at the end of the insulating zone that has been formed or prior to this insulation step, bringing the two wires **7***a*, **7***b* into electrical contact, for example, by moving them closer together using movable jaws similar to the positioning members **12** of the intermediate zone and welding them together. Alternatively, it may be planned to dispense a conductive glue or any other conductive material on and between the two wires **7***a*, **7***b* in order to establish this electrical contact. A loop is thus formed. If this operation is not carried out, the formation of the loop can be obtained later, after removing a segment of the storage coil, before the device is integrated into an object;
- **[0111]** encapsulation of the chip **1** in a protective material such as a rigid resin, allowing it to be mechanically and chemically protected. This encapsulation step can be omitted when an electrically insulating material has been previously dispensed on the chip and the wires;
- **[0112]** cutting one of the wires along the chip **1**, for example, by forming a notch (laser cut) **22** in the encapsulation layer deep enough to cause the wire to break locally; and
- **[0113]** operational testing of the chip **1**, and programming of the chip **1** to assign it a unique identification number.

[0114] In this second example, it is not necessary to cut a segment of wire to form the antenna. A chain **21** composed of two wires **7***a*, **7***b* on which the chips **1** are assembled is preserved. Segments forming an operational transmission reception device can be removed from the device chain that is formed according to the method described above, wherein, like the previous example, an object can be integrated in order to identify same. This chain **21** is schematically shown in FIG. **5***b*.

[0115] As shown in FIG. **5***c*, each transmission reception device **20** includes a chip **1** with two longitudinal grooves **2***a*, **2***b* parallel to each other and arranged on two opposite sides of the chip **1**. The transmission reception device also includes an operational transmission reception circuit **4**, and two wire segments **7***a*, **7***b* accommodated in the grooves **2***a*, **2***b*. It also includes two wire segments **7***a*, **7***b* accommodated in the grooves **2***a*, **2***b* and spreading out on either side of these grooves **2***a*, **2***b*. The wires **7***a*, **7***b* can be in contact with each other on one side of the chip **1** to form a loop and the longitudinal section of the wires accommodated in the grooves **2***a*, **2***b* is in electrical contact with the terminals **4***a*, **4***b* of an operational circuit **4** arranged in the grooves **2***a*, **2***b* via a bonding material **17**. The wire segments constituting the loop, and possibly the chip, can be at least partially embedded in an electrically insulating material **23**, thus avoiding electrical contact between same. The chip **1** is embedded and encapsulated in a protective material **19**, especially when it has not been embedded in the insulating material. The encapsulation material(s) has/have a notch **22** that has been used to cut one of the wires to make the antenna functional.

[0116] The transmission reception device **15**, **20** of the first and second examples can be inserted into a textile thread, for example, by taping, as taught in document U.S. Pat. No. 8,814,054. More generally, it can be inserted into a textile or plastic material, a fabric or a sheath.

[0117] Thus, the textile thread or segments of this thread including the transmission reception device, or more generally the textile or plastic material, the fabric or the sheath in which the device has been inserted, can itself be integrated into an object, whether textile or not.

[0118] Of course, the present disclosure is not limited to the mode of implementation described and alternative embodiments can be provided without going beyond the scope of the present disclosure as defined by the claims.

1. A system for inserting a wire into at least one semiconductor chip, the chip having a groove for receiving a longitudinal section of the wire and the groove containing a pad made of a bonding material having a melting point, the system comprising:

positioning members for deploying and moving a length of the wire between a first end and a second end of a workspace;

a handling device for handling the semiconductor chip, the handling device capable of placing the chip in an insertion position in which the groove is placed opposite the wire;

a positioning member for arranging the longitudinal section of the wire along the groove, in forced abutment against the pad; and

a heating member for heating a zone comprising the pad to a processing temperature above the melting point when the chip is placed in the insertion position, the heating of the zone comprising the pad causing melting of the pad and provoking insertion of the wire into the groove.

2. The system of claim **1**, wherein the positioning members are configured to deploy two parallel wires between the first end and the second end, and wherein the insertion position is located between the two wires.

3. The system of claim **1**, further comprising at least one additional member arranged in the workspace, downstream or upstream of the insertion position of the chip.

4. The system of claim **1**, wherein the additional member and the positioning member are positioned and configured in the workspace so that the processes performed by these members can be conducted simultaneously.

5. The system of claim **1**, wherein the system is configured to allow solidification of the bonding material to assemble the wire and the chip after inserting the wire into the groove.

6. The system of claim **1**, wherein the heating member comprises a device configured to flow hot air onto at least a portion of the chip.

7. The system of claim **1**, wherein the heating member comprises an induction heating member located and configured to inductively heat at least a portion of the chip.

8. The system of claim **1**, wherein the system is configured to prepare the longitudinal section of the wire to be inserted into the groove before or during the positioning of the longitudinal section of the wire along the groove.

9. The system of claim **8**, wherein the system is configured to deposit a coating layer on the longitudinal section of the wire.

10. The system of claim **8**, wherein the system is configured to clean and/or deoxidize the longitudinal section of the wire.

11. The system of claim **1**, wherein the system is configured to dispense an adhesive into the groove and/or on the wire after positioning the longitudinal section of the wire along the groove.

12. The system of claim **1**, wherein the system is further configured to encapsulate the chip and/or at least a portion of the wire after inserting the wire into the groove.

13. The system of claim **1**, wherein the wire is electrically conductive.

14. The system of claim **1**, wherein the system is configured to sequentially insert the wire into a plurality of chips to form a chip chain.

15. The system of claim **1**, wherein the system is configured to allow simultaneous insertion of two wires into two grooves, respectively, of the chip.

16. The system of claim **1**, wherein the positioning members for deploying and moving the length of the wire between the first end and the second end of the workspace include a wire supply member and a storage member.

17. The system of claim **16**, wherein the wire supply member includes a first reel, and wherein the storage member includes a second reel.

18. The system of claim **16**, wherein the positioning member for arranging the longitudinal section of the wire along the groove comprises a wheel or roller.

19. The system of claim **1**, wherein the handling device for handling the semiconductor chip comprises a pick-and-place machine.

20. A system for fastening at least one wire to at least one semiconductor chip, comprising:

a wire supply member for supplying the at least one wire to a workspace;

a storage member for receiving the at least one wire after it has passed from the wire supply member, through the workspace, and to the storage member;

a handling device for handling the at least one semiconductor chip, the handling device located and configured to place the at least one semiconductor chip at a location within the workspace;

a movable positioning member located and configured to press a longitudinal section of the at least one wire along a groove and in forced abutment against at least one pad of the at least one semiconductor ship; and

a heating member located and configured to heat at least a zone of the workspace in which the at least one pad of the at least one semiconductor ship pad is located when the chip is placed in an insertion position within the workspace by the handling device.

* * * * *