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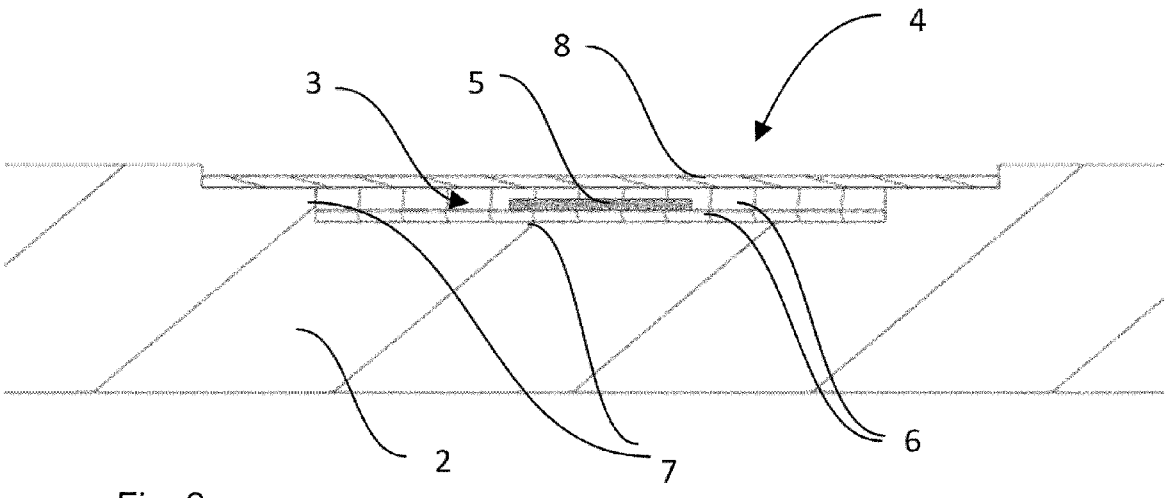


Fig. 2

(57) Abstract: An electronic device (1) comprising a frame element (2) and at least one signal transmission structure (3) arranged within at least one recess (4) in said frame element (2). The signal transmission structure (3) comprises at least one conductive signal element (5) enclosed in a dielectric volume (6). The device (1) further comprises at least one first shielding layer (7) extending in said recess (4) and at least one second shielding layer (8) extending across an opening of said recess (4). The first shielding layer (7) and the second shielding layer (8) enclose said dielectric volume (6), such that the signals in said signal element (5) are shielded electromagnetically from other external signals, and correspondingly, such that the further components of the electronic device (1) are shielded electromagnetically from the signals in said signal element (5).

WO 2022/008026 A1

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ELECTRONIC DEVICE COMPRISING SIGNAL TRANSMISSION STRUCTURE

TECHNICAL FIELD

The disclosure relates to an electronic device comprising a frame element and at least one signal transmission structure.

BACKGROUND

The amount of electric signalling, and hence energy transfer between different electronic blocks, in electronic devices has been increasing over the last years. In current devices, there is a vast number of sensors, antennas, cameras, switches, batteries, and secondary printed circuit boards (PCB) which all need to be connected to the main electrical engine board of the device, and which have to be arranged such that they do not influence each other negatively.

Common solutions for facilitating such increased signalling is to use flexible printed circuit boards (FPC), cabling, coaxial cables, and similar for signal transmission. However, such solutions all face several problems such as the minimum amount of space required being relatively large, grounding issues, bending problems, and limited possible usage of electronic components with 2.5D flexible printed circuits.

As an example of such problems, coaxial cables require sufficient free space being available within the device. Furthermore, the bending radius of coaxial cables is large, relative the dimensions of the device. Grounding to aluminium parts is unreliable due to oxidation, and the cable screen is easily damaged during the manual hand assembly process.

Flexible printed circuit boards (FPC) also require sufficient free space being available within the device, in order to accommodate the FPC. Furthermore, FPC's have very large bending radiuses due to their layered construction being relatively thick, and hence, cannot bend sharply. Furthermore, there are often adhesive peel off issues, which can cause air gaps between for example an antenna and the main device body, which in turn causes antenna detuning. Due to such adhesion issues, and due to oxidation, grounding to aluminium parts is unreliable.

Hence, there is a need for providing more flexible and reliable signal transmission solutions.

SUMMARY

It is an object to provide an electronic device having an improved signal transmission structure. The foregoing and other objects are achieved by the features of the independent claim. Further implementation forms are apparent from the dependent claims, the description, and the figures.

According to a first aspect, there is provided an electronic device comprising a frame element and at least one signal transmission structure arranged within at least one recess in the frame element. The signal transmission structure comprises at least one conductive signal element enclosed in a dielectric volume. The device further comprises at least one first shielding layer extending in the recess, and at least one second shielding layer extending across an opening of the recess, the first shielding layer and the second shielding layer enclosing the dielectric volume.

This solution allows the signal element to be arranged within a frame of the electronic device, such as the back cover or chassis, and to partially use this frame as a signal transmission structure. The dielectric and the shielding layers enclose and shield the signal transmission structure from any external influence, as well as shield the other components of the device from the signals in the signal transmission structure. By providing the signal transmission structure within the frame, the signal element is protected mechanically and it does not take up any space within the device, leaving more free and available space for additional components, and/or allowing the electronic device to be kept as thin as possible since no additional space is necessary for accommodating the signal transmission structure.

In a possible implementation form of the first aspect, the first shielding layer and the second shielding layer comprise conductive material. The conductive shielding layers keep the signal of the signal element inside the dielectric volume. In an ideal situation, no signal leaks out from, or into, the signal transmission structure due to the conductivity of the shielding layers.

In a possible implementation form of the first aspect, the frame element comprises a conductive material, and the first shielding layer is an integral surface of the recess. This allows the frame to be made of conductive high-end materials such as aluminum, while at the same time accommodating the signal transmission structures of the device.

In a possible implementation form of the first aspect, the frame element comprises a dielectric material, and the first shielding layer is a separate conductive element which covers a surface of the recess, the conductive element being arranged in abutment with the surface of the recess. This allows the frame to be made of dielectric high-end materials such as glass, while at the same time providing a way of accommodating and shielding the signal transmission structures of the device.

In a possible implementation form of the first aspect, the dielectric volume comprises at least one dielectric material or at least one compound of dielectric material, providing as much flexibility in the manufacture of the electronic device as possible.

In a possible implementation form of the first aspect, the electronic device comprises a plurality of recesses, the recesses being arranged in one plane and/or in multiple parallel planes, and each recess comprising a signal transmission structure. This allows the device to accommodate a plurality of signal transmission structures, arranged in any suitable configuration which fits the form factor of the device, and which do not affect each other.

In a possible implementation form of the first aspect, the signal transmission structure comprises at least two conductive signal elements, the conductive signal element being arranged in at least one of one plane and multiple parallel planes. This allows the device to accommodate a plurality of conductive signal elements, arranged in any suitable configuration which fits the form factor of the device, and which do not affect each other.

In a possible implementation form of the first aspect, each recess is shielded by one second shielding layer each, allowing full flexibility in the placement of the recesses and signal transmission structures in the device.

