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(54) Title: INTEGRATED OPTICAL WAVEGUIDE EVANESCENT FIELD SENSOR

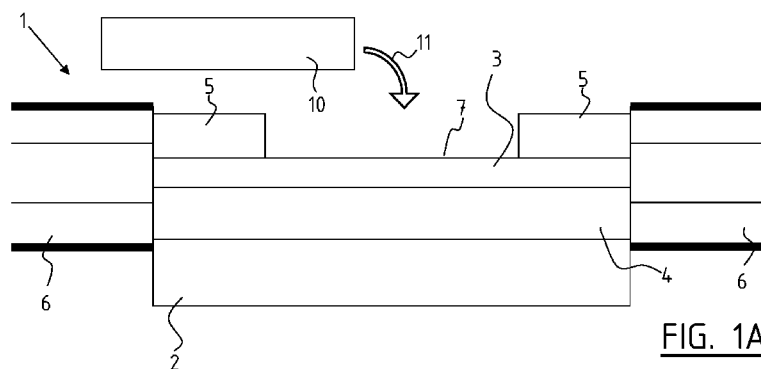


FIG. 1A

(57) Abstract: Integrated optical waveguide evanescent field sensor for sensing of chemical and/or physical quantities, comprising a substrate carrying a waveguide layer structure provided with - a waveguide core layer (3) sandwiched between two cladding layers (4, 5) formed by a lower (4) and a upper cladding layer (5), of a lower refractive index than the waveguide core layer, - a sensing section comprising a sensing layer (10) included in the upper cladding layer, wherein said sensing layer is exchangeable as a separate element.

Integrated optical waveguide evanescent field sensor

The invention relates to an integrated optical waveguide evanescent field sensor for sensing of chemical and/or physical quantities, comprising a substrate carrying a waveguide layer structure comprising

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- a waveguide core layer sandwiched between two cladding layers formed by a lower and an upper cladding layer, of a lower refractive index than the waveguide core layer,
- 10 - a sensing section comprising a sensing layer included in the upper cladding layer.

Integrated optical waveguide evanescent field sensors can be used for sensing of chemical and/or physical quantities.

15 During use, the sensor is usually connected to a measuring device with use of an optical fiber, wherein the optical fiber is optically connected to the waveguide core layer. A disadvantage of the known sensor is that sensing usually needs to be done by skilled persons.

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It is an object of the invention to obviate this disadvantage in the sense that an integrated optical waveguide evanescent field sensor is provided wherein sensing can be done by any unskilled person.

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In order to accomplish that objective, an integrated optical waveguide evanescent field sensor of the kind referred to in the introduction is characterized in that said sensing layer is exchangeable as a separate element.

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By having the sensing layer of the sensor as a separate

element, the sensing of chemical and/or physical quantities can easily be done by an unskilled person. For example, this is due to that only said separate element is exchanged for a new sensing session, such that any optical fiber connected to said sensor may remain connected to the remaining parts of said sensor. Since the connection of the sensor with the optical fiber is very precise, such that only skilled person can normally connect the sensor with the optical fiber, this allows for the sensing to be done by any (un)skilled person.

With sensors for sensing of chemical and/or physical quantities care must be taken that cross contamination of different sensors and/or in between sensing sessions does not occur. Because of the separate sensing layer according to the invention, cross contamination can be prevented because the sensing layer can be disposed after said sensing is done.

Another advantage is that a separate element allows for manufacturing the separate element apart from said sensor, thereby allowing more freedom of production and/or reduction of the production costs. Also, at the production site the separate element may be wrapped in such a way that it is protected from the environment. In this way contamination of the sensing layer of the sensor can be prevented.

Normally, the sensing layer must be applied to the sensor in a controlled environment, and therefore, also sensing normally takes place in the controlled environment. With a sensing layer that is exchangeable as separate element according to the invention, only the sensing layer may be manufactured in a controlled environment. After manufacturing, the sensing layer can be applied to the

sensor anywhere, such that sensing can easily take place outside the controlled environment. This allows for more freedom of use of the sensor according to the invention.

5 Also, said separate element allows for the possibility to exchange the element for a different kind of element, such that different types of sensing can easily be done, without the need to replace the sensor completely. Therefore, the flexibility of use of the sensor according to the invention
10 is enhanced.

The sensing section comprising the sensing layer is included within a window obtained by locally removing the originally applied cladding layer. Such a window has a depth of
15 approximately one to two micron and equals the thickness of the originally applied cladding layer. Such a thickness is required to fully shield the evanescent field from the environment outside this cladding layer. In this respect it is an aspect of the invention that said exchangeable sensing
20 layer has a form and dimensions that correspond to said window, such that it can be fitted into said window, or that said exchangeable sensing layer is deformable, such that it can form itself to said window, such that no (air) gap, or at least a small gap, between the sensing layer and the core
25 layer is present and a good optical connection between the sensing layer and the core layer is provided. With such a sensing layer according to the invention, the sensing layer and the core layer may be in contact with each other during sensing, but without interaction between the sensing layer
30 and the core layer in the form of a chemical bond. This way, both a good optical connection between the sensing layer and the core layer during sensing, and an easy exchange of the sensing layer when required are provided.

In a preferred embodiment of the sensor according to the invention, said waveguide layer structure comprises a second waveguide core layer sandwiched between two second cladding layers formed by a second lower and a second upper cladding layer, of a lower refractive index than the second waveguide core layer. An advantage of this embodiment is that one of the first and second waveguide core layers can be used as a reference branch.

Preferably said sensor comprises a second sensing section comprising a second sensing layer included in said second upper cladding layer. This embodiment has the advantage that multiple sensing may be done, wherein different analyte molecules may be sensed. Also, the sensing of the same analyte molecules may be done at both sensing sections, such that the accuracy of the measurements may be improved. Further, one of the sensing layers may be chemically insensitive, such that this channel functions as the reference channel.

In a practical embodiment of the sensor according to the invention, the waveguide layer structure comprises a splitter for optically splitting a common input waveguide core layer into said first and second waveguide core layers at a first junction.

In another practical embodiment of the sensor according to the invention, the waveguide layer structure comprises a combiner for optically coupling said first and second waveguide core layers into a common output waveguide core layer at a second junction.

In another preferred embodiment of the sensor according to the invention, said sensing layer comprises a gel, particularly a hydrogel, that is preferably non-adhesive with respect to the core layer. A gel, particularly a hydrogel, has the advantage that the gel can easily be exchanged as a separate element because it provides enough structure to be handled, while forming itself to the part of the sensor that it is applied on, so that a good optical connection between the sensing layer and the core layer is provided. Normally, the sensing layer is adhered to the sensor by bonding, because it is believed that no gap may exist between the two layers for proper sensing by the evanescent field. Therefore, a person skilled in the art would not use a gel that is non-adhesive with respect to said core layer as a sensing layer, because the person skilled in the art would not believe this would work. However, the applicant has now found that the required optical connection can be provided by such a non-adhesive gel because it forms itself to the sensor, such that a small gap is obtained. Such a small gap between the sensing layer and the core layer may exist provided that there is sufficient penetration of the evanescent field in the sensing layer. Preferably said gap remains constant during sensing. It is an aspect of the invention that the gap between the gel and the core layer is less than 300 nm, preferably less than 100 nm, even more preferably less than 10 nm. In particular is said gap smaller than the penetration depth of the evanescent field.

