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(54) Benævnelse: **Substrat og fremgangsmåde til brudforberedelse af et substrat til i det mindste en effekthalvlederkomponent**

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Description

The invention relates to a method for preparing the breaking up of a substrate for at least one power semiconductor component according to the preamble of Claim 1. Furthermore, the invention relates to a substrate relating to this according to the preamble of Claim 10.

In power semiconductor modules which are known from the prior art, power semiconductor components such as, for example, power semiconductor switches and diodes are generally arranged on a substrate and connected to one another in an electrically conductive fashion by means of a conductor layer of the substrate, bond wires and/or a film composite. The power semiconductor switches are generally in the form of transistors, for example, IGBTs (Insulated Gate Bipolar Transistors) or MOSFETs (Metal Oxide Semiconductor Field Effect Transistors), or in the form of thyristors.

The power semiconductor components which are arranged on the substrate here are frequently connected electrically to form an individual so-called half bridge circuit or a plurality of such circuits which are usually used for rectifying and inverting electrical voltages and currents. The substrate is generally connected directly or indirectly to a heat sink.

In order to manufacture a power semiconductor module, power semiconductor components are arranged on the substrate and connected to the substrate. In this context, the substrate can be, for example, in the form of a DCB substrate. The substrate has a patterned, electrically conductive metal layer which forms conductor tracks owing to its structure. The power semiconductor components are connected to one another via the conductor tracks, with the result that load currents which flow through the power semiconductor components and which can have a high current strength also flow through the conductor tracks of the electrically conductive metal layer. In order to produce a DCB substrate, for example a piece of sheet metal of a uniform thickness is, according to the customary technology, bonded onto an electrically non-conductive insulating material body, usually composed of a ceramic, and the conductor track structure is then etched out of the piece of sheet metal.

The substrate is usually manufactured in the form of a relatively large unit which is subsequently individuated by breaking it into individual substrate units. The individual substrate units each form, for example, the substrate for a power semiconductor module. The breaking up of the substrate can take place here either before or after connection of the power semiconductor components to the substrate.

In the prior art, before the breaking up process a constant removal of material from the insulating material body of the substrate is carried out by means of a laser beam along desired fracture edges of the substrate, and the substrate, and in particular the insulating material body of the substrate, is therefore selectively weakened along the desired fracture edges in a mechanically uniform fashion. When the substrate is broken up, the substrate is loaded mechanically in such a way that high mechanical loading of the substrate comes about at the desired fracture edge, with the result that said substrate breaks along the desired fracture edge.

During the breaking up of the substrate, the problem occurs that undesired breakages frequently occur on the fracture edge on the insulating material body, and in particular in the corners, and the substrate therefore becomes unusable since its dielectric strength is no longer ensured.

DE 10 2008 043 539 A1 discloses a method according to the preamble of Claim 1 for laser etching brittle components in order to prepare for their later individuation by applying bag-like shot holes of a laser beam, wherein the shot holes are arranged linearly in rows and form a laser etching line which serves as a fracture initiation line, wherein at least two laser etching lines which intersect one another at an intersection point are formed on a component, wherein at least one selectively controlled intersection point shot holes, which does not come about randomly is formed at the intersection point, said intersection point shot holes weakening the component selectively at the intersection point. Furthermore, DE 10 2008 043 539 A1 discloses a substrate according to the preamble of Claim 10.

JPH 072 73069 A discloses a wafer into which lines are etched in order to individuate them into chips.

The object of the invention is to reduce undesired breakages on the insulating material body of a substrate during the breaking up of the substrate for at least one power semiconductor component.

This object is achieved by means of a method according to Claim 1 for preparing the breaking up of a substrate for at least one power semiconductor component having the following method steps:

a) preparing the substrate, wherein the substrate has an electrically non-conductive insulating material body,

b) removal of material from the insulating material body along desired fracture edges of the substrate, wherein the removal of material is carried out in such a way that in corner regions at which at least two desired fracture edges meet a greater degree of removal of material is carried out along the at least two desired fracture edges compared to the removal of material which is carried out in the other regions of the desired fracture edges, wherein the length of a corner region, running along a desired fracture edge, is 0.5% to 30% of the distance, running along the desired fracture edge, between two adjacent corner points of the desired fracture edge at which at least two desired fracture edges meet.

