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THEREOF

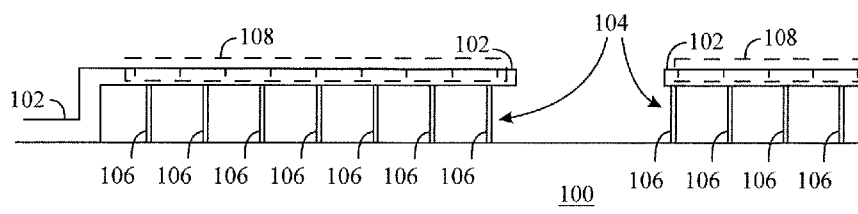


FIG. 1

(57) Abstract: An apparatus associated with an analysis of a thin film layer comprises two layer structures (100, 102) with a cavity (104) therebetween, and an opening (110) through one of the layer structures (102) to the cavity (104), the cavity (104) being configured to receive, through the opening (110), material used to form a thin film layer (900) inside the cavity (104). At least one of the two layer structures (100, 102) comprises at least one positional indicator (108) for an analysis associated with the thin film layer (900).

Apparatus associated with analysis of thin film layer and manufacturing method thereof

Field

- 5 The invention relates to an apparatus associated with an analysis of a thin film layer, and a method of manufacturing the apparatus.

Background

Conformal thin films are used in significant technological applications
10 ranging from semiconductor devices to energy applications, catalysis and pharmaseuticals. "Conformality" means the ability of a thin film to cover all surfaces of a three-dimensional object with the same thickness, composition, and properties.

For quick and repeatable analysis of the conformality, the conformality
15 test structures should have a reliable internal length scale calibration. For example, equipment manufacturers, precursor companies, semiconductor device manufacturers and/or other companies associated with atomic layer deposition and/or chemical vapor deposition (ALD/CVD) would like to have accurate means to analyse conformality. Additionally universities and/or research institutes often
20 need a proper equipment to perform conformality analysis. However, there is no accurate or standard way to analyse thin film conformality, although a lateral high-aspect-ratio (LHAR) test structure made with silicon techniques has lately been used for the analysis. Hence, there is a need to improve the test structure.

Brief description

25

The present invention seeks to provide an improvement in the measurements. According to an aspect of the present invention, there is provided an apparatus associated with an analysis of a thin film layer as specified in claim 1.

According to another aspect of the present invention, there is provided a method of manufacturing an apparatus associated with an analysis of a thin film layer in claim 10.

The invention has advantages. The at least one positional indicator
5 enables the analysis of the thin film layer faster, more accurate and easier.

List of drawings

Example embodiments of the present invention are described below, by way of example only, with reference to the accompanying drawings, in which

10 Figure 1 to 5 illustrate an examples of an apparatus associated with the analysis of a thin film layer;

Figure 6A illustrates an example of positional indicators in the range 1000 μm to 5000 μm ;

15 Figure 6B illustrates an example of positional indicators in the range 100 μm to 1000 μm ;

Figure 6C illustrates an example of positional indicators in the range 0 μm to 150 μm ;

Figure 6D illustrates an example number of lines and their positions with respect to each other in range distances from 0 μm to 1000 μm ;

20 Figure 6E illustrates an example number of lines and their positions with respect to each other in range distances from 1100 μm to 4900 μm ;

Figure 6F illustrates an example of positional indicators comprising at least two sub-indicators;

Figure 7 illustrates a top view of an example of the apparatus;

25 Figure 8A illustrates another top view of an example of the apparatus;

Figure 8B illustrates an example of an apparatus with more than one opening;

Figure 9 illustrates an example of an apparatus a thin film layer inside a cavity; and

Figure 10 illustrates an example of a flow chart of a manufacturing method of the apparatus.

Description of embodiments

5 The following embodiments are only examples. Although the specification may refer to "an" embodiment in several locations, this does not necessarily mean that each such reference is to the same embodiment(s), or that the feature only applies to a single embodiment. Single features of different embodiments may also be combined to provide other embodiments.

10 Furthermore, words "comprising" and "including" should be understood as not limiting the described embodiments to consist of only those features that have been mentioned and such embodiments may contain also features/structures that have not been specifically mentioned.

 It should be noted that while Figures illustrate various embodiments,

15 they are simplified diagrams that only show some structures and/or functional entities. The connections shown in the Figures may refer to logical or physical connections. It is apparent to a person skilled in the art that the described apparatus may also comprise other functions and structures than those described in Figures and text. It should be appreciated that details of some functions or

20 structures are irrelevant to the actual invention. Therefore, they need not be discussed in more detail here.

 Figures 1 to 5 illustrate examples of an apparatus associated with the analysis of a thin film layer. In Figure 1, the apparatus, which may comprise a chip of a lateral high-aspect-ratio LHAR structure, comprises a substrate 100 which

25 may be made of silicon, for example. The substrate 100 may also be made of SiO₂ (silicon dioxide silica, quartz), germanium (Ge), gallium arsenide (GaAs) or the like. The apparatus also comprises a membrane 102, which may be made of polysilicon, for example. The membrane 102 may be made of the same material or materials as the substrate 100. The thickness of the membrane 102 may range

30 from tens of nanometers to ten thousand nanometers, for example. The thickness of the membrane 102 is, however, not limited to this range. Thus, the apparatus

comprises two layer structures one of which is the substrate 100 and another of which is the membrane 102.

A cavity 104 spreads out horizontally between the two layer structures 100, 102. The apparatus has also an opening 110 through the
5 membrane 102 to the cavity 104. The cavity 104 is configured to receive, through the opening 110, material used to form a thin film layer 900 (see Figure 9) inside the cavity 104. A height of the cavity 104 may be in a range from tens of nanometers to two thousand nanometers, for example. The height of the cavity 104 is, however, not limited to this range.

10 In an embodiment shown in Figures 1 to 3, the cavity 104 has at least one pillar 106 between the two layer structures 100, 102. The pillar 106 or the pillars 106 may support the cavity 104 and prevent a collapse of the cavity 104. The at least one pillar 106 may be made of thermal oxide growth or silicon, for example.