Another advantage of the gel according to the invention is that receptors, for example antibodies, can be applied to such a gel. According to an aspect of the invention, the receptors are only located in the end zone of the gel that is facing the core layer, in particular near the surface of

the gel that is facing the core layer. Preferably, the receptors are only present in a thin surface layer with a thickness that corresponds to the penetration depth of the evanescent field. Such a gel has the advantage that the analyte can only interact with the receptors in a location that can be sensed by the evanescent field. For example, when receptors are present near the surface of the gel that is facing away from said core layer, which is the surface on which the analyte will be applied, the analyte will interact with those receptors which are outside the evanescent field and can therefore not be sensed by the evanescent field. Furthermore, due to that the analyte will interact with those receptors that are outside the evanescent field, the analyte will not diffuse further into the gel to the surface of the gel that is facing the core layer and that can be sensed, such that no sensing or incorrect sensing takes place.

The invention also relates to such a sensing layer comprising a gel for use in an integrated optical waveguide evanescent field sensor for sensing of chemical and/or physical quantities.

The invention further relates to a method for manufacturing such a sensing layer, comprising the steps of:

- providing a sensing layer comprising a gel for use in an integrated optical waveguide evanescent field sensor for sensing of chemical and/or physical quantities;
- exposing the surface of the sensing layer that will be facing the core layer in use to receptors, in particular to a solution containing the receptors;
- waiting for a predetermined amount of time, such that the

receptors diffuse into the gel; and

- covalently coupling the receptors to the sensing layer after waiting the predetermined amount of time.

- 5 The predetermined amount of time is preferably chosen such, that the receptors will diffuse as far into the gel that they are only present in a thin surface layer with a thickness that corresponds to the penetration depth of the evanescent field.

10

Preferably, said gel comprises a substance chosen from a group comprising agarose, acrylamide, polyacrylamide, polyethyleneglycol, polysaccharide and mixtures thereof.

- 15 Agarose, acrylamide, polyacrylamide, polyethyleneglycol, polysaccharide and mixtures thereof have the advantage that they may have a large pore size, up to 200 nm, thus allowing analyte molecules, such as proteins, in particular antibodies, to diffuse through the gel layer in order to reach the sensor surface, while particles that are larger than the pore size cannot diffuse through the gel surface. Also, receptor molecules can be covalently coupled to the substance, which receptor molecules may interact with the analyte molecules to be sensed.

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Preferably said gel comprises 0.1 to 10% of said substance, preferably 0.2 to 5%, even more preferably 0.5 to 2%.

- Preferably, said gel comprises carboxymethylated, sulfonated and/or sulfated polysaccharides.

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An advantage of carboxymethylated, sulfonated and/or sulfated polysaccharides is that this allows the gel to be

rehydrated. After applying the gel to the sensor, the gel may dry out, thereby reducing in thickness and pore size, such that it may not function well anymore as the sensing layer. By rehydrating the gel, the original gel structure, in particular the pore size, is reestablished. An additional advantage of carboxymethylated, sulfonated and/or sulfated polysaccharides is the use of well-established protocols for receptor molecule immobilization that are developed for these materials.

Preferably said gel comprises 0.25 to 5% carboxymethylated, sulfonated and/or sulfated polysaccharides, preferably 0.5%.

In yet another preferred embodiment of the sensor according to the invention said sensing layer comprises a carrier that is provided on the surface of the sensing layer that is facing away from said core layer. The carrier has the advantage that the sensing layer can easily be exchanged by holding the carrier without the need to touch the sensing layer itself. Thereby contamination of the sensing layer may be prevented.

Preferably, said carrier is made of a porous material. A porous material has the advantage that the carrier may directly be exposed to a sample material comprising analyte molecules, because the analyte molecules will seep through the porous carrier to the sensing layer.

In another embodiment of said sensor according to the invention said carrier contains micro-fluidic channels adapted for transporting the analyte molecules to the sensing layer. Such micro-fluidic channels have the advantage that the carrier may directly be exposed to the

sample material comprising analyte molecules, because the analyte molecules will seep through the micro-fluidic channels to the sensing layer.

5 Preferably, said sensor comprises releasable force means adapted for applying a force on said sensing layer during sensing. Applying a force has the advantage that the optical connection between the sensing layer and the core layer is improved, because the sensing layer is forced against the
10 core layer and thereby forced to form itself to the core layer. Said releasable force means may comprise a mechanical and/or an electrostatic and/or a magnetic force. The invention also relates to a method for sensing an analyte with such a sensor comprising releasable force means,
15 comprising the step of applying a force on said sensing layer during sensing.

Preferably, said first and/or said second lower cladding layer has/have a refractive index that is lower than the
20 refractive index of the sensing layer and/or said first and/or said second upper cladding layer. In particular, the refractive index of the lower cladding layer may be lower than that of the sensing layer. An advantage of a lower cladding layer with a lower refractive index than that of
25 the sensing layer is that the part of the light extending into the sensing layer can be increased.

In a practical configuration of the sensor according to the invention said substrate is formed by said first and/or said
30 second lower cladding layer as one integral part.

The invention will now be explained in more detail with reference to figures illustrated in a drawing, wherein:

- figures 1A-1C show the steps of sensing with a first embodiment of the sensor according to the invention, wherein the sensing layer is mounted (1A), sensing(1B),
5 and wherein the sensing layer is removed (1C);
- figures 2A-2C show the steps of sensing with a second embodiment of the sensor according to the invention, wherein the sensing layer is mounted (2A), sensing(2B),
10 and wherein the sensing layer is removed (2C);
- figures 3A-3C show the steps of sensing with a third embodiment of the sensor according to the invention, wherein the sensing layer is mounted (3A), sensing(3B),
15 and wherein the sensing layer is removed (3C);
- figure 4 is a cross-section of a fourth embodiment of the sensor according to the invention;
- 20 - figure 5 is a cross-section of a fifth embodiment of the sensor according to the invention; and
- figures 6A-6T are schematic representations of configurations of the sensor according to the
25 invention.

Figures 1A-1C show an integrated optical waveguide evanescent field sensor 1 for sensing of chemical and/or physical quantities, comprising a substrate 2 carrying a
30 waveguide layer structure provided with a waveguide core layer 3 sandwiched between two cladding layers formed by a lower cladding layer 4 and a upper cladding layer 5, of a lower refractive index than the waveguide core layer.