This object is also achieved by means of a substrate according to Claim 10 for at least one power semiconductor component, wherein the substrate has an electrically non-conductive insulating material body, wherein material of the insulating material body is removed along at least two desired fracture edges of the substrate, wherein more material per unit length is removed along the desired fracture edges in corner regions at which at least two desired fracture edges meet than in the other regions along desired fracture edges, wherein the length of a corner region, running along a desired fracture edge, is 0.5% to 30% of the distance, running along the desired fracture edge, between two adjacent corner points of the desired fracture edge at which at least two desired fracture edges meet.

Advantageous embodiments of the invention can be found in the dependent claims.

Advantageous embodiments of the method arise in a way which is analogous to advantageous embodiments of the substrate, and vice versa.

The process is advantageous if the removal of material is carried out by means of a laser beam since a laser beam permits particularly variable and reliable removal of material from the insulating material body.

In addition, it proves advantageous if the removal of material is carried out by means of a pulsed laser beam, and in order to bring about the removal of material the pulsed laser beam forms depressions in the insulating material body along the desired fracture edges since variable removal of material in a way which is adapted to the insulating material body can easily be achieved by forming depressions.

Furthermore, it proves advantageous if more depressions are made per unit length by the laser beam in the insulating material body along the desired fracture edges in corner regions at which at least two desired fracture edges meet, than in the other regions of the desired fracture edges.

This measure makes it easily possible to achieve variable removal of material in a way which is adapted to the insulating material body.

Furthermore, it proves advantageous if the depressions are made in the insulating material body by the pulsed laser beam in that in a first partial method step, first depressions are made by the laser beam in the insulating material body along the desired fracture edges of the substrate, and, in a second partial method step, second depressions are made by the laser beam in the insulating material body along the desired fracture edges, in the corner regions at which at least two desired fracture edges meet. As a result, a variable removal of material along the desired fracture edges can be particularly easily implemented.

In addition it proves advantageous if the first and second depressions are arranged in such a way that the centres of the first and second depressions correspond locally, or the centres of the first and second depressions are arranged offset with respect to one another. As a result it is particularly easily possible to achieve precise control of the degree of removal of material.

In addition, it proves advantageous if the power of the laser beam is higher in the corner regions at which at least two desired fracture edges meet than the power of the laser beam in the other regions of the desired fracture edges. By increasing the power of the laser beam in the corner regions at which at least two desired fracture edges meet, it is possible in a particularly easy way to carry out variable removal of material along the desired fracture edges.

Furthermore, it proves advantageous if in the first and second partial method steps the laser beam has the same power, since the laser-beam-generating device which generates the laser beam can then be of a particularly simple design.

Furthermore, a method for breaking up a substrate for at least one power semiconductor component proves advantageous, wherein the method includes a method for preparing the breaking up of a substrate for at least one power semiconductor component according to one of the preceding claims, wherein the following further method step is carried out:

c) breaking up of the substrate along the desired fracture edges of the substrate.

Exemplary embodiments of the invention are illustrated in the figures and explained in more detail below. In the drawings:

Fig. 1 is a schematic view from above of a substrate according to the invention,

Fig. 2 is a schematic sectional view of a first embodiment of a substrate according to the invention,

Fig. 3 is a schematic sectional view of a further embodiment of a substrate according to the invention, and

Fig. 4 is a schematic sectional view of a further embodiment of a substrate according to the invention.

Fig. 1 is a schematic view from above of a substrate 1 according to the invention. Fig. 2 is a schematic sectional view of a first embodiment of the substrate 1 according to the invention along a desired fracture edge A. Within the scope of the described exemplary embodiment, the substrate 1 is embodied as a DCB substrate, but it can also be embodied in the form of another type of substrate.

Within the scope of the exemplary embodiment, the substrate 1 has an electrically non-conductive insulating material body 2 and an electrically conductive patterned line layer 16 which is arranged on the insulating material body 2 and which forms electrical conductor tracks 3 as a result of its structure. The substrate 1 preferably has a further electrically conductive line layer, wherein the insulating material body 2 is arranged between the patterned line layer 16 and the further line layer. In general, on the finished power semiconductor module a heat sink, which serves to cool the power semiconductor components arranged on the substrate 1, is arranged on the further line layer. The patterned line layer 16 and the further line layer can be composed, for example, of copper. The electrically non-conductive insulating material body 2 is preferably composed of a ceramic.