In a possible implementation form of the first aspect, a plurality of recesses are shielded by one common second shielding layer ,allowing the number of individual shielding layers to be reduced.

In a possible implementation form of the first aspect, the second shielding layer covers the open side of the recess completely including the side walls of the recess.

In a possible implementation form of the first aspect, the conductive signal element is arranged coaxially within the recess along a longitudinal axis.

In a possible implementation form of the first aspect, the first shielding layer and the second shielding layer are configured to shield the signal transmission structure and/or an exterior, including other components of the electronic device, of the signal transmission structure electromagnetically.

In a possible implementation form of the first aspect, the first shielding layer and the second shielding layer generate electromagnetic insulation of the signal transmission structure(s) below 50 GHz.

In a possible implementation form of the first aspect, the conductive signal element is configured to transmit electromagnetic signals, AC current, or DC current, allowing the solution to be applied for signal transmission to a variety of components.

In a possible implementation form of the first aspect, the electromagnetic signals are within the radiofrequency range, allowing the signal transmission structure to be used for e.g. antennas.

In a possible implementation form of the first aspect, the frame element is an outer housing or an inner frame of the electronic device, allowing the frame element to be an already existing and necessary part of the electronic device such that no additional elements are needed.

In a possible implementation form of the first aspect, the frame element is an electromechanically passive element, which does not require any additional components to drive the frame element, and which is stable and remains mainly unaffected by external events.

In a possible implementation form of the first aspect, the first shielding layer and the second shielding layer are arranged in to form a tubular shape enclosing the signal transmission structure completely.

In a possible implementation form of the first aspect, the first shielding layer and the second shielding layer are conductively connected, such that the signal transmission structure is shielded from the exterior, and reverse, in all directions.

In a possible implementation form of the first aspect, the conductive signal element is galvanically, capacitively, or inductively coupled to at least one electronically driven element arranged in the electronic device.

In a possible implementation form of the first aspect, the conductive signal element is galvanically, capacitively, or inductively coupled to a circuit board of the electronic device.

In a possible implementation form of the first aspect, the conductive signal element comprises one of a stripline, microstrip line, and differential signal lines.

In a possible implementation form of the first aspect, the recess and, optionally, the conductive signal element extends three-dimensionally within the frame element such that a longitudinal axis of the recess, and optionally the conductive signal element, changes direction at least once. This allows the signal transmission structure to extend wherever possible within the frame, in two or three dimensions, such that the conductive signal element may be stepped or extend e.g. both horizontally and vertically.

These and other aspects will be apparent from the embodiments described below.

BRIEF DESCRIPTION OF THE DRAWINGS

In the following detailed portion of the present disclosure, the aspects, embodiments and implementations will be explained in more detail with reference to the example embodiments shown in the drawings, in which:

Fig. 1 shows a partial perspective view of an electronic device in accordance with an embodiment of the present invention;

Fig. 2 shows a cross-section of a device frame and signal transmission structure in accordance with an embodiment of the present invention;

Fig. 3 shows a cross-section of a device frame and signal transmission structure in accordance with a further embodiment of the present invention;

Figs. 4 to 12 show schematic cross-sections of an arrangement of one or several signal transmission structures in accordance with various embodiments of the present invention.

DETAILED DESCRIPTION

Fig. 1 shows an electronic device 1 comprising a frame element 2. The frame element 2 may be an outer housing, such as a back cover or side frame extending between the back cover and the display, or an inner frame supporting components such as the main engine board and/or the outer housing. The frame element may be an electromechanically passive element, is not connected to any additional components driving the frame element, but is instead a fixed, immobile component which does not interact or is affected by the other components of the electronic device 1.

At least one signal transmission structure 3 is arranged within at least one recess 4 in the frame element 2. The frame element 2 may be provided with one recess 4, as shown in Figs. 2 to 9, or with a plurality of recesses 4, as shown in Figs. 10 to 12. The plurality of recesses 4 may be arranged in one plane, as shown in Fig. 11. The plurality of recesses 4 may be arranged in multiple parallel plane, as shown in Fig. 10. As shown in Fig. 12, a first plurality of recesses 4 may be arranged both in one first plane, while at least one further recess 4 is arranged in a second plane parallel with the first plane. Any number of recesses and planes is possible, the configuration depends on the components and form factor of the electronic device 1. The recesses 4 may be mechanically milled into the frame element 2.

Each recess 4 comprises a signal transmission structure 3. The signal transmission structure 3 comprises at least one conductive signal element 5 enclosed in a dielectric volume 6. The dielectric volume 6 comprises at least one dielectric material or at least one compound of dielectric material. The dielectric volume 6 has low conductivity and therefore insulates the conductive signal element 5 from its exterior, keeping the signal in the signal element 5 as strong as possible.

The conductive signal element 5 may comprise a stripline, microstrip line, or differential signal lines. The conductive signal element 5 may be configured to transmit electromagnetic signals, AC current, or DC current. In one embodiment, the electromagnetic signals are within the radiofrequency range.

The signal transmission structure 3 may comprise at least two conductive signal elements 5, and the conductive signal elements 5 may be arranged in one plane, as shown in Figs. 5, 7, 11, and 12, and/or in multiple parallel planes, as shown in Figs. 9, 10, and 12. As shown in Figs. 2 to 4, 6, 8, and 10 to 12, each recess 4 may comprise only one conductive signal element 5. As shown in Figs. 5, 7, 9, and 12, each recess 4 may comprise a plurality of conductive signal elements 5 extending, for example, in parallel and/or substantially in alignment within the recess 4.

Any combination of number, arrangement, and shapes of recesses 4 and conductive signal elements 5 is possible and can be adapted to the specific needs and preconditions, the embodiments shown in the Figs. only being illustrative examples.

The shapes of each recess 4 is primarily adapted to the shape of the conductive signal element(s) 5 arranged within the recess 4. The main contributor for insertion loss, i.e. loss of signal when traveling in and out of a given circuit or component, of the conductive signal element 5 is the cross-sectional area and/or surface area of the conductive signal element 5. For example, the conductive signal element 5 may be very wide, i.e. have a relatively large surface area as shown in Figs. 3, 4, 6, and 10; be very thick, i.e. have a relatively large cross-sectional area as shown in Figs. 6 to 9, or both in combination. A circular shape, i.e. a circular cross-section, is the most efficient shape in terms of volume.

When the conductive signal element 5 is a stripline or microstrip line, it may be preferable to match the impedance of the conductive signal element 5, to a value of 50 Ohms. When the conductive signal element 5 instead comprises differential signal lines, it may be preferable to match the impedance of the conductive signal element 5, to a value of 100 Ohms. Nevertheless, the required impedance matching of the conductive signal element 5 depends on the system comprising the conductive signal element 5, wherefore any suitable impedance value is possible.

In a relatively wider conductive signal element 5, the resistive losses of the signal element 5 as well as the impedance are reduced. Hence, it would be necessary to increase the thickness of the dielectric volume 6, and hence the depth of the recess 4, in order to increase the impedance back up to e.g. 50 Ohm. However, the depth of the recess 4 is limited by the thickness of the

frame element 2 as well, and a tradeoff has to be made between insertion losses and mechanical dimensions. Hence, the shape of the recess 4 and dielectric volume 6 is a result of this tradeoff.

