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(54) Title: INTERDIGITATED ELECTRODE

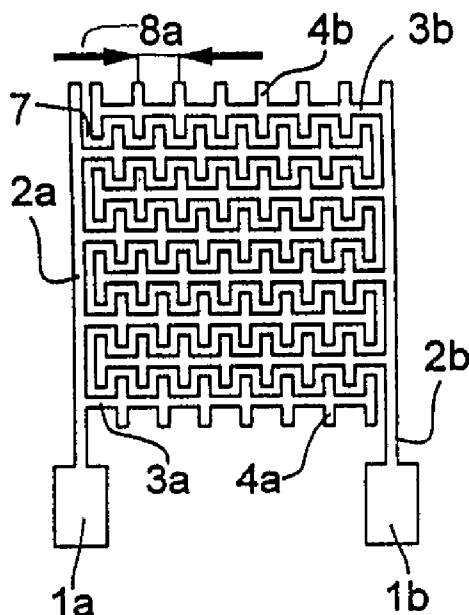


Fig. 2

(57) Abstract: The invention relates to an Interdigitated electrode for measuring the electrical parameters of a medium surrounding it which electrode consists of electrode halves (1a, 1b) containing interdigital electrode fingers (3a, 3b) and electrode backbones (2a, 2b) connecting the electrode fingers (3a, 3b) where the electrode fingers (3a, 3b) of the individual electrode halves (1a, 1b) are situated opposite to each other and there is an interdigital gap (7) between them. The electrode fingers (3a, 3b) also contain side branches (4a, 4b) where the side branches (4a, 4b) are repeated at intervals (8a), and the size of the intervals (8a) is expediently constant, and the lengths of the side branches (4a) of one of the electrode halves (1a) reach to or into the space between the side branches (4b) of the other electrode half (1b) facing it.



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— *of inventorship (Rule 4.17(iv))*

INTERDIGITATED ELECTRODE

The present invention relates to an interdigitated electrode for measuring the electrical parameters of a medium surrounding it, which electrode consists of electrode halves containing electrode fingers and electrode backbones connecting the electrode fingers where the electrode fingers of the individual electrode halves are situated opposite to each other and there is an interdigital gap between them. The interdigital gap is the smallest distance between the electrode fingers of the electrode halves facing each other. The interdigitated electrode according to the invention can primarily be applied in case of biological, chemical and physical sensors for the measurement of the electrical parameters, where measurement is interpreted broadly, so as to also include the possible influencing of the electrical parameters.

Traditional interdigitated electrodes are also called comb electrodes, because the one and the other half of the electrode system are composed of narrow and at the same time long, straight conductive surfaces that are arranged similarly to the teeth of a comb. Thus, a traditional interdigitated electrode is similar to two combs facing each other where the teeth of one comb are inserted between those of the other comb.

In the course of electronic measurements, the interdigitated electrode structure acts, in typical cases, as a capacitance. However, it has the advantage over the plane capacitor that in contrast to the narrow lateral slots of a plane capacitor of similar capacitance, the interdigitated electrode structure is in connection with its surroundings on a surface area that is greater by orders of magnitude. Owing to this feature the interdigitated electrode can be used very well in sensing methods derived from measuring the changes in the capacitance or the impedance.

A typical field of application of interdigitated electrode structures is the interdigital transducer, hereinafter: IDT, used in capacitive or impedance spectroscopy based biosensors. Here, the presence of organic molecules, such as DNA, bacteria antigens, virus antibodies, etc. on the surface of the electrode system and in the liquid layer typically lower than 1 mm above the electrode system, causes changes in capacitance or impedance compared to a reference measurement in a sample not containing these molecules.

The operation speed of biosensors cannot, in general, be compared to that of standard electronic sensors of a setup time of milliseconds or microseconds, because the speed of the process of sensing is usually limited by the diffusion of molecules to be detected and in certain cases associated to reaching of equilibrium concentrations. The aim of the electrodes of IDTs used in sensor technologies until now has been to reproduce the largely homogeneous electrical field arising in a plane capacitor as evenly as possible in two dimensions and thereby make it possible to measure precisely the changes in capacitance and/or impedance arising as a result of interaction with the surroundings of the IDT electrodes.

Such a traditional, simple combed interdigitated electrode geometry is presented for example in the patent application with publication No. US2005059105. It contains an interdigitated electrode suited for the detection of micro-organisms, having a gap narrower in size than $5\text{ }\mu\text{m}$, that reveals the impedance change arising simultaneously with the adhesion of the micro-organisms.