In the exemplary embodiment, the substrate 1 is to be individuated by breaking up the substrate 1 to form individual substrate units 4a and 4b. The individual substrate units 4a and 4b respectively form, for example, the substrate for a power semiconductor module. The breaking up of the substrate 1 can take place here either before or after the connection of the power semiconductor components to the substrate 1.

In the exemplary embodiment, the substrate 1 has two individual substrate units 4a and 4b in a state in which they are not yet individuated, wherein the individual substrate units 4a and 4b respectively have two conductor tracks 3. The individual substrate units 4a and 4b are also known specifically in the specialist field as so-called useful units.

In a first method step according to the invention the substrate 1 is therefore made available.

In a further method step according to the invention, removal of material from the insulating material body 1 takes place along fracture edges A, B, C, D and E of the substrate 1 desired by the user, wherein the removal of material is carried out in such a way that a greater degree of removal of material is carried out in corner regions 14 at which at least two desired fracture edges meet than the removal of material which is carried out in the other regions 17 of the desired fracture edges A, B, C, D and E. The desired fracture edges A, B, C, D and E preferably run around the individual substrate units 4a and 4b and between the individual substrate units 4a and 4b. The corner regions 14 are illustrated marked in black in Fig. 1. The other regions 17 of the desired fracture edges A, B, C, D and E constitute, in the exemplary embodiment, the regions of the desired fracture edges A, B, C, D and E lying between the corner regions 14, and the regions of the desired fracture edges C and E lying between the corner regions 14 and the outer edges 21 of the insulating material body 2. During the removal of material, material is removed from the insulating material body 1 and said material is as a result weakened mechanically along the desired fracture edges. The invention is distinguished, in particular, by the fact that the technically customary constant removal of material over the entire length of the desired fracture edges A, B, C, D and E is not carried out along said desired fracture edges but instead a higher degree of removal of material compared to the other regions 17 of the desired fracture edges A, B, C, D and E is carried out in the corner regions 14.

Mechanical weakening of the substrate 1 and, in particular, of the insulating material body 2 is therefore greater in the corner regions 14 than in the other regions 17 of the desired fracture edges A, B, C, D and E. During the later breaking up of the substrate 1, the substrate 1 is loaded in a technically customary mechanical fashion such that high mechanical loading of the substrate occurs at the desired fracture edge, with the result that said substrate does not break along the desired fracture edge and a real fracture edge which corresponds to the desired fraction edge occurs. As a result of the fact that in the invention the substrate 1 and, in particular, the insulating material body 2 are weakened to a greater extent in the corner regions 14 than in the other regions 17 of the desired fracture edges, when the substrate 1 is broken up the propagation of fractures generally occurs starting from the corner regions 14, and along the respective fracture edge in the direction of the centre of the fracture edge. In this context, breakages of the insulating material body 1 occur only very rarely at the fracture edge, i.e. breakages occur significantly less often than in the case of the technically customary constant weakening of the insulating material body 1 along the entire fracture edge.

The degree of removal of material corresponds to the mass of the removed material per length unit along the desired fracture edge, wherein the length unit can be, for example, 1 cm.

The removal of material is preferably carried out by means of a laser beam 20 which is illustrated in schematic fashion with an arrow in Fig. 2. Alternatively, the removal of material could, however, also be implemented, for example, by means of milling, grinding, sawing or drilling. The laser beam 20 is generated by a laser-radiation-generating device 19.

Fig. 2 is a schematic sectional view of a first embodiment of the substrate 1 according to the invention. The laser-radiation-generating device 19 generates a continuous laser beam. The laser beam 20 is guided over the substrate 1 along the desired fracture edges A, B, C, D and E of the substrate 1 and as such implements the removal of material from the insulating material body 2. In this context, the power of the laser beam 20 is increased in the corner regions 14 of the desired fracture edges A, B, C, D and E compared to the power which the laser beam has in the other regions 17 of the desired fracture edges A, B, C, D and E, and the removal of material in the corner regions 14 is therefore increased. It is alternatively also possible for the power of the laser beam 20 not to be changed along the entire fracture edges but instead for the speed at which the laser beam 20 is moved along the desired fracture edges in the corner regions 14 of the desired fracture edges A, B, C, D and E to be reduced compared to the speed at which the laser beam 20 is moved along the desired fracture edges A, B, C, D and E in the other regions 17 of the desired fracture edges.