15 In an embodiment shown in Figures 4 and 5, the cavity 104 may be supportless. That is, there are no pillars 106 between the two layer structures 100, 102. In this embodiment, the cavity 104 is thus empty of solid structures extending between the substrate 100 and the membrane 102.

In Figure 1, the membrane 102 comprises positional indicators 108,
20 which may be utilized in an analysis of the thin film layer 900. The positional indicators 108 may be on an outer surface of the membrane 102. The outer surface is opposite to the inner surface of the membrane 102, the inner surface being a part of the surface of the cavity 104. In an embodiment, the positional indicators 108 may differ by a materialistic property from the membrane 102.

25 In Figure 2, the substrate 100 comprises the positional indicators 108 which may be on a surface of the substrate 100, the substrate 100 being a part of the surface of the cavity 104. In an embodiment, the positional indicators 108 may differ by a materialistic property from the substrate 100 in a similar manner as explained of the positional indicators 108 on the membrane 102 in Figure 1.

30 Figure 3 illustrates an example of the positional indicators 108 which are materialistic parts added on the surface of the membrane 102. The

materialistic parts may be of the same material as or different material from the membrane 102. The at least one positional indicator 108 is easy to add to the apparatus during the manufacturing process.

Figure 4 illustrates an example the apparatus which has no pillars 106 in the cavity 104. Figure 4 also illustrates an example of the positional indicators 108 which are materialistic parts added on the surface of the substrate 100. The materialistic parts may be of the same material as or different material from the substrate 100.

Figure 5 also illustrates an example the apparatus which has no pillars 106 in the cavity 104. Figure 5 further illustrates an example of the positional indicators 108 which are materialistic parts added inside the membrane 102. That is, the at least one positional indicator 108 may be on the surface or within the membrane 102. In this example, the materialistic parts of the positional indicators 108 are of different material from that of the membrane 102. In a similar manner, the at least one positional indicator 108 may be on or within the substrate 100.

In the manner described above it can be expressed that at least one of the two layer structures 100, 102 comprises positional indicators 108 used in the analysis of the thin film layer 900. For example, determination of how far the thin film layer 900 extends in the cavity 104 measured from the opening 110 may be based on information obtained from the positional indicators 108. Additionally, an aspect ratio (AR) may be determined on the basis of the height of the cavity 104 and the determination of how far the thin film layer 900 extends in the cavity 104. The at least one positional indicator 108, *per se*, doesn't limit the analysis of the thin film layer 900.

In an embodiment, the at least one positional indicator 108 may have a property, which is configured to carry information associated with a position of the at least one positional indicator 108 with respect to the opening 110. The property may refer to a dimension or a type of material of the at least one positional indicator 108. The property may refer to thickness, density, crystallinity or composition of material of the at least one positional indicator

108. The composition may refer to chemical elements or compounds of the at least one positional indicator 108. The at least one positional indicator 108 may comprise at least one pure or at least approximately pure substance of at least one chemical element or compound. The composition may refer to a mixture of
5 chemical elements or compounds. To carry information associated with a position of the at least one positional indicator 108, the property of one positional indicator 108 may be different from that of at least one other positional indicator 108. In an embodiment, the positional indicators 108 may differ by a materialistic property from the layer structure 100, 102 on the surface of or
10 inside which it is.

The property may carry information associated with a distance from the opening 110, for example. The distance may refer to the shortest length between the circumference of the opening 110 and the positional indicator 108, for example. The distance may be the shortest separation between the center or
15 the longitudinal axis of the opening 110 and the positional indicator 108, for example.

In an embodiment, a cross sectional dimension of the at least one positional indicator 108 is configured to carry the information about the position. The cross sectional dimension may be a width, for example. In an embodiment,
20 the cross sectional dimension may be parallel to the substrate 100. That is, a normal of the cross sectional dimension may thus be parallel to a normal of the substrate 100. This is convenient when the analysis of the thin film layer 900 is performed from a direction of the normal of the substrate, i.e. using a top view. In an embodiment, the cross sectional dimension may be perpendicular to the
25 normal of the substrate 100. In an embodiment, the cross sectional dimension may be perpendicular to the substrate 100. This is convenient when the analysis of the thin film layer 900 is performed from a direction perpendicular to the normal of the substrate, i.e. using a side view.

In embodiment examples of which shown in Figures 6A to 6F, the at
30 least one positional indicator 110 may comprise at least two sub-indicators 600, 602, 604 a distance between which carries the information about the position.

Distances from the opening 110 may also carry the information about the position. In a similar manner, width of a positional indicator may carry information about the position.

In each of Figures 6A to 6C, there are two views with respect to the apparatus. In the upper view the apparatus is seen from top and in the lower view the apparatus is seen from side.

Figure 6A illustrates an example of positional indicators in the range 1000 μm to 5000 μm , and the position is encoded using three lines 600, 602, 604. The line 600 is thicker than the two other lines 602, 604. The width of the line 600 may be about 2 μm , for example. The width of the thinner lines 602, 604 may be about 0.5 μm , for example. The distance between the thinner lines 602, 604 may be about 1 μm , for example. A distance between the pair of thinner lines 602, 604 and the thicker line 600 varies in a function of the position. The shortest distance between the pair of the thinner lines 602, 604 and the thicker line 600 may be about 2 μm , for example. Then the distance between the pair of the thinner lines 602, 604 and the thicker line 600 may increase with the increasing distance from the opening 110.

Figure 6B illustrates an example of positional indicators in the range 100 μm to 900 μm , and the position is encoded using two lines 600, 602 in distances shorter than 1000 μm . The line 600 is thicker than the other line 602. The width of the line 600 may be about 2 μm also in this example. Correspondingly, the width of the thinner line 602 may be about 0.5 μm , for example. A distance between the thinner line 602 and the thicker line 600 varies in a function of the position. The shortest distance between the thinner line 602 and the thicker line 600 may be about 2 μm , for example. Then the distance between the thinner line 602 and the thicker line 600 may increase with the increasing distance from the opening 110.

