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(54) **Method for producing a spark plug and spark plug**

Herstellungsverfahren einer Zündkerze und Zündkerze

Méthode de fabrication d'une bougie d'allumage et bougie d'allumage

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Description

[0001] The present invention relates to a method of producing a spark plug, and also to a spark plug.

[0002] JP-A-2002-237365 (and US-A1-2002/0105254) discloses in Fig. 26 a ground electrode in which a noble metal tip is laser-welded to an inner side face that is formed into a tapered shape as it advances toward the tip end side, so as to protrude from the inner side face.

[0003] When the ground electrode is formed into a tapered shape after the noble metal tip is laser welded, impact occurring during formation of the tapered shape may cause a crack or the like in a molten bond formed by the welding. Particularly, this phenomenon has a high tendency to occur when laser welding is conducted in a state where, in order to improve ignitability, a noble metal tip having a small diameter of 0.8 mm or less protrudes by 0.5 mm or more from the inner side face of the ground electrode.

[0004] The present invention has been achieved in view of the above-described problem. It is therefore an object of the present invention to provide a method of producing a spark plug in which the reliability of a molten bond can be improved.

[0005] The above object has been achieved by providing a method of producing a spark plug as defined in claim 1 and a spark plug as defined in claim 6.

[0006] In the case of a diameter of 0.8 mm or less in which a molten bond has a small sectional area, the weld strength is easily reduced. In the case where the protrusion distance of the noble metal tip is 0.5 mm or more, stress due to vibration in the process of forming the tapered faces tends to be easily concentrated in the molten bond. By contrast, when a spark plug is produced by the method of the invention, it is possible to avoid this problem.

[0007] Preferably, the laser welding is conducted after the noble metal tip primarily containing a noble metal is positioned such that the minimum distance between either of the tapered faces and the tip end face of the ground electrode, and the noble metal tip is set to 0.1 mm or more and 0.8 mm or less.

[0008] In the laser welding of the noble metal tip, when the irradiation angle of a laser beam is about $\pm 20°$ with respect to an extension face of the inner side face of the ground electrode to which the discharge portion is to be bonded, the laser welding can be stably conducted. During a laser welding process, although both the discharge portion and the ground electrode must be simultaneously melted, the laser beam can be focused within a range of about 0.8 mm or less. Nickel which is the principal component of the ground electrode base member is more easily melted than the noble metal tip primarily containing a noble metal. Because of these reasons, when laser welding is conducted after positioning the discharge portion in accordance with the invention as described above, the laser welding can be stably conducted.

[0009] In order to prevent spark discharge at the molten bond, preferably, the distance between the tip end face of the noble metal tip and the molten bond is increased. Specifically, the height (t) of the unmelted portion of the noble metal tip is set to 0.3 mm or more. In this manner, a spark plug in which the height of the unmelted portion protruding from the molten bond is large tends to be easily broken. This is because of stress concentration due to vibrations in the process of forming the tapered faces. When the laser welding is conducted after the tapered faces are formed, it is possible to avoid stress concentration on the molten bond occurring during formation of the tapered faces.

[0010] The height (t) of the unmelted portion is defined by the minimum distance between the tip end face of the noble metal tip and the molten bond.

[0011] When the edges formed at a corner between the inner side face and the tapered faces are angular, the electric field is easily concentrated in these portions. As a result, in such a structure, spark discharge at the molten bond easily occurs, and hence the molten bond is susceptible to damage. By contrast, when the edges formed by the inner side face of the ground electrode and the tapered faces are melted during the laser welding and the molten bond is formed into a curved shape at a corner formed between the inner side face and the tapered faces, damage of the molten bond due to concentration of an electric field can be effectively prevented.

[0012] Since the spark plug has a discharge portion in which the diameter is 0.8 mm or less and the height is 0.5 mm or more, the electric field strength is easily concentrated at the tip end of the discharge portion. Moreover, the molten bond is formed so as to extend from the inner side face to the tapered faces, and a corner formed between the inner side face and the tapered faces has a rounded shape. Therefore, concentration of electric field strength hardly occurs in these portions. Because of a synergistic effect due to these two structural features, the electric field strength is concentrated at the tip end of the discharge portion, and hence stable spark discharge is enabled at a low discharge voltage. The spark plug is formed by laser-welding the noble metal tip after the tapered faces are formed. Therefore, the molten bond is not broken by vibrations in the process of forming the tapered faces.

