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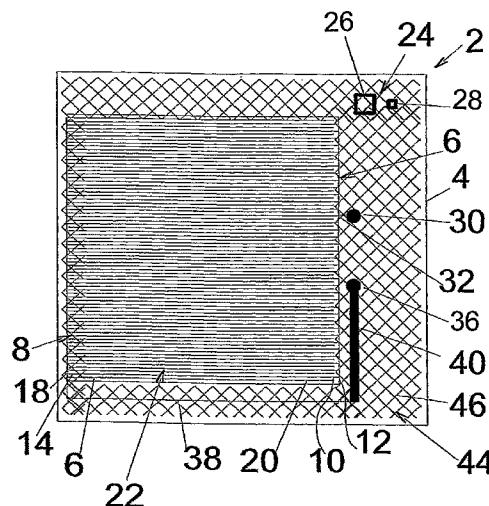
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(54) Title: AN INTERDIGITATED MICROELECTRODE AND A PROCESS FOR PRODUCING THE INTERDIGITATED MICROELECTRODE



(57) Abstract: An interdigitated microelectrode (2) comprising a substrate (4), a first layer (6) of a first metal on the substrate (4), and a second layer (8) of a second metal on the substrate (4), the first layer (6) comprising a plurality of line microelectrodes (10) which are connected at a first end (12) and are not connected at a second end (14), the second layer (8) comprising a plurality of line microelectrodes (16) which are connected at a first end (18) and are not connected at a second end (20), the line microelectrodes (10) of the first layer (6) and the line microelectrodes (16) of the second layer (8) being such that they extend into each other but do not touch each other thereby to form an interdigitated microelectrode array (22), and the first metal being different from the second metal. A process for producing the interdigitated microelectrode (2) is also disclosed.

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AN INTERDIGITATED MICROELECTRODE AND
A PROCESS FOR PRODUCING THE
INTERDIGITATED MICROELECTRODE

This invention relates to an interdigitated microelectrode, and to a process for producing the interdigitated microelectrode. The interdigitated microelectrode may be used as an electrochemical sensor, for example in the form of a water sensing device for sensing properties in water.

Interdigitated microelectrode for use as electrochemical sensors are well known. The electrochemical sensors are used in the study of redox cycling electrochemical reactions, and for measuring chemical species where a signal at a second electrode is improved by the presence of species generated at the first electrode. One such example of the measurement of chemical species is in the measurement of dissolved oxygen, where the potential required to detect the oxygen is reduced by the presence of protons which are generated at a first electrode and which lower the pH. Another example of the measurement of chemical species is the measurement of chlorine in water. In the majority of the known electrochemical sensors, the microelectrodes are manufactured on a silicon base, using expensive microelectronic processes. Due to the complexity of these microelectronic processes and their attendant costs, the first and the second microelectrodes are made from the same metal. This means that if one of the desired

reactions must take place on an electrode of a particular type, the effectiveness of the other electrode may be compromised.

It is an aim of the present invention to obviate or reduce the above mentioned problems.

Accordingly, in one non-limiting embodiment of the present invention there is provided an interdigitated microelectrode comprising a substrate, a first layer of a first metal on the substrate, and a second layer of a second metal on the substrate, the first layer comprising a plurality of line microelectrodes which are connected at a first end and are not connected at a second end, the second layer comprising a plurality of line microelectrodes which are connected at a first end and are not connected at a second end, the line microelectrodes of the first layer and the line microelectrodes of the second layer being such that they extend into each other but do not touch each other thereby to form an interdigititated microelectrode array, and the first metal being different from the second metal.

In another non-limiting embodiment of the present invention, there is provided a process for producing an interdigitated microelectrode, which process comprises providing a substrate, providing a first layer of a first metal on the substrate, and providing a second layer of a second metal on the substrate, the first layer comprising a plurality of line microelectrodes which are connected at a first end and are not connected at a second end, the second layer comprising a plurality of line microelectrodes which are connected at a first end and are not connected at a second end, the line microelectrodes of the first layer and the line microelectrodes of the second

layer being such that they extend into each other but do not touch each other thereby to form an interdigitated microelectrode array, and the first metal being different from the second metal.

The interdigitated microelectrode of the present invention is such that it is able to be produced by a process which is less costly and less complex than known manufacturing processes. This enables the first and the second metals to be different from each other so that the problem associated with using the same metal for the first and the second electrodes is overcome.

The interdigitated microelectrode and the process of the present invention may include the provision of registration means for use in ensuring that the line microelectrodes of the first layer and the line microelectrodes of the second layer do not touch each other. The line microelectrodes of the second layer can be provided such that they are correctly aligned. The registration means may be first and second formations provided on the substrate. Preferably, the registration means, for example the first and the second formations, are provided on the substrate at the time of providing the first layer of the first metal.

The interdigitated microelectrode and the process of the present invention may include providing first electrical connection means for the first layer of the first metal. The first electrical connection means may be a through hole. The through hole may be a plated through hole. Other types of first electrical connection means may be employed.

The interdigitated microelectrodes and the process of the present invention may include providing second electrical connection means for the

second layer of the second metal. The second electrical connection means may be a through hole. The through hole may be a plated through hole. Other types of second electrical connection means may be employed.