Figure 6C illustrates an example of positional indicators for 10 micrometers and 50 micrometers, and the position is encoded using one line 600 and two lines 600, 602. The line 600 is thicker than the other line 602. The width of the line 600 may be about 2 μm also in this example. Correspondingly, the

width of the thinner line 602 may be about 0.5 μm , for example. Each distance from the opening 110 which is a multiple of 10 micrometers is marked with a thin line 602. An exception to this rule is each distance which is a multiple of 50 μm . These distances of multiples of 50 μm are marked with a thicker line 600. Neither
5 of these rules hold for distance of multiples of 100 μm because these distances are marked with a combination of the thin line 602 and the thicker line 600. All these three rules may be applied when marking distances for multiples of 10 micrometers, 50 micrometers and 100 micrometers.

Figure 6D illustrates an example number of lines and their positions
10 with respect to each other in range distances from 0 μm to 1000 μm .

Figure 6E illustrates an example number of lines and their positions with respect to each other in range distances from 1100 μm to 4900 μm . In Figures 6E and 6F the leftmost line is the thick line 600 and the other lines are the thinner lines 602, 604.

Figure 6F has a ruler 0 mm to 5 mm for distances between the
15 positional indicators and the opening 110. The multiples of a predefined distance may be marked with a single element positional indicator 108, for example. The predefined distance may be 10 μm . This example is illustrated in upper right corner of Figure 6F. For accurate and repeatable measurement of the
20 conformality, the structures have in this manner a reliable internal length scale calibration. This is true also for other examples in this application.

All the positional indicators 108 of integer values of distances in millimeters may have two sub-indicators 600, 602. In general, all the positional indicators 108 of integer values of distances in a desired length unit may have
25 two sub-indicators 600, 602. The separation between the sub-indicators 600, 602 may be a thousand times smaller than the real distance from the opening 110, for example. Thus, a distance of three millimeters may be indicated by a distance of 3 μm between the sub-indicators 600, 602 at a position the distance from the opening 110 of which is 3 mm. In general, the separation between the sub-
30 indicators 600, 602 may be a predetermined times smaller than the real distance

from the opening 110. This example is illustrated in upper left corner of Figure 6F.

The positional indicators 108 of distances of 100 μm and 200 μm may have two sub-indicators 604, 606 directly adjacent to the single element positional indicator 108 of the multiples of the predefined distance (10 μm). A distance between the two sub-indicators 604, 606 indicates a distance to the opening 110. The separation between the sub-indicators 604, 606 may a thousand times smaller than the real distance from the opening 110, for example. In Figure 6F, the distance between the two sub-indicators 604, 606 is 2 μm which refers to the distance 2 mm to the opening 110. This example is illustrated in lower right corner of Figure 6F.

The positional indicators 108 of distances of 300 μm , 400 μm , 500 μm , 600 μm , 700 μm , 800 μm and 900 μm need not include the single element positional indicator 108 of the multiples of the predefined distance (10 μm), and thus they may only have the two sub-indicators 604, 606. The distance between the sub-indicators may indicate the distance to the opening 110 in a similar manner as explained above.

At the distance 1000 μm there may be a single element positional indicator 108.

For distances larger than 1000 μm , three sub-indicators 608, 610, 612 may be used. A distance between the two sub-indicators 608, 610 at right may indicate a whole number value of the distance and a distance between the third sub-indicator 612 and one of the two sub-indicators 608, 610 may indicate a decimal value of the distance. The whole number of the distance in the example of Figure 6F is 2 mm because the distance between the two sub-indicators 608, 610 is 2 μm . The decimal value is 0.8 mm because the distance between the third sub-indicator 612 and the second sub-indicator 610 is 8 μm . Thus, the distance to the opening is 2.8 mm in the example at the lower left corner of Figure 6F.

In an embodiment, the position indicators 108 include a shape of numeric symbols which directly indicate the distance to the opening 110.

In an embodiment, the position indicators 108 include a shape of alphabets for directly indicating the distance to the opening 110. The alphabets may be in a human language.

5 In an embodiment, the position indicators 108 include a shape of writing symbols which directly indicate the distance to the opening 110. The writing symbols may be in a machine language or in a human language or symbols for an analysis system.

In an embodiment, the property is associated with material of the at least one positional indicator 108 and the property is configured to cause a
10 unique interaction with radiation used in a detection of the position, the unique interaction being associated with the position for its indication. In this example, each of the positional indicators 108 made of a single element or of a plurality of the sub-indicators 600 to 612 have a deterministic interpretation which is different from interpretation of any other positional indicator 108.

15 A difference of the materialistic property may be a refraction index and/or a scattering efficiency of the radiation used in detection of the positional indicators 108. In an embodiment, the radiation used in detection of the positional indicators 108 may be optical radiation and/or radiation of electrons, for example. In an embodiment, the optical radiation may be visible light. In an
20 embodiment, the optical radiation may be infrared light. In an embodiment, no material is added to or removed from the membrane 102 for producing the positional indicators 108. In an embodiment, the materialistic property may be density, for example, a variation of which may also vary the interaction between the radiation used in detection and the positional indicators 108.

25 Figure 7 shows a top view of an example of the apparatus. In an embodiment, the opening 110 may be elongated or rectangular.

In an embodiment shown in Figure 7, the positional indicators 108, which are at the same distance from the opening 100, form a continuous line 700, 702 around the opening 110. Different lines 700, 702 have different properties.
30 The edge of the opening 110 may be straight or round. The opening 110 may continue to one side 706 or to both sides of the apparatus an example of which is

shown with dashed lines in Figure 7. Thus, the opening 110 may be open at one side or at both sides. More generally, the apparatus may comprise one opening 110 or more than one opening 110.

Figure 8A shows a top view of an example of the apparatus. In an embodiment shown in Figure 8, the positional indicators 108, which are at the same distance from the opening 100, form discontinuous line 800, 802 around the opening 110. That is, the positional indicators 108 form a shape of the discontinuous line 800, 802. The discontinuity may be caused by a physical separation between said positional indicators 108 in the same line 800, 802.

In an embodiment, a tangent of each line 700, 702, 800, 802 formed by the positional indicators 108 is at a known angle with respect to the longitudinal axis 704 of the opening 110 which is elongated.

In an embodiment, a tangent of each line 700, 702, 800, 802 formed by the positional indicators 108 is parallel to the longitudinal axis 704 of the opening 110 which is elongated.

In an embodiment, a longitudinal axis of each of the positional indicators 108 is at a known angle with respect to the longitudinal axis 704 of the opening 110 which is elongated. The known angle may be parallel.