[0013] Preferred examples of a material of the noble metal tip are Pt alloys such as Pt-20 wt% Ni, Pt-20 wt% Rh, and Pt-20 wt% Rh-5 wt% Ni, and Ir alloys such as Ir-5 wt% Pt, Ir-20 wt% Rh, Ir-5 wt% Pt-1 wt% Rh-1 wt% Ni, and Ir-11 wt% Ru-8 wt% Rh-1 wt% Ni. The material is not restricted to these examples, and other known noble metal tips can be suitably applied.

[0014] Embodiments of the invention will now be described, by way of example only, with reference to the accompanying drawings in which:

Fig. 1 is a front view showing an embodiment of a spark plug which is produced by the method of the

present invention.

Figs. 2A to 2E are views diagrammatically showing steps of producing the spark plug of the invention.

Fig. 3 is a diagram showing the minimum distance L between tapered faces and a tip end portion of a ground electrode, and a discharge portion.

Fig. 4 shows test results obtained in evaluating weldability in the case where the minimum distance L is set to have a value of 0 to 1.0 mm.

Figs. 5A and 5B are diagrams showing a state after laser welding in the case where the discharge portion is positioned so as to attain the value of L at which a desirable result is obtained.

Fig. 6 shows the relationship between a ratio of the length (t) of an unmelted portion (straight portion) of a noble metal tip to a horizontal sectional area (S), and a crack occurrence rate after the tapered faces are processed.

[0015] Description of Reference Numerals and Symbols:

1	metal shell
1a	thread portion
2	insulator
3	center electrode
4	ground electrode
4a	inner side face
4b	tapered face
4c	tip end face
51	tip end portion
52	discharge portion
52a	noble metal tip
53	molten bond
6	discharge gap

[0016] Hereinafter, a method of producing a spark plug which is a preferred embodiment of the invention will be described. However, the present invention should not be construed as being limited thereto.

[0017] Fig. 1 shows a spark plug which is produced by the production method of the embodiment. As shown in Fig. 1, the spark plug has a cylindrical metal shell 1. The metal shell 1 comprises a thread portion 1a for fixing the spark plug to an engine block which is not shown. An insulator 2 which is made of alumina ceramic (Al_2O_3) or the like is fixed to the inside of the metal shell 1. A center electrode 3 is fixed to an axial hole 2a of the insulator 2. A tip end portion 2b of the insulator 2 is exposed from the metal shell 1.

[0018] The center electrode 3 is a columnar member in which a metal material having a high thermal conductivity, such as Cu is placed inside the electrode, and another metal material that has high thermal resistance and corrosion resistance, such as a nickel-base alloy consisting of INCONEL 600 (trademark), covers the outside of the metal material having a high thermal conductivity. A tip end portion 51 of the center electrode is exposed from the tip end portion 2b of the insulator 2. The tip end portion 51 is formed by a noble metal tip made of an iridium alloy. The tip end portion 51 is formed so as to have a circular shape in section. In consideration of the heat dissipation property of the tip end portion 51 and the flame quenching effect of the center electrode 3, for example, the tip end portion 51 has a diameter of 0.6 mm and a length of 0.8 mm.

[0019] The center electrode 3 has a small-diameter portion 3c at the tip end side, and has a straight portion at the tip end of the small-diameter portion 3c. A noble metal tip made of 95 wt% of iridium and 5 wt% of platinum is placed on the tip end of the straight portion, and then bonded by laser welding, thereby forming the tip end portion 51. The outer diameter of the straight portion is slightly larger than that of the noble metal tip. The laser welding is conducted at eight spots at an outer periphery of the noble metal tip which are arranged at intervals of 45° in a circumferential direction.