In case of interdigitated electrodes known up to now the degree of the strength and the homogeneity of the electric field arising between the electrode fingers belonging to the antipoles, i.e., the individual electrode halves is largely identical along the length of the electrode fingers, considering the area relatively far from the ends of the electrode fingers. This means that the degree of inhomogeneity could even be increased on the majority of the surface of the electrode if the electrical field distribution were not always identical along the longitudinal axis of the electrode fingers.

Based on the foregoing the object of the invention is to design an interdigitated electrode at which, as a result of the applied voltage, the degree of the inhomogeneity of the developing electric field will be higher than in case of a traditional interdigitated electrode produced by a similar manufacturing technology, and this construction causes no major change as regards the surfaces occupied by the interdigital gap and the electrode halves.

Our invention is based on the recognition that the degree of the inhomogeneity of the developing electric field can be enhanced if the electrode fingers of the interdigitated electrode also contain side branches.

The present invention is, accordingly, an interdigitated electrode for measuring
5 the electrical parameters of a medium surrounding it, which electrode consists of electrode halves containing interdigital electrode fingers and electrode backbone connecting the electrode fingers where the electrode fingers of the individual electrode halves are situated opposite to each other and there is an interdigital gap between them, in addition the electrode fingers also contain side branches
10 where the side branches are repeated at intervals and the size of the intervals is expediently constant, and the lengths of the side branches of an electrode half reach to or into the spaces between the side branches of the other electrode half facing it.

There are also some further preferred embodiments of the invention which are
15 described in the attached subclaims.

By means of the solution according to the invention such an inhomogeneous electrical field can be formed which consists of many elementary fields free of symmetry, while at the same time, the length of the interdigital gap
20 manufacturable per surface unit is approximately the same as in the case of the traditional IDT arrangement having a more homogeneous electrical field. Owing to this, with the interdigitated electrode arrangements according to the invention, capacitive or impedimetric biosensors can be prepared that are of a faster operation and more sensitive than those with traditional interdigitated electrodes.

Solutions according to the present invention and their differences as compared
25 to the traditional interdigitated electrode arrangement are presented in detail with preferred embodiments by means of drawings.

Figure 1: A typical arrangement of a traditional interdigitated electrode

Figure 2: A preferred embodiment of the arrangement of an interdigitated electrode according to the invention

30 Figure 3: Another preferred embodiment of the arrangement of an interdigitated electrode according to the invention

Figure 4: A further preferred embodiment of the arrangement of an interdigitated electrode according to the invention with secondary side branches

Figure 5: A further preferred embodiment of the arrangement of an interdigitated electrode according to the invention with tertiary side branches

5 The traditional interdigitated electrode presented in Figure 1 comprises electrode halves 1a and 1b that consist of electrode backbones 2a and 2b as well as of several 3a and 3b electrode fingers, where there is an interdigital gap 7 between electrode fingers 3a and 3b. Electrode backbones 2a and 2b connect the electrode fingers 3a and 3b and are connected to the poles of an
10 electrochemical work-station.

In case of preferred embodiments according to the invention presented in Figures 2, 3, 4 and 5, the electrode halves 1a, 1b contain, in addition to the electrode backbones 2a and 2b and the electrode fingers 3a and 3b also side
15 branches 4a and 4b starting from the electrode fingers 3a and 3b where the side branches 4a and 4b are, according to the present example, repeated regularly, at constant intervals 8a. In Figure 2, the lengths of the side branches 4a of one electrode half 1a reach into the space between the side branches 4b of the other electrode half 1b facing it, but good results can be reached also if the side
20 branches 4a of one electrode half 1a just reach to the space between the side branches 4b of the other electrode half 1b facing it, as it can be seen in Figure 3. Furthermore, in the solution according to Figure 3 the side branches 4a and 4b of the electrode fingers 3a and 3b on the electrode halves 1a and 1b on two adverse sides of the same electrode finger are not situated in a symmetric
25 position, that means they are not in the same line, like in Figure 2, but they are shifted as compared to each other. A number of versions differing from the examples presented herein are feasible, for example also wherein the length of the side branches of the electrode finger is variable, e.t.c..

30 In addition to the aforesaid, in Figure 4, formations of secondary side branches 5a, 5b are also shown, with constant repetitions at secondary intervals 8b. The denomination of secondary side branch means that additional side branches start out from the side branches according to Figure 2 or Figure 3. In Figure 5

formations of tertiary side branches 6a, 6b can be seen, with regular repetitions at tertiary intervals 8c. Tertiary side branches are formed when additional side branches start out from the secondary side branches according to Figure 4.

