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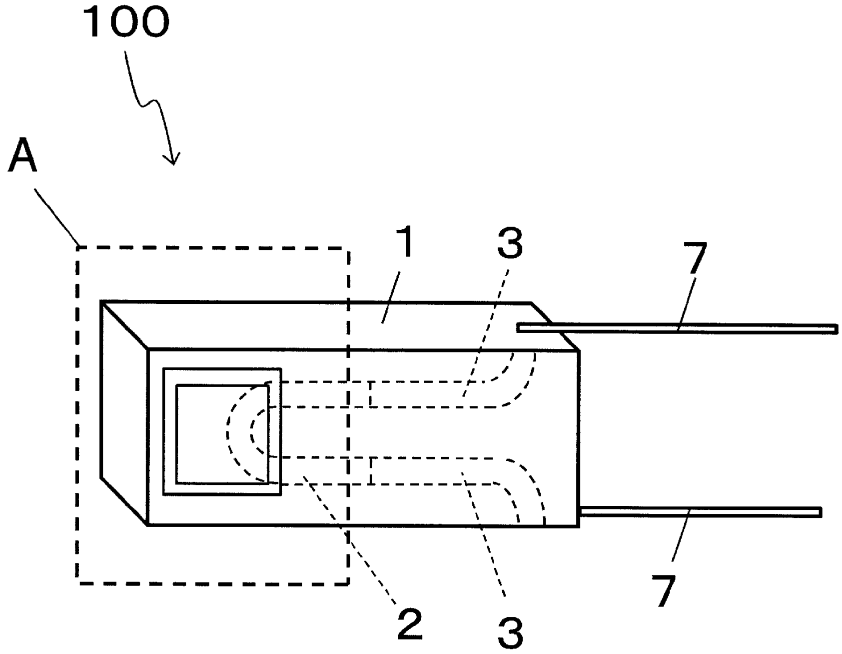
(54) **HEATER**

(57) A heater of the present invention comprises a ceramic structure, and a heating resistor embedded in the ceramic structure and including a folded portion. The ceramic structure includes, in a surface facing the folded portion, a groove portion that surrounds the folded portion in opposing relation.

Fig. 1



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Description

Technical Field

[0001] The present invention relates to a heater that is used for a hair iron, a water heater, an oxygen sensor, an air-fuel ratio sensor, a glow plug, various types of combustors, a semiconductor manufacturing apparatus, etc.

Background Art

[0002] One example of heaters for use in a hair iron and so on is a ceramic heater described in Japanese Unexamined Patent Application Publication No. 2006-40882 (hereinafter referred to as Patent Literature (PTL) 1). The ceramic heater described in PTL 1 includes a ceramic base body, a heating section in the ceramic base body, and a lead section in the ceramic base body, the lead section being connected to the heating section.

[0003] In the ceramic heater (hereinafter simply referred to also as the "heater") described in PTL 1, the heating section (heating resistor) includes two linear portions arrayed side by side, and a folded portion connecting those linear portions to each other. In the heater having such a shape, particularly, a portion of the ceramic base body (ceramic structure), which is positioned between the two arrayed linear portions near the folded portion, tends to be heated to high temperature. Therefore, a surface of the ceramic structure exhibits a temperature distribution that a region (hereinafter referred to as a "maximally heating region") facing the above-mentioned portion of the ceramic base body takes the highest temperature, and that the temperature gradually lowers as a distance from the maximally heating region increases with the maximally heating region being a center. When an uneven temperature distribution is generated in the surface of the ceramic structure as mentioned above, there is a possibility that a crack may occur in the surface of the ceramic structure with repeated use of the heater. As a result, it has been difficult to improve long-term reliability of the heater.

Summary of Invention

[0004] A heater according to one aspect of the present invention includes a ceramic structure, and a heating resistor embedded in the ceramic structure and including a folded portion, in which the ceramic structure includes, in a surface facing the folded portion, a groove portion that surrounds the folded portion in opposing relation.

[0005] A heater according to another aspect of the present invention includes a ceramic structure, and a heating resistor embedded in the ceramic structure and including a folded portion, in which the ceramic structure includes a recess in a region of a surface facing the folded portion, the region overlapping the folded portion.

Brief Description of Drawings

[0006]

Fig. 1 is a perspective view of a heater according to one embodiment of the present invention.

Fig. 2(a) is a partial enlarged view representing, in enlarged scale, an area A of the heater illustrated in Fig. 1, and Fig. 2(b) is a sectional view taken along a B-B' cross-section.

Fig. 3 is a partial enlarged view of a heater according to a modification of the present invention.

Fig. 4 is a sectional view of a heater according to a modification of the present invention.

Fig. 5 is a sectional view of a heater according to a modification of the present invention.

Fig. 6(a) is a partial enlarged view of the heater according to a modification of the present invention, and Fig. 6(b) is a sectional view taken along a C-C' cross-section.

Fig. 7 is a sectional view of a heater according to a modification of the present invention.

Fig. 8 is a sectional view of a heater according to a modification of the present invention.

Description of Embodiments

[0007] A heater 100 according to one embodiment of the present invention will be described in detail below with reference to the drawings.

[0008] Fig. 1 is a perspective view of the heater 100 according to one embodiment of the present invention. Fig. 2(a) is a partial enlarged view representing, in enlarged scale, an area A of the heater 100 illustrated in Fig. 1, and Fig. 2(b) is a sectional view taken along a B-B' cross-section. As illustrated in Fig. 1, the heater 100 according to one embodiment of the present invention includes a ceramic structure 1, a heating resistor 2, power feeders 3, and lead terminals 7. In Fig. 1, the heating resistor 2 and the power feeders 3 are illustrated by broken lines in a way of seeing through the ceramic structure 1. The heater 100 is, for example, used for a hair iron, a water heater, an oxygen sensor, an air-fuel ratio sensor, a glow plug, a semiconductor manufacturing apparatus, and so on.

[0009] The ceramic structure 1 serves as a member for holding the heating resistor 2 and the power feeders 3 therein. Because the heating resistor 2 and the power feeders 3 are disposed inside the ceramic structure 1, environmental resistance of the heating resistor 2 and the power feeders 3 can be improved. The ceramic structure 1 is a rod-like member. The ceramic structure 1 is made of a ceramic material, e.g., alumina, silicon nitride, aluminum nitride, or silicon carbide. When the ceramic structure 1 is in the form of a square rod, for example, a short side of an outer periphery of the ceramic structure 1 has a length of 25 mm, and a long side thereof has a length of 25 mm. A length of the ceramic structure 1 in the longitudinal direction is 50 mm.

[0010] The heating resistor 2 is a member that generates heat when a current is supplied to it. The heating resistor 2 is embedded in the ceramic structure 1. The heating resistor 2 faces a surface (hereinafter referred to as a "principal surface") of the ceramic structure 1, the surface including the long side of the outer periphery of the ceramic structure 1 and the side of the ceramic structure 1 in the longitudinal direction. As illustrated in Fig. 2, the heating resistor 2 includes two linear portions 22 arrayed side by side, and a folded portion 21 connecting those linear portions 22 to each other and having outer and inner circumferences each of which has a semicircular shape. Also in Fig. 2, the heating resistor 2 is illustrated by broken lines in a way of seeing through the ceramic structure 1. The folded portion 21 of the heating resistor 2 is disposed near a fore end of the ceramic structure 1, and the linear portions 22 extend from respective ends of the folded portion 21 toward the rear end side of the ceramic structure 1. The heating resistor 2 is made of a conductive ceramic material, e.g., tungsten carbide. The heating resistor 2 has a line width of 0.2 to 1.5 mm and a thickness of 0.3 to 3 mm, for example. The curvature radius of the folded portion 21 is, for example, 0.15 to 1 mm at the inner circumference and 0.5 to 2 mm at the outer circumference. The heat generated from the heating resistor 2 is conducted through the ceramic structure 1 and is radiated to the outside from surfaces of the ceramic structure 1.