In an embodiment, a radial direction from a center of the opening 110 a cross section of which is a circle intersects a tangent of each line of the positional indicators 108 around the opening 110 perpendicularly. In this example, a normal of the cross section is parallel to that of the substrate 100.

In an embodiment, a radial direction from a center of the opening 110 a cross section of which is a circle intersects each of the positional indicators 108 perpendicularly.

In an embodiment shown in Figure 8B, there are more than one opening 110 in the apparatus. In Figure 8B the openings 110 are side by side but they may also be one after another. The positional indicators 108 may be related to both of the openings 110.

Figure 9 illustrates an example of the apparatus which has the thin film 900 inside the cavity 104. The material of the thin film 900 may also cover

other parts of the apparatus. The material of the thin film 900 may include Al_2O_3 , SiO_2 , Ir (iridium), TaN (tantalum nitrogen), alucone, HfO_2 , ZrO_2 , Si_3N_4 , TiO_2 or the like without limiting to these materials. The thin film 900 may be deposited using atomic layer deposition (ALD), chemical vapor deposition (CVD), physical vapor deposition (PVD) techniques, for example, without limiting to these. The thin film 900 has been deposited on the substrate 100 through the opening 110. The material of the thin film may also cover other surfaces of the cavity 104. For the analysis, the membrane 102 may easily be peeled off which enables a better plan-view/top-view for a visible microscope instead of a cross-section for an electron microscope. However, it is also possible that the membrane 102 is not peeled off. In a microscopic scanning of a prior art LHAR test structure the analysis may go astray because of a direction and/or position may be lost. But now, by using the scale of the at least one positional indicator 108 it is possible to have accurate estimates of the spread of the thin film layer 900 in the cavity 104. The at least one positional indicator 108 also make the analysis faster.

The analysis may thus be performed using an optical microscope or an electronic microscope, for example. The electron microscope may be a scanning electron microscope (SEM), for example. The analysis may be performed without peeling off the membrane 102. The apparatus comprising at least one LHAR chip/wafer with at least one distance indicator 108 is a suitable solution for thin film conformality analysis aimed for the semiconductor and other markets.

All in all, the existence of the at least one positional indicator enables the analysis of the thin film layer faster, more accurate and easier.

Figure 10 illustrates a flow chart of a method of manufacturing an apparatus associated with an analysis of a thin film layer. In step 1100, a cavity 104 is formed between two layer structures 100, 102. In step 1102, at least one positional indicator 108 is formed on or in at least one of the two layer structures 100, 102 for an analysis associated with the thin film layer 900. In step 1104, an opening 110 is formed through one of the layer structures 102 to the cavity 104, the cavity 104 being configured to receive, through the opening 110, material used to form a thin film layer 900 inside the cavity 104. In an embodiment, the

steps 1100 to 1104 are performed in an order starting from the step 1100 and ending to the step 1104. In an embodiment, the first step may be the step 1102 and after that may come the step 1100, the step 1104 then remaining the final step.

- 5 It will be obvious to a person skilled in the art that, as technology advances, the inventive concept can be implemented in various ways. The invention and its embodiments are not limited to the example embodiments described above but may vary within the scope of the claims.

Claims

1. An apparatus associated with an analysis of a thin film layer, wherein the apparatus comprises two layer structures (100, 102) with a cavity
5 (104) therebetween, and at least one opening (110) through one of the layer structures (102) to the cavity (104), the cavity (104) being configured to receive, through the at least one opening (110), material used to form a thin film layer (900) inside the cavity (104), c h a r a c t e r i z e d in that
at least one of the two layer structures (100, 102) comprises at least
10 one positional indicator (108) for an analysis associated with the thin film layer (900).
2. The apparatus of claim 1, c h a r a c t e r i z e d in that the at least one positional indicator (108) has a property, which is configured to carry information associated with a position of the at least one positional indicator
15 (108) with respect to the opening (110).
3. The apparatus of claim 2, c h a r a c t e r i z e d in that a cross sectional dimension of the at least one positional indicator (108) is configured to carry the information about the position.
4. The apparatus of claim 2, c h a r a c t e r i z e d in that the at least
20 one positional indicator (108) comprises at least two sub-indicators (600, 602, 604) a distance between which is or distances of which are configured to carry the information about the position.
5. The apparatus of claim 2, c h a r a c t e r i z e d in that the property is associated with material of the at least one positional indicator (108) and the
25 property is configured to cause a unique interaction with radiation used in a detection of the position, the unique interaction being configured to indicate the position.

6. The apparatus of claim 1, characterized in that the thin film layer (900) is at least one of the following: Al_2O_3 , SiO_2 , Ir (iridium), TaN, alucone, HfO_2 , ZrO_2 , Si_3N_4 and TiO_2 .

7. The apparatus of claim 1, characterized in that thin film layer (900) being deposited through the opening (110) to the cavity (104) by at least one of the following: atomic layer deposition (ALD), chemical vapor deposition (CVD) and physical vapor deposition (PVD) techniques.

8. The apparatus of claim 1, characterized in that the cavity (104) between the two layer structures (100, 102) is configured to be supportless.

9. The apparatus of claim 1, characterized in that the cavity (104) is configured to have at least one pillar (106) between the two layer structures (100, 102).

10. A method of manufacturing an apparatus associated with an analysis of a thin film layer, the method comprising forming (1100) a cavity (104) between two layer structures (100, 102), characterized by

forming (1102) at least one positional indicator (108) to at least one of the two layer structures (100, 102) for an analysis associated with the thin film layer (900); and

forming (1104) at least one opening (110) through one of the layer structures (102) to the cavity (104), the cavity (104) being configured to receive, through the at least one opening (110), material used to form a thin film layer (900) inside the cavity (104).