Fig. 3 is a schematic sectional view of a further embodiment of the substrate 1 according to the invention along the desired fracture edge A. In contrast to the formation of the invention according to Fig. 2, in the embodiment of the invention according to Fig. 3 the removal of material is carried out by means of a pulsed laser beam, and in order to achieve the removal of material the pulsed laser beam forms depressions in the insulating material body 2 along the desired fracture edges A, B, C, D and E. In Fig. 3, for the sake of clarity only a first depression 18 and a second depression 18’ are provided with a reference symbol. The depressions preferably are approximately conical in shape, which is illustrated in a schematic form in Fig. 3 as a cone shape. The depressions each have a centre M. In the exemplary embodiment, a depression is generated with each laser pulse. More depressions per unit length are preferably formed by the laser beam 20 in the insulating material body along the desired fracture edges in corner regions 14 at which at least two desired fracture edges meet than in the other regions of the desired fracture edges. The depressions are preferably formed in the insulating material body by the pulsed laser beam in that, in a first partial method step, first depressions are formed by the laser beam in the insulating material body along the desired fracture edges of the substrate, and in a second partial method step second depressions are formed by the laser beam in the insulating material body along the desired fracture edges in corner regions 14 at which at least two desired fracture edges meet. The centres M of the first and second depressions are arranged here offset with respect to one another along the respective fracture edge, wherein the centres M of directly adjacent first and second depressions can be at any desired distances from one another, with the result that the first and second depressions can also engage one in the other or be completely separated from one another. By additionally forming second depressions, the removal of material is increased in corner regions 14 at which at least two desired fracture edges meet, compared to the removal of material which is carried out in the other regions 17 of the desired fracture edges A, B, C, D and E.

Alternatively, more depressions per unit length can be formed by the laser beam 20 in the insulating material body along the desired fracture edges in corner regions 14 at which at least two desired fracture edges meet than in the other regions of the desired fracture edges in that the pulse frequency of the laser beam is increased in the corner regions compared to the pulse frequency of the laser beam 20 in the other regions 17 of the desired fracture edges, or in that the speed at which the laser beam 20 is moved along the desired fracture edges is reduced in the corner regions 14 of the desired fracture edges A, B, C, D and E compared to the speed at which the laser beam 20 is moved along the desired fracture edges A, B, C, D and E in the other regions 17 of the desired fracture edges.

Fig. 4 is a schematic sectional view of a further embodiment of the substrate 1 according to the invention along the desired fraction edge A. The exemplary embodiment according to Fig. 4 corresponds to the exemplary embodiment according to Fig. 3, wherein in contrast to the exemplary embodiment according to Fig. 3, in the exemplary embodiment according to Fig. 4 the first and second depressions are arranged in such a way that the centres of the first and second depressions correspond locally, with the result that the first and second depressions fuse to form composite depressions. In Fig. 4, only one composite depression 18″ is provided with a reference symbol, for the sake of clarity.

In the embodiment of the invention according to Fig. 3 or Fig. 4, in the first and second partial method steps the laser beam has the same power. Of course, it is, however, also possible that in the embodiments of the invention according to Fig. 3 and Fig. 4 the power of the laser beam is higher in the corner regions 14 at which at least two desired fracture edges meet than the power of the laser beam in the other regions 17 of the desired fracture edges. As a result of this measure it is possible, for example, to increase the size of the second depressions compared to the size of the first depressions.

Alternatively, in order to produce the depressions illustrated in Fig. 4, the depressions can also be formed according to the invention in such a way that the removal of material is carried out by means of a pulsed laser beam, and in order to bring about the removal of material the pulsed laser beam forms depressions in the insulating material body 2 along the desired fracture edges, wherein the power of the laser beam is higher in the corner regions at which at least two desired fracture edges meet than the power of the laser beam in the other regions of the desired fracture edges, with the result that the depressions arranged in the corner regions 14 are larger than the depressions arranged in the other regions.