It is to be noted that the side branches are not necessary to be repeated at regular intervals, this is useful primarily with regard to a compact placing and a simpler manufacturing.

As we have recognized, it is advantageous for the result if the layout of the electrode is articulated as much as possible which makes further inferior side branch formations reasonable. Articulation is only limited by the possibility of the technology and the rationality.

Interdigitated electrodes may be produced for example by thick film, thin film or printed circuit board technology, from gold or gold-plated-copper, furthermore from platinum or palladium-platinum alloy or other materials, on the surface of a substrate such as glass, ceramics, plastic foil, etc.. When using thin film technology, it is recommended that vacuum evaporation through a mask or, instead of masking, subsequent removal, for example by photolithography or so-called ablation technique be employed.

Interdigitated electrodes may be produced in relatively wide range of sizes, for example, from 0.1 mm^2 to 1 cm^2 of surface area. The optimum thickness of the metal constituting the electrode should preferably be defined between 10 nm and $20 \text{ }\mu\text{m}$ while the size of the interdigital gap is between $0.1 \text{ }\mu\text{m}$ and 1 mm, in general.

The invention presented here may be realised in many embodiments different from those described in the examples above but still remaining within the scope and spirit of the present invention, therefore, our solution cannot be regarded as limited to these examples.

CLAIMS:

1. Interdigitated electrode for measuring the electrical parameters of a medium surrounding it which electrode consists of electrode halves (1a, 1b) containing interdigital electrode fingers (3a, 3b) and electrode backbones (2a, 2b) connecting the electrode fingers (3a, 3b) where the electrode fingers (3a, 3b) of the individual electrode halves (1a, 1b) are situated opposite to each other and there is an interdigital gap (7) between them, **characterized in that** the electrode fingers (3a, 3b) also contain side branches (4a, 4b) where the side branches (4a, 4b) are repeated at intervals (8a), and the size of the intervals (8a) is expediently constant, and the lengths of the side branches (4a) of one of the electrode halves (1a) reach to or into the space between the side branches (4b) of the other electrode half (1b) facing it.
2. Interdigitated electrode according to claim 1, **characterized in that** the side branches (4a, 4b) contain further secondary side branches (5a, 5b), which secondary side branches are repeated at secondary intervals (8b) and the size of the secondary intervals (8b) is expediently constant.
3. The interdigitated electrode according to claim 2, **characterized in that** the lengths of the secondary side branches (5a) of one of the electrode halves (1a) reach to or into the space between the secondary side branches (5b) of the other electrode half (1b) facing it.
4. The interdigitated electrode according to claims 2 or 3, **characterized in that** the secondary side branches (5a, 5b) contain further tertiary side branches (6a, 6b), which tertiary side branches (6a, 6b) are repeated at tertiary intervals (8c) and the size of the tertiary intervals (8c) is expediently constant.
5. The interdigitated electrode according to claim 4, **characterized in that** it contains further inferior side branches.

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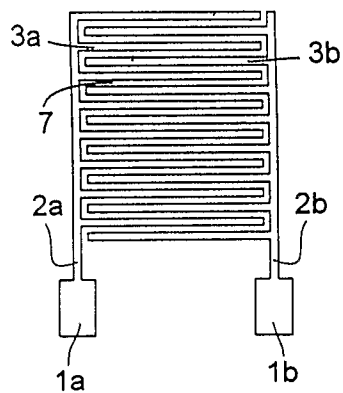