Coupled to both endzones of the sensor 1 are optical fibers 6, such that the optical fiber 6 is optically connected to the waveguide core layer 3.

5 In case of buried waveguides, the optical field is completely contained in the core and buffer layers and the propagation of light is not affected by environmental disturbances. By using etching techniques, the top cladding 5 is locally removed at well-defined positions. In this so-called sensing window 7, the evanescent field 8 of the light 10 that travels through waveguide layer structure, extends into the environment above the sensor 1 and becomes susceptible to environmental changes. A sensing layer 10 that binds specifically with analyte molecules of interest 15 may be provided as an exchangeable element on the surface of the sensing window 7. The sensing layer 10 is a gel comprising a substance chosen from a group comprising agarose, acrylamide, polyacrylamide, polyethyleneglycol, polysaccharide and mixtures thereof. Preferably said gel 20 comprises 0.1 to 10% of said substance, preferably 0.2 to 5%, even more preferably 0.5 to 2%. The gel may also comprise carboxymethylated, sulfonated and/or sulfated polysaccharides. Preferably said gel comprises 0.25 to 5% carboxymethylated, sulfonated and/or sulfated 25 polysaccharides, preferably 0.5%.

As is shown in figure 1A, the sensing layer 10 is provided to the sensor 1 in the direction of arrow 11. Figure 1B shows, that in use, the sensing layer 10 is exposed to a 30 sample material 12, wherein specific binding of the analyte molecules to the sensing layer 10 in the sensing window 7 is probed by the evanescent field 8 of the light 9 travelling through the waveguide layer structure. This causes a change

of the propagation speed of the light which is a measure of the amount of analyte molecules binding to the sensing layer 10. When the sensing is done, the sensing layer 10 may be disposed in the direction of arrow 13.

5

Figure 2 show a second embodiment of the sensor 1 according to the invention, wherein said sensing layer 10 comprises a porous carrier 20 that is provided on the surface of the sensing layer 10 that is facing away from said core layer 3.

10 The sensing layer 10 can easily be provided to said sensor 1 with use of the carrier 20, which carrier 20 can easily be held by a user for displacing the sensing layer 10, thereby not touching the sensing layer 10 such that contamination may be prevented. As is shown in figure 2B, for sensing, the
15 sample material 12 is exposed to the carrier 20 of the separate element, such that analyte molecules will seep through the porous carrier 20 to the sensing layer 10. After sensing is done, the separate element may easily be removed with use of the carrier 20.

20

Figure 3 shows a third embodiment of the sensor 1 according to the invention. As is shown, in this embodiment the carrier 20 comprises micro-fluidic channels 30 adapted for transporting the analyte molecules to the sensing layer 10.

25

Optionally, releasable force means adapted for applying a force on said sensing layer 10 during sensing are present (not shown). The releasable force means for example comprise a mechanical force in the form exerting a pressure on the
30 carrier 20.

Figure 4 shows a fourth embodiment of the sensor 1 according to the invention. In this embodiment the analyte molecules

40 comprise fluorescent labels 41, such that when the evanescent field 8 of the light 9 travels through the sensing layer 10 the bonded molecules 40 are excited and will become fluorescent. The fluorescence of the sensing layer 10 is measured by a CCD camera 42, such that the fluorescence is a measure for the amount of analyte molecules binding to the sensing layer 10.

Figure 5B shows a fifth embodiment of the sensor 1 wherein the lower cladding layer 4 has a refractive index that is lower than the refractive index of the sensing layer 10. It is clear when figure 5B is compared to figure 5A, wherein the refractive index of the lower cladding layer 4 is higher or equal than that of the sensing layer 10, that the evanescent field 8 extending into the sensing layer 10 is increased due to this lower refractive index. Therefore, accuracy of the measurements can be improved.

Figures 6A-T show several configurations of the sensor according to the invention. As appears from these figures, many configurations are possible. Therefore, it is clear that that these figures are not exclusive. Further, it is clear that all these possible configurations and/or not shown configurations fall within the scope of the appended claims. For clarity, the elements are numbered only in some figures.

Figure 6A shows a configuration wherein the waveguide layer structure 40 is formed as a single path. Such a sensor is also called a planar waveguide sensor. This is a cheap and simple configuration of the sensor according to the invention.

Figure 6B shows a configuration wherein the waveguide layer structure 40 is formed as a single channel. Such a sensor is also called a channel waveguide sensor. This is a cheap and simple configuration of the sensor according to the invention.

Figures 6C and 6D show configurations wherein the waveguide layer structure 40 is formed as two parallel paths, respectively two parallel channels, wherein only one of the paths or channels comprises a sensing layer 10. The path or channel without the sensing layer 10 may act as a reference branch. Because no specific binding occurs in the reference branch due to the absence of the sensing layer 10, the propagation speed of the light does not change, thus resulting in a phase difference between light coming from the sensing branch and the reference branch. The induced phase difference is proportional to the amount of analyte molecules binding to the sensing layer 10.

Figures 6E and 6F show configurations wherein the waveguide layer structure 40 is formed as three parallel paths, respectively three parallel channels, wherein all of the paths or channels comprise a sensing layer 10. Multiple paths or channels each comprising a sensing layer 10 have the advantage that different analyte molecules may be sensed at the same time. Also, one of the paths or channels may comprise a sensing layer 10 that shows no specific binding, such that this branch may act as a reference branch. Because no specific binding occurs in the reference branch, the propagation speed of the light does not change, thus resulting in a phase difference between light coming from the sensing branch and the reference branch. The induced phase difference is proportional to the amount of analyte

molecules binding to the sensing layer 10. Also, the accuracy of the sensing may be improved due to multiple sensing branches.

5 Figures 6I and 6J show configurations with an array with sensing sections comprising sensing layers 10. These configurations have the advantage that with use of only one branch, multiple and/or different sensing sessions can be done at the same time.

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Figures 6K-6T show configurations wherein multiple parallel channels may have one common input channel and/or one common output channel. The sensor 1 therefore comprises a splitter for optically splitting the common input waveguide core layer into said first and second waveguide core layers at a first junction 50 and/or a combiner for optically coupling said first and second waveguide core layers into a common output waveguide core layer at a second junction 51.

20 The invention is not restricted to the variants shown in the drawing, but it also extends to other preferred embodiments that fall within the scope of the appended claims.

Claims

1. Integrated optical waveguide evanescent field sensor for sensing of chemical and/or physical quantities, comprising a substrate carrying a waveguide layer structure comprising

5

- a waveguide core layer sandwiched between two cladding layers formed by a lower and an upper cladding layer, of a lower refractive index than the waveguide core layer,

10

- a sensing section comprising a sensing layer included in the upper cladding layer, **characterized in that** said sensing layer is exchangeable as a separate element.

15

2. Integrated optical waveguide evanescent sensor according to claim 1, wherein the waveguide layer structure comprises a second waveguide core layer sandwiched between two second cladding layers formed by a second lower and a second upper cladding layer, of a lower refractive index than the second waveguide core layer.