[0011] Returning to Fig. 1, the power feeders 3 are a pair of wiring members that electrically connects the heating resistor 2 to a power supply (not illustrated) outside the ceramic structure 1 in cooperation with the lead terminals 7. The power feeders 3 are mostly embedded in the ceramic structure 1, and are electrically connected at one ends to the heating resistor 2. Stated in another way, respective one ends of the power feeders 3 are electrically connected to different ends of the heating resistor 2. On the other hand, respective other ends of the power feeders 3 are led out to the surface of the ceramic structure 1 at the rear end side and are connected to the different lead terminals 7 for connection to the external power supply. The power feeders 3 are formed linearly as wired lines that are routed inside the ceramic structure 1. The power feeders 3 are each made of a conductive ceramic material, e.g., tungsten carbide, and formed as a wired line having lower resistance than the heating resistor 2. Each of the power feeders 3 has a line width of, e.g., 0.2 to 2 mm and a thickness of, e.g., 0.3 to 4 μm.

[0012] The lead terminals 7 are rod-like conductive members that electrically connect the power feeders 3 to the external power supply. The lead terminals 7 are joined respectively to the power feeders 3 that are led out to different surfaces of the ceramic structure 1 at the side opposite to the side where the heating resistor 2 is disposed. The lead terminals 7 are made of, e.g., nickel. The lead terminals 7 and the power feeders 3 are joined to each other by employing, e.g., a brazing alloy. For example, a silver solder is used as the brazing alloy. Dimensions of each of the lead terminals 7 are, for example, 0.2 to 2 mm in width, 0.2 to 2 mm in thickness, and 10 mm or more in length.

[0013] Returning to Fig. 2(a), in the heater 100 of this embodiment, the heating resistor 2 includes the two linear portions 22 arrayed side by side, and the folded portion 21 connecting those linear portions 22 to each other. In the heater 100 having such a shape, particularly, a portion of the ceramic structure 1, which is positioned between the two arrayed linear portions 22 near the folded portion 21, tends to be heated to high temperature. Therefore, a surface of the ceramic structure 1 takes high temperature particularly in a region (maximally heating region 10) that faces the above-mentioned portion of the ceramic base body. In Fig. 2(a), the maximally heating region 10 is denoted by a two-dot-chain line.

[0014] In consideration of the above point, in the heater 100 of this embodiment, the ceramic structure 1 includes, in the surface of its region at the side closer to the fore end than the maximally heating region 10, a groove portion 4 surrounding the folded portion 21 of the heating resistor 2 in opposing relation. In this embodiment, the groove portion 4 is in the form of a rectangular frame surrounding the folded portion 21 in opposing relation. Therefore, the surface of a portion of the ceramic structure 1 where the groove portion 4 is formed (i.e., a bottom surface of the groove portion 4) can be positioned closer to the heating resistor 2 than the surface of a region around such a portion. With that arrangement, temperature in the surface of the portion of the ceramic structure 1 where the groove portion 4 is formed is more apt to increase. Thus, since the groove portion 4 in which temperature is more apt to increase is formed near the maximally heating region 10, the temperature difference between the maximally heating region 10 and a region in the vicinity of the former can be reduced. Hence unevenness of temperature distribution in a surface of the heater 100 can be suppressed. As a result, long-term reliability of the heater 100 can be improved.

[0015] When the outer circumference of the folded portion 21 has the curvature radius of 1 mm, the groove portion 4 is formed in a square shape dimensioned, for example, such that a width is 0.15 mm, a depth is 0.1 mm, and one side of an outer periphery is 2 mm.

[0016] Furthermore, in the heater 100 of this embodiment, a region surrounded by the groove portion 4 is positioned at the side closer to the fore end of the ceramic structure 1 than the maximally heating region 10. Stated in another way, a part of the groove portion 4, the part being positioned closest to the rear end of the ceramic structure 1, is positioned at the side closer to the fore end of the ceramic structure 1 than the maximally heating region 10. With that arrangement, unevenness of the temperature distribution can be further suppressed at the fore end side of the ceramic structure 1 where a heating target is disposed. It is to be noted that the position of the maximally heating region 10 can be confirmed by measuring the temperature of the surface of the ceramic structure 1 with a radiation thermometer, for example.

[0017] Moreover, as illustrated in Fig. 2(b), when looking at a cross-section of the ceramic structure 1 sectioned in a direction perpendicular to the surface of the ceramic structure 1, the groove portion 4 preferably has a curved shape. With that feature, thermal stress generated upon the ceramic structure 1 being heated to the high temperature can be suppressed from being concentrated in the groove portion 4.

[0018] In addition, preferably, a slope of the groove portion 4 at the inner peripheral side is more moderate than that at the outer peripheral side. With that feature, when gas is supplied and flows around the heater 100, the gas flow coming into the groove portion 4 from the outer peripheral side is moderated at the inner peripheral side, whereby the gas is made more likely to stay in the groove portion 4.

[0019] The present invention is not limited to the above-described embodiment, and it can be practiced with a variety of modifications, improvements, etc. within the scope not departing from the gist of the present invention. For example, as illustrated in Fig. 3, the groove portion 4 may be formed in a circular ring shape. With that feature, thermal stress generated upon the ceramic structure 1 being heated to the high temperature can be suppressed from being concentrated in the groove portion 4.

[0020] Alternatively, as illustrated in a sectional view of Fig. 4, a projection 5 may be formed on the surface of the ceramic structure 1 along the outer periphery of the groove portion 4 in continuous relation. With the presence of the projection 5 surrounding the groove portion 4, when gas is supplied and flows around the heater 100, the gas is even more likely to stay in the groove portion 4. When the depth of the groove portion 4 is, for example, 0.1 mm as measured from the region surrounded by the groove portion 4, the projection 5 is formed at a height of 0.01 mm or more as measured from the region surrounded by the groove portion 4.

[0021] As illustrated in Fig. 5, when looking at a cross-section of the ceramic structure 1 sectioned in the direction perpendicular to the surface of the ceramic structure 1, the projection 5 may have a curved shape. With that feature, when gas is supplied and flows around the heater 100, the gas can more easily flow into the inside surrounded by the projection 5. As a result, the gas can be efficiently combusted at the inside surrounded by the projection 5. The shape of the projection 5 may be, e.g., circular-arc or semi-elliptic.

[0022] As illustrated in Figs. 6(a) and 6(b), a recess 6 may be formed, instead of the groove portion 4 surrounding the folded portion 21 in opposing relation, in a region of the surface of the ceramic structure 1, the region overlapping the folded portion 21. With the arrangement that the recess 6 is formed in a region of a surface of the ceramic structure 1, the surface facing the folded portion 21 and the region overlapping the folded portion 21, the surface of a portion of the ceramic structure 1 where the recess 6 is formed (i.e., a bottom surface of the recess 6) can be positioned closer to the heating resistor 2 than the surface of a region around such portion. Accordingly, temperature in the surface of the portion of the ceramic structure 1 where the recess 6 is formed is more apt to increase. Thus, since the recess 6 in which temperature is more apt to increase is formed near the maximally heating region 10, the temperature difference between the maximally heating region 10 and a region in the vicinity of the former can be reduced. Hence unevenness of temperature distribution in the surface of the heater 100 can be suppressed. As a result, long-term reliability of the heater 100 can be improved. When the outer circumference of the folded portion 21 has the curvature radius of 1 mm, the recess 6 is formed in a square shape dimensioned, for example, such that a depth is 0.1 mm and one side of an outer periphery is 2 mm.