Within the scope of the exemplary embodiment, the substrate 1 is subsequently broken up along the desired fracture edges A, B, C, D and E of the substrate 1. When the substrate is broken up, the substrate is loaded mechanically in such a way that high mechanical loading of the substrate occurs at the desired fracture edge, with the result that said substrate breaks along the desired fracture edge. The breakage of the substrate 1 can occur here either before or after the connection of the power semiconductor components to the substrate 1. In the exemplary embodiment, during the breakage the side parts 10 and 13 are firstly broken away and then the side parts 11 and 12, and subsequently the substrate is broken at the desired fracture edge D and as such individuated into the first and second individual substrate units 4a and 4b.

At this point it is to be noted that in the figures identical elements are provided with identical reference symbols.

Furthermore, at this point it is to be noted that in the present invention the length b of a corner region, running along a desired fracture edge, is 0.5% to 30% of the distance a, running along the desired fracture edge, between two adjacent corner points 30 of the desired fracture edge at which at least two desired fracture edges meet (see Fig. 1).

Patentkrav

1. Fremgangsmåde til brudforberedelse af et substrat (1) til i det mindste en effekthalvlederkomponent med følgende fremgangsmådetrin:
a) tilvejebringelse af substratet (1), hvor substratet (1) har et elektrisk ikke-ledende isoleringsmaterialelegeme (2),
b) materialefjernelse på isoleringsmaterialelegemet (2) langs ønskede brudkanter (A,B,C,D,E) af substratet (1), hvor materialefjernelsen gennemføres sådan, at der i hjørneområder (14), ved hvilke i det mindste to ønskede brudkanter (A,B,C,D,E) mødes, langs de i det mindste to ønskede brudkanter gennemføres en materialefjernelse, der er højere i forhold til den materialefjernelse, der gennemføres i de øvrige områder (17) af de ønskede brudkanter (A,B,C,D,E), kendetegnet ved, at den langs en ønsket brudkant (A,B,C,D,E) forløbende længde (b) af et hjørneområde (14) udgør 0,5 % til 30 % af den langs den ønskede brudkant (A,B,C,D,E) forløbende afstand (a) mellem to tilstødende hjørnepunkter (30) af den ønskede brudkant (A,B,C,D,E), ved hvilke i det mindste to ønskede brudkanter (A,B,C,D,E) mødes.

2. Fremgangsmåde ifølge et af de foregående krav, kendetegnet ved, at materialefjernelsen gennemføres ved hjælp af en laserstråle (20).

3. Fremgangsmåde ifølge krav 2, kendetegnet ved, at materialefjernelsen gennemføres ved hjælp af en pulserende laserstråle (20), og den pulserende laserstråle (20) med henblik på opnåelsen af materialefjernelsen langs de ønskede brudkanter (A,B,C,D,E) indfører fordybninger (18,18',18") i isoleringsmaterialelegemet (2).

4. Fremgangsmåde ifølge krav 3, kendetegnet ved, at i hjørneområder (14), ved hvilke i det mindste to ønskede brudkanter mødes, indføres der af laserstrålen (20) i isoleringsmaterialelegemet (2) flere fordybninger (18,18') pr. længdeenhed langs de ønskede brudkanter (A,B,C,D,E) end i de

øvrige områder (17) af de ønskede brudkanter (A,B,C,D,E).

5. Fremgangsmåde ifølge krav 4, kendetegnet ved, at fordybningerne (18,18',18") indføres af den pulserende laserstråle (20) i isoleringsmaterialelegemet (2), idet der i et første delfremgangsmådetrin af laserstrålen (20) langs de ønskede brudkanter (A,B,C,D,E) af substratet (1) indføres første fordybninger (18') i isoleringsmaterialelegemet (2), og der i et andet delfremgangsmådetrin af laserstrålen (20) i de hjørneområder (14), ved hvilke i det mindste to ønskede brudkanter (A,B,C,D,E) mødes, langs de ønskede brudkanter (A,B,C,D,E) indføres anden fordybninger (18') i isoleringsmaterialelegemet (2).