20

3. Integrated optical waveguide evanescent sensor according to claim 2, wherein the sensor comprises a second sensing section comprising a second sensing layer included in said second upper cladding layer.

25

4. Integrated optical waveguide evanescent sensor according to claim 2 or 3, wherein the waveguide layer structure comprises a splitter for optically splitting a common input waveguide core layer into said first and second waveguide core layers at a first junction.

30

5. Integrated optical waveguide evanescent sensor according to claim 2, 3 or 4, wherein the waveguide layer structure comprises a combiner for optically coupling said first and second waveguide core layers into a common output waveguide core layer at a second junction.

6. Integrated optical waveguide evanescent sensor according to claim 1, 2 or 3, wherein said sensing layer comprises a gel, particularly a hydrogel.

7. Integrated optical waveguide evanescent sensor according to claim 6, wherein said gel comprises a substance chosen from a group comprising agarose, acrylamide, polyacrylamide, polyethyleneglycol, polysaccharide and mixtures thereof.

8. Integrated optical waveguide evanescent sensor according to claim 6 or 7, wherein said gel comprises carboxymethylated, sulfonated and/or sulfated polysaccharides.

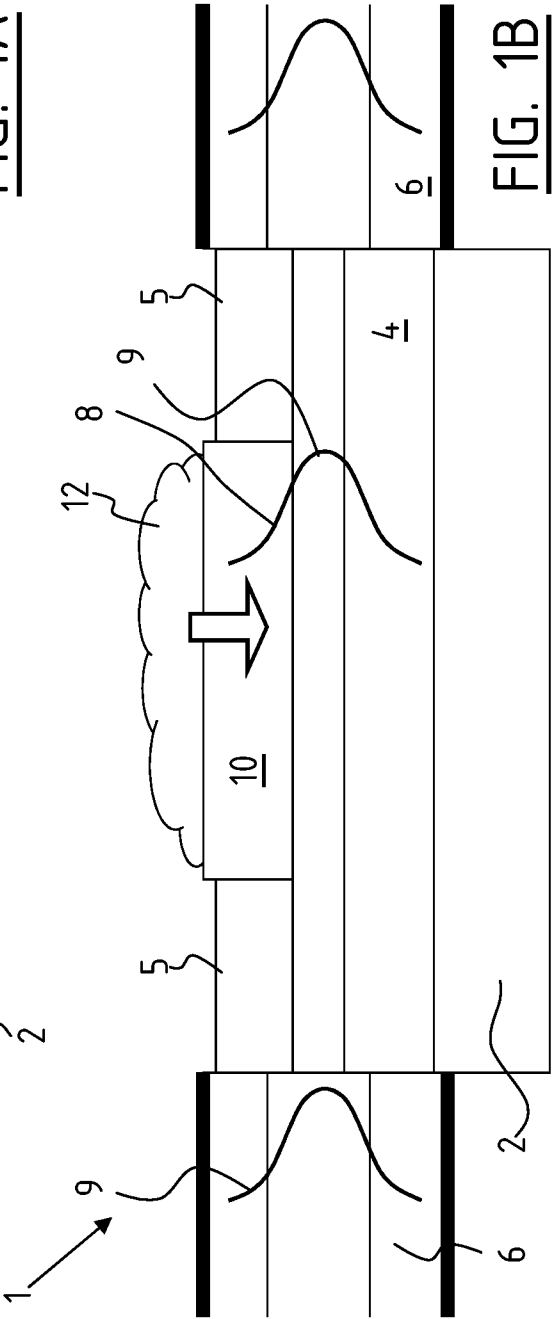
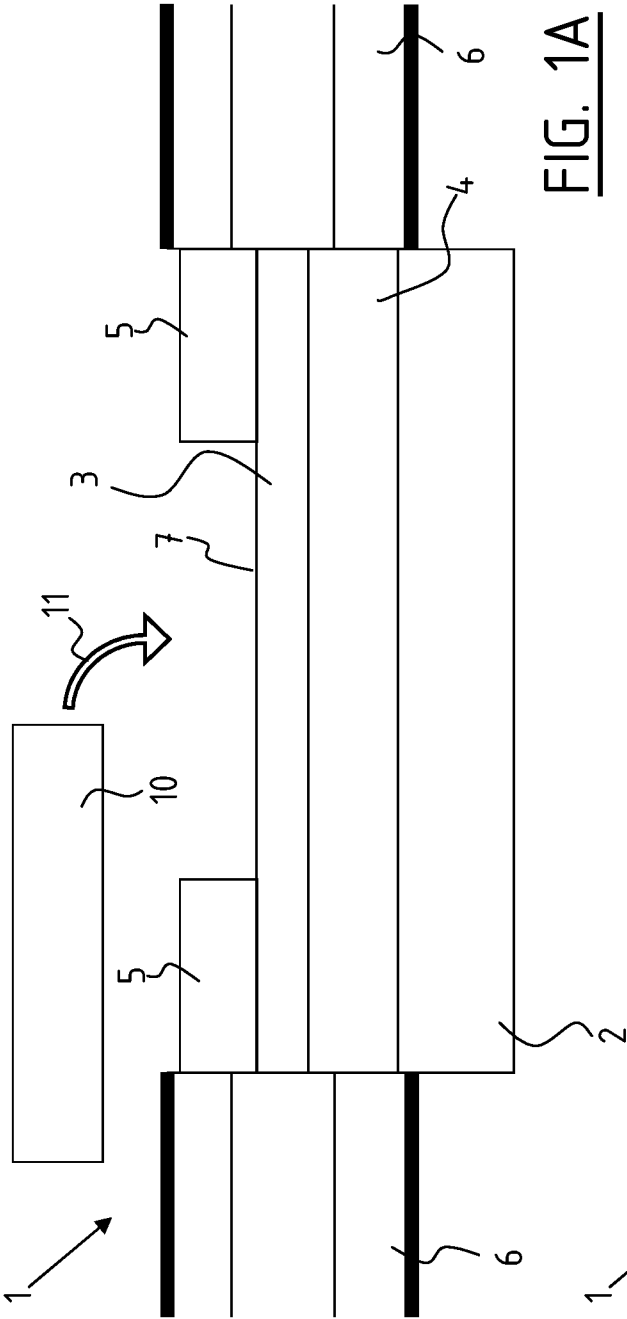
9. Integrated optical waveguide evanescent sensor according to any of the preceding claims 1-8, wherein said sensing layer comprises a carrier that is provided on the surface of the sensing layer that is facing away from said core layer.

10. Integrated optical waveguide evanescent sensor according to claim 9, wherein said carrier is made of a porous material.

11. Integrated optical waveguide evanescent sensor

according to claim 9, wherein said carrier comprises micro-fluidic channels adapted for transporting an analyte to the sensing layer.