Figs. 2 to 9 show embodiments comprising only one recess 4. Figs. 2 to 4 show embodiments comprising one recess 4 comprising one conductive signal element 5 each. The recess 4 cross-section is rectangular. Fig 5. shows an embodiment comprising one recess comprising two conductive signal element 5 arranged in one plane, in a recess 4 having a rectangular cross-section. Fig. 6 shows an embodiment comprising one recess 4 comprising one conductive signal element 5, wherein the cross-section of the recess 4 is such that the recess 4 has a rounded bottom. Fig 7. shows an embodiment comprising one recess comprising two conductive signal element 5 arranged in one plane, wherein the cross-section of the recess 4 is such that the recess 4 has a rounded bottom just as shown in Fig. 6. Fig. 9 shows an embodiment comprising one recess comprising two conductive signal elements 5 arranged in two parallel planes, and wherein the cross-section of the recess 4 is such that the recess 4 has a rounded bottom. Fig. 8 shows an embodiment comprising one recess 4 comprising one conductive signal element 5, wherein the cross-section of the recess 4 is triangular, such that the side walls of the recess 4 are angled and the bottom of the recess is formed by the apex of the triangle. Figs. 10 to 12 show embodiments comprising several recesses 4, arranged in parallel planes as in Fig. 10, in one common plane as in Fig. 11, or both as in Fig. 12. Figs. 10 to 12 show embodiments comprising one conductive signal element 5 per recess 4. Fig. 12 also shows one recess 4 comprising two conductive signal elements 5.

Each conductive signal element 5 may be arranged coaxially within the recess 4 along a longitudinal axis A of the recess. The longitudinal axis A may extend completely straight. Furthermore, the recess 4 may extend three-dimensionally within the frame element 2 such that the longitudinal axis A of the recess 4 changes direction at least once (not shown). Correspondingly, the conductive signal element 5 may extend three-dimensionally within the recess 4 such that it changes direction at least once, with the recess 4 or independently of the extent of the recess 4.

The electronic device 1 further comprises at least one first shielding layer 7 extending in the recess 4 and at least one second shielding layer 8 extending at least partially across an opening of the recess 4. The first shielding layer 7 and the second shielding layer 8 enclose the dielectric volume 6, and, hence, the signal transmission structure(s) 3 enclosed within the dielectric

volume 6. The first shielding layer 7 and the second shielding layer 8 may be arranged to form a tubular shape enclosing the signal transmission structure 3 completely. The first shielding layer 7 and the second shielding layer 8 may be conductively connected.

The first shielding layer 7 and the second shielding layer 8 may be configured to shield the signal transmission structure 3 and/or an exterior of the signal transmission structure 3 electromagnetically. The first shielding layer 7 and the second shielding layer 8 may generate electromagnetic insulation of the signal transmission structures 3 below 50 GHz. One or several of the frame element 2, the conductive signal element 5, the dielectric 6, the first shielding layer 7, and the second shielding layer 8 may be provided by e.g. a 3D printing process.

Preferably, the first shieling layer 7 and the second shielding layer 8 comprise of the same, or different, conductive materials. The conductive materials are used as electromagnetic shields, i.e. for reducing the electromagnetic field by blocking the field with barriers made of conductive or magnetic materials. The shielding can also reduce the coupling of radio waves, electromagnetic fields, and electrostatic fields. The amount of reduction depends very much upon the material used, its thickness, the size of the shielded volume and the frequency of the fields of interest and the size, shape and orientation of apertures in a shield to an incident electromagnetic field. The signals of the conductive signal element 5 may be shielded from the exterior by the first shieling layer 7 and the second shielding layer 8, or, correspondingly, the exterior mat be shielded from the signals of the conductive signal element 5.

In several embodiments, shown in Figs. 2 and 4 to 10, frame element 2 comprises a conductive material such as aluminum, such that the first shielding layer 7 is formed by the surface of the recess 4. The surface of the recess comprises both the bottom surface of the recess and the side walls of the recess.

In further embodiments, such as that shown in Fig. 3, the frame element 2 comprises a dielectric material such as glass, and the first shielding layer 7 is an additional and separate conductive element 9. The conductive element 9 is arranged in direct abutment with the surface of the recess 4 and such that it covers the surface of the recess 4.

The second shielding layer 8 may cover the open side of the recess 4 completely, i.e. including the side walls of the recess as well as side edges such that the second shielding layer 8 is wider than the width of the opening of the recess 4.

Each recess 4 may be shielded by one second shielding layer 8 each, as shown in Figs. 2 to 10 and the upper recess of Fig. 12. Furthermore, as shown in Fig. 11 and the lower recesses of Fig. 12, a plurality of recesses 4 may be shielded by one common second shielding layer 8.

In one embodiment, the conductive signal element 5 is galvanically, capacitively, or inductively coupled to at least one electronically driven element arranged in the electronic device 1 (not shown). The conductive signal element 5 may be galvanically, capacitively, or inductively coupled to a circuit board of the electronic device 1.

The various aspects and implementations have been described in conjunction with various embodiments herein. However, other variations to the disclosed embodiments can be understood and effected by those skilled in the art in practicing the claimed subject-matter, from a study of the drawings, the disclosure, and the appended claims. In the claims, the word "comprising" does not exclude other elements or steps, and the indefinite article "a" or "an" does not exclude a plurality. A single processor or other unit may fulfill the functions of several items recited in the claims. The mere fact that certain measures are recited in mutually different dependent claims does not indicate that a combination of these measured cannot be used to advantage. A computer program may be stored/distributed on a suitable medium, such as an optical storage medium or a solid-state medium supplied together with or as part of other hardware, but may also be distributed in other forms, such as via the Internet or other wired or wireless telecommunication systems.

The reference signs used in the claims shall not be construed as limiting the scope. Unless otherwise indicated, the drawings are intended to be read (e.g., cross-hatching, arrangement of parts, proportion, degree, etc.) together with the specification, and are to be considered a portion of the entire written description of this disclosure. As used in the description, the terms "horizontal", "vertical", "left", "right", "up" and "down", as well as adjectival and adverbial derivatives thereof (e.g., "horizontally", "rightwardly", "upwardly", etc.), simply refer to the orientation of the illustrated structure as the particular drawing figure faces the reader.

Similarly, the terms “inwardly” and “outwardly” generally refer to the orientation of a surface relative to its axis of elongation, or axis of rotation, as appropriate.

CLAIMS

1. An electronic device (1) comprising a frame element (2) and at least one signal transmission structure (3) arranged within at least one recess (4) in said frame element (2),

said signal transmission structure (3) comprising:
-at least one conductive signal element (5) enclosed in a dielectric volume (6);

said device (1) further comprising
at least one first shielding layer (7) extending in said recess (4); and
at least one second shielding layer (8) extending across an opening of said recess (4),
said first shielding layer (7) and said second shielding layer (8) enclosing said dielectric volume (6) .