[0020] A ground electrode 4 is fixed by welding to one end of the metal shell 1. The ground electrode 4 is made of a metal material such as a nickel-base alloy consisting of INCONEL 600 (trademark), and has an inner side face (a face opposed to the center electrode) 4a having a width that is smaller as it advances toward the tip end side, in a portion of the inner side face positioned between a pair of tapered faces 4b. A noble metal tip 52a primarily containing a noble metal is bonded to the inner side face 4a by laser welding so as to protrude by about 0.8 mm from the inner side face 4a, thereby forming a discharge portion 52. A discharge gap 6 is formed by the discharge portion 52 and the tip end portion 51 of the center electrode 3. The discharge portion 52 has a circular section shape having a diameter of 0.7 mm, and is formed of an alloy of 80 wt% of platinum and 20 wt% of iridium. Usually, the ground electrode 4 is formed so as to have a width of about 2.2 to 2.8 mm, and the tip end face positioned between the pair of tapered faces is formed so as to have a width of about 0.6 to 1.2 mm. As used herein "primarily containing a noble metal" means that the content of a noble metal(s) is larger than 50 wt%.

[0021] The wear amount due to spark discharge tends to be larger at the tip end portion 51 of the center electrode 3 than at the discharge portion 52 of the ground electrode 4. The temperature of the ground electrode 4 tends to increase more rapidly than the temperature of the center electrode 3. In this embodiment, therefore, the tip end portion 51 is made of an iridium alloy having a higher wear resistance against spark discharge, and the discharge portion 52 is made of a platinum alloy in which oxidation and volatilization can be avoided even at a high temperature.

[0022] Next, a method of producing the spark plug will be specifically described with reference to Fig. 2. A substantially cylindrical metal shell 1' which has not yet been subjected to a threading process is formed by a process such as a cold extrusion process and a cutting process. In the metal shell 1', a tool engagement portion 1d having

a hexagonal section shape is formed on on one end side with respect to an axial middle portion 1b, and a thread forming portion 1a' which is substantially cylindrical, and in which the diameter is smaller than that of the center portion 1 b, is formed on the other end side (see Fig. 2A).

[0023] The ground electrode 4 having the tapered faces 4b formed at the tip end is resistance-welded to a tip end face 1e of the thread forming portion 1a' (see Fig. 2B). Then, a rolling process is applied to the thread forming portion 1 a' of the metal shell 1' to form the thread portion 1 a (Fig. 2C). Next, a surface treatment such as galvanizing is applied to the metal shell 1', and the insulator 2 holding the center electrode 3 to which the noble metal tip is welded to form the tip end portion 51 is attached to the metal shell 1' (Fig. 2D). The noble metal tip 52a is placed in a portion of the inner side face 4a which is positioned between the pair of tapered faces 4b, and in which the width is smaller than the original width of the ground electrode. The interface between the inner side face 4a and the noble metal tip 52a is irradiated with a laser beam in a substantially horizontal direction, thereby forming the discharge portion 52 in the ground electrode 4 (Fig. 2E).

[0024] In this embodiment, the ground electrode 4 in which the tapered faces are previously formed is resistance-welded to thread forming portion 1a'. Alternatively, the tapered faces may be formed after the resistance welding is conducted. Alternatively, the discharge portion 52 may be formed by provisionally welding the noble metal tip 52a to the inner side face 4a of the ground electrode 4 by resistance welding or the like, forming the tapered faces, and thereafter conducting laser welding. In other words, the tapered faces may be formed in the ground electrode 4 at any step so long as laser welding has not yet been conducted.

EXAMPLES

[0025] A preferred arrangement of the discharge portion 52 in the above-described embodiment of the invention will now be described with reference to Figs. 3 to 5.