The first layer of the first metal is preferably a thick film printed first layer. The thick film printed first layer may be provided by silk screen printing.

The second layer of the second metal is preferably a thick film printed second layer. The thick film printed second layer may be provided by silk screen printing.

The line width of the line microelectrodes of the second layer may be such that the line width is reduced after deposition of the second layer on the substrate. Preferably, the line width is reduced by photolithography and etching. The line width may be reduced to less than 25 microns.

The interdigitated microelectrode and the process of the present invention may include providing a sealing layer which seals parts of the interdigitated microelectrode but which does not seal the interdigitated microelectrode array. The sealing layer may be a dielectric sealing layer. Other types of sealing layer may be employed.

Preferably, the first metal is platinum. Other first metals may be employed. Preferably the second metal is gold. Other second metals may be employed. Preferably the substrate is a ceramic substrate, for example a silicon substrate or sintered alumina. Other substrates may be employed. The substrate may be glazed or unglazed.

The present invention also extends to an interdigitated microelectrode when produced by the process of the invention.

The present invention also extends to an electrochemical sensor comprising the interdigitated microelectrode. The electrochemical sensor is preferably in the form of a water sensing device for sensing properties in water. The water sensing device may be used to sense properties in water on its own, in water in aqueous solutions, in water in the air, or in water in oil.

Embodiments of the invention will now be described solely by way of example and with reference to the accompanying drawings in which:

Figure 1 shows an interdigitated microelectrode;

Figure 2 shows how a substrate sheet is able to be marked to form a plurality of different pieces of substrate which can then be separated into individual pieces of substrate;

Figure 3 shows in enlarged form one of the pieces of substrate obtained from Figure 2, the piece of substrate shown in Figure 2 being the substrate shown in Figure 1;

Figure 4 shows the substrate of Figure 3 provided with a first layer of a first metal, and with registration means;

Figure 5 shows the product of Figure 4 additionally provided with a second layer of a second metal; and

Figure 6 shows an enlarged view how the line width of line microelectrodes in the second layer has been reduced.

Referring to the drawings, there is shown an interdigitated microelectrode 2 comprising a substrate 4. A first layer 6 of a first metal is on the substrate 4. A second layer 8 of a second metal is also provided on the substrate 4. The first layer 6 comprises a plurality of line microelectrodes 10

which are connected at a first end 12 and which are not connected at a second end 14. The second layer 8 comprises a plurality of line microelectrodes 16 which are connected at a first end 18 and which are not connected at a second end 20.

As can be seen from Figure 1, the line microelectrodes 10 of the first layer 6 and the line microelectrodes 16 of the second layer 8 extend into each other. They do not touch each other. They form an interdigitated microelectrode array 22. The first metal of the first layer 6 is different from the second metal of the second layer 8.

The interdigitated microelectrode 2 includes registration means 24 for ensuring that the line microelectrodes 10 of the first layer 6 and the line microelectrodes 16 of the second layer 8 do not touch each other. The registration means 24 comprises a first square formation 26 and a second and smaller square formation 28.

The interdigitated microelectrode 2 includes first electrical connection means 30 for the first layer 6 of the first metal. The first end 12 of the first layer 6 is connected by line 32 to the first electrical connection means 30 which is in the form of a through plated hole plated with the first metal. Similarly, the interdigitated microelectrode 2 includes second electrical connection means 36 for the second layer 8 of the second metal. The second electrical connection means 36 is a through plated hole which is connected to the second layer 8 by a line 38 and a strip 40. The line 38 and the strip 40 form part of the second layer 8. The first layer 6 of the first metal and the

second layer 8 of the second metal are thick film printed layers, which are provided by silk screen printing.

As shown in Figure 6, the line width 42 of the line microelectrodes 16 is reduced after deposition of the second layer 8 on the substrate 4. The line width 42 is reduced to the required width size by photolithography and etching. As shown in Figure 6, the line width is less than 25 microns.

As shown in Figure 1, the interdigitated microelectrode 2 is provided with a sealing layer 44 which seals outer peripheral parts 46 of the interdigitated microelectrode 2, but which does not seal the interdigitated microelectrode array 22.

The interdigitated microelectrode 2 is such that the sealing layer 44 is a dielectric sealing layer, the first metal is platinum, the second metal is gold, and the substrate is a ceramic substrate in the form of silicon.

The process of producing the interdigitated microelectrode 2 shown in Figure 1 can be appreciated from Figures 2 – 6 which show sequentially various stages in the formation of the interdigitated microelectrode 2. A preferred manufacturing process is as follows. This preferred manufacturing process may be summarised as comprising the following steps.

1. Process a ceramic substrate 1, forming holes 3 and laser scribing individual substrate shapes as shown in Figure 2, to form individual substrates 4 as shown in Figure 3.
2. Print the first layer 6 of the first metal as shown in Figure 4, lining up with the registration means 24.

3. Print the second layer 8 of the second metal as shown in Figure 5, lining up with the first layer 6 of the first metal.
4. Etch the second layer 8 of the second metal using photolithography to achieve required definition and line width as shown in Figure 6.
5. If necessary, through plate the connection holes forming the registration means 24.
6. Print the sealing layer 44 of the hermetically sealing dielectric material in order to waterproof the interdigitated microelectrode 2 where necessary, so that only the thin parts of the interdigitated microelectrode array 22 are exposed.