1/6

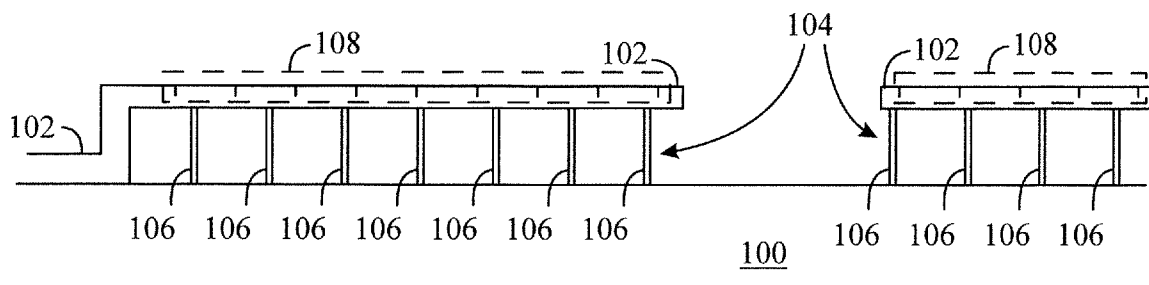


FIG. 1

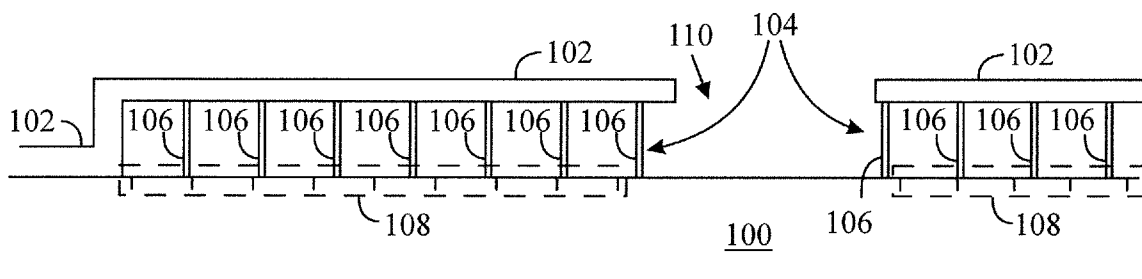


FIG. 2

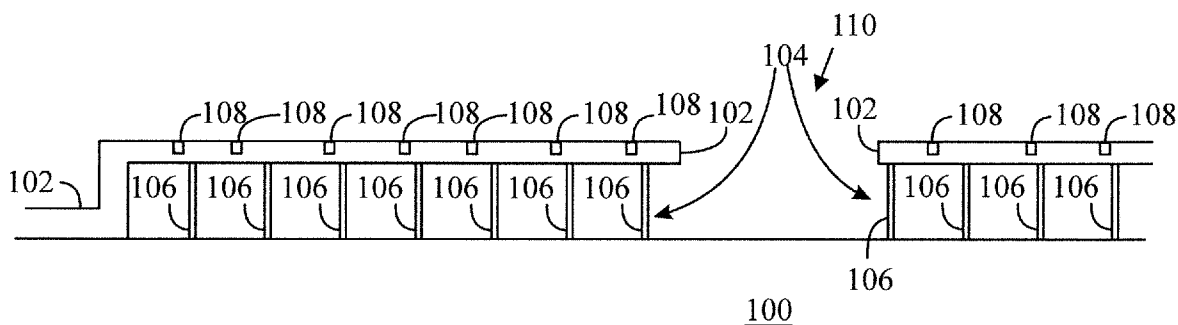


FIG. 3

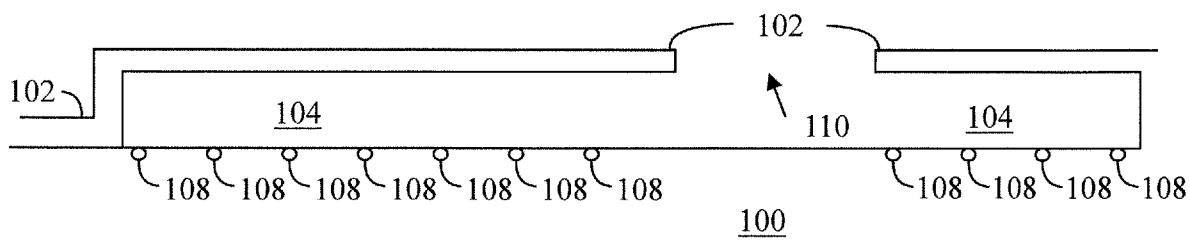


FIG. 4

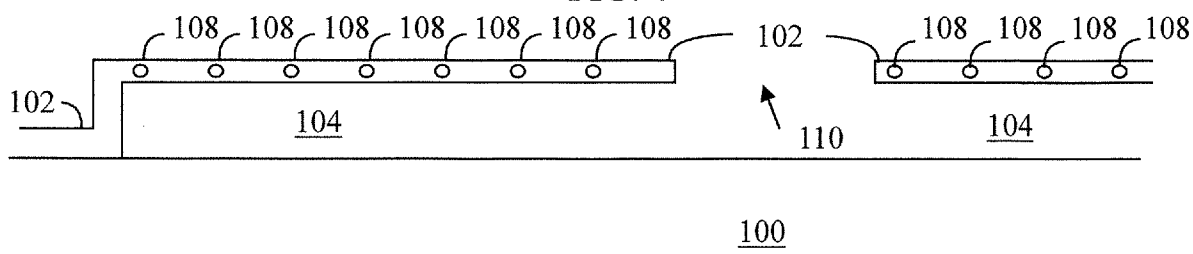


FIG. 5

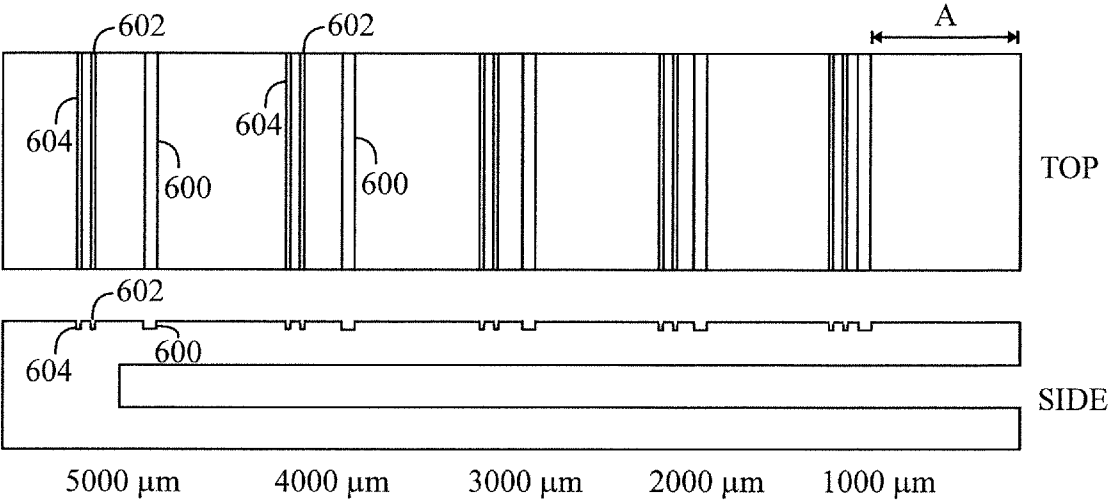


FIG. 6A

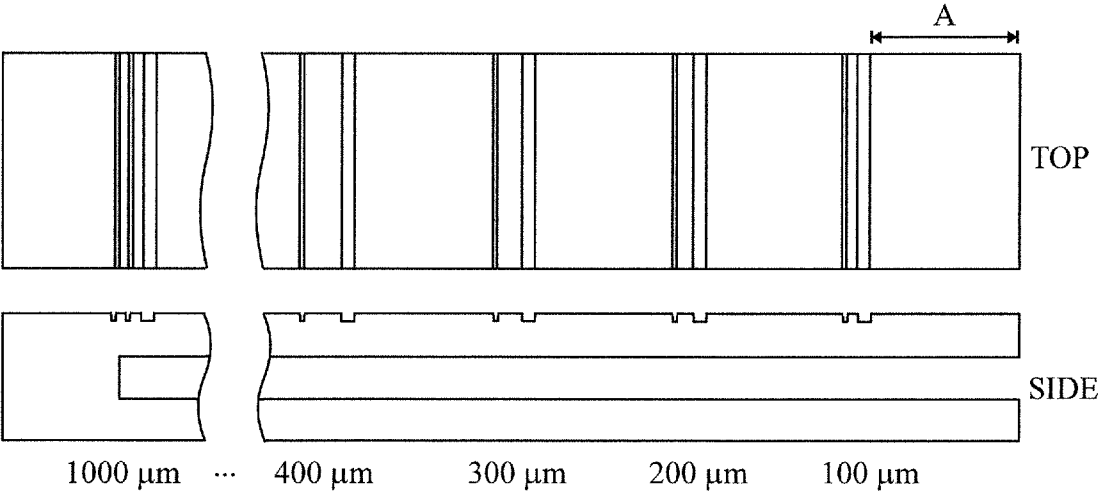


FIG. 6B

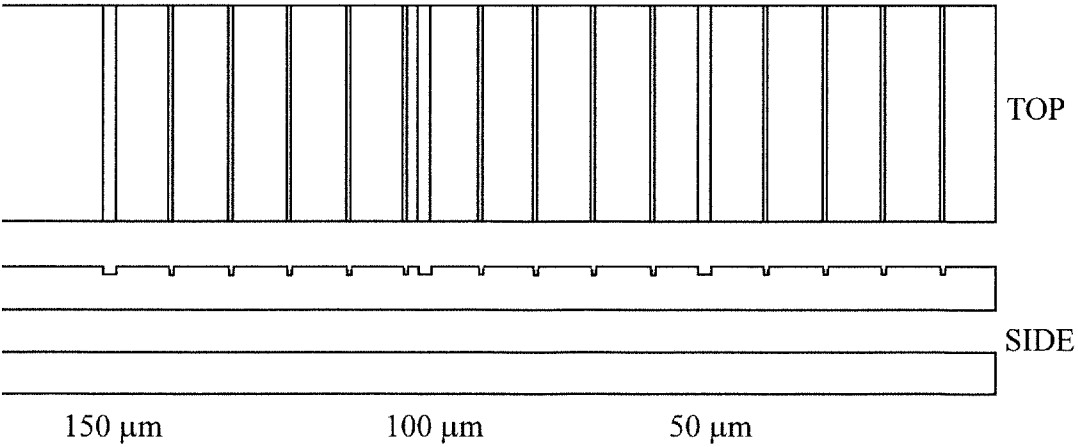


FIG. 6C

3/6

Major indicators	Distance	Looks like this (opening is on the left)	Line width, μm	intermediate space between
	10 μm		0.5	
	20 μm		0.5	
	30 μm		0.5	
	40 μm		0.5	
	50 μm		1	
	60 μm		0.5	
	70 μm		0.5	
	80 μm		0.5	
	90 μm		0.5	
x	100 μm		2 - 0.5	1
	110 μm		0.5	
	120 μm		0.5	
	130 μm		0.5	
	140 μm		0.5	
	150 μm		1	
	160 μm		0.5	
	170 μm		0.5	
	180 μm		0.5	
	190 μm		0.5	
x	200 μm		2 - 0.5	2
	210 μm		0.5	
	220 μm		0.5	
	230 μm		0.5	
	240 μm		0.5	
	250 μm		1.0	
	260 μm		0.5	
	270 μm		0.5	
	280 μm		0.5	
	290 μm		0.5	
x	300 μm		2 - 0.5	3
	350 μm		1.0	
x	400 μm		2 - 0.5	4
	450 μm		1.0	
x	500 μm		2 - 0.5	5
	550 μm		1.0	
x	600 μm		2 - 0.5	6
	650 μm		1.0	
x	700 μm		2 - 0.5	7
	750 μm		1.0	
x	800 μm		2 - 0.5	8
	850 μm		1.0	
x	900 μm		2 - 0.5	9
	950 μm		1.0	
x	1000 μm		2 - 0.5 - 0.5	1, 1