[0023] Furthermore, in the heater 100 illustrated in Fig. 6, the region where the recess 6 overlaps the folded portion 21 is positioned at the side closer to the fore end of the ceramic structure 1 than the maximally heating region 10. Stated in another way, a part of the recess 6, the part being positioned closest to the rear end of the ceramic structure 1, is positioned at the side closer to the fore end of the ceramic structure 1 than the maximally heating region 10. With that arrangement, unevenness of the temperature distribution can be further suppressed at the fore end side of the ceramic structure 1 where a heating target is disposed.

[0024] As illustrated in Fig. 7, when looking at a cross-section of the ceramic structure 1 sectioned in the direction perpendicular to the surface of the ceramic structure 1, the recess 6 may have a curved shape. With that feature, concentration of thermal stress generated upon the ceramic structure 1 being heated to the high temperature can be suppressed in the recess 6.

[0025] As illustrated in Fig. 8, a recess 61 may be formed in overlapped relation to a region of a surface of the ceramic structure 1 at the side opposite to the surface where the recess 6 is formed, the region facing the folded portion 21 of the heating resistor 2. With that feature, even when both the surfaces of the heater 100 are used to heat a heating target, the temperature distribution in the surface of the ceramic structure 1 can be made more even.

[0026] The shape of the ceramic structure 1 is not limited to the above-mentioned square rod, and it may be a round rod. Furthermore, a fore end portion of the ceramic structure 1 may have a hemisphere shape.

[0027] The folded portion 21 of the heating resistor 2 is not always limited to the form folded into a semicircular shape as illustrated in the drawings, and it may be folded into a an acute-angular shape or a polygonal shape, e.g., a rectangular shape.

[0028] The folded portion 21 of the heating resistor 2, which faces the surface of the ceramic structure 1, is not always required to be formed such that the folded portion

21 and the linear portions 22 face the surface of the ceramic structure 1 in parallel as illustrated in the drawings. The folded portion 21 may face the surface of the ceramic structure 1 in a state inclined relative to the same.

[0029] One example of a method for manufacturing the heater 100 of this embodiment will be described below. First, conductive pastes each containing conductive ceramic powder, a resin binder, etc. and becoming one of the heating resistor 2 and the power feeders 3 after firing are prepared. Furthermore, a ceramic paste containing insulating ceramic powder, a resin binder, etc. and becoming an insulating base body, which constitutes the ceramic structure 1, after firing is prepared.

[0030] Then, a compact made of the conductive paste, having a predetermined shape, and becoming the heating resistor 2 is formed, for example, by the injection molding method using the conductive paste for the heating resistor 2. In a state where the compact becoming the heating resistor 2 is held in a metallic mold, the metallic mold is filled with the conductive paste for the power feeders 3, and compacts made of the conductive paste, having predetermined shapes, and becoming the power feeders 3 are formed integrally with the above-mentioned compact. This leads to a state where the compacts of the heating resistor 2 and the power feeders 3 connected to the heating resistor 2 are held in the metallic mold.

[0031] Then, in the state where the compacts of the heating resistor 2 and the power feeders 3 are held in the metallic mold, a part of the metallic mold is replaced with another one for molding the ceramic structure 1. Thereafter, the ceramic paste for the ceramic structure 1 is filled into the metallic mold.

[0032] At that time, by employing the metallic mold capable of forming the groove portion 4 or the recess 6 in a region of the surface of the ceramic structure 1, the region facing the folded portion 21 of the heating resistor 1, a compact of the heater 100 is obtained in which the heating resistor 2 and the power feeders 3 are covered with the compact of the ceramic paste, and in which the groove portion 4 surrounding the folded portion 21 in opposing relation or the recess 6 overlapping the folded portion 21 is formed in the region of the surface of the ceramic structure 1, the region facing the folded portion 21 of the heating resistor 2. Then, the compact of the heater 100 including the groove portion 4 or the recess 6, which has the desired shape and size, in the surface of the ceramic structure 1 can be obtained by a method of raising pressure applied to eject an ejection pin when the compact is released from the metallic mold, or by a method of cutting a principal surface of the compact.

[0033] Then, the heater 100 can be fabricated by firing the obtained compact at about 1700°C. The firing is preferably performed in an atmosphere of non-oxidizing gas, e.g., hydrogen gas.

EXAMPLE

[0034] The heater 100 according to EXAMPLE of the present invention was fabricated as follows. First, the heating resistor 2 was fabricated by injection molding, namely by injecting a conductive paste, which contained 50% by mass of tungsten carbide powder, 35% by mass of silicon nitride powder, and 15% by mass of a resin binder, into a metallic mold. In a state where the molded heating resistor 2 was held in the metallic mold, the metallic mold was filled with the above-mentioned conductive paste becoming the power feeders 3, whereby the power feeders 3 were formed and connected to the heating resistor 2.

[0035] Next, in a state where the heating resistor 2 and the power feeders 3 were held in a metallic mold, injection molding was performed by injecting, into the metallic mold, a ceramic paste containing 85% by mass of silicon nitride powder, and 10% by mass of biytterbium trioxide, and 5% by mass of tungsten carbide, the latter two serving as sintering aids. As a result, the heater 100 was formed in which the heating resistor 2 and the power feeders 3 were embedded in the ceramic structure 1, the heating resistor 2 including the folded portion 21 near the fore end of the ceramic structure 1.

[0036] As Sample 1, a sample was fabricated in which the recess 6 in a depth of 50 μm with one side having a length of 2.3 mm was formed in a region of a principal surface (5 mm x 30 mm) of the ceramic structure 1, the region being positioned at the fore end side of the ceramic structure 1 and overlapping the folded portion 21. Furthermore, metallic molds having various shapes were prepared, and heaters 100 (Samples 2 to 4) having principal surfaces different in configuration from that of Sample 1 were fabricated. Those Samples each had dimensions of 5 mm in thickness, 10 mm in width, and 30 mm in length, and they were different only in configuration of the principal surface from Sample 1.

[0037] More specifically, in Sample 2, the groove portion 4 in a depth of 50 μm with one side having a length of 2.3 mm was formed in the principal surface in such a configuration that an inner wall surface at the inner side is inclined more moderately than an inner wall surface at the outer side. In Sample 3, the groove portion 4 in a depth of 50 μm with one side having a length of 2.3 mm was formed in the principal surface, and the projection 5 having a height of 20 μm was further formed in a state surrounding the groove portion 4. In Sample 4, the groove portion 4 in a depth of 50 μm with one side having a length of 2.3 mm was formed in the principal surface, and the projection 5 having a curved surface with a height of 20 μm at a top thereof was further formed in a state surrounding the groove portion 4. In addition, Comparative Example 1 in which the principal surface was flat was prepared as a comparative sample.

[0038] Next, after putting each of Samples 1 to 4 and Comparative Example 1, obtained as described above, in a cylindrical die made of carbon, it was hot-pressed at temperature of 1650°C to 1780°C under pressure of 30 MPa to 50 MPa for sintering in a non-oxidizing gas atmosphere of nitrogen gas.

[0039] By comparing with the heater of Comparative Example 1, the heaters 100 of Samples 1 to 4 representing EXAMPLE of the present invention were confirmed on whether durability was improved.