2. The electronic device (1) according to claim 1, wherein said first shieling layer (7) and said second shielding layer (8) comprises conductive material.

3. The electronic device (1) according to claim 1, wherein said frame element (2) comprises a conductive material, said at least one first shielding layer (7) being a surface of said recess (4).

4. The electronic device (1) according to claim 1 or 2, wherein said frame element (2) comprises a dielectric material, said at least one first shielding layer (7) being a conductive element (9) covering a surface of said recess (4), said conductive element (9) being arranged in abutment with said surface of said recess (4).

5. The electronic device (1) according to any one of the previous claims, wherein said dielectric volume (6) comprises at least one dielectric material or at least one compound of dielectric material.

6. The electronic device (1) according to any one of the previous claims, wherein said device (1) comprises a plurality of recesses (4), said recesses (4) being arranged in one plane and/or in multiple parallel planes, and each recess (4) comprising a signal transmission structure (3).

7. The electronic device (1) according to any one of the previous claims, wherein said signal transmission structure (3) comprises at least two conductive signal elements (5), said conductive signal element (5) being arranged in at least one of one plane and multiple parallel planes.

8. The electronic device (1) according to any one of the previous claims, wherein each recess (4) is shielded by one second shielding layer (8) each.

9. The electronic device (1) according to any one of claims 1 to 7, wherein a plurality of recesses (4) are shielded by one common second shielding layer (8).

10. The electronic device (1) according to any one of the previous claims, wherein said first shielding layer (7) and said second shielding layer (8) are configured to shield said signal transmission structure (3) and/or an exterior of said signal transmission structure (3) electromagnetically.

11. The electronic device (1) according to any one of the previous claims, wherein said first shielding layer (7) and said second shielding layer (8) generate electromagnetic insulation of said signal transmission structure(s) (3) below 50 GHz.

12. The electronic device (1) according to any one of the previous claims, wherein said conductive signal element (5) is configured to transmit electromagnetic signals, AC current, or DC current.

13. The electronic device (1) according to any one of the previous claims, wherein said frame element (2) is an electromechanically passive element.

14. The electronic device (1) according to any one of the previous claims, wherein said first shielding layer (7) and said second shielding layer (8) are conductively connected.

15. The electronic device (1) according to any one of the previous claims, wherein said conductive signal element (5) comprises one of a stripline, microstrip line, and differential signal lines.

16. The electronic device (1) according to any one of the previous claims, wherein said recess (4) and, optionally, said conductive signal element (5) extends three-dimensionally within said frame element (2) such that a longitudinal axis (A) of said recess (4), and optionally said conductive signal element (5), changes direction at least once.