FIG. 6D

4/6

Major indicators	Distance	Looks like this (opening is on the left)	Line width, μm	intermediate space between
x	1100 μm		0.5 - 0.5 - 0.5	1, 1
	1200 μm		0.5 - 0.5 - 0.5	1, 2
	1300 μm		0.5 - 0.5 - 0.5	1, 3
	1400 μm		0.5 - 0.5 - 0.5	1, 4
	1500 μm		0.5 - 0.5 - 0.5	1, 5
	1600 μm		0.5 - 0.5 - 0.5	1, 6
	1700 μm		0.5 - 0.5 - 0.5	1, 7
	1800 μm		0.5 - 0.5 - 0.5	1, 8
	1900 μm		0.5 - 0.5 - 0.5	1, 9
	2000 μm		2 - 0.5 - 0.5	2, 1
	2100 μm		0.5 - 0.5 - 0.5	2, 1
	2200 μm		0.5 - 0.5 - 0.5	2, 2
	2300 μm		0.5 - 0.5 - 0.5	2, 3
	2400 μm		0.5 - 0.5 - 0.5	2, 4
	2500 μm		0.5 - 0.5 - 0.5	2, 5
	2600 μm		0.5 - 0.5 - 0.5	2, 6
	2700 μm		0.5 - 0.5 - 0.5	2, 7
	2800 μm		0.5 - 0.5 - 0.5	2, 8
	2900 μm		0.5 - 0.5 - 0.5	2, 9
x	3000 μm		2 - 0.5 - 0.5	3, 1
	3100 μm		0.5 - 0.5 - 0.5	3, 1
	3200 μm		0.5 - 0.5 - 0.5	3, 2
	3300 μm		0.5 - 0.5 - 0.5	3, 3
	3400 μm		0.5 - 0.5 - 0.5	3, 4
	3500 μm		0.5 - 0.5 - 0.5	3, 5
	3600 μm		0.5 - 0.5 - 0.5	3, 6
	3700 μm		0.5 - 0.5 - 0.5	3, 7
	3800 μm		0.5 - 0.5 - 0.5	3, 8
	3900 μm		0.5 - 0.5 - 0.5	3, 9
x	4000 μm		2 - 0.5 - 0.5	4, 1
	4100 μm		0.5 - 0.5 - 0.5	4, 1
	4200 μm		0.5 - 0.5 - 0.5	4, 2
	4300 μm		0.5 - 0.5 - 0.5	4, 3
	4400 μm		0.5 - 0.5 - 0.5	4, 4
	4500 μm		0.5 - 0.5 - 0.5	4, 5
	4600 μm		0.5 - 0.5 - 0.5	4, 6
	4700 μm		0.5 - 0.5 - 0.5	4, 7
	4800 μm		0.5 - 0.5 - 0.5	4, 8
	4900 μm		0.5 - 0.5 - 0.5	4, 9