[0040] In more detail, each sample was set in a gas heater, and an ignition temperature of the gas heater was examined. On the basis of the examined result, an endurance test was carried out by repeating a cycle of, after supplying a current for 30 sec at the ignition temperature, raising temperature at the fore end of the ceramic structure up to 1200°C, and then stopping the supply of the current for 60 sec.

[0041] As a result, the heaters 100 of Samples 1 to 4 continued the normal operation even after the number of cycles reached 230000 or more. In the heater of Comparative Example 1, however, a crack occurred in the principal surface of the ceramic structure 1 near the maximally heating region 10 when the number of cycles reached about 60000.

[0042] As another evaluation test, a temperature distribution in a region from the fore end of the ceramic structure 1 to the maximally heating region 10 was measured by employing a radiation thermometer. In more detail, the temperature distribution in the surface of the ceramic structure 1 was measured under the condition that, after raising the temperature at the fore end of the ceramic structure 1 up to 1200°C, the ceramic structure 1 was left to stand for 5 min in a state keeping application of a voltage.

[0043] As a result, in the heater of Comparative Example 1, the temperature in the maximally heating region of the ceramic structure was 1240°C, and the temperature at the fore end of the ceramic structure was 1200°C. In contrast, in the heater 100 of Sample 1, the temperature in the maximally heating region 10 was 1250°C, the temperature at the fore end was 1230°C, and the temperature in the recess 6 was 1240°C. In the heater 100 of Sample 2, the temperature in the maximally heating region 10 was 1250°C, the temperature at the fore end was 1230°C, and the temperature in the groove portion 4 was 1240°C. In the heater 100 of Sample 3, the temperature in the maximally heating region 10 was 1250°C, the temperature at the fore end was 1230°C, and the temperature in the groove portion 4 was 1240°C. In the heater 100 of Sample 4, the temperature in the maximally heating region 10 was 1250°C, the temperature at the fore end was 1230°C, and the temperature in the groove portion 4 was 1240°C.

[0044] As seen from the above results, the temperature difference in the principal surface of the ceramic structure was relatively large, i.e., 40°C, in the heater of Comparative Example 1, while the relevant temperature difference was relatively small, i.e., 20°C, in the heaters 100 of Samples 1 to 4. Thus, it was confirmed that unevenness of the temperature distribution in the principal surface of the ceramic structure 1 can be reduced by employing the configuration of the heater 100 of the present invention. Consequently, it was also understood that a possibility of the occurrence of a crack in the principal surface of the ceramic structure 1 can be reduced even with repeated use of the heater 100.

[0045] As still another evaluation test, Samples 2 to 4 and Comparative Example 1 were each set inside a casing for the test, the casing being provided with a gas inlet. While continuously supplying gas to flow into the casing, measurement was performed on a time until the gas was ignited after starting supply of a current to each of the heaters 100 of Samples 2 to 4 and the heater of Comparative Example 1, and a time until extinction after stopping the supply of the current. The gas was prepared by evaporating diesel fuel. As a result, in the heaters 100 of Samples 2 and 3, the time until the ignition was within 40 sec. In contrast, in the heater of Comparative Example 1, the time until the ignition took 60 sec. As seen from that result, in the heaters 100 of Samples 2 and 3, the time until the ignition is shortened by 20 sec and ignitibility is improved in comparison with the heater of Comparative Example 1.

[0046] The above result is presumably attributable to the fact that, since the heater 100 of Sample 2 includes the groove portion 4 in which the inner wall surface at the inner side is inclined more moderately than the inner wall surface at the outer side, the flow of the gas incoming from the outer peripheral side of the groove portion 4 is moderated near the inner wall surface at the inner side and the gas is more likely to stay in the groove portion 4, whereby ignitibility is improved. Regarding Sample 3, it is thought that, because of including the projection 5 that surrounds the groove portion 4, the gas is even more likely to stay in the groove portion 4, whereby ignitibility is improved.

[0047] Moreover, comparing the time taken for the extinction after the end of heating between the heater of Comparative Example 1 and the heater 100 of Sample 4, the time until the extinction after stopping the supply of the current was about 70 sec in the heater 100 of Sample 4, while the time until the extinction was about 100 sec in the heater of Comparative Example 1. Such a result is presumably attributable to the fact that, because of the projection 5 having the curved shape, when the gas is supplied and flows around the heater 100, the gas can more easily flow into the inside surrounded by the projection 5, whereby the gas can be efficiently combusted at the inside surrounded by the projection 5.

Reference Signs List

[0048]

1: ceramic structure
10: maximally heating region
2: heating resistor
21: folded portion
22: linear portion
3: power feeder
4: groove portion

5: projection
6: recess
7: lead terminal
100: heater

Claims

1. A heater comprising a ceramic structure, and a heating resistor embedded in the ceramic structure and including a folded portion, wherein the ceramic structure includes, in a surface facing the folded portion, a groove portion that surrounds the folded portion in opposing relation.

2. The heater according to Claim 1, wherein the groove portion has a circular ring shape.

3. The heater according to Claim 1 or 2, wherein the groove portion has a curved shape when looking at a cross-section of the ceramic structure sectioned in a direction perpendicular to the surface of the ceramic structure.

4. The heater according to any one of Claims 1 to 3, wherein a wall surface of the groove portion is inclined more moderately at an inner peripheral side than at an outer peripheral side.

5. The heater according to any one of Claims 1 to 4, wherein a projection is continuously formed along an outer periphery of the groove portion.

6. The heater according to Claim 5, wherein the projection has a curved shape when looking at a cross-section of the ceramic structure sectioned in a direction perpendicular to the surface of the ceramic structure.

7. A heater comprising a ceramic structure, and a heating resistor embedded in the ceramic structure and including a folded portion, wherein the ceramic structure includes a recess in a region of a surface facing the folded portion, the region overlapping the folded portion.