[0026] Fig. 3 is a diagram showing positioning of the discharge portion 52 with respect to the inner side face 4a of the ground electrode 4, i.e., the minimum distance L between the tapered faces 4b and the tip end face 4c of the ground electrode 4, and the noble metal tip 52a. Fig. 4 shows test results obtained in evaluating weldability in the case where the minimum distance L is set to have a value of 0 to 1.0 mm. The weldability was evaluated in the following manner. A spark plug was repeatedly subjected to 1,000 cycles in each of which the tip end of the spark plug on the side of the spark discharge gap was heated by a gas burner for two minutes to 1,000°C in the vicinity of the molten bond between the ground electrode 4 and the noble metal tip 52a, and then air cooled for one minute (corresponding to a travel distance of about 100,000 km in a durability test on an actual engine under usual traveling conditions). Then, the spark plug which had undergone the test was cut and polished in a plane passing through the center axis of the discharge portion 52, and the section was magnified and observed under a microscope. The length of an oxidized portion (oxidation length) at the interface between the noble metal tip 52a and the ground electrode 4 was measured in the observation field. The measured length of the oxidized portion was divided by the total length of the interface, and the division result was set as an oxidation rate. In a spark plug in which the oxidation rate was larger than 50% the weldability was judged not good (X), that in which the rate was 30 to 50% was judged to have good peel resistance (○), and that in which the rate was smaller than 30% was judged as being excellent (◎).

[0027] As shown in Fig. 4, satisfactory results were obtained when L was 0.1 to 0.8 mm, and the best results were obtained when L was 0.3 to 0.5 mm.

[0028] Fig. 5 is a diagram showing a state after laser welding in the case where the discharge portion 52 is formed by placing the noble metal tip 52a on the inner side face 4a of the ground electrode 4 so as to attain the value of L at which the best result is obtained. Fig. 5B is a partial sectional view taken along the line A-A' in Fig. 5A. As shown in Fig. 5B, a molten bond 53 is formed so as to extend from the inner side face 4a to the tapered faces 4b. The molten bond 53 has a curved shape which protrudes outward in a convex shape, and has a radius of curvature R, at a corner between the inner side face 4a and the tapered faces 4b. Preferably, the radius of curvature R is in the range of 0.3 mm to 1.0 mm (in the examples, about 0.4 mm).

[0029] In the noble metal tip 52a, a portion (unmelted portion) which is not melted by the laser welding has a height t of 0.45 mm. The minimum distance (the height t of the unmelted portion) between the tip end face of the noble metal tip 52a and the molten bond 53 is set to 0.3 mm or more. In the resulting structure, therefore, discharge at the molten bond hardly occurs.

[0030] Moreover, the noble metal tip 52a is laser-welded so as to satisfy a relationship of $t \geq 0.78 \times S$ between the height (t) of the unmelted portion of the noble metal tip 52a and a horizontal sectional area S of the noble metal tip 52a.

[0031] With respect to a noble metal tip having a height of 0.8 mm and a tip diameter ϕ of 0.7 mm (the horizontal sectional area = about 0.385 mm^2), while changing the height (t) of an unmelted portion in the range of 0.1 mm to 0.55 mm, the relationship between t/S and the crack occurrence rate was evaluated in the case where tapered faces were formed after the noble metal tip was laser-welded. The results are shown in Fig. 6.

[0032] Fig. 6 shows that when tapered faces are formed after a noble metal tip satisfying $t \geq 0.78 \times S$ is laser-welded, the crack occurrence rate is high. By contrast, in the Examples, the noble metal tip is welded to the ground electrode in which the tapered faces are previously formed. Even in the case of a noble metal tip satisfying $t \geq 0.78 \times S$, therefore, it is possible to prevent

cracks from occurring.

[0033] In the Examples, as shown in Fig. 5A, the edges formed at a corner between the tapered faces 4b of the ground electrode and the tip end face 4c are melted by a laser beam to have a curved shape which protrudes outward in a convex shape, and which has a radius of curvature r. According to this configuration, the electric field strength can be further suppressed from concentrating at such edges as compared with the case where the edges formed by the tapered faces 4b of the ground electrode and the tip end face 4c are angular as shown in Fig. 3. Therefore, this configuration prevents the molten bond 53 from becoming damaged.

