



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
30.12.2009 Bulletin 2009/53

(51) Int Cl.:
F27D 1/16 (2006.01) **F27D 1/10** (2006.01)
F27D 1/00 (2006.01) **F23M 5/02** (2006.01)

(21) Application number: **08164699.4**

(22) Date of filing: **19.09.2008**

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MT NL NO PL PT RO SE SI SK TR
Designated Extension States:
AL BA MK RS

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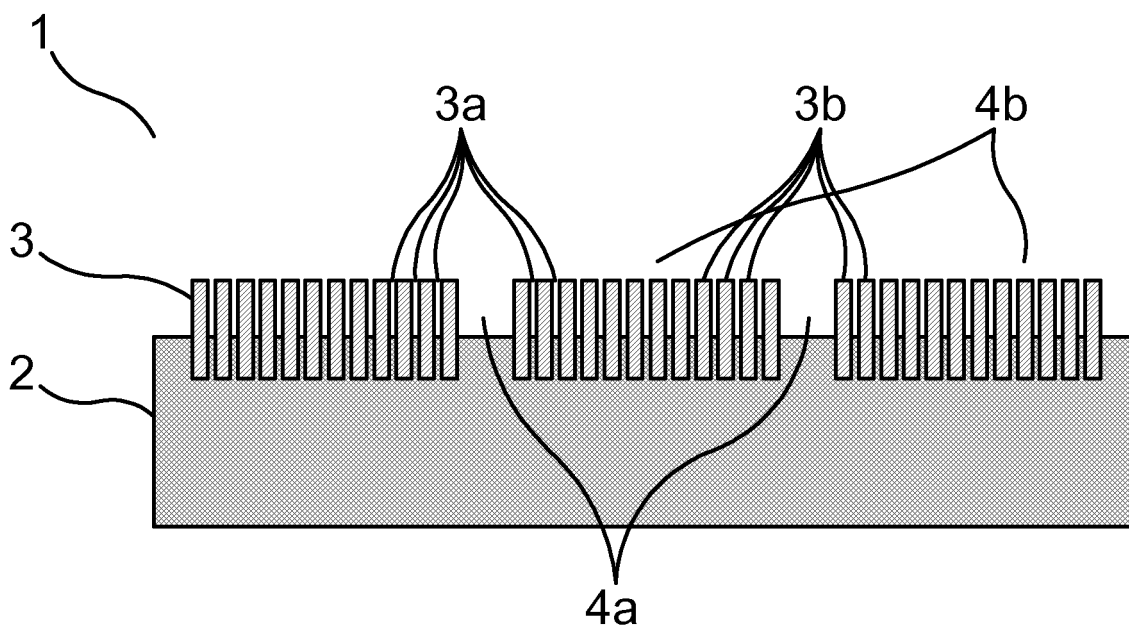
(30) Priority: **26.06.2008 SE 0801515**

(54) **Lining element for an industrial furnace**

(57) Lining element (1) for an industrial furnace, comprising a first layer (2) of a first refractory material.
The invention is characterised in that the surface of

the lining element (1) which is intended to be arranged facing in towards the heated volume of the furnace at least partially is coated with a second layer (3) of a second refractory material, where the second material is porous.

Fig. 1



Description

[0001] The present invention relates to a refractory lining for use in an industrial furnace, a method for the manufacturing of such a lining and the use of such a lining during operation in an industrial furnace.

[0002] The heated space in industrial furnaces is normally lined with a refractory material, for example in the form of brick or cast elements. In some situations during operation in such furnaces, very rapid changes in temperature occur, so called thermal shock. For example, this is the case in so called oxyfuel and DFI (Direct Flame Impingement) applications, especially during DFI heating of metal strips. During such operation, the lining is exposed to extremely rapid heating, because of the high power of the industrial furnace. Cooling of the lining may also be extremely rapid, for example since the furnace is fed with comparatively cold metal material.

[0003] Such thermal shock leads to heavy wear on the material of the lining in the form of fissuring and other deterioration, leading in turn to elevated costs and loss of time when the material has to be replaced.

[0004] In order to reduce the thermal wear on the material in the lining, it has been proposed to use material containing fibres. Such materials have attractive thermal shock properties, but the fibres in the material run the risk of being torn loose and follow the heated material. At a later point, this may give rise to problems in subsequent processing steps, such as hot-galvanizing, when the torn loose fibres are mixed in with the material.

[0005] The present invention solves the above described problems.