Fig. 1

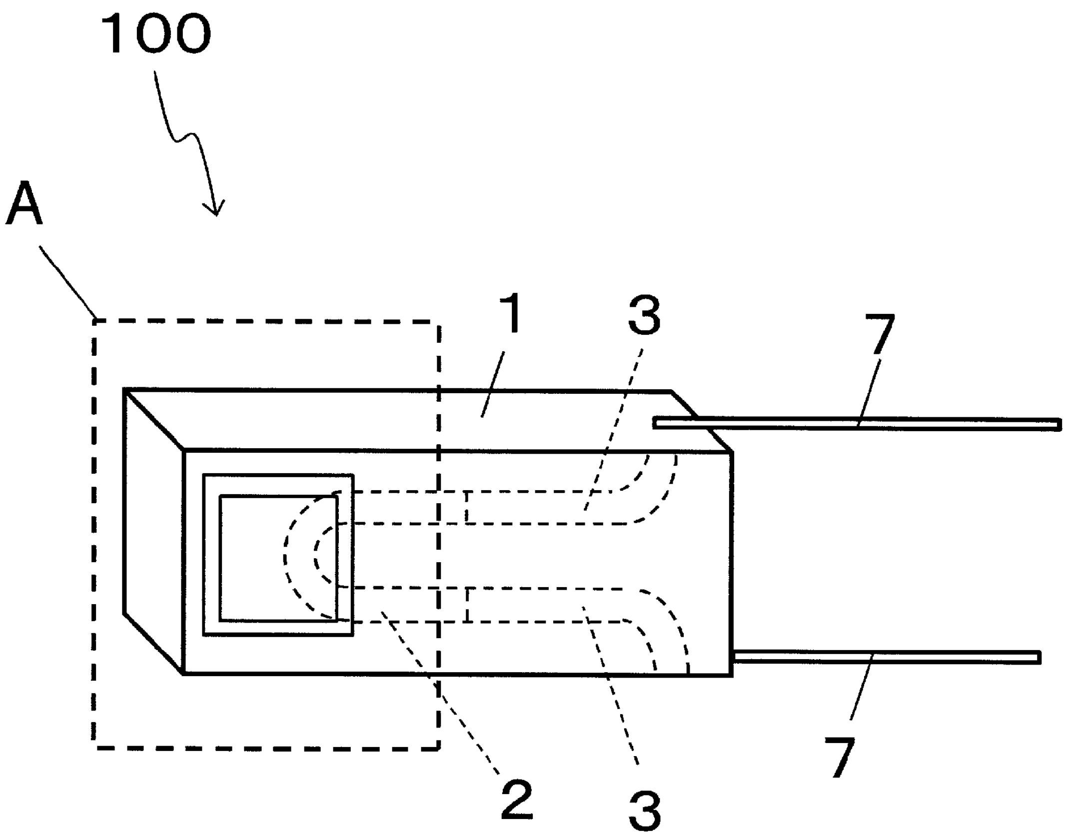


Fig. 2

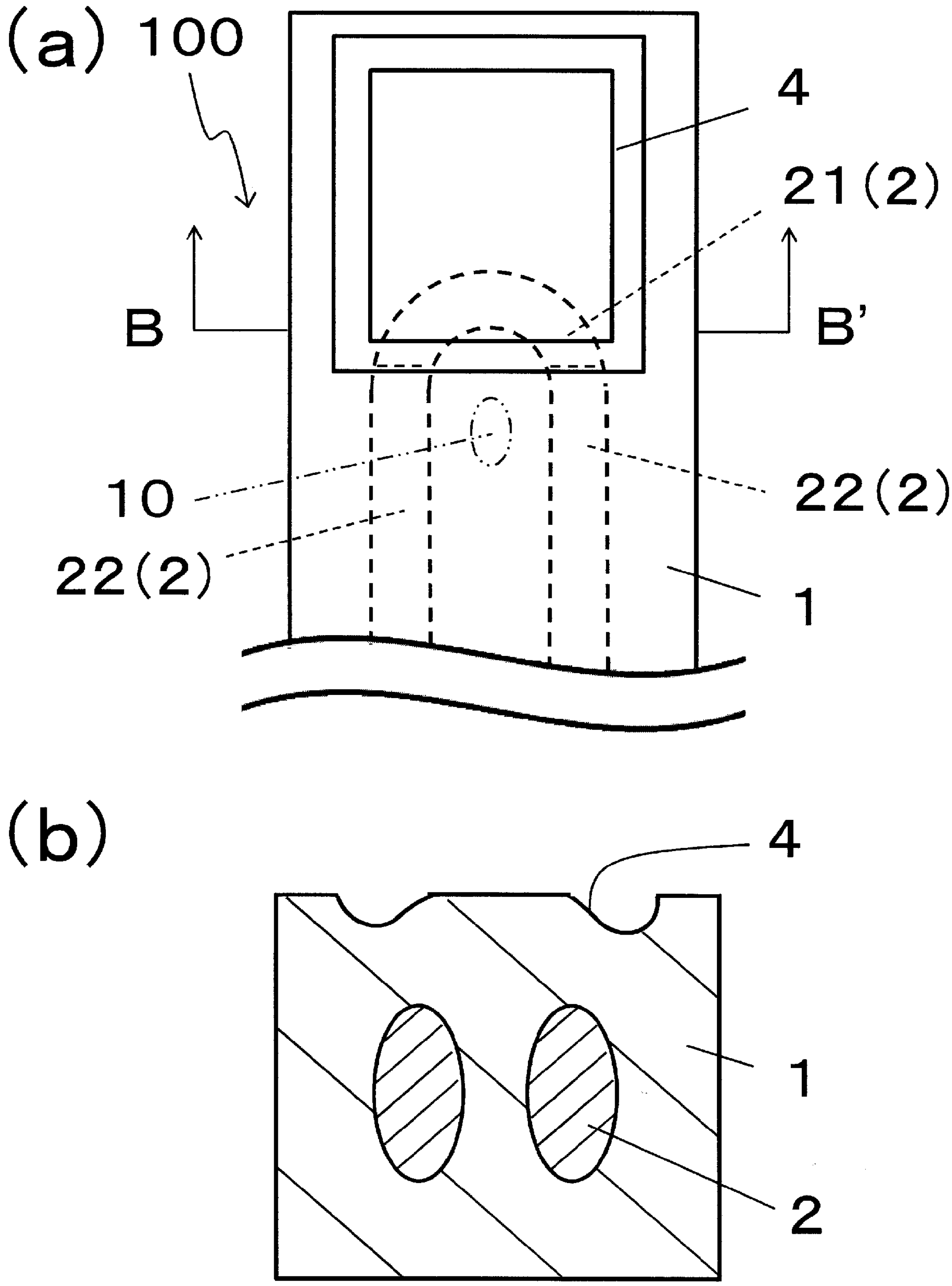


Fig. 3

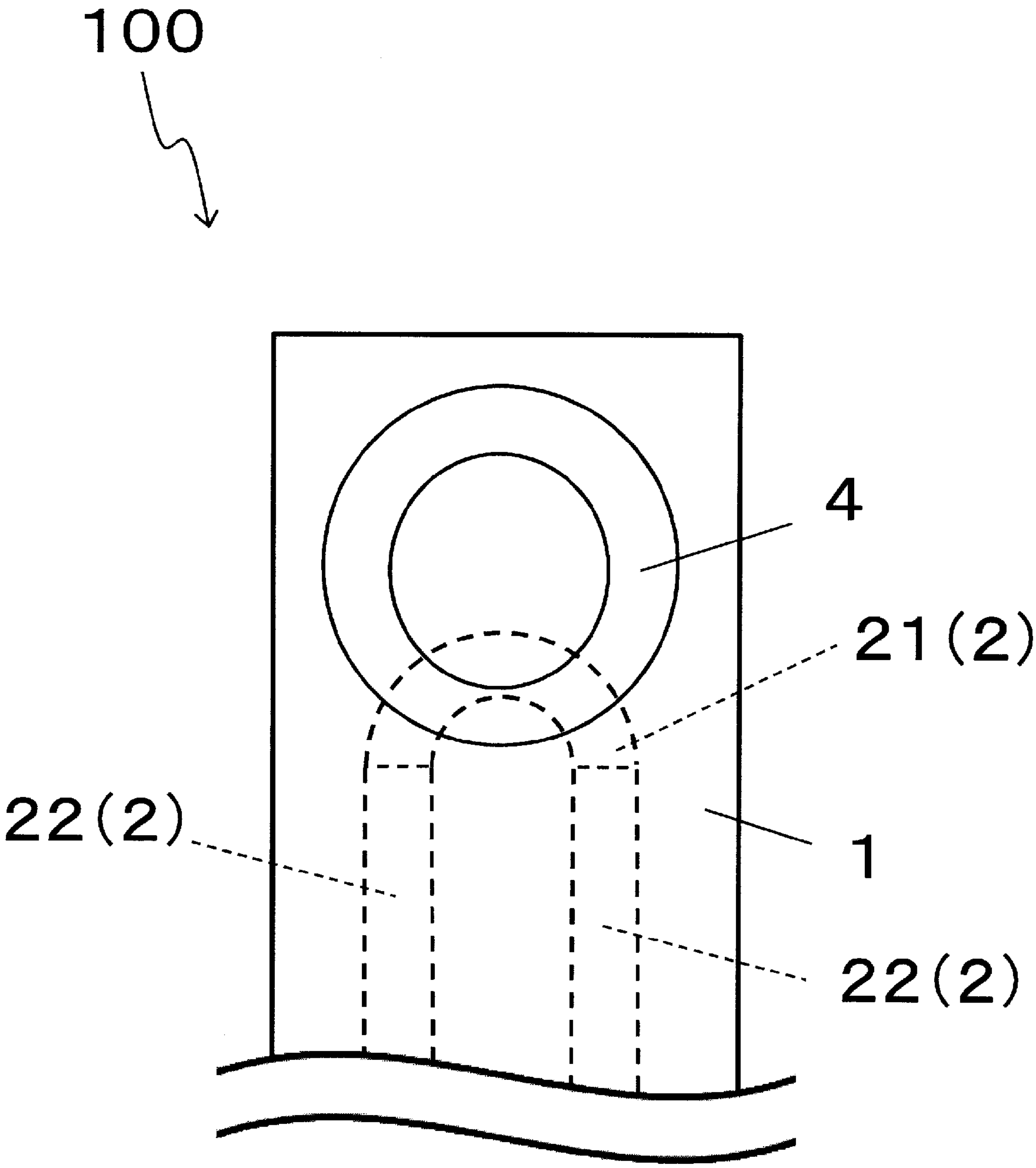