In the process of the present invention, the first layer 6 may be of 5mm x 5mm in size, and it may be printed on a substrate 4 which has a thickness of 0.625mm. The printing may be thick film printing using silk screen printing of a platinum resonate ink. The platinum resonate ink is typically dried and baked, and may be reprinted for increased electrode track thickness. The first and the second square formations 26, 28 are of different sizes as mentioned above. If desired, only one of the formations may be employed, then in this case it may be of 0.1 – 3mm across. The line microelectrodes 10 of the first layer 6 may be of line width limited by the capabilities of the printing apparatus providing the first layer 6. The line width may be from 50 – 250 μ m and 2 – 5mm long. Other dimensions may of course be employed. The

through plated hole connection (or other appropriate electrical connection means) is able to be used for making an electrical connection to the rear side of the interdigitated microelectrode 2 as shown in Figure 1.

The second layer 8 is printed as a gold layer, which is aligned with the first layer 6 using the registration means 24. The gold is in the form of a gold ink that is designed to be etched and re-baked at high temperatures, whilst maintaining good adhesion to the substrate 4. The thick film deposition of the first and the second layers 6, 8 respectively is a low cost method of providing the first and the second layers 6, 8 on the substrate 4. The gold layer 8 may be used for chlorine detection in water. The gold layer 8 is processed using photolithography to reduce the line width as illustrated in Figure 6. This reduction of the line width may be effected using a thin film process. The registration means 24 is able to be used in order to minimise alignment errors, which is advantageous if the thin film process to reduce the line width takes place at a separate site. Thin film photolithography is a more precise process than thick film screen printing, and the more precise process may be required in order to obtain the required line width.

The final processing of the interdigitated microelectrode 2 includes the addition of the sealing layer 44. The sealing layer 44 protects parts of the interdigitated microelectrode 2 that are not required to be chemically active.

As an alternative to having electrical connection means 30, 36 in the form of through plated holes, electrical connections may be on edge or top surfaces of the interdigitated microelectrode 2. In this connection, it may be

preferred to keep the top surface of the interdigitated microelectrode 2 free of any obstructions.

The gold ink employed is preferably ESL 8886A supplied by ESL Europe. The platinum ink employed is preferably ESL 5051 supplies by ESL Europe. The ceramic substrate is preferably Maruwa HA-96-2 with a glaze of GS-40. This is a glazed ceramic substrate, but an unglazed ceramic substrate may also be used.

The interdigitated microelectrode 2 is especially advantageous in the form of an electrochemical sensor for water quality measurements. For example chlorine in the water may be measured. Alternatively, monochloramine and dissolved oxygen may be measured, especially in drinking water.

The use of thick film printing techniques and materials enables the construction of the interdigitated microelectrode 2 to be produced more economically and cost effectively than known expensive microelectronic methods used in producing interdigitated microelectrodes.

When the interdigitated microelectrode 2 is used with the second metal being gold, then chlorine in water is able to be detected. In order to measure all of the chlorine molecules present, it is necessary to generate protons on the second electrode. In applications including the presence of other contaminants such for example as iron and manganese, and at the potentials required to produce protons (over 1.0 volts, depending upon the ambient pH and temperature), a gold electrode can become fouled by metal oxide deposits or oxidised, severely limiting the life of the interdigitated

microelectrode 2. In this case, another more robust material in the form of the different material employed for the first layer 6 is able to be used to drive the reaction to produce the protons, thereby avoiding the problems that would occur if the interdigitated microelectrode 2 were to be produced with the first and the second metals both being gold.

It is to be appreciated that the embodiments of the invention described above with reference to the accompanying drawings have been given by way of example only and that modifications may be effected.

CLAIMS

1. An interdigitated microelectrode comprising a substrate, a first layer of a first metal on the substrate, and a second layer of a second metal on the substrate, the first layer comprising a plurality of line microelectrodes which are connected at a first end and are not connected at a second end, the second layer comprising a plurality of line microelectrodes which are connected at a first end and are not connected at a second end, the line microelectrodes of the first layer and the line microelectrodes of the second layer being such that they extend into each other but do not touch each other thereby to form an interdigititated microelectrode array, and the first metal being different from the second metal.

2. An interdigitated microelectrode according to claim 1 and including registration means for use in ensuring that the line microelectrodes of the first layer and the line microelectrodes of the second layer do not touch each other.

3. An interdigitated microelectrode according to claim 1 or claim 2 and including first electrical connection means for the first layer of the first metal.

4. An interdigitated microelectrode according to claim 3 in which the first electrical connection means is a through hole.

5. An interdigitated microelectrode according to claim 4 in which the through hole is a plated through hole.
- 6 An interdigitated microelectrode according to any one of the preceding claims and including second electrical connection means for the second layer of the second metal.
7. An interdigitated microelectrode according to claim 6 in which the second electrical connection means is a through hole.
8. An interdigitated microelectrode according to claim 7 in which the through hole is a plated through hole.
9. An interdigitated microelectrode according to any one of the preceding claims in which the first layer of the first metal is a thick film printed first layer.
10. An interdigitated microelectrode according to any one of the preceding claims in which the second layer of the second metal is a thick film printed second layer.
11. An interdigitated microelectrode according to any one of the preceding claims in which the line width of the line microelectrodes of the second layer is such that the line width is reduced after deposition of the second layer on the substrate.