- 5 12. Integrated optical waveguide evanescent sensor according to any of the preceding claims 1-11, further comprising releasable force means adapted for applying a force on said sensing layer during sensing.
- 10 13. Integrated optical waveguide evanescent sensor according to any of the preceding claims 1-12, wherein said first and/or said second lower cladding layer has/have a refractive index that is lower than the refractive index of the sensing layer and/or said first and/or said second upper
15 cladding layer.
14. Integrated optical waveguide evanescent sensor according to any of the preceding claims 1-13, wherein said substrate is formed by said first and/or said second lower
20 cladding layer as one integral part.



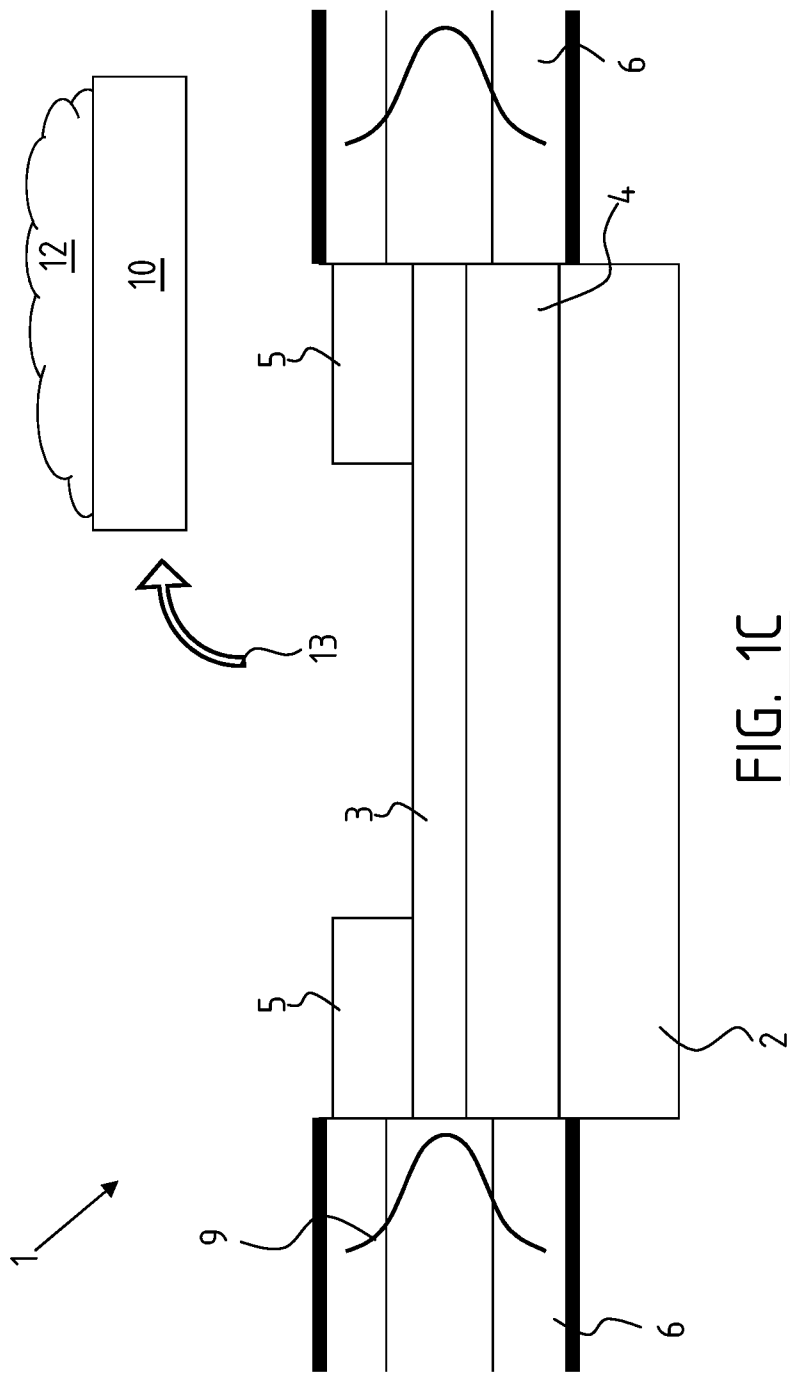
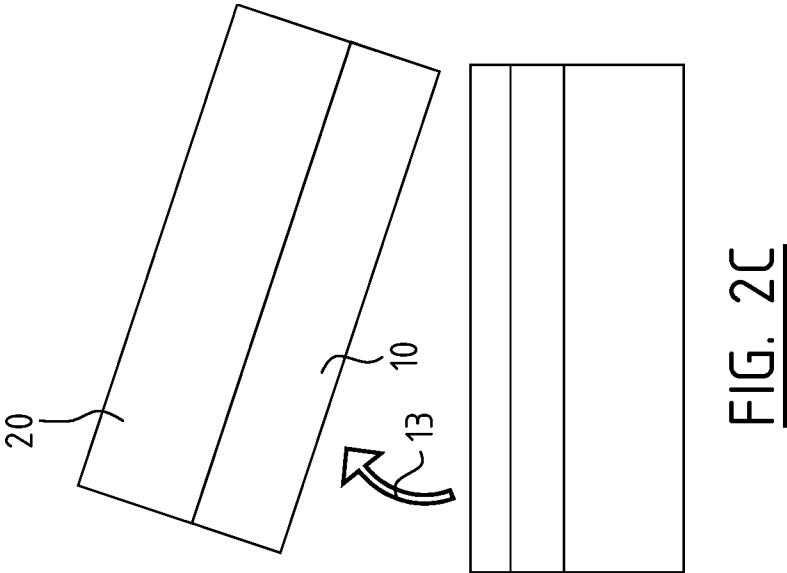
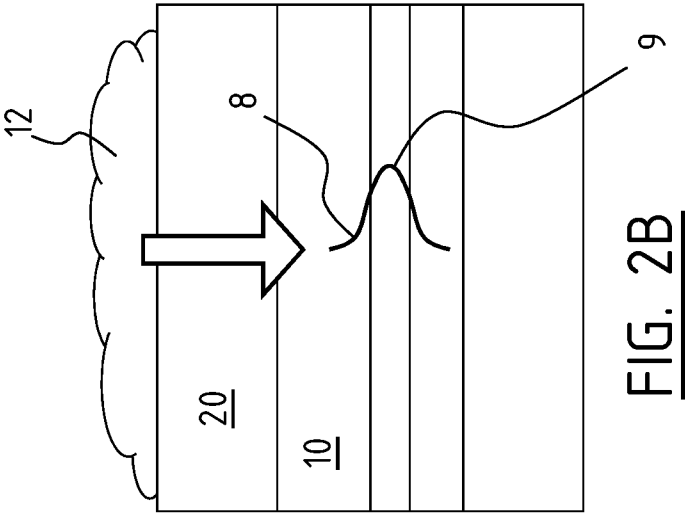
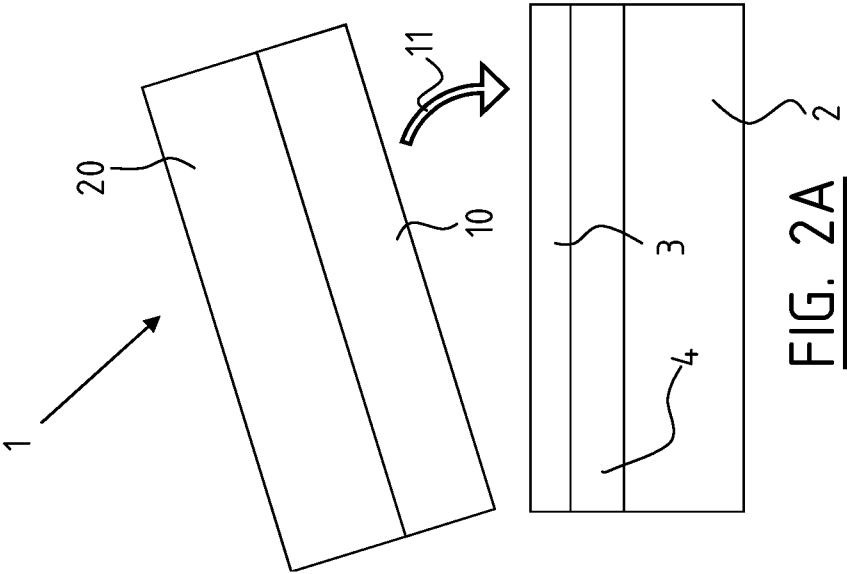