Fig. 4

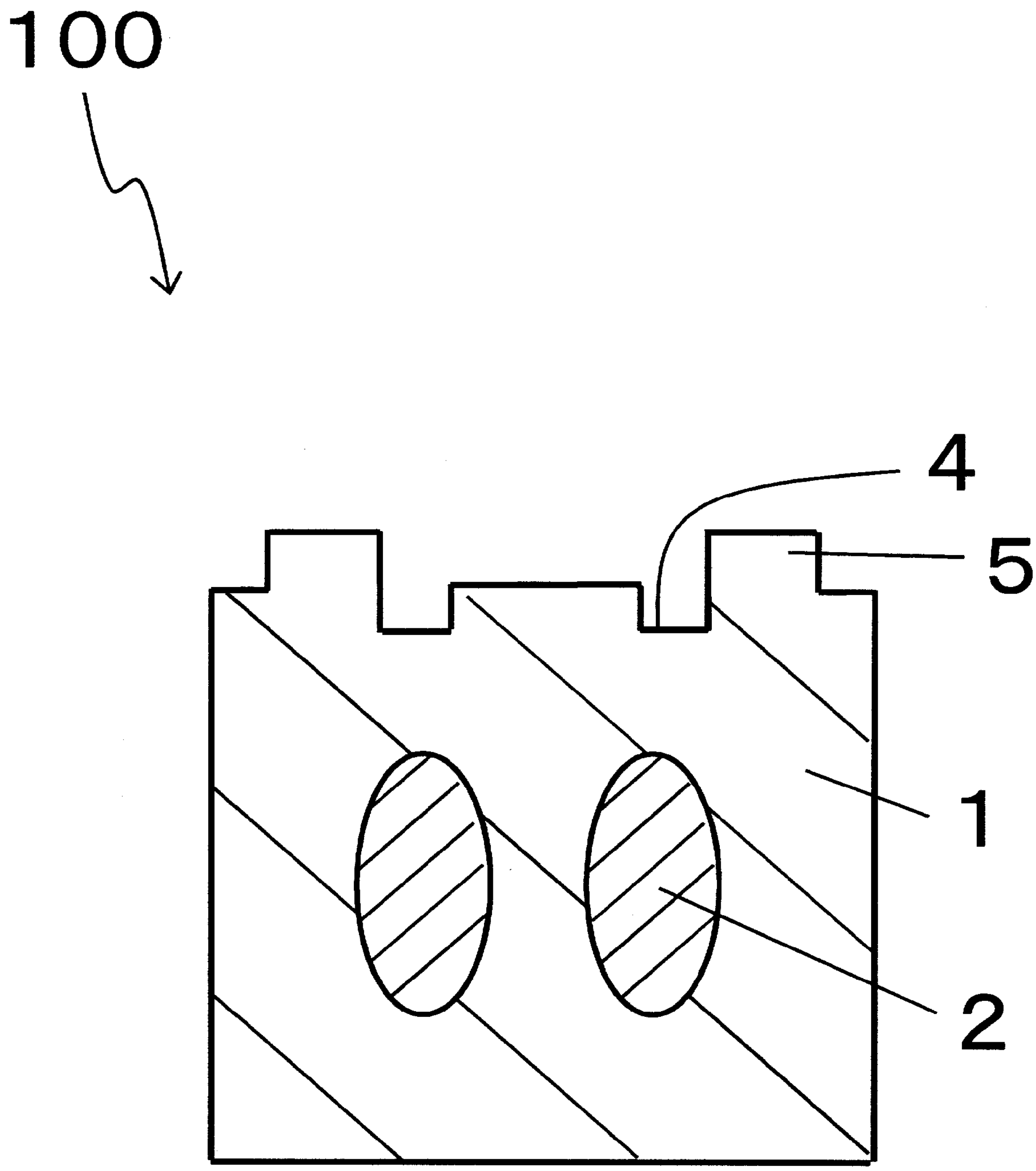


Fig. 5

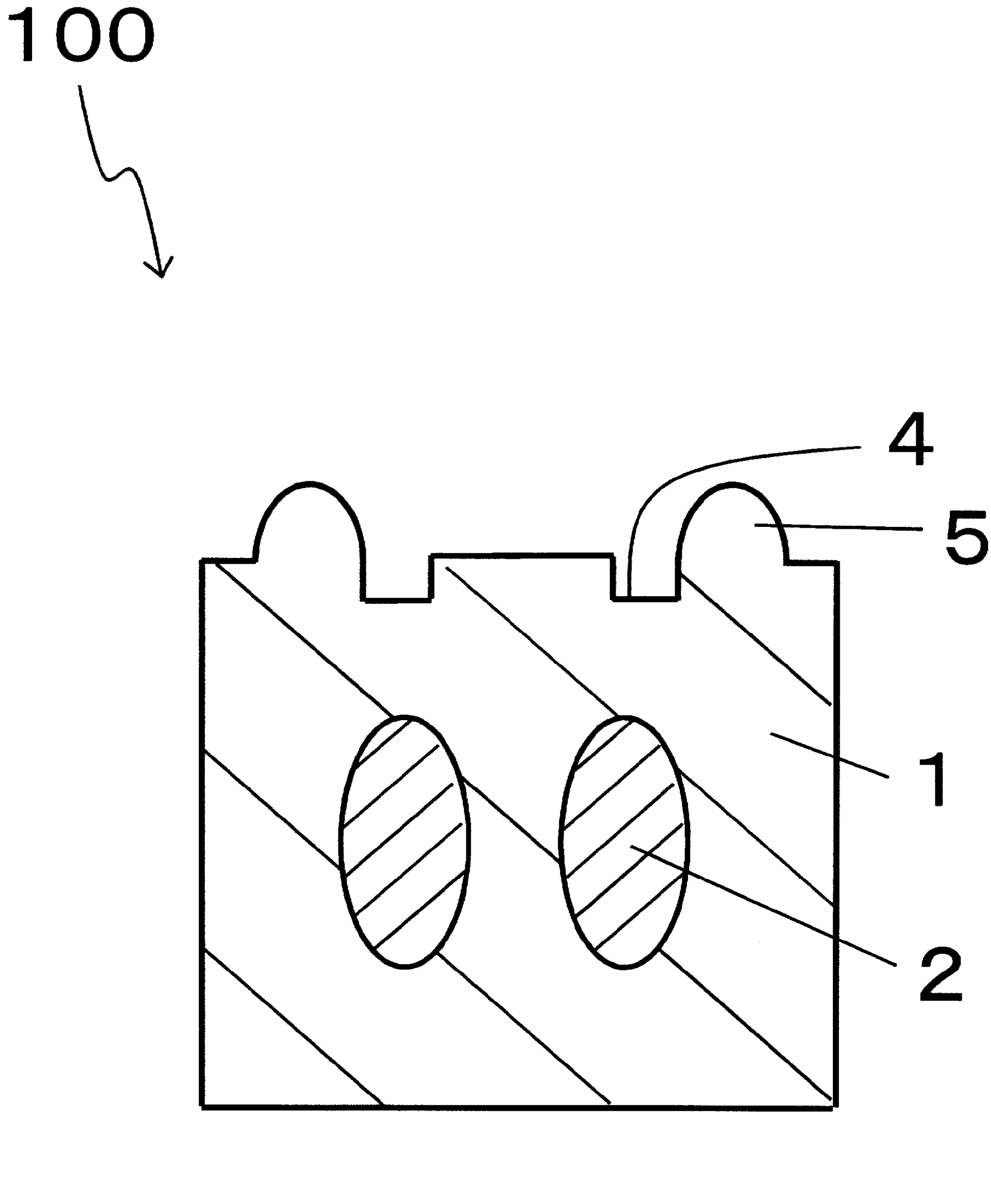