12. An interdigitated microelectrode according to claim 11 in which the line width is reduced by photolithography and etching.
13. An interdigitated microelectrode display according to claim 12 in which the line width is reduced to less than 25 microns wide.
14. An interdigitated microelectrode according to any one of the preceding claims and including a sealing layer which seals parts of the interdigitated microelectrode but does not seal the interdigitated microelectrode array.
15. An interdigitated microelectrode according to claim 14 in which the sealing layer is a dielectric sealing layer.
16. An interdigitated microelectrode according to any one of the preceding claims in which the first metal is platinum.
17. An interdigitated microelectrode according to any one of the preceding claims in which the second metal is gold.
18. An interdigitated microelectrode according to any one of the preceding claims in which the substrate is a ceramic substrate.
19. An interdigitated microelectrode according to claim 18 in which the ceramic substrate is silicon or sintered alumina.

20. A process for producing an interdigitated microelectrode, which process comprises providing a substrate, providing a first layer of a first metal on the substrate, and providing a second layer of a second metal on the substrate, the first layer comprising a plurality of line microelectrodes which are connected at a first end and are not connected at a second end, the second layer comprising a plurality of line microelectrodes which are connected at a first end and are not connected at a second end, the line microelectrodes of the first layer and the line microelectrodes of the second layer being such that they extend into each other but do not touch each other thereby to form an interdigitated microelectrode array, and the first metal being different from the second metal.
21. A process according to claim 20 and including providing registration means for use in ensuring that the line microelectrodes of the first layer and the line microelectrodes of the second layer do not touch each other.
22. A process according to claim 20 or claim 21 and including providing first electrical connection means for the first layer of the first metal.
23. A process according to claim 22 in which the first electrical connection means is a through hole.
24. A process according to claim 23 in which the through hole is a plated through hole.

25. A process according to any one of claims 20 – 24 and including providing second electrical connection means for the second layer of the second metal.
26. A process according to claim 25 in which the second electrical connection means is a through hole.
27. A process according to claim 26 in which the through hole is a plated through hole.
28. A process according to any one of claims 20 – 27 in which the first layer of the first metal is a thick film printed first layer.
29. A process according to any one of claims 20 – 28 in which the second layer of the second metal is a thick film printed second layer.
30. A process according to any one of claims 20 – 29 in which the line width of the line microelectrodes of the second layer is such that the line width is reduced after deposition of the second layer on the substrate.
31. A process according to claim 30 in which the line width is reduced by photolithography and etching.

32. A process according to claim 31 in which the line width is reduced to less than 25 microns wide.
33. A process according to any one of claims 20 – 32 and including providing a sealing layer which seals parts of the interdigitated microelectrode but which does not seal the interdigitated microelectrode array.
34. A process according to claim 33 in which the sealing layer is a dielectric sealing layer.
35. A process according to any one of claims 20 – 34 in which the first metal is platinum.
36. A process according to any one of claims 20 – 35 in which the second metal is gold.
37. A process according to any one of claims 20 – 36 in which the substrate is a ceramic substrate.
38. A process according to claim 37 in which the ceramic substrate is silicon or sintered alumina.
39. An interdigitated microelectrode when produced by a process according to any one of claims 20 – 38.

40. An electrochemical sensor comprising an interdigitated microelectrode according to any one of claims 1 – 19 and 39.
41. An electrochemical sensor according to claim 40 and in the form of a water sensing device for sensing properties in water.