[0006] Thus, the invention relates to a lining element for an industrial furnace, comprising a first layer of a first refractory material, and is characterised in that the surface of the lining element which is intended to be arranged inwards, facing the heated volume of the furnace, at least partially is coated with a second layer of a second refractory material, where the second material is porous.

[0007] In the following, the invention will be described in detail, with reference to exemplifying embodiments of the invention and to the appended drawings, where:

Figure 1 is a schematic cross sectional side view of a lining according to a first preferred embodiment of the present invention.

Figure 2 is a schematic cross sectional side view of a lining according to a second preferred embodiment of the present invention.

Figure 3 is a detail top view of the lining shown in Figure 1.

[0008] Figure 1 illustrates a part of a lining according to a preferred embodiment of the present invention, in the form of a lining element 1 for mounting inside the heated volume of an industrial furnace. Suitable areas

of use for such a lining element 1 are together with other elements as a part of a ceiling-, flooring-, or wall covering inside a furnace.

[0009] The lining 1 comprises a first, lower layer 2, manufactured from a refractory material, and according to a preferred embodiment solid. The lower layer 2 has an insulating and supporting effect, and also adds to the strength of the element 1. Suitable materials for the lower layer are such fusible materials that have high heat resistance, for example ceramic materials such as aluminium-, zirconium-, or silicon oxides.

[0010] Across parts of the surface of the lining element 1 which surface is intended to be arranged facing in towards the heated volume of the furnace during operation, the lower layer 2 is coated with an upper layer 3. Similarly to the lower layer 2, the upper layer 3 is manufactured from a refractory material, preferably from a ceramic material such as Al_2O_3 . The upper layer 3 may, but needs not, be manufactured from the same material as the lower layer 2.

[0011] According to the present invention, the upper layer 3, which is arranged facing in towards the heated volume of the furnace, is porous. According to a preferred embodiment, the upper layer 3 has a structure with a plurality of elongated pores 3a, in the form of essentially parallel tubes.

[0012] According to an especially preferred embodiment, the pores 3a, together with the walls 3b between the pores, constitute a honeycomb structure. In other words, the material of the upper layer 3 forms a honeycomb structure perpendicularly to the pore direction if observed in cross-section. This is illustrated in Figure 3, which shows the honeycomb structure as seen from above.

[0013] It is preferred that the average inner diameter of the pores 3a is between 0.5 and 3 mm, and that their average mutual distance is between 0.5 and 5 mm. According to a preferred embodiment, essentially all pores 3a have the same form and dimensions, and are homogeneously distributed across the surface of the lower layer 2 that is coated with the upper layer 3.

[0014] As is clear in Figure 1, the pores 3a extend essentially vertically to the surface of the lining element 1 facing in towards the heated volume of the furnace. Moreover, the pores 3a are open out towards this surface, and therefore also out towards the heated volume of the furnace. The pore ends facing away from the heated volume of the furnace are, on the other hand, clogged by the material of the lower layer 2, since the porous upper layer 3 is partly lowered into the lower layer 2, see below.

[0015] In Figure 2 is illustrated, in a way corresponding to that of Figure 1, a lining element 11 according to a second preferred embodiment of the present invention. The lining element 11 comprises, in a way similar to what has been described above in connection with Figure 1, a lower layer 12, which suitably has the corresponding properties as those described above in connection to the lower layer 2.

[0016] Parts of the surface of the lower layer 12, which surface is arranged to face in towards the heated volume of the furnace during operation, are coated with an upper layer 13, manufactured from a material that corresponds to what has been described above in connection with the upper layer 3. Similarly to the upper layer 3, the upper layer 13 is furthermore porous, and comprises elongated, parallel pores 13a, which are separated by walls 13b. However, contrarily to the upper layer 3, the pores 13a in the upper layer 13 run essentially parallel to the surface of the lining element 11.

[0017] In Figure 2, it is also illustrated how the pores not being arranged in a position lowered down into the lower layer 12 are open in both ends.

[0018] It has surprisingly proved that when the surface of the lining element is coated with such a porous material 3, 13, the resistance to thermal shock is dramatically increased, both during rapid heating and rapid cooling. Consequently, the elements last longer and they do not need replacing as often, which saves money and time.

[0019] According to a preferred embodiment, the upper layer 3, 13 is between 1 and 5 cm thick.