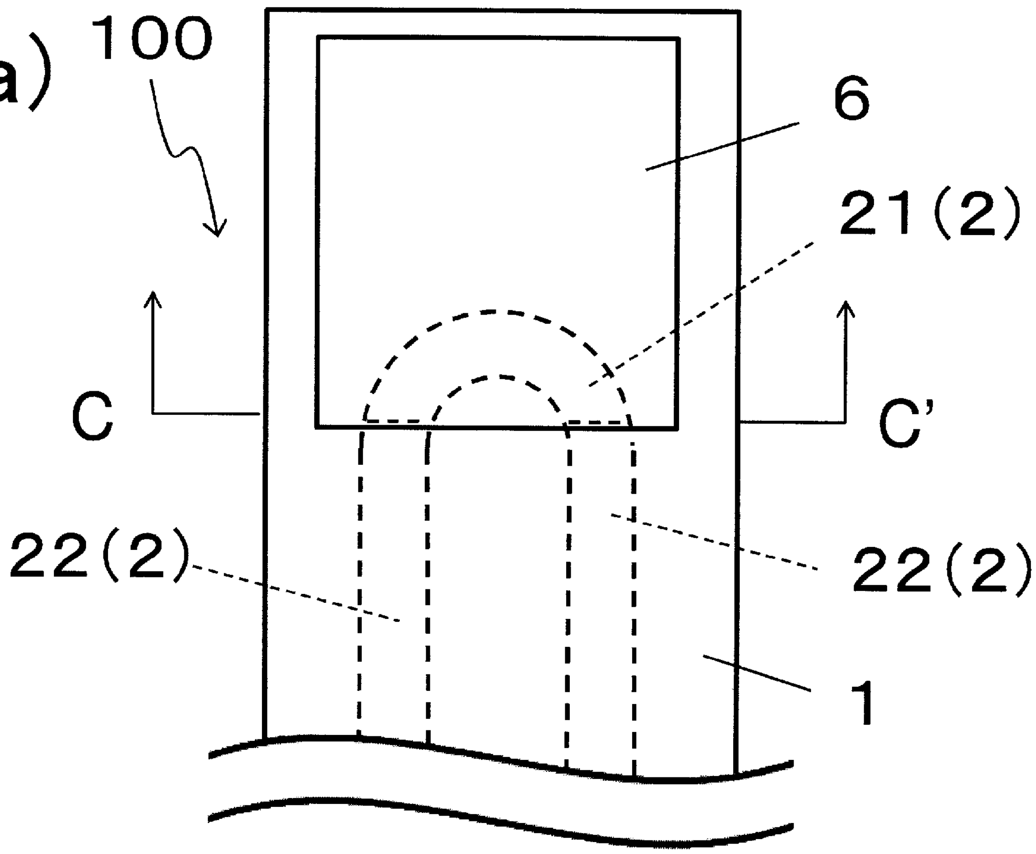


Fig. 6

(a)



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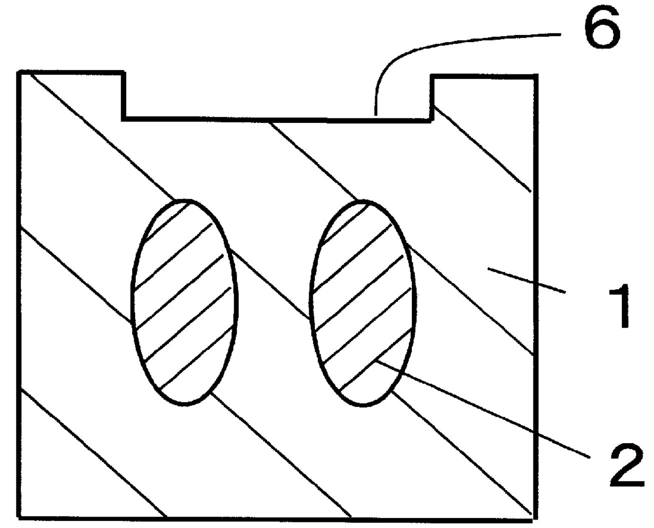