FIG. 6E

5/6

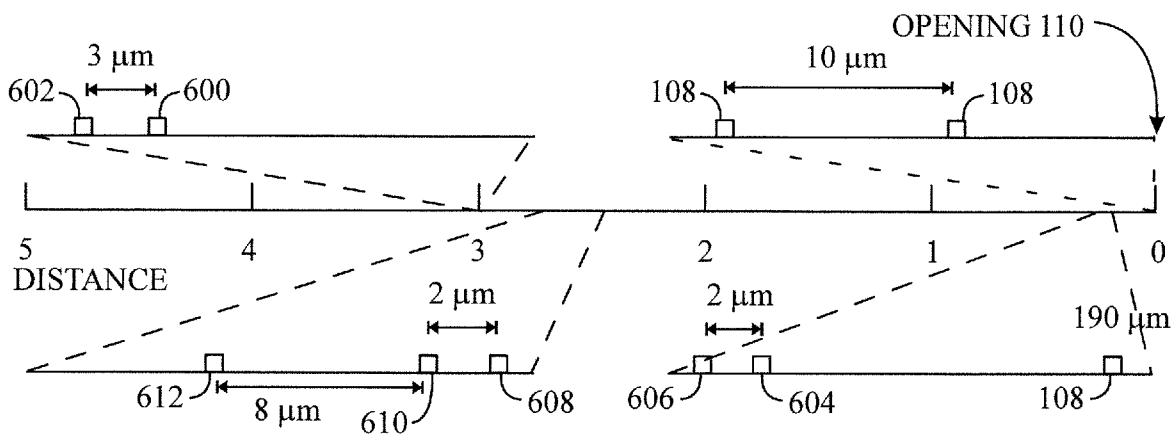


FIG. 6F

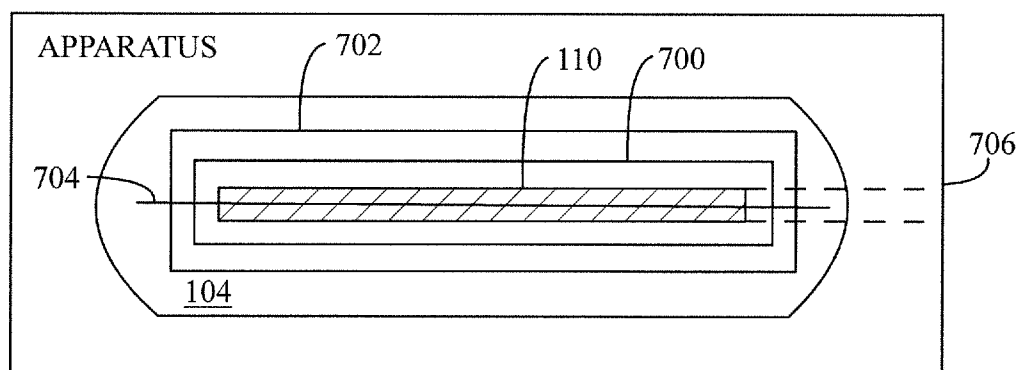


FIG. 7

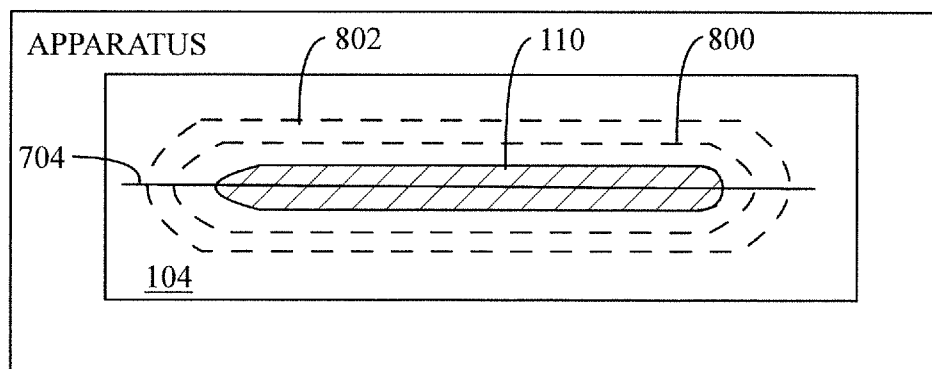


FIG. 8A

6/6

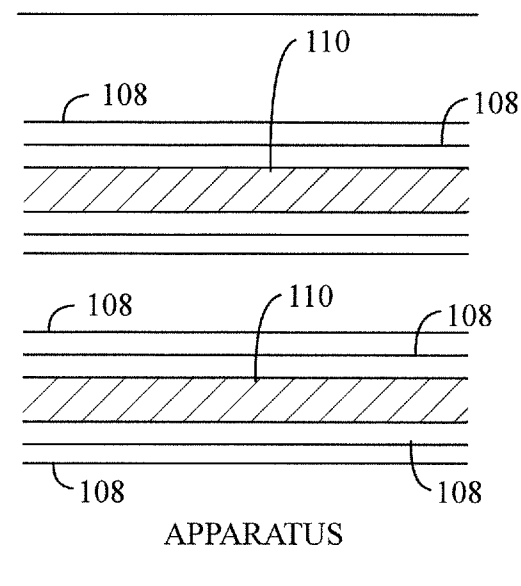


FIG. 8B

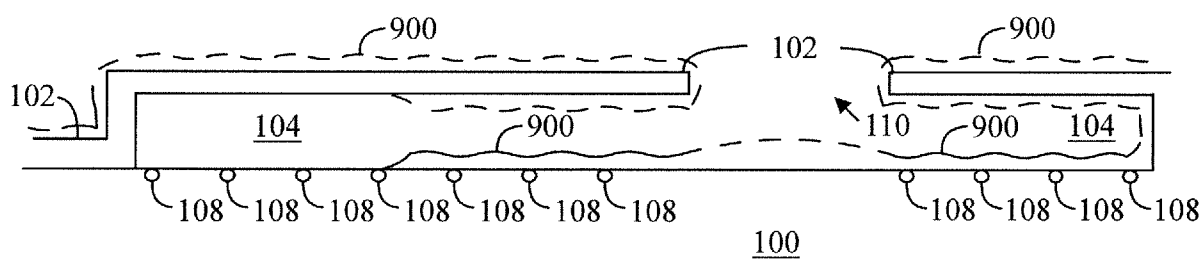


FIG. 9

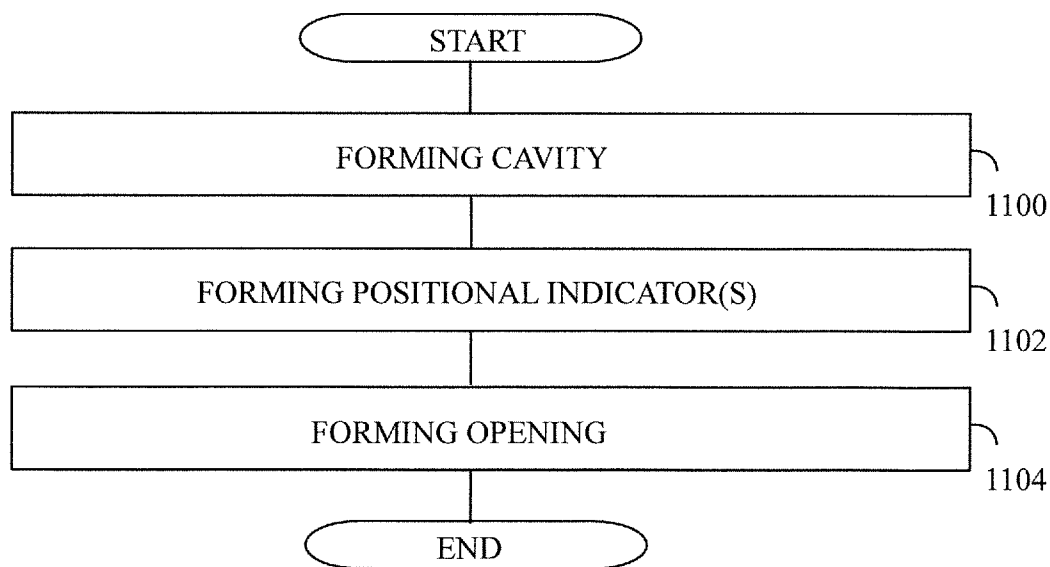


FIG. 10

INTERNATIONAL SEARCH REPORT

International application No
PCT/FI2017/050312

A. CLASSIFICATION OF SUBJECT MATTER
INV. G01B21/00 C23C14/00 C23C16/00
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)
G01B C23C

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, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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A	paragraph [0021] - paragraph [0027]; figure 1A paragraph [0034] - paragraph [0041] -----	4
X	US 2004/053435 A1 (IKUSHIMA KIMIYA [JP] ET AL) 18 March 2004 (2004-03-18)	1-4,6-10
A	paragraph [0133] - paragraph [0134]; figure 12A -----	5
X	WO 2012/085335 A1 (TEKNOLOGIAN TUTKIMUSKESKUS VTT [FI]; SAARILAHTI JAAKKO [FI]) 28 June 2012 (2012-06-28)	1-3,6-10
A	page 5, line 25 - page 5, line 28; figure 1c page 10, line 29 - page 11, line 12 page 16, line 12 - page 17, line 5 ----- -/-	4,5



Further documents are listed in the continuation of Box C.



See patent family annex.

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"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

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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

10 July 2017

Date of mailing of the international search report

18/07/2017

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Authorized officer

Beyfuß, Martin

INTERNATIONAL SEARCH REPORT

International application No

PCT/FI2017/050312

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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A	column 3, line 63 - column 4, line 64; figures 1a,b -----	4,5
X	US 2013/147021 A1 (PUURUNEN RIIKKA [FI] ET AL) 13 June 2013 (2013-06-13)	1-3,6-10
A	paragraph [0049] - paragraph [0051]; figure 2b -----	4,5
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A	paragraph [0067] - paragraph [0072]; figures 3,4 -----	4,5

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International application No

PCT/FI2017/050312

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