[0020] It is possible to let the porous, upper layer 3, 13 cover the surface of the lower layer 2, 12, which surface during operation faces in towards the furnace space, completely or essentially completely. According to a preferred embodiment, the upper layer 3, 13 covers the main part of the surface of the lower layer 2, 12.

[0021] According to an especially preferred embodiment, the upper layer 3, 13 covers the surface of the lower layer 2, 12 merely in patches. According to this embodiment, the spots 4b, 14b covered by the upper layer 3, 13 form a regular pattern on the surface of the lower layer 2, 12. Especially attractive thermal properties have been achieved using lining elements where the covered spots 4b, 14b are isolated from each other by the use of thin, elongated, not covered areas 4a, 14a. For example, the upper, porous layer 3, 13 may be arranged on the lower layer 2, 12 in the form of quadratic or rectangular units arranged next to, at a distance from and separated from each other.

[0022] When the upper material 3, 13 hence is arranged to merely cover the lower material 2, 12 in patches and in modules, with elongated spaces 4a, 14a between the modules 4b, 14b, even better resistance to thermal shock is obtained. The reason for this is believed to be that the thermally induced geometrical material changes, arising as a consequence of the large temperature gradients occurring during operation, in the free ends of the modules 4b, 14b facing into the heated volume of the furnace, will not result in fatigue of material to the same extent as is the case when the upper layer 3, 13 is arranged to cover the lower layer 2, 12 completely.

[0023] According to a preferred embodiment, each module 4b, 14b has a maximum diameter perpendicularly to the surface of the element 1 of between about 5 and 10 cm. According to an especially preferred embodiment, the modules 4b, 14b are in the form of quadratic

units with dimensions 5 x 5 cm or 10 x 10 cm. Furthermore, it is preferred that the width of the spaces 4a, 14a is essentially smaller than the surface dimensions of the modules 4b, 14b.

[0024] It is realised that a lining element 1, 11 according to the present invention also may comprise other layers, except the lower 2, 12 and the upper 3, 13 layers, as long as the outermost layer, facing in towards the heated volume of the furnace, is comprised of the upper, porous layer 3, 13.

[0025] According to the present invention, a lining element 1, 11 according to the present invention is manufactured by, in a first step, casting the lower layer 2, 12 to the desired thickness. According to a preferred embodiment, the lower layer is cast to such a thickness so that the final total thickness of the element, including the upper layer 3, 13 and any additional layers, becomes between about 30 and 50 cm.

[0026] Thereafter, in a second step, the upper layer 3, 13 is formed by modules 4b, 14b of porous material, which are lowered some distance down into the not yet solidified, molten material forming the lower layer 2, 12. The porous material is lowered down into the molten material to such a depth so that it partly protrudes above the surface of the molten material, preferably between 5 and 10 cm.

[0027] The pore ends which after lowering are positioned below the surface of the molten material are clogged by the molten material, why pores arranged perpendicularly to the surface of the molten material only will have those pore ends open which face in towards the heated volume of the furnace.

[0028] Thereafter, in a third step, the molten material is allowed to solidify. Thereby, the modules 4b, 14b of porous material are also fixed in the lower layer 2, 12, and, as a consequence, they will also form the upper layer 3, 13. The lining element 1, 11, thus formed may be of the type essentially illustrated in Figure 1, having perpendicular pore direction, or of the type essentially illustrated in Figure 2, with parallel pore direction. It is realised that other types of pore geometries also may be used.

[0029] According to a preferred embodiment, the modules 4b, 14b of porous material are lowered down into the molten material to form a regularly recurring pattern with spaces 4a, 14a between the modules 4b, 14b, in accordance to what has been described above.

[0030] According to the present invention, the lining elements 1, 11 of the invention may advantageously be used as building elements and/or insulation in an industrial furnace. It is especially preferred to use elements of the invention in furnaces driven by one or several DFI burners and/or with one or several oxyfuel burners, since the lining in such furnaces in many applications are exposed to very heavy thermal shocks during operation. An especially suitable area of use for lining elements 1, 11 according to the invention is in furnaces for continuous DFI heating of metal strips, where the metal strip contin-

uously is conveyed through the furnace and past one or several DFI burners. Lining elements being arranged near such a DFI burner are exposed to very heavy thermal shocks during operation.

[0031] Thus, by using lining elements according to the present invention in such an industrial furnace, the advantage is achieved that each element will resist thermal shock better than conventional lining elements. This will lead to decreased needs for maintenance and replacements of lining elements, in turn leading to decreased costs and better up-time of the industrial furnace. Moreover, the problems of contamination of torn loose fibres from lining materials containing fibres are avoided. An additional advantage is that the pores in the upper layer allow for a lower total weight for each lining element, which lessens the total weight for the lining.