FIG. 1C



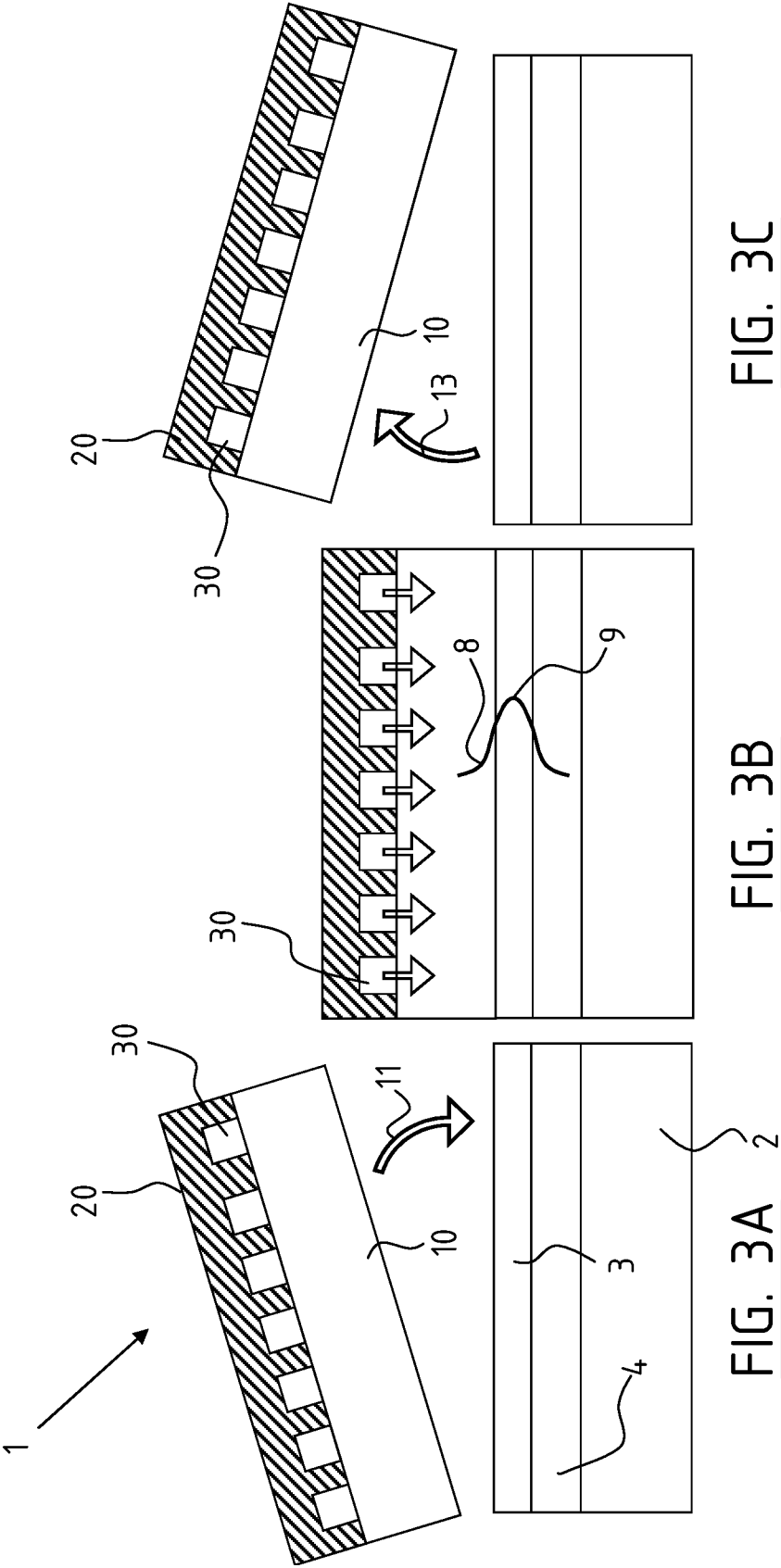


FIG. 3C

FIG. 3B

FIG. 3A

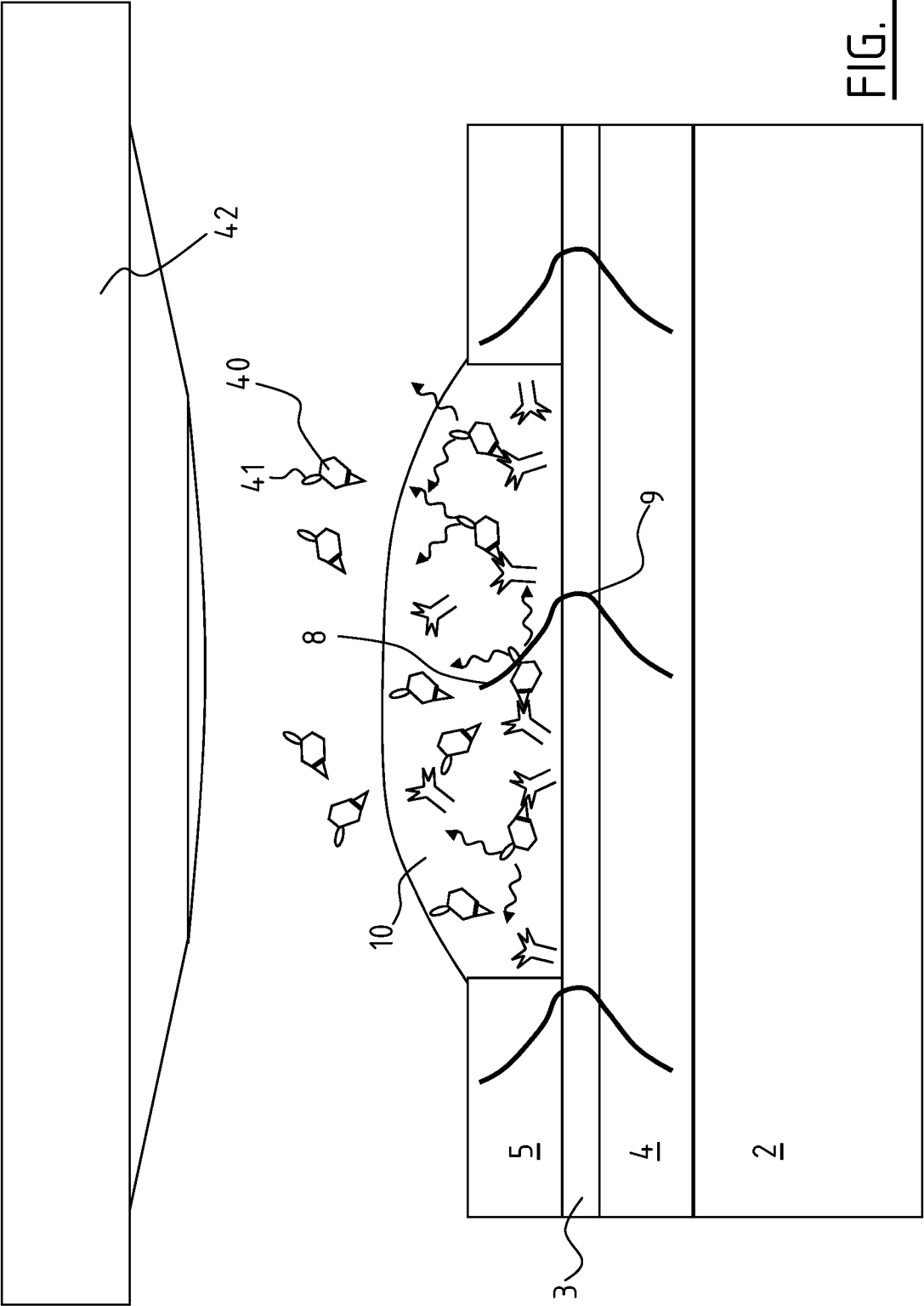


FIG. 4

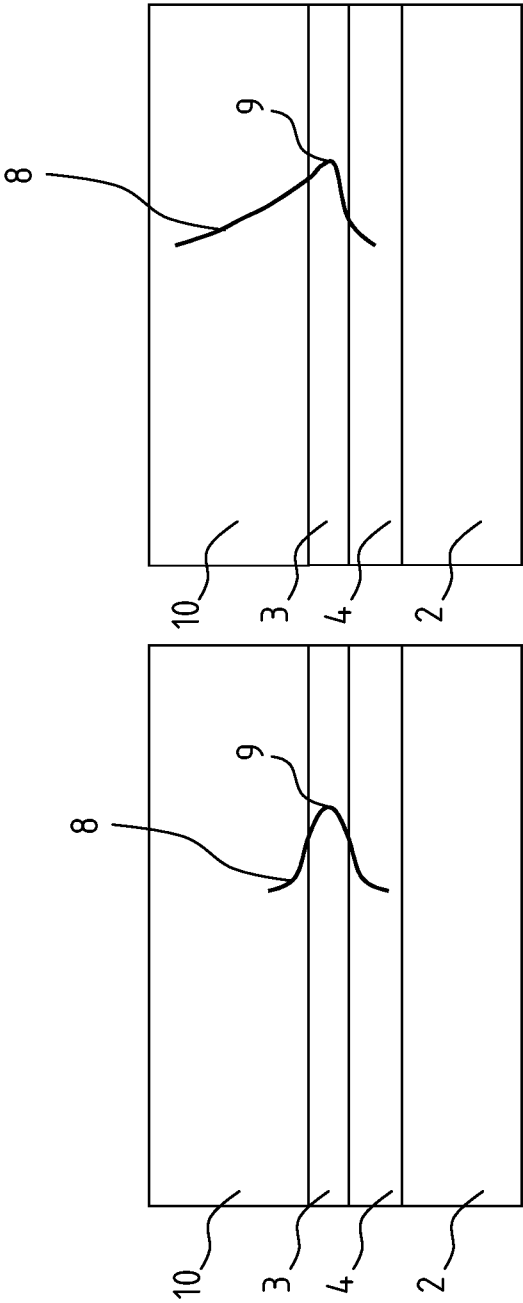


FIG. 5A

FIG. 5B

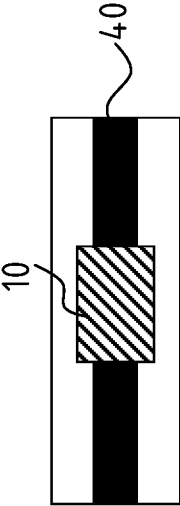


FIG. 6A

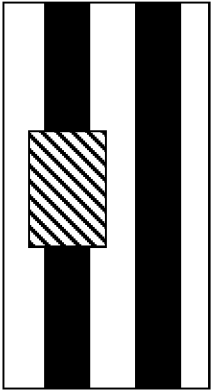


FIG. 6C

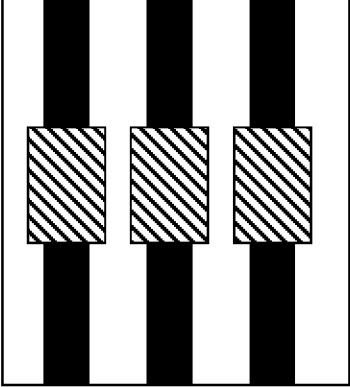


FIG. 6E

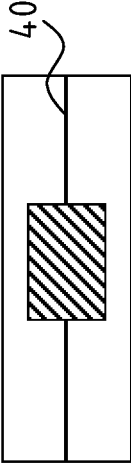


FIG. 6B

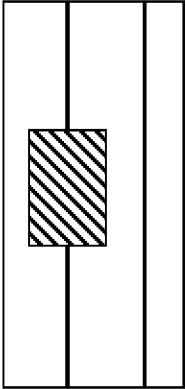


FIG. 6D

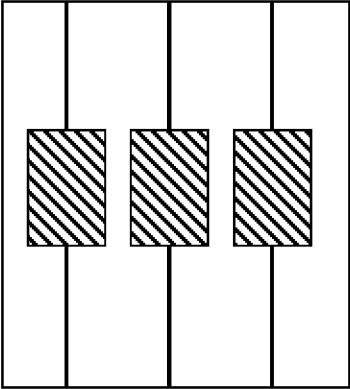


FIG. 6F

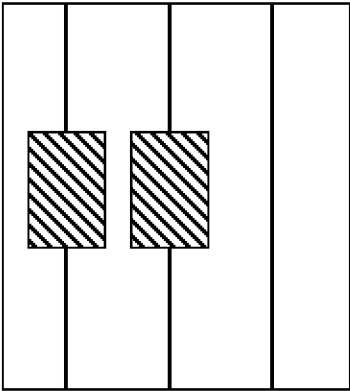


FIG. 6H

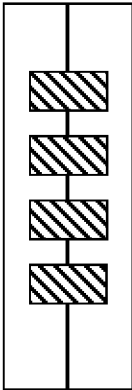


FIG. 6J

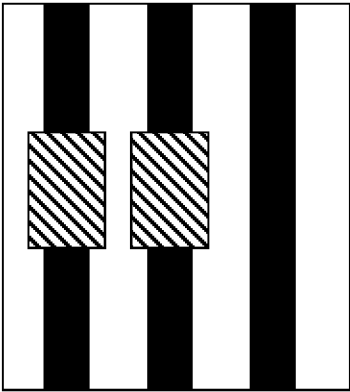


FIG. 6L

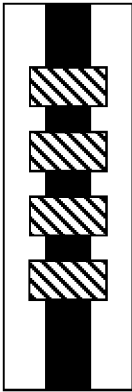


FIG. 6N

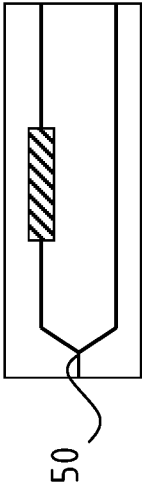


FIG. 6K

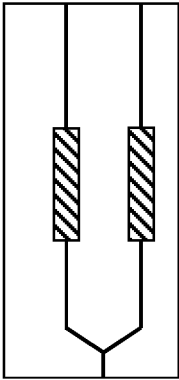


FIG. 6L

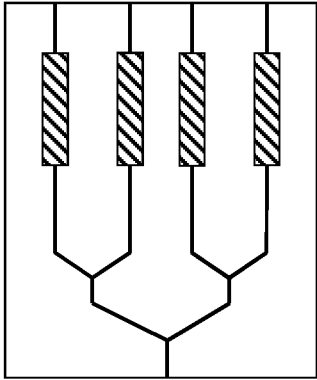