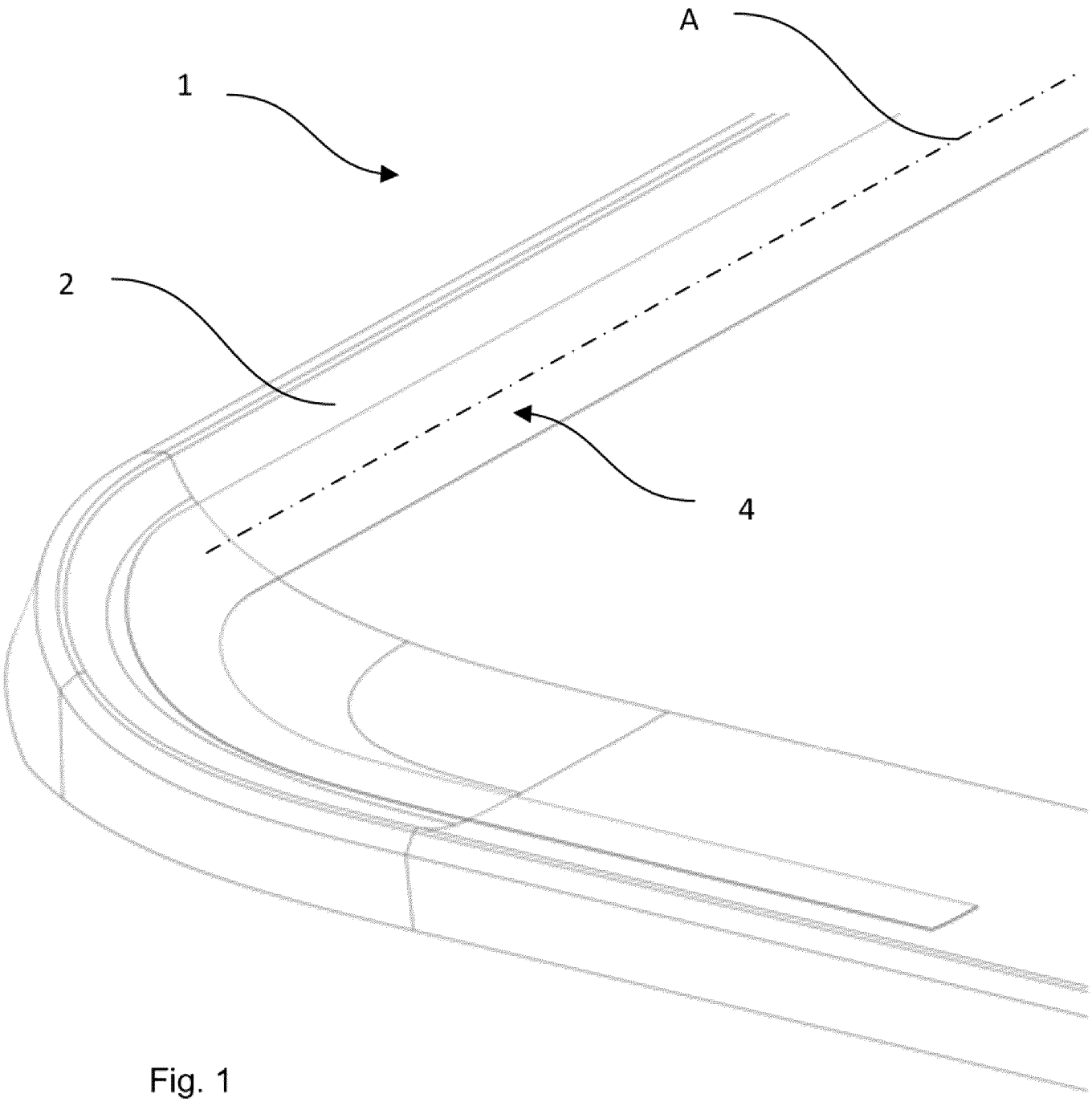


Fig. 1

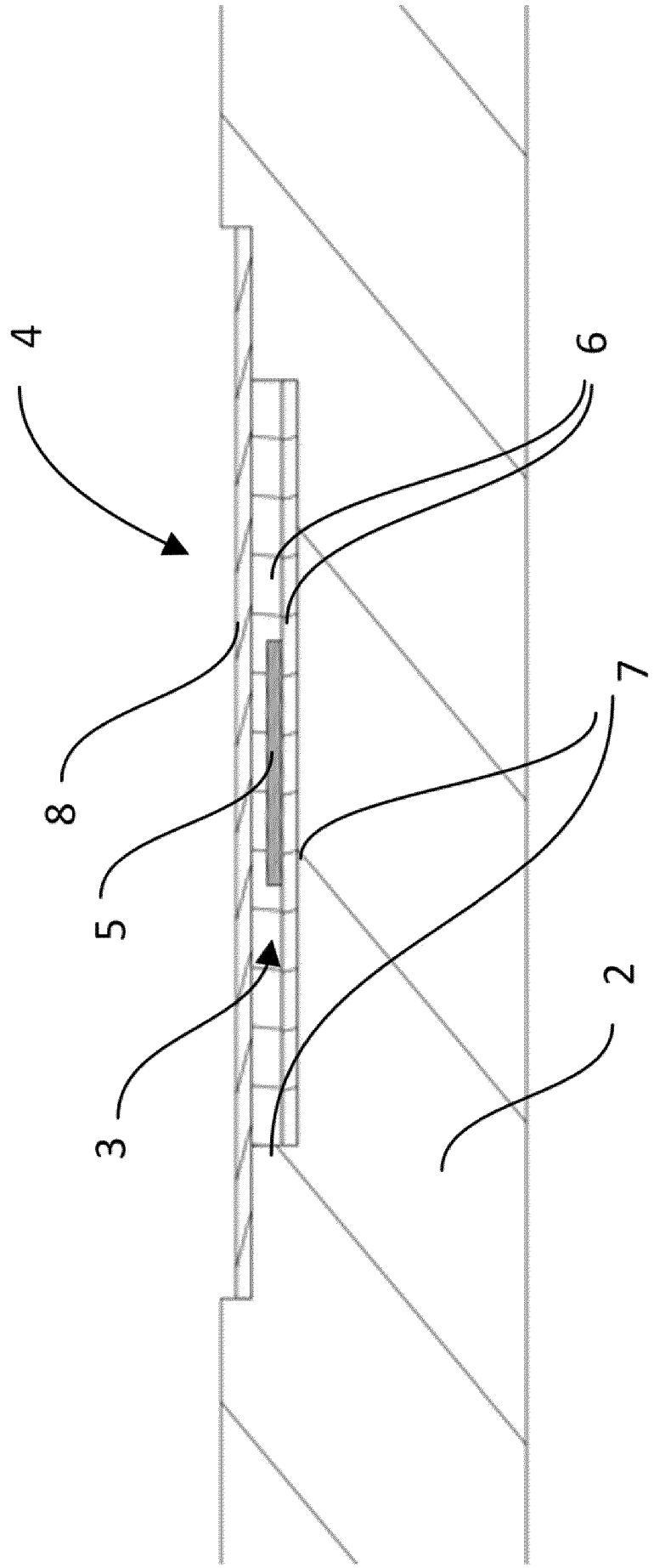


Fig. 2

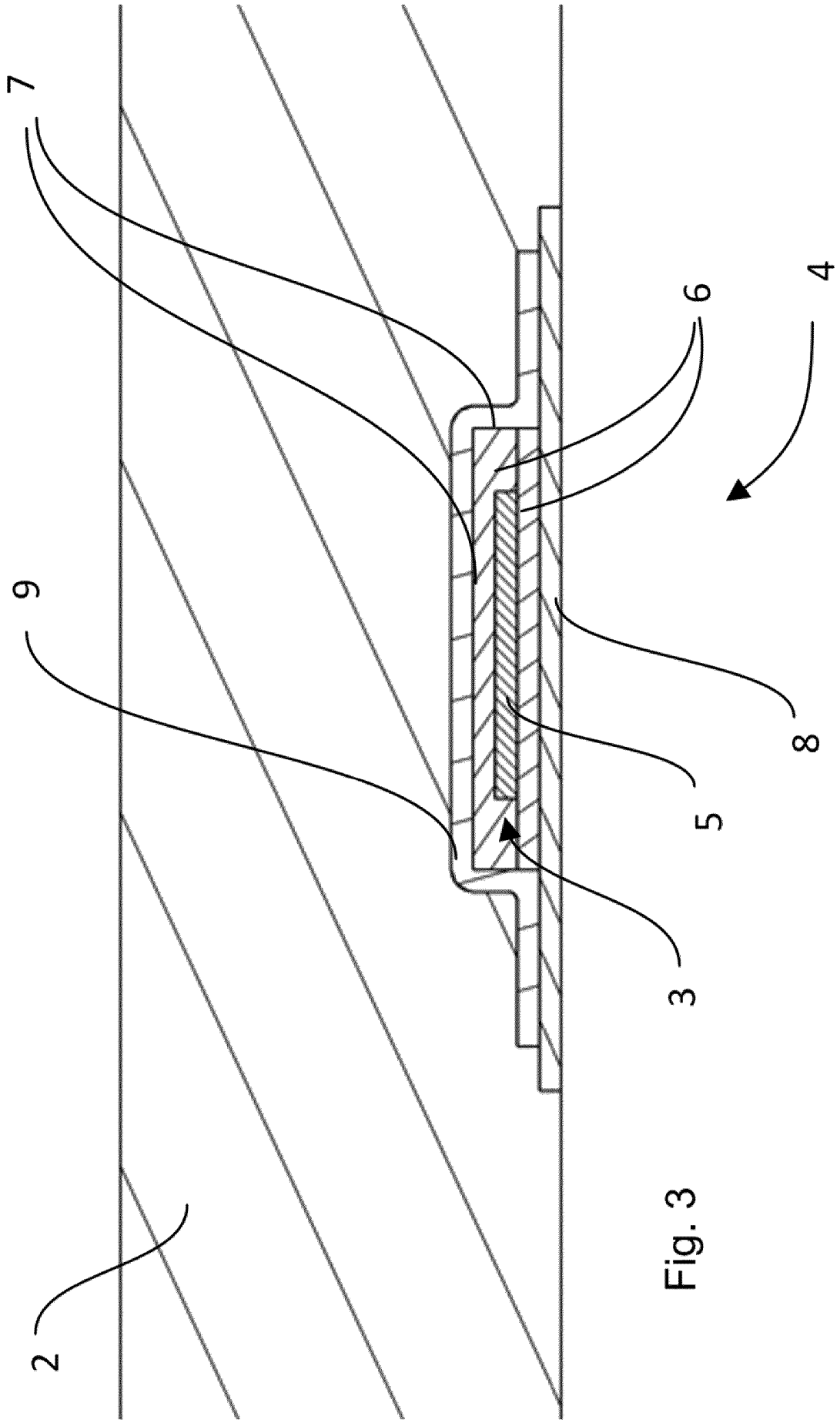


Fig. 3

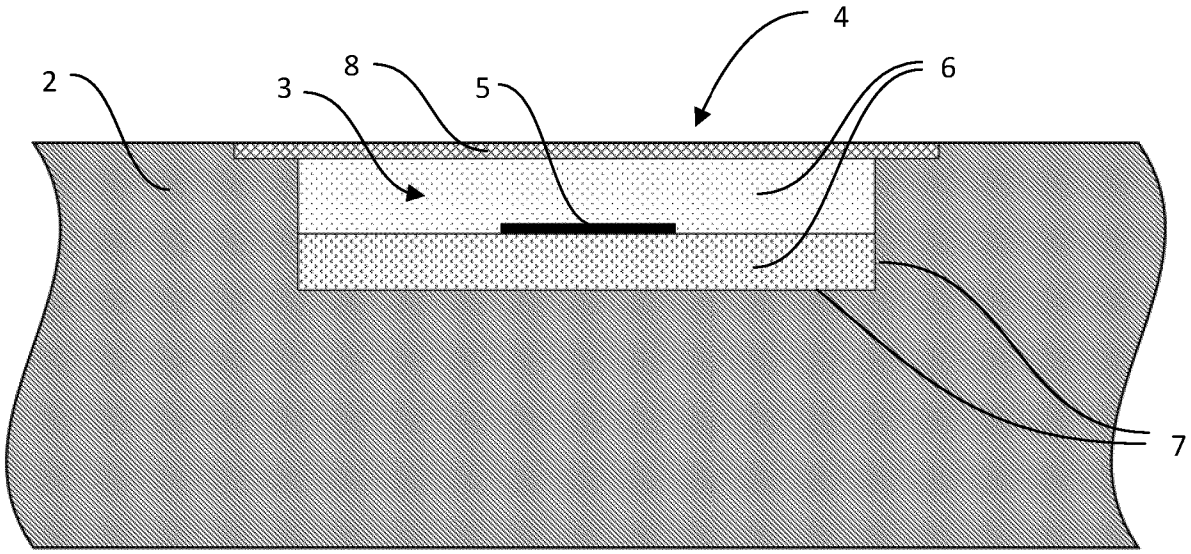


Fig. 4

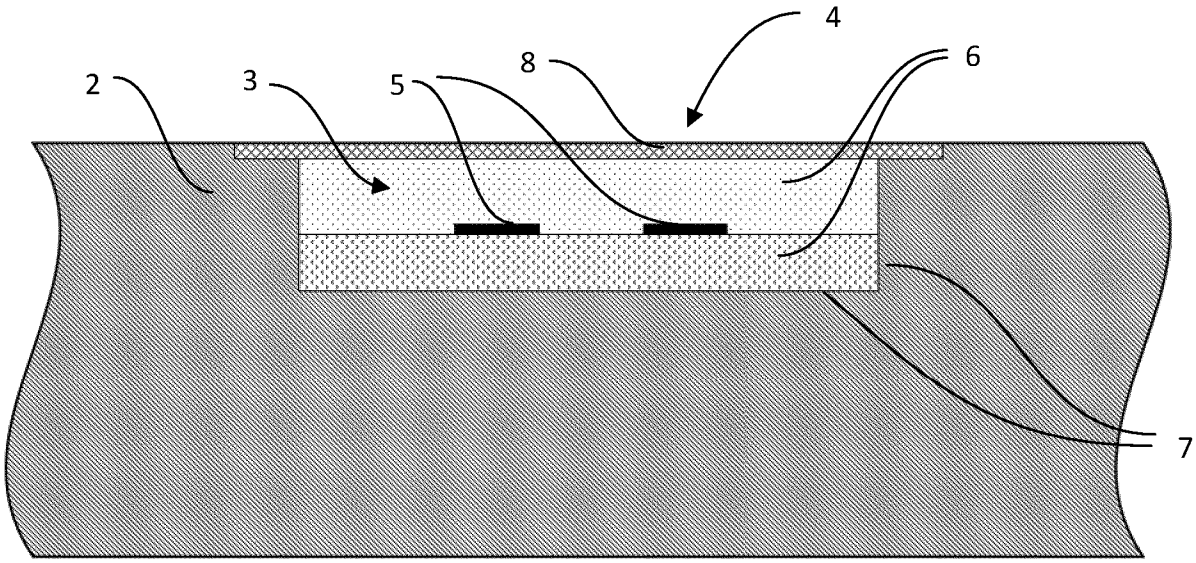


Fig. 5

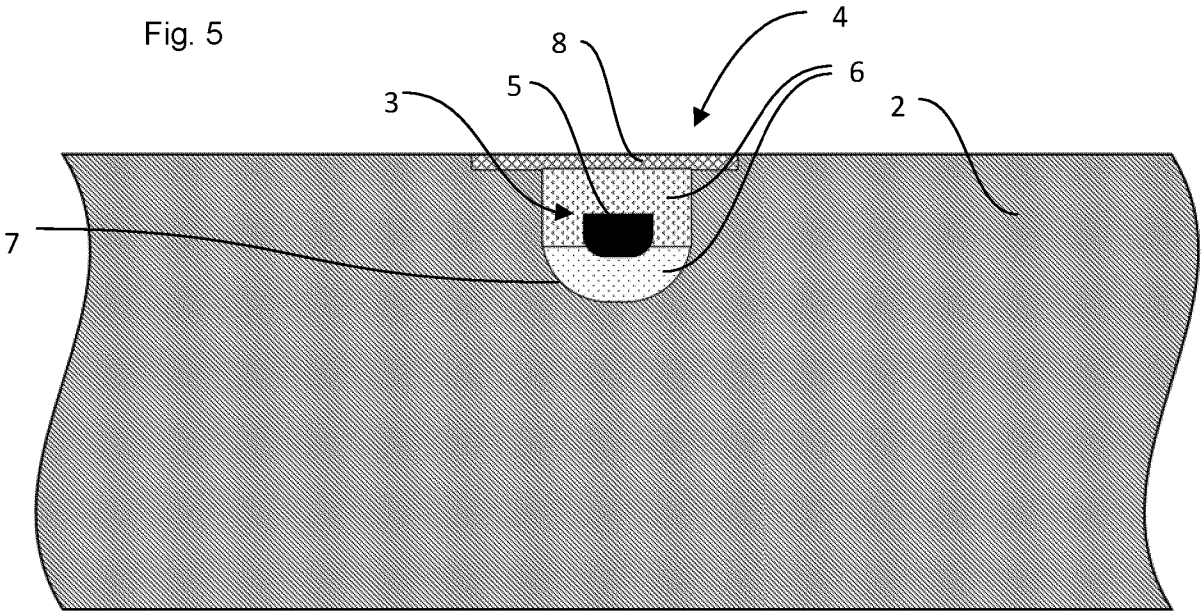


Fig. 6

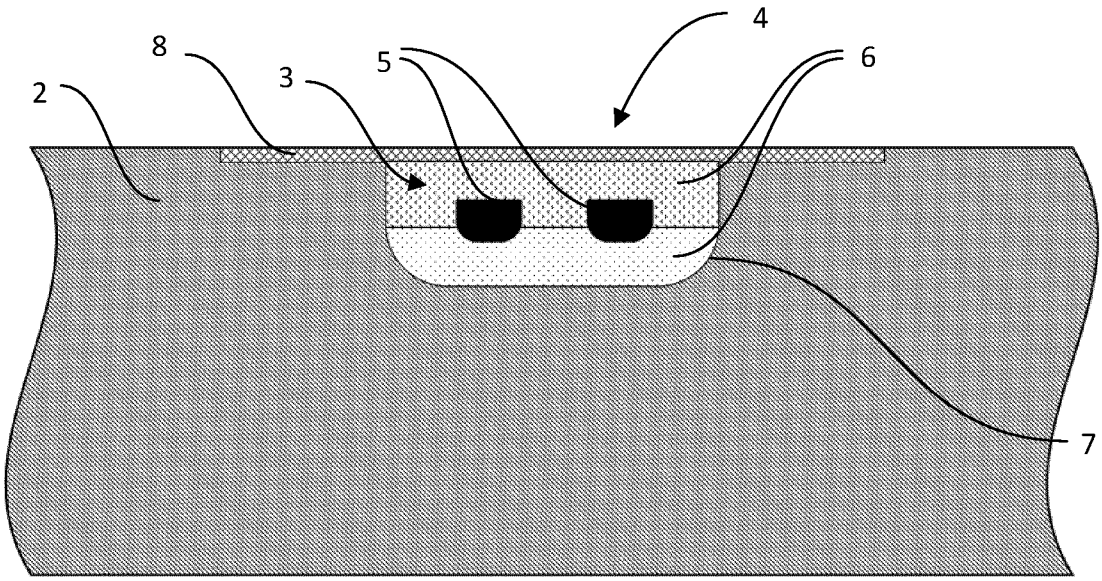


Fig. 7

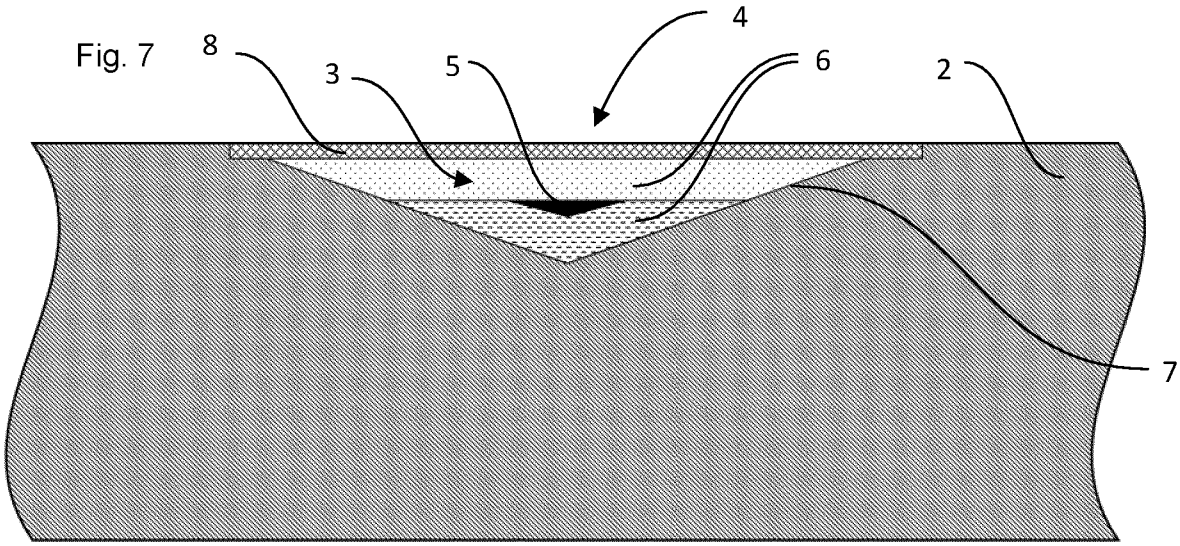