[0032] Above, preferred embodiments have been described. However, it is apparent for the skilled person that many modifications may be made to the described embodiments without departing from the spirit of the invention.

[0033] For example, other types of pores may be used in the porous material of the upper layer 3, 13, such as isolated or completely or partially connected bubbles filled with gas, such as air or a *per se* known, inert gas. Furthermore, the pores may be elongated but have other pore directions than those illustrated in Figure 1 and Figure 2, respectively. Especially, the pores may have varying directions of extension and/or be combined with bubbles. To this end, it is essential that the pores occupy a substantial part of the total volume of the upper layer in order to achieve the advantages of the present invention.

[0034] Examples of other useful pore structures, except for the above described, parallel and elongated pores, are foam or sponge structures.

[0035] An alternative process of manufacturing lining elements according to the present invention is to, in the above described second step, instead of lowering down modules of porous material, lower down a plurality of hollow tubes in to the molten material. The tubes may be of a suitable, refractory material, whereby the upper layer may be finished when the tubes have been allowed to fix in the molten material as this has solidified in the third step. Alternatively, additional refractory material may be cast, in a separate, fourth step, around the tubes fixed in the cast material, so that the upper, porous material thereby is formed.

[0036] When such tubes are used for the manufacturing of the upper layer 3, 13, it is preferred that the upper layer 3, 13 is arranged to merely cover the surface of the lower layer 2, 12 in patches, in accordance with what has been described above. This may take place in a *per se* conventional manner.

[0037] Hence, the invention shall not be limited by the described embodiments, but be variable within the frame of the enclosed claims.

Claims

1. Lining element (1;11) for an industrial furnace, comprising a first layer (2;12) of a first refractory material, **characterised in that** the surface of the lining element (1;11) which is intended to be arranged facing in towards the heated volume of the furnace at least partially is coated with a second layer (3;13) of a second refractory material, where the second material is porous.
2. Lining element (1;11) according to claim 1, **characterised in that** the second material has a porous structure in which the pores (3a;13a) are elongated and parallel.
3. Lining element (1;11) according to claim 2, **characterised in that** the pores (13a) extend parallel to the surface of the lining element (1;11).
4. Lining element (1;11) according to claim 2, **characterised in that** the pores (3a) extend vertically to the surface of the lining element (1;11) and that the pores (3a) are open out towards the surface of the lining element (1;11).
5. Lining element (1;11) according to any one of claims 2 - 4, **characterised in that** the pores (3a;13a) together form a honeycomb structure when seen in cross section.
6. Lining element (1;11) according to any one of the preceding claims, **characterised in that** the second layer (3;13) covers the main part of the surface of the lining element (1;11), at the same time as the second layer (3;13) covers the surface of the lining element (1;11) merely in patches, and **in that** the covered spots (4b;14b) are isolated from each other by thin, elongated areas (4a;14a) which are not covered by the second material.
7. Lining element (1;11) according to any one of the preceding claims, **characterised in that** the average inner diameter of the pores (3a;13a) is between 0.5 and 3 mm.
8. Lining element (1;11) according to any one of the preceding claims, **characterised in that** the average mutual distance between the pores (3a;13a) is between 0.5 and 5 mm.
9. Lining element (1;11) according to any one of the preceding claims, **characterised in that** the second material is between 1 and 5 cm thick.
10. Lining element (1;11) according to any one of the preceding claims, **characterised in that** the second material is a ceramic material such as for example

Al_2O_3 .

11. Method for the manufacturing of a lining element (1; 11) according to any one of the claims 1 - 10, **characterised in that** the first material, in a first step, is cast to desired thickness, and **in that** the second material, in a second step, is lowered down into the molten material before it has solidified, to such a depth so that the second material partly protrudes above the molten material, and **in that** the molten material thereafter, in a third step, is allowed to solidify.
12. Method according to claim 11, **characterised in that** the second material is in the form of prefabricated modules (4b;14b) of porous material, and **in that** the second material in the second step is lowered down so that the modules (4b;14b) form a regular pattern with spaces (4a;14a) between the modules (4b;14b).
13. Use of a lining element (1;11) according to any one of the claims 1 - 10 in an industrial furnace.
14. Use according to claim 13, **characterised in that** the industrial furnace comprises a DFI burner.
15. Use according to claim 14, **characterised in that** the industrial furnace is intended for continuous DFI heating of metal strips.
16. Use according to any one of the claims 13 - 15, **characterised in that** the industrial furnace comprises an oxyfuel burner.