6. Fremgangsmåde ifølge krav 5, kendetegnet ved, at de første og anden fordybninger (18,18') er anbragt sådan, at midterne (M) af de første og anden fordybninger (18,18') stemmer stedligt overens, eller midterne (M) af de første og anden fordybninger (18,18') er anbragt forskudt i forhold til hinanden.

7. Fremgangsmåde ifølge et af kravene 2 til 6, kendetegnet ved, at i de hjørneområder (14), ved hvilke i det mindste to ønskede brudkanter (A,B,C,D,E) mødes, er laserstrålens (20) effekt højere end laserstrålens (20) effekt i de øvrige områder (17) af de ønskede brudkanter (A,B,C,D,E).

8. Fremgangsmåde ifølge krav 5 eller 6, kendetegnet ved, at ved det første og andet delfremgangsmådetrin har laserstrålen (20) den samme effekt.

9. Fremgangsmåde til brydning af et substrat til i det mindste en effekthalvlederkomponent, hvor fremgangsmåden indebærer en fremgangsmåde til brudforberedelse af et substrat til i det mindste en effekthalvlederkomponent ifølge et af de foregående krav, med følgende yderligere fremgangsmådetrin:
c) brydning af substratet (1) langs de ønskede brudkanter (A,B,C,D,E) af substratet (1).

10. Substrat til i det mindste en effekthalvlederkomponent, hvor substratet (1) har et elektrisk ikke-ledende isoleringsmaterialelegeme (2), hvor der langs ønskede brudkanter (A,B,C,D,E) af substratet (1) fjernes materiale af isoleringsmaterialelegemet (2), hvor der i hjørneområder (14), ved hvilke i det mindste to ønskede brudkanter (A,B,C,D,E) mødes, langs de i det mindste to ønskede brudkanter (A,B,C,D,E) fjernes mere materiale pr. længdeenhed end i de øvrige områder langs de ønskede brudkanter (A,B,C,D,E), kendetegnet ved, at den langs en ønsket brudkant (A,B,C,D,E) forløbende længde (b) af et hjørneområde (14) udgør 0,5 % til 30 % af den langs den ønskede brudkant (A,B,C,D,E) forløbende afstand (a) mellem to tilstødende hjørnepunkter (30) af den ønskede brudkant (A,B,C,D,E), ved hvilke i det mindste to ønskede brudkanter (A,B,C,D,E) mødes.