Fig. 7

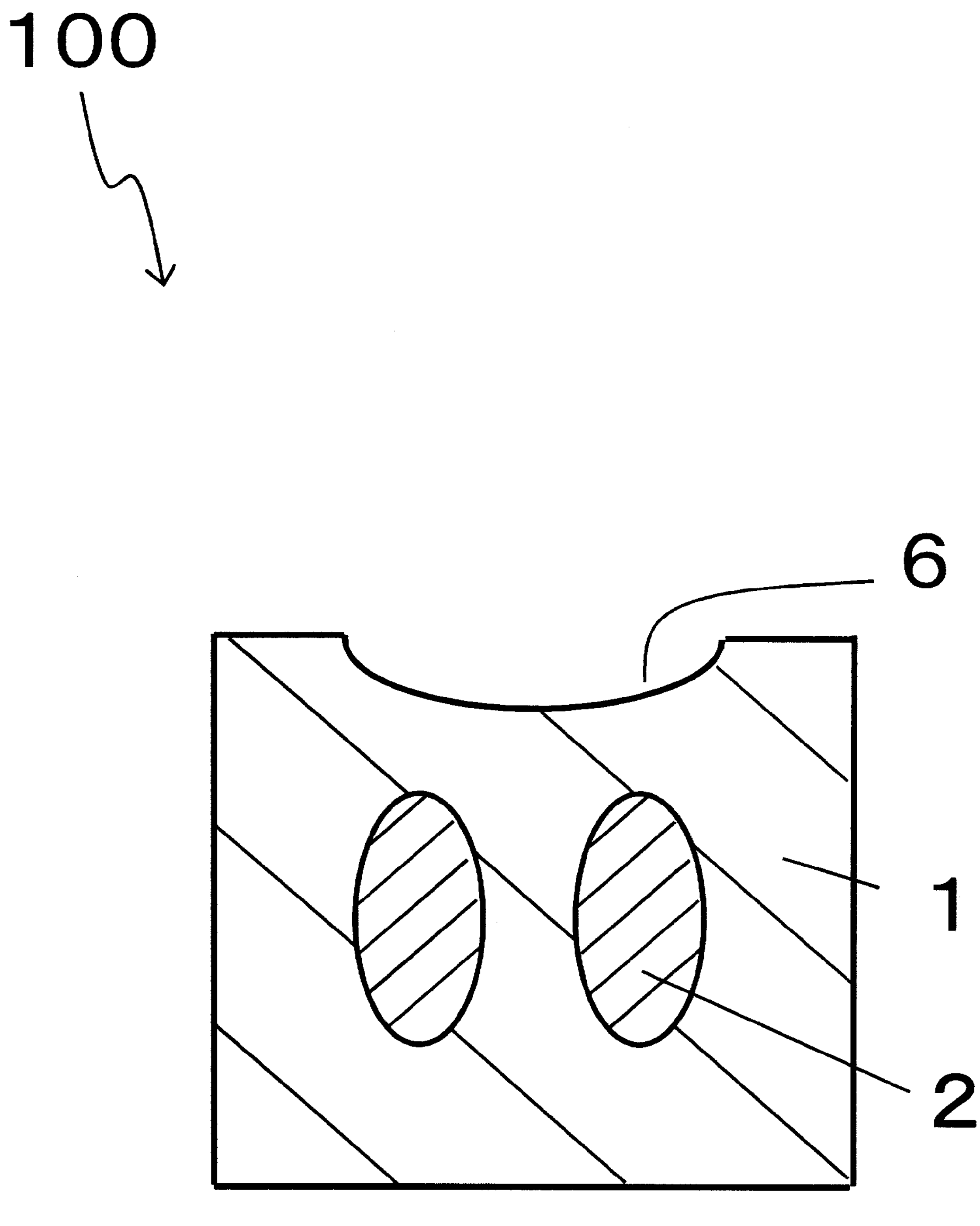
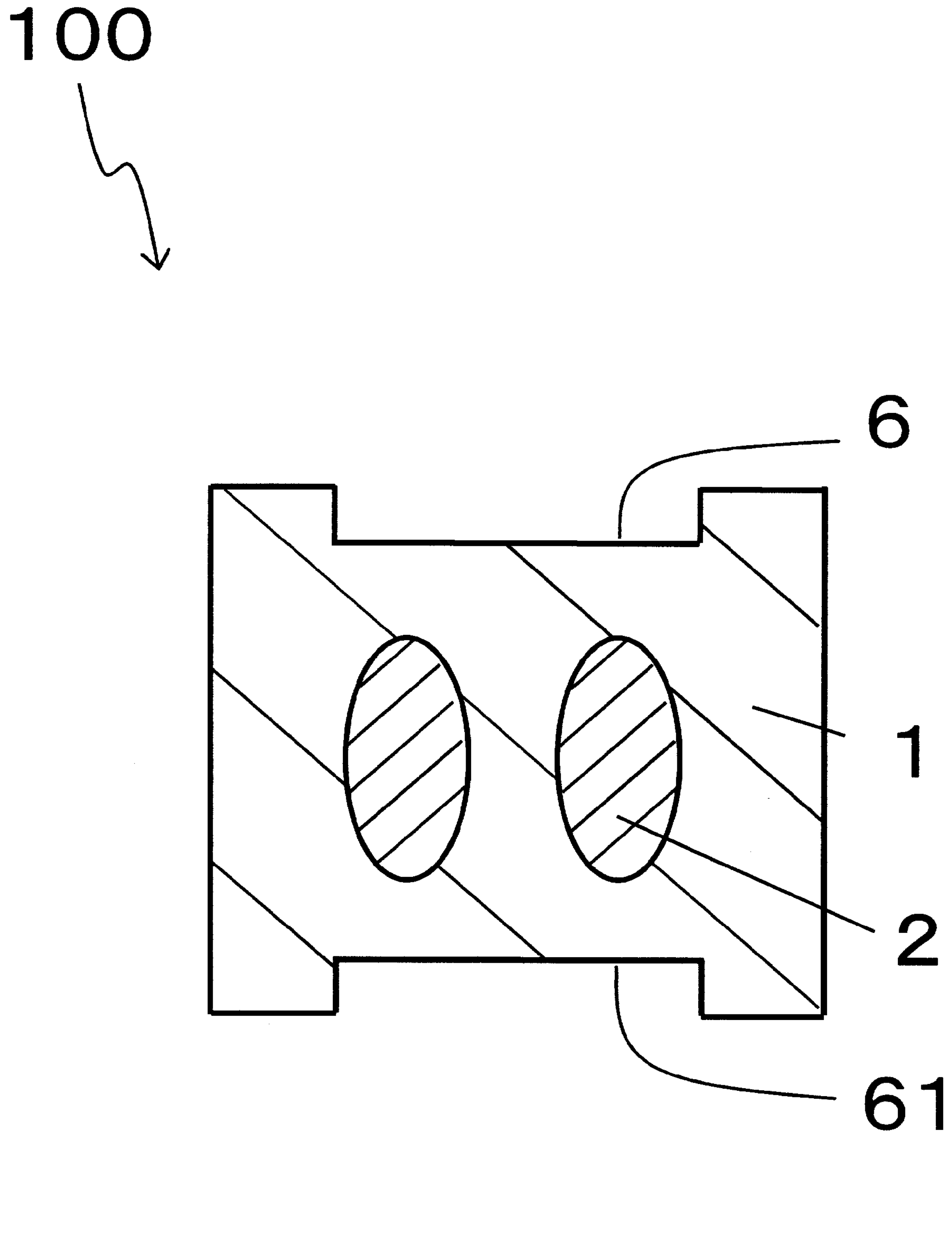


Fig. 8



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2013/085105

A. CLASSIFICATION OF SUBJECT MATTER
H05B3/48(2006.01)i, *F23Q7/00*(2006.01)i

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)
H05B3/48, F23Q7/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2014
Kokai Jitsuyo Shinan Koho	1971-2014	Toroku Jitsuyo Shinan Koho	1994-2014

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 48427/1978(Laid-open No. 150727/1979) (Nippon Heater Kabushiki Kaisha), 19 October 1979 (19.10.1979), entire text; fig. 1 to 5 (Family: none)	1,2 3-7
A	JP 2009-231161 A (NGK Spark Plug Co., Ltd.), 08 October 2009 (08.10.2009), paragraphs [0011] to [0025], [0045]; fig. 1 to 4 (Family: none)	1-7

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
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"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
20 March, 2014 (20.03.14)	01 April, 2014 (01.04.14)

Name and mailing address of the ISA/	Authorized officer
Japanese Patent Office	
Facsimile No.	Telephone No.

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2013/085105

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 3-183942 A (NGK Spark Plug Co., Ltd.), 09 August 1991 (09.08.1991), page 2, lower left column, line 17 to page 3, lower left column, line 12; page 4, upper right column, line 11 to page 5, upper left column, line 7; fig. 1 to 3, 5 to 7 (Family: none)	7
A	JP 1-29427 Y2 (Noritz Corp.), 07 September 1989 (07.09.1989), claims; page 2, column 4, lines 4 to 11; fig. 1 to 5 (Family: none)	1-6

Form PCT/ISA/210 (continuation of second sheet) (July 2009)

REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

- JP 2006040882 A **[0002]**