Fig. 8

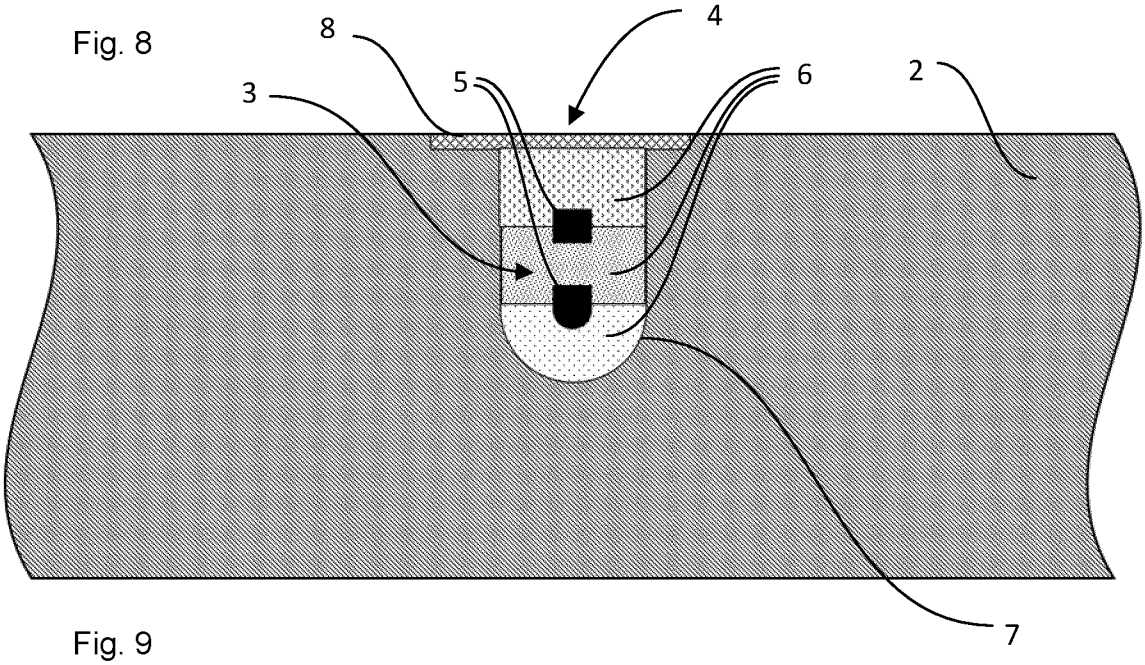


Fig. 9

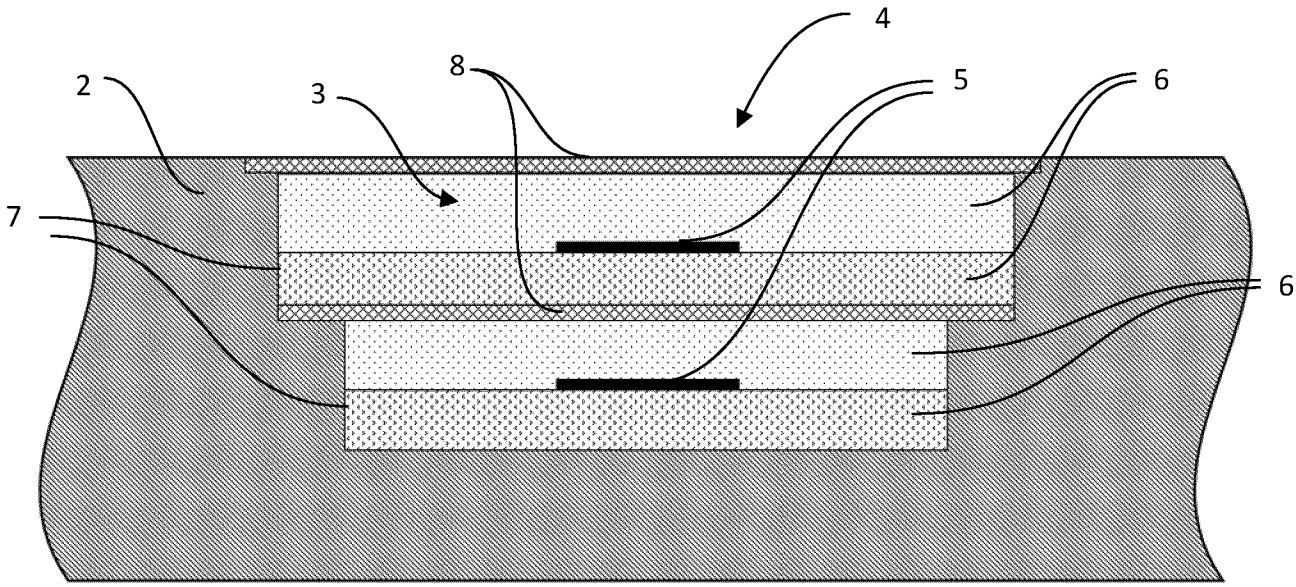


Fig. 10

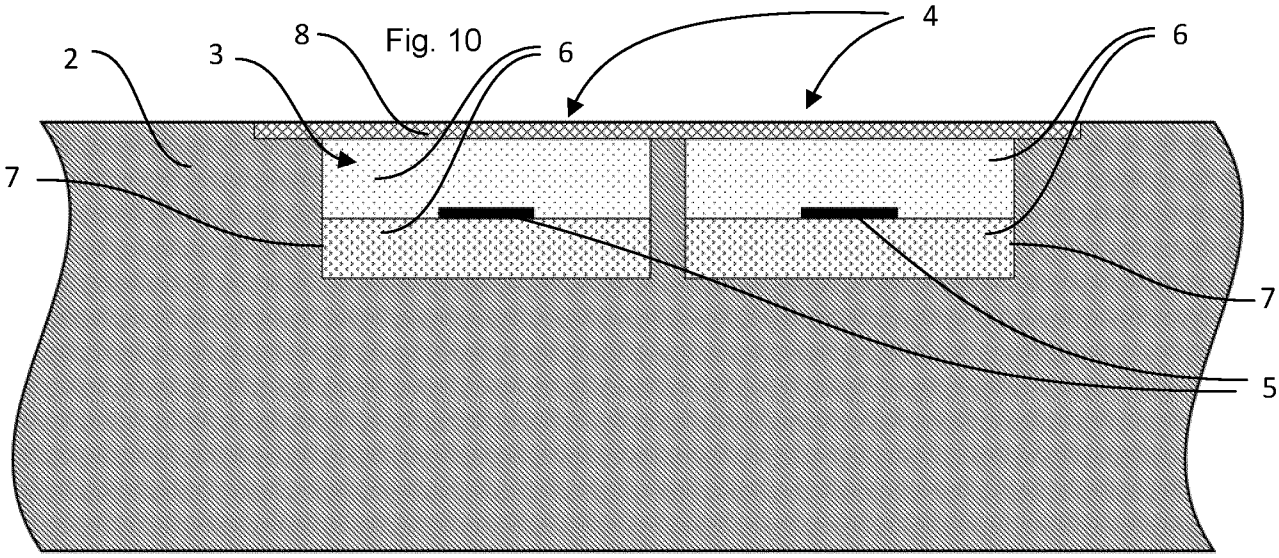


Fig. 11

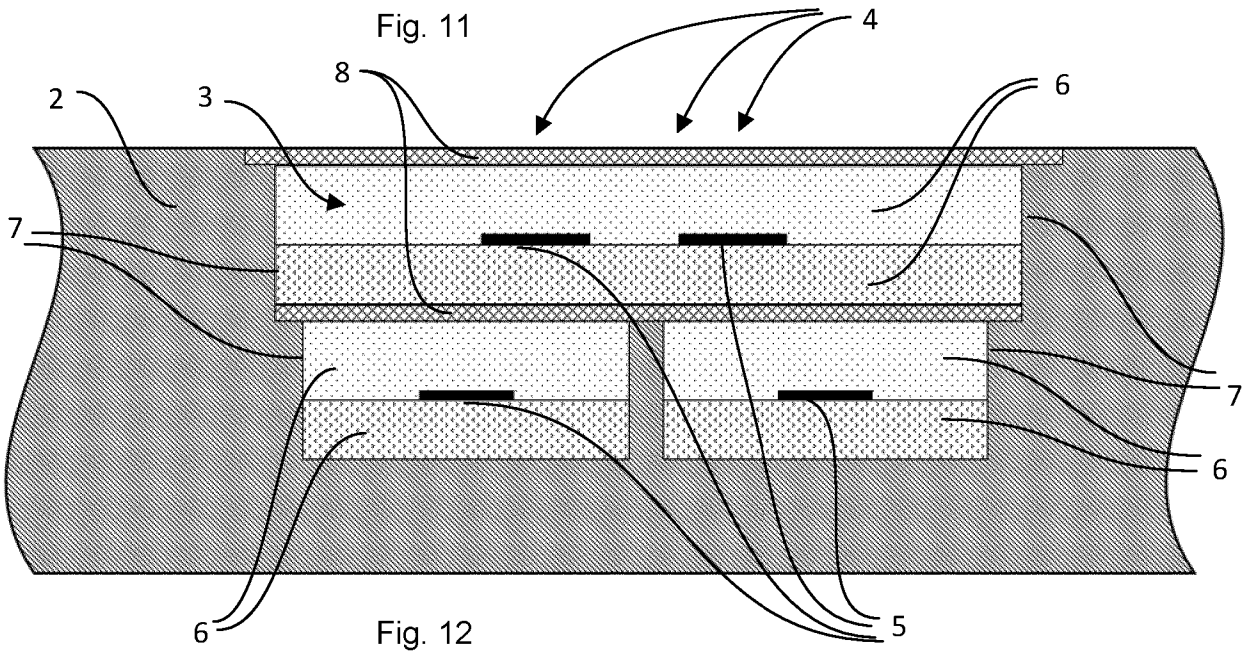


Fig. 12

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2020/068948

A. CLASSIFICATION OF SUBJECT MATTER
INV. H05K3/46
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H05K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2016/111879 A1 (MICROSOFT TECHNOLOGY LICENSING LLC [US]) 14 July 2016 (2016-07-14) paragraph [0008] paragraph [0009] paragraph [0011] -----	1-16
A	WO 00/39854 A1 (DYNAMIC SOLUTIONS INTERNATIONA [KR]) 6 July 2000 (2000-07-06) figures 19-21 -----	1

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
22 March 2021	31/03/2021

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Castagné, Olivier

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2020/068948

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2016111879 A1	14-07-2016	TW 201633868 A	16-09-2016
		US 2016204494 A1	14-07-2016
		WO 2016111879 A1	14-07-2016
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		WO 0039854 A1	06-07-2000