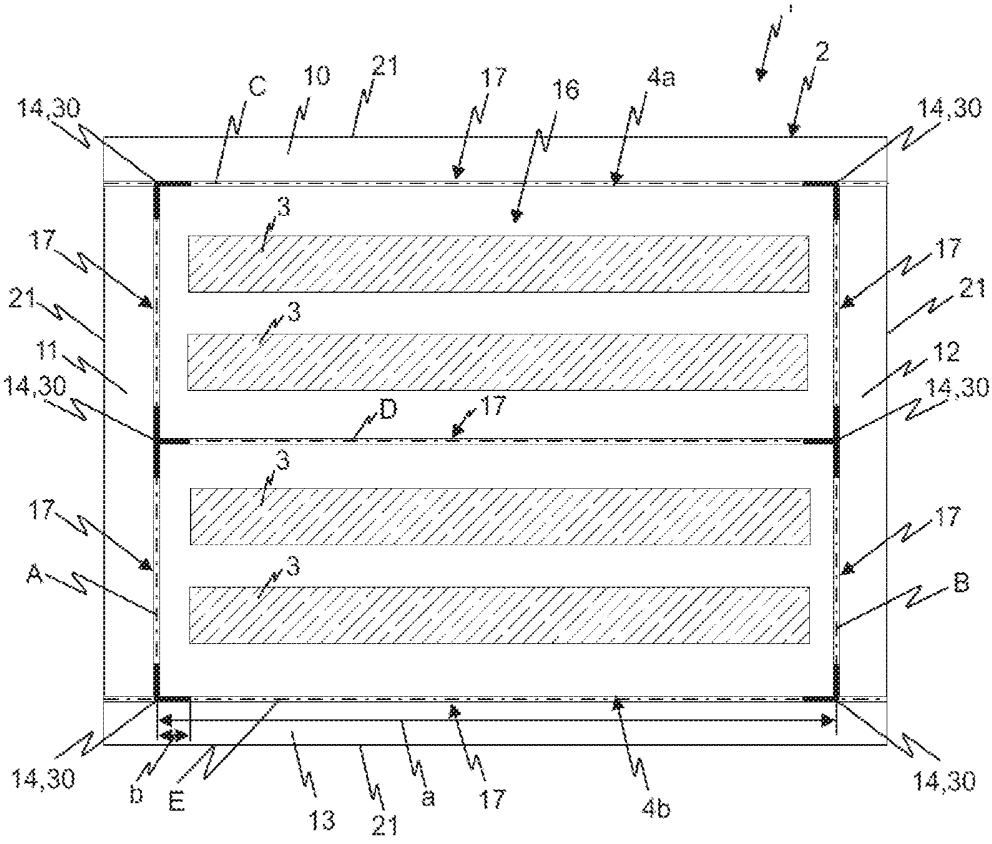

FIG 1

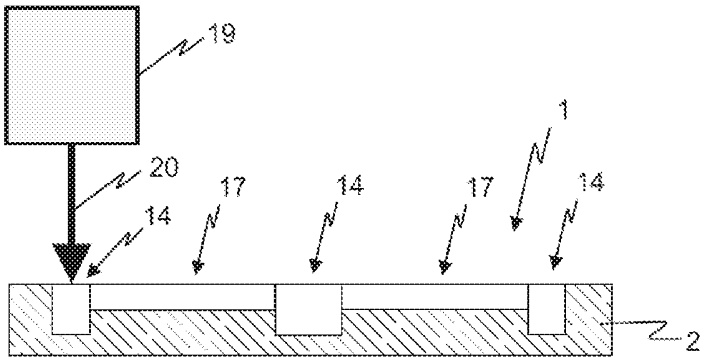

FIG 2

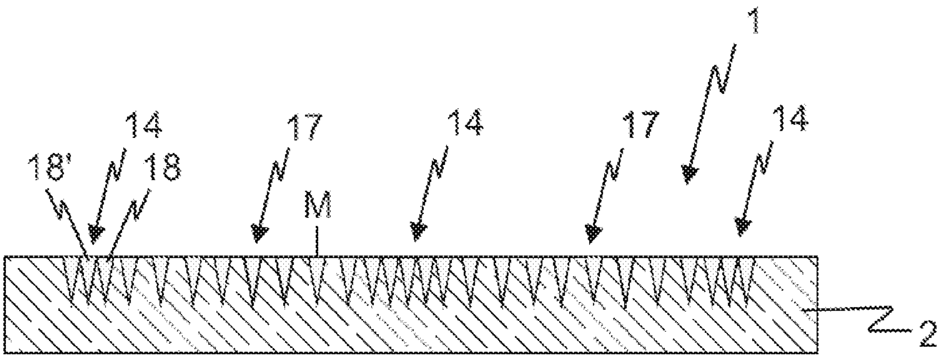

FIG 3

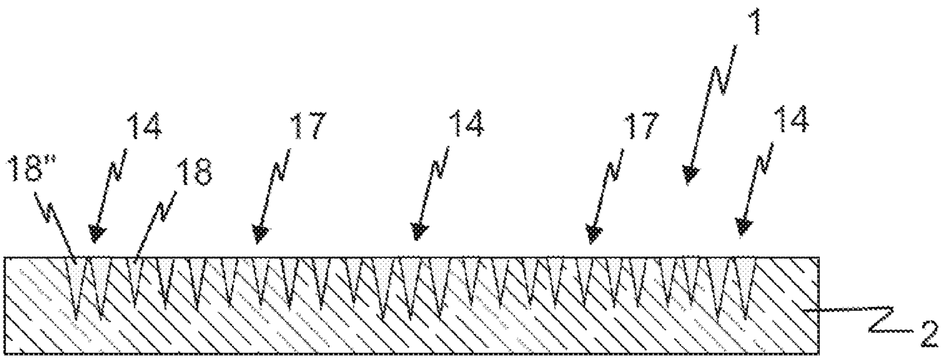

FIG 4