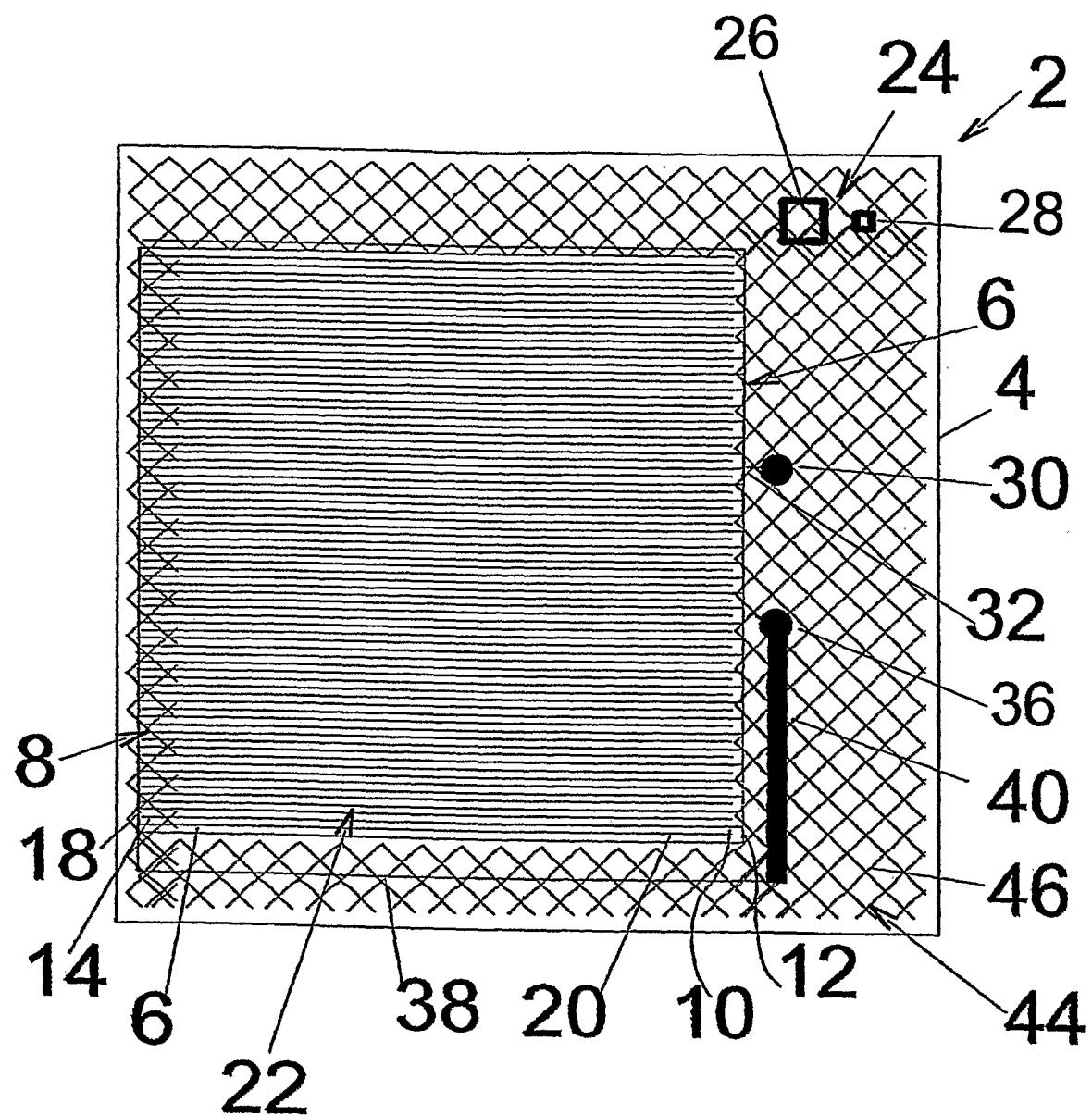


FIG 1