FIG. 6M

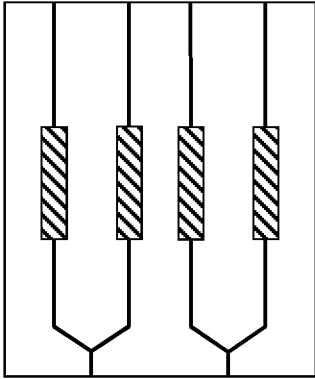


FIG. 6N

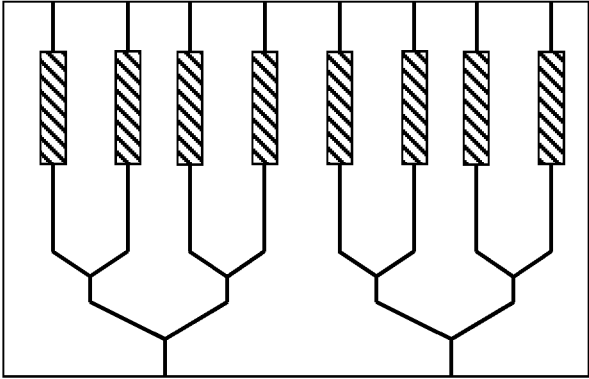


FIG. 6O

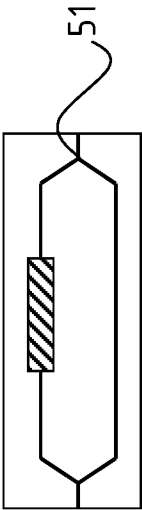


FIG. 6P

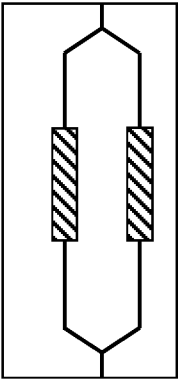


FIG. 6Q

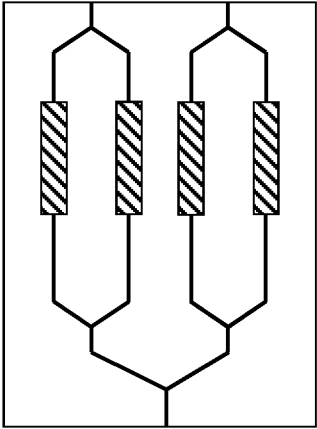


FIG. 6R

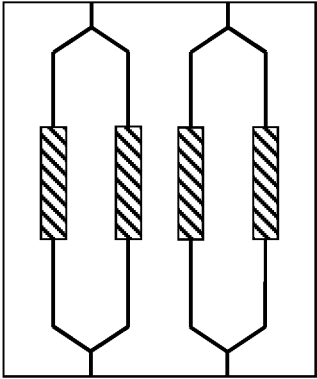


FIG. 6S

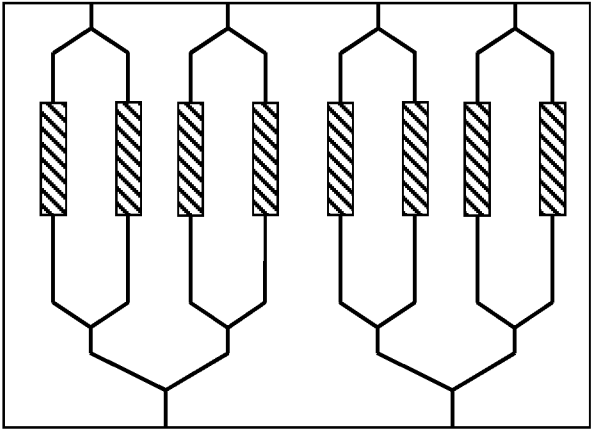


FIG. 6T

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2011/059972

A. CLASSIFICATION OF SUBJECT MATTER INV. G01N21/77 G01N33/543 G02B6/38 G01N21/55 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) G01N G02B		
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 practical, search terms used) EPO-Internal, BIOSIS, EMBASE, INSPEC, COMPENDEX, Sequence Search, WPI Data		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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	----- -/-	
☒ Further documents are listed in the continuation of Box C. ☒ See patent family annex.		
* Special categories of cited documents : "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier document but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "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 18 November 2011		Date of mailing of the international search report 05/12/2011
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016		Authorized officer Mason, William

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2011/059972

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
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A	US 7 483 140 B1 (CHO HYOUNG JIN [US] ET AL) 27 January 2009 (2009-01-27) figures 1-3 -----	1-14

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