[0034] In Fig. 5A, as viewed from the tip end face of the noble metal tip 52a, a middle portion of the molten bond 53 on the side of the metal shell (the rear end side) has an inward recessed shape. Namely, this portion has a structure in which the width (the minimum distance between the outer peripheral edge of the molten bond 53 and the outer peripheral face of the noble metal tip 52a) is smaller than the width of another portion. The reason therefor is as follows. The front face of the noble metal tip on the side of the metal shell is hardly irradiated with a laser beam, because of obstruction by the metal shell. Therefore, the laser irradiation is conducted in an oblique direction. In the front face of the noble metal tip on the side of the metal shell, as a result, the width of the molten bond is smaller than that of another portion. Even in such a shape, in order to obtain sufficient bonding strength between the noble metal tip 52a and the ground electrode 4, preferably, a minimum width of 0.25 mm or more is ensured in the recessed portion.

[0035] It should further be apparent to those skilled in the art that various changes in form and detail of the invention as shown and described above may be made. It is intended that such changes be included within the scope of the claims appended hereto.

Claims

1. A method of producing a spark plug, said spark plug including:

   a center electrode (3);
   an insulator (2) which holds said center electrode (3) therein in a state where a tip end portion (51) of said center electrode (3) protrudes therefrom;
   a metal shell (1) which holds said insulator (2) therein;
   a ground electrode (4) which is fixed to said metal shell (1), said ground electrode (4) having an inner side face (4a) having a width that is smaller as it advances toward a tip end side, in a portion of the inner side face (4a) positioned between a pair of tapered faces (4b); and
   a discharge portion (52) which is bonded to said inner side face (4a) of said ground electrode (4) by laser welding so as to attain a diameter of 0.8 mm or less and a height of 0.5 mm or more, a discharge gap (6) being formed between said discharge portion (52) and said tip end portion (51) of said center electrode (3), **characterized in that** said method comprises:

   forming said tapered faces (4b) before said discharge portion (52) is laser-welded to said inner side face (4a), forming said molten bond (53) by laser welding so as to extend from said inner side face (4a) to said tapered faces (4b), said molten bond (53) having a curved shape (R) at a corner formed between said inner side face (4a) and said tapered faces (4b).

2. The method as claimed in claim 1, which comprises forming said discharge portion (52) by bonding a noble metal tip (52a) to said inner side face (4a) after said noble metal tip (52a) primarily containing a noble metal is positioned so as to set a minimum distance between said tip (52a), and either of said tapered faces (4b) and a tip end face (4c) of said ground electrode (4) of from 0.1 to 0.8 mm.

3. The method as claimed in claim 1 or 2, which comprises forming a molten bond (53) by laser welding, leaving said noble metal tip (52a) with an unmelted portion having a height of 0.3 mm or more.

4. The method as claimed in claim 1, 2 or 3, which comprises forming a molten bond (53) by laser welding, satisfying a relationship of $t \geq 0.78 \times S$, between a height in mm, t of an unmelted portion of said noble metal tip (52a) and a horizontal sectional area in mm^2, S of said noble metal tip (52a).

5. The method as claimed in claim 1, wherein said molten bond (53) has a curved shape which has a radius of curvature of from 0.3 to 1.0 mm.

6. A spark plug comprising:

   a center electrode (3);
   an insulator (2) which holds said center electrode (3) therein in a state where a tip end portion (51) of said center electrode (3) protrudes therefrom;
   a metal shell (1) which holds said insulator (2) therein;
   a ground electrode (4) which is fixed to said metal shell (1), said ground electrode (4) having an inner side face (4a) having a width that is smaller as it advances toward a tip end side, in a portion of the inner side face (4a) positioned between a pair of tapered faces (4b);

a discharge portion (52) in which a noble metal tip (52a) is bonded to said inner side face (4a) of said ground electrode (4) by laser welding so as to attain a diameter of 0.8 mm or less and a height of 0.5 mm or more, a discharge gap (6) being formed between said discharge portion (52) and said tip end portion (51) of said center electrode (3); and
a molten bond (53), in which said noble metal tip (52a) and said ground electrode (4) are melted together, **characterized in that** said molten bond (53) extends from said inner side face (4a) to said tapered faces (4b), said molten bond (53) having a curved shape (R) at a corner formed between said inner side face (4a) and said tapered faces (4b).