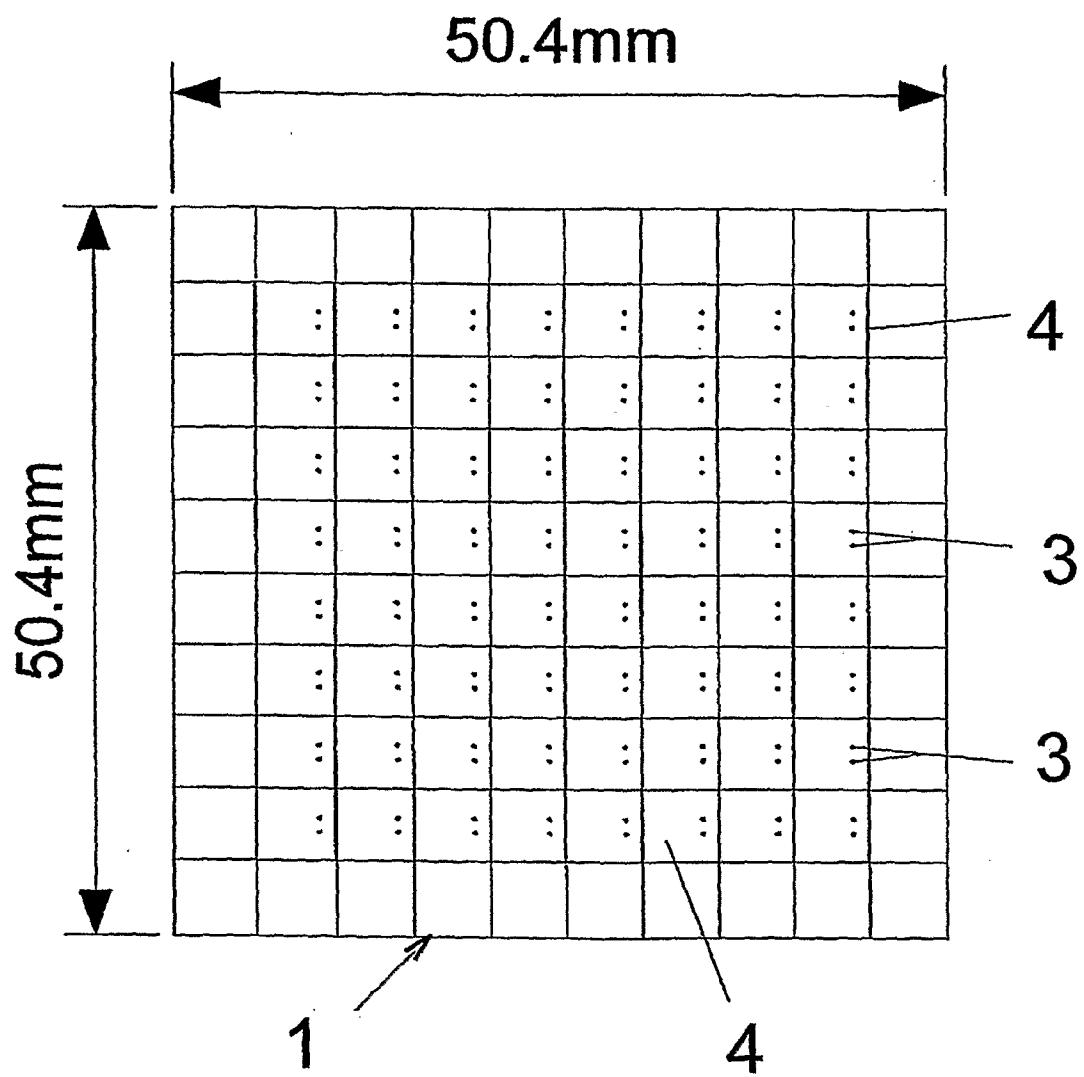
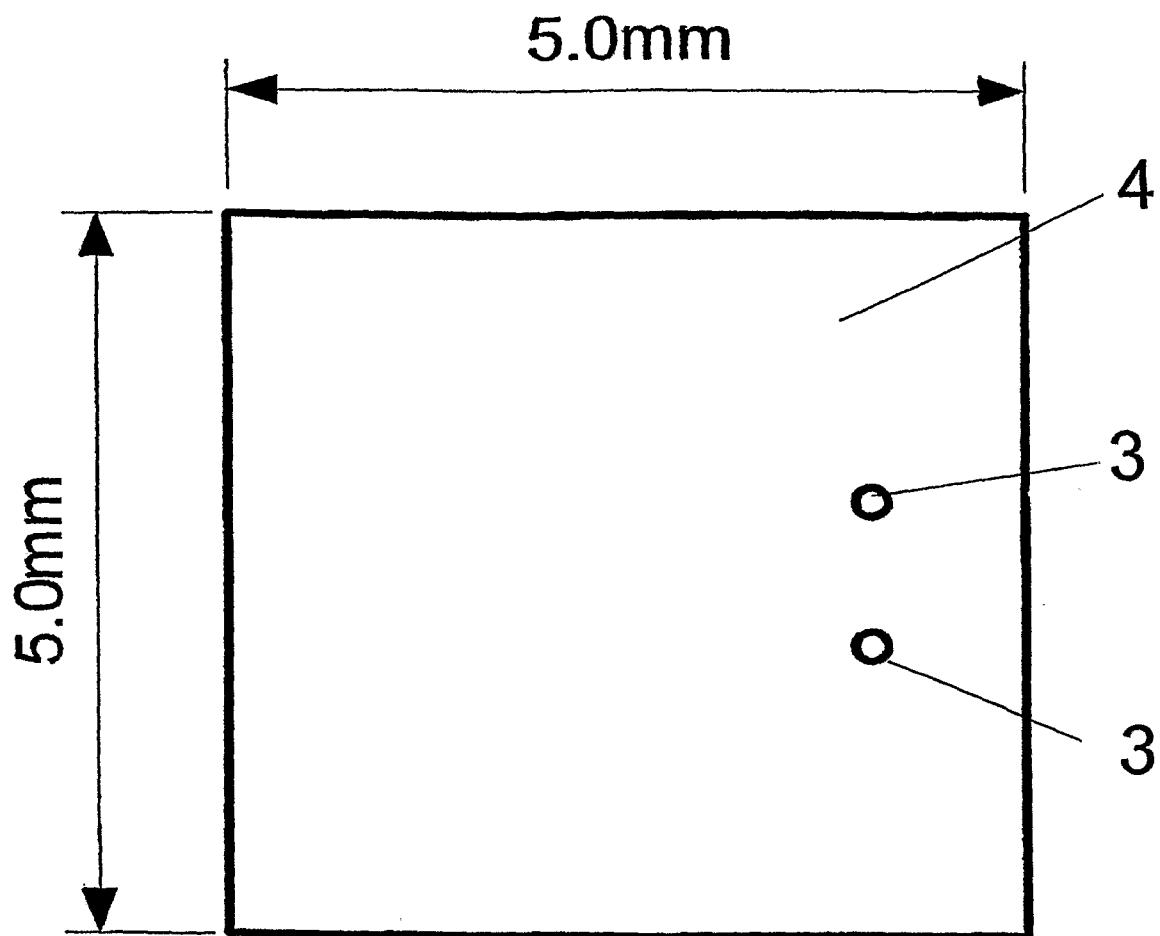