Fig. 1

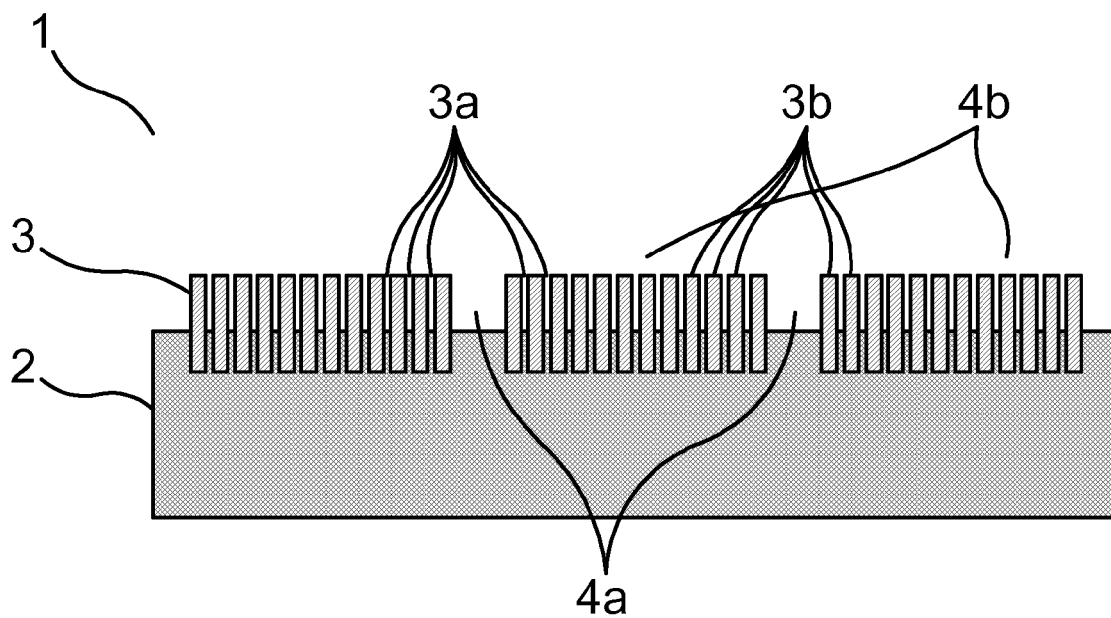


Fig. 2

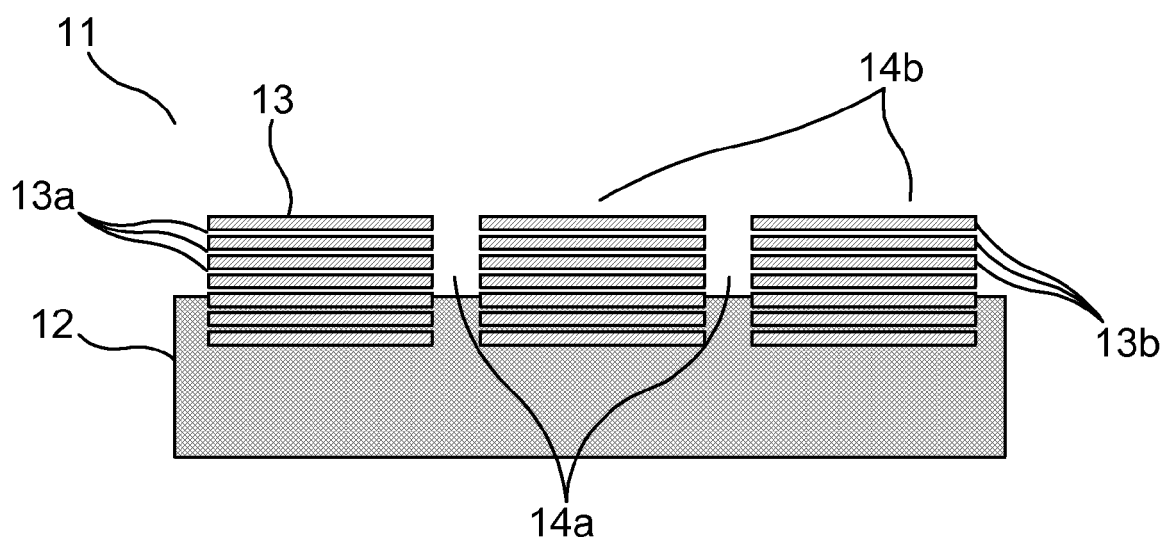
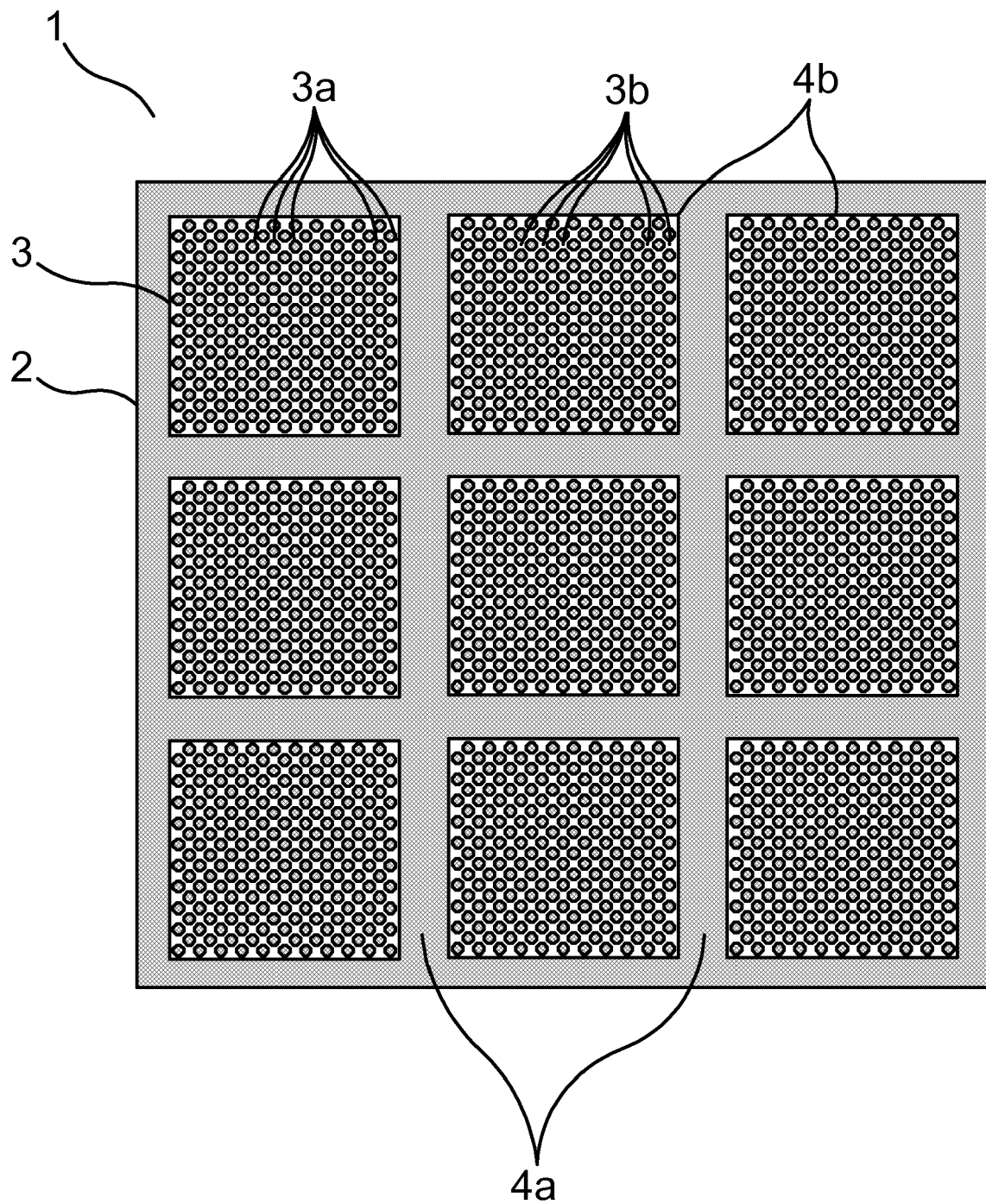


Fig. 3





EUROPEAN SEARCH REPORT

Application Number
EP 08 16 4699

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Place of search The Hague		Date of completion of the search 11 December 2008	Examiner Peis, Stefano
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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**ANNEX TO THE EUROPEAN SEARCH REPORT
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