Fig. 1

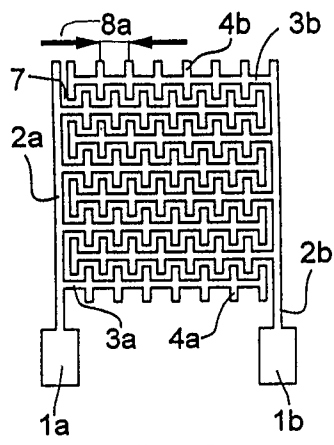


Fig. 2

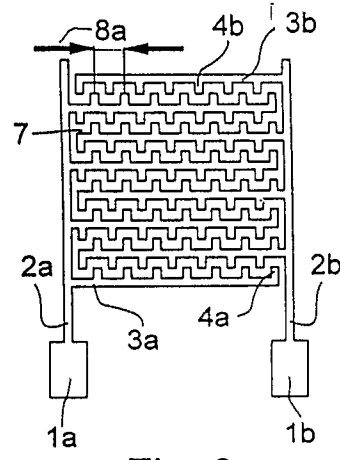


Fig. 3

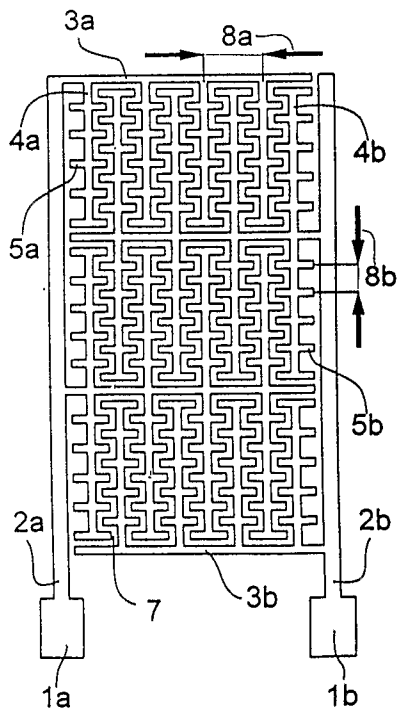


Fig. 4

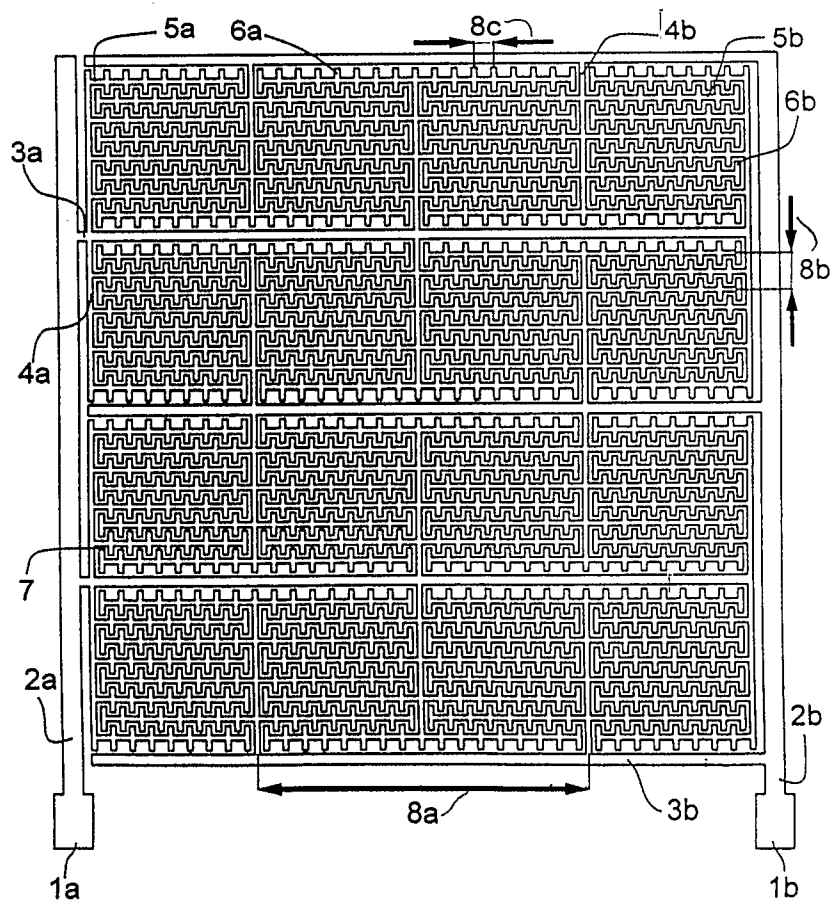


Fig. 5

INTERNATIONAL SEARCH REPORT

International application No
PCT/HU2008/000024

A. CLASSIFICATION OF SUBJECT MATTER
INV. G01N27/07 G01N27/22

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

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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X	GOUGH C E ET AL: "High Tc coplanar resonators for microwave applications and scientific studies" PHYSICA C, NORTH-HOLLAND PUBLISHING, AMSTERDAM, NL, vol. 282-287, no. 2001, 1 August 1997 (1997-08-01), pages 395-398, XP004111023 ISSN: 0921-4534 paragraph [03.2]; figure 9	1-5
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☒ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

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Date of the actual completion of the international search

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INTERNATIONAL SEARCH REPORT

International application No
PCT/HU2008/000024

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/HU2008/000024

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