FIG 2

**FIG 3**

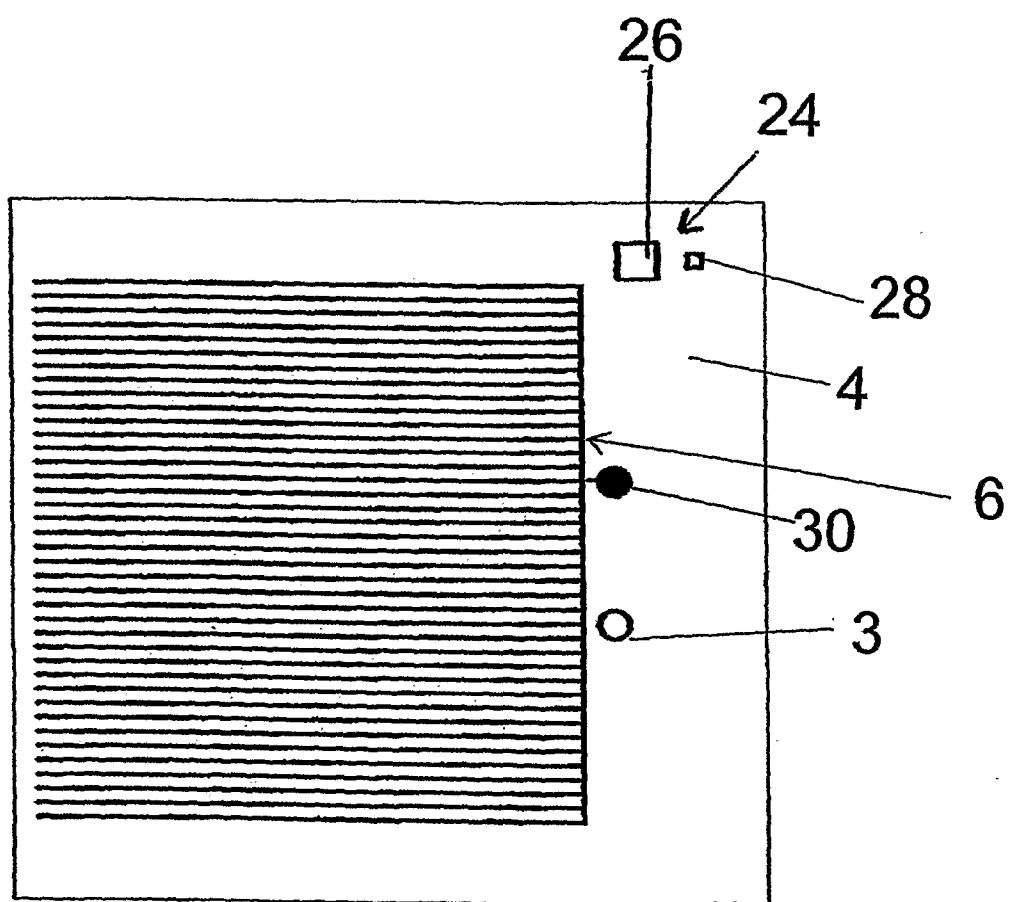


FIG 4

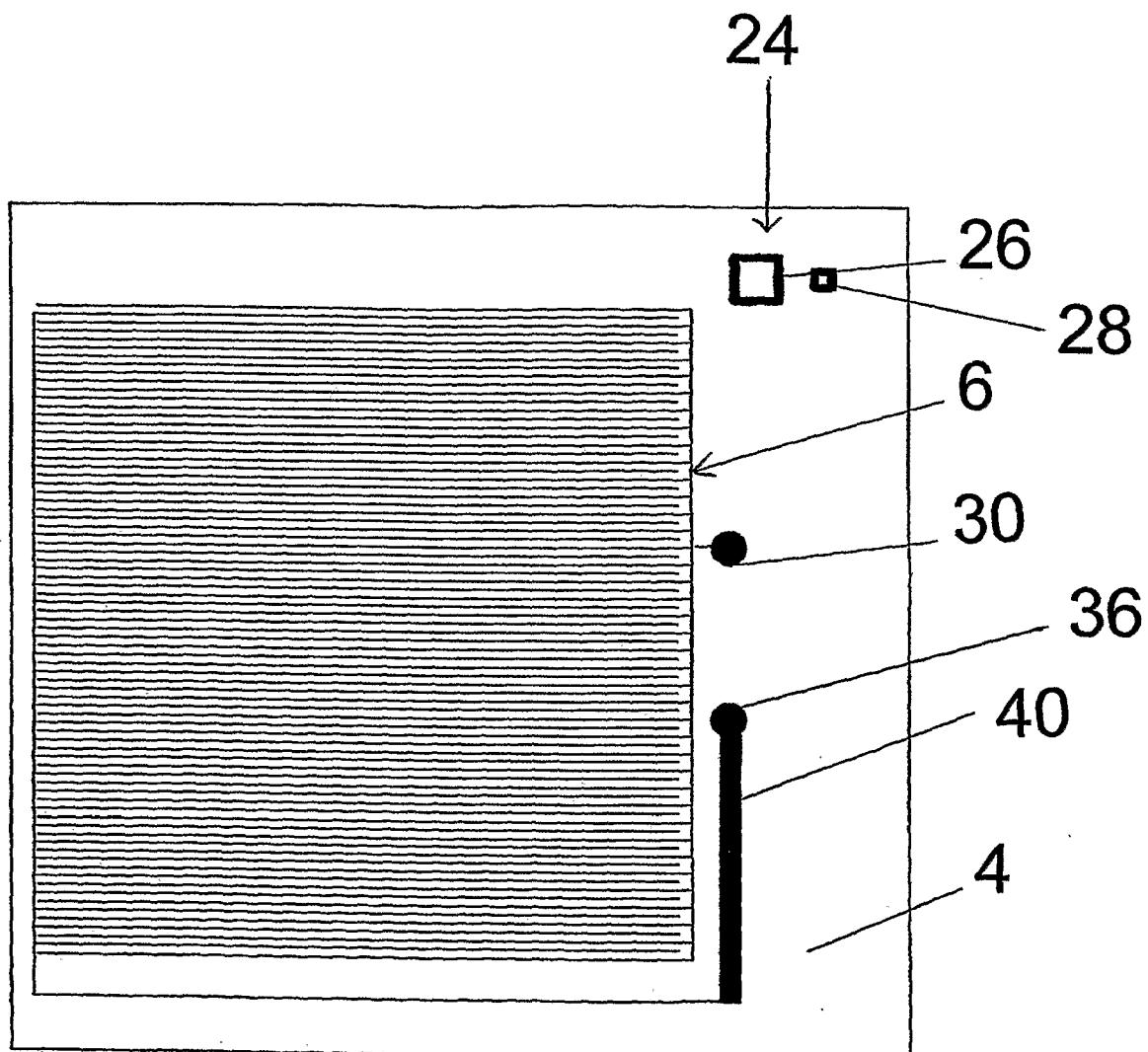


FIG 5

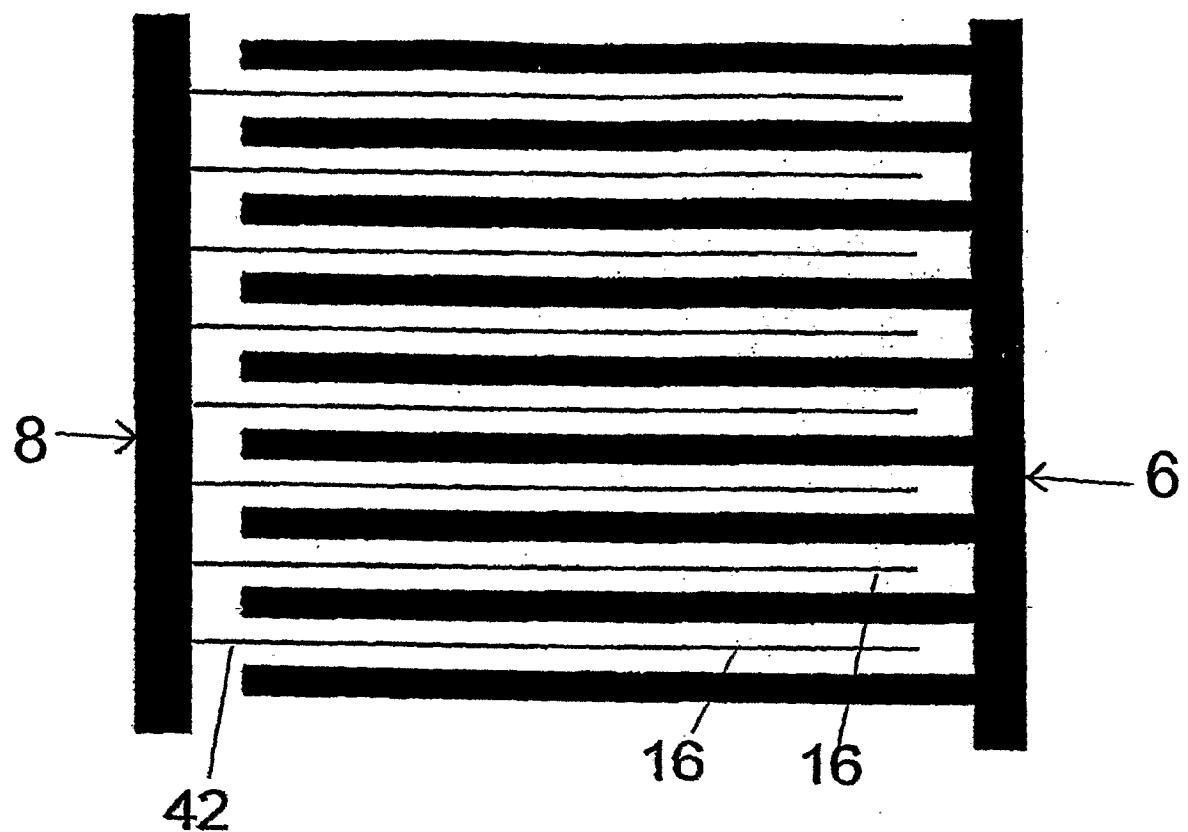


FIG 6

INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2007/000259

A. CLASSIFICATION OF SUBJECT MATTER
INV. G01N27/30 G01N27/403 G01N27/49

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

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, WPI Data, COMPENDEX, INSPEC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 6 270 651 B1 (ESSALIK ABETIF [CA] ET AL) 7 August 2001 (2001-08-07) column 2, lines 1-4 column 3, lines 60-62 column 4, line 45 - column 5, line 8 figure 1 ----- US 5 425 869 A1 (NODING STEPHEN A [US] ET AL) 20 June 1995 (1995-06-20) column 8, lines 49-64 column 9, line 66 - column 10, line 2 column 14, line 53 - column 15, line 43 figures 19,20 ----- -/--	1-10, 14-29, 33-41
X		1-10, 14-29, 33-41

Further documents are listed in the continuation of Box C.

See patent family annex.

* Special categories of cited documents :

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Date of the actual completion of the international search	Date of mailing of the international search report
23 March 2007	03/04/2007
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Authorized officer Meyer, Fred

INTERNATIONAL SEARCH REPORT

International application No PCT/GB2007/000259

C(Continuation). 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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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/GB2007/000259

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