7. The spark plug as claimed in claim 6, wherein said molten bond (53) has a curved shape which has a radius of curvature of from 0.3 to 1.0 mm.

8. The spark plug as claimed in claim 6 or 7, wherein said noble metal tip (52a) is welded such that an unmelted portion of said noble metal tip (52a) protrudes by 0.3 mm or more from said molten bond (53).

9. The spark plug as claimed in claim 6, 7 or 8, wherein said noble metal tip (52a) satisfies a relationship of $t \geq 0.78 \times S$, between a height in mm, t of said unmelted portion and a horizontal sectional area in mm^2, S.

10. The spark plug as claimed in any one of claims 6 to 9, wherein said noble metal tip (52a) comprises an alloy selected from the group consisting of a Pt-Ni alloy, a Pt-Rh alloy, a Pt-Rh-Ni alloy, an Ir-Pt alloy, an Ir-Rh alloy, an Ir-Pt-Rh-Ni alloy, and an Ir-Ru-Rh-Ni alloy.

11. The spark plug as claimed in any one of claims 6 to 10, wherein said molten bond (53) has a shape in which a middle portion on a side of said metal shell (1) is inward recessed as viewed from a tip end face of said noble metal tip (52a), and a minimum distance between an outer peripheral edge of said molten bond (53) in said recessed portion and an outer peripheral face of said noble metal tip (52a) is 0.25 mm or more.

Patentansprüche

1. Verfahren zum Herstellen einer Zündkerze, wobei die Zündkerze Folgendes umfasst:

eine Mittelelektrode (3);
einen Isolator (2), der darin die Mittelelektrode (3) in einem Zustand hält, bei dem ein Spitzenendteil (51) der Mittelelektrode (3) daraus hervorragt;
ein Metallgehäuse (1), das den Isolator (2) darin hält;
eine Masseelektrode (4), die an dem Metallgehäuse (1) befestigt ist, wobei die Masseelektrode (4) eine innere Seitenfläche (4a) hat, die eine Breite hat, welche kleiner ist, während sie zu einer Spitzenendseite fortschreitet, in einem Teil der inneren Seitenfläche (4a), die zwischen einem Paar von verjüngten Flächen (4b) positioniert ist; und
einen Entladeteil (52), der an der inneren Seitenfläche (4a) der Masseelektrode (4) durch Laserschweißen befestigt ist, um so einen Durchmesser von 0,8 mm oder weniger und eine Höhe von 0,5 mm oder mehr zu erreichen, wobei ein Entladungsspalt (6) zwischen Entladungsteil (52) und dem Spitzenendteil (51) der Mittelelektrode (3) gebildet ist, **dadurch gekennzeichnet, dass** das Verfahren Folgendes umfasst:

Bilden der verjüngten Flächen (4b), bevor der Entladungsteil (52) an der inneren Seitenfläche (4a) lasergeschweißt wird, Bilden der geschmolzenen Bindung (53) durch Laserschweißen, um so sich von der inneren Seitenfläche (4a) aus zu den verjüngten Flächen (4b) zu erstrecken, wobei die geschmolzene Bindung (53) eine gekrümmte Form (R) an einer Ecke hat, die zwischen der inneren Seitenfläche (4a) und den verjüngten Flächen (4b) gebildet ist.

2. Verfahren nach Anspruch 1, das das Bilden des Entladungsteils (52) durch Bonden einer Edelmetallspitze (52a) an der inneren Seitenfläche (4a) umfasst, nachdem die Edelmetallspitze (52a), die primär ein Edelmetall enthält, so positioniert ist, dass sie eine minimale Distanz zwischen der Spitze (52a) und einer der verjüngten Flächen (4b) und einer Spitzendfläche (4c) der Masseelektrode (4) von 0,1 bis 0,8 mm einstellt.

3. Verfahren nach Anspruch 1 oder 2, das das Bilden einer geschmolzenen Bindung (53) durch Laserschweißen umfasst, wobei die Edelmetallspitze (52a) mit einem ungeschmolzenen Teil zurückgelassen wird, der eine Höhe von 0,3 mm oder mehr hat.

4. Verfahren nach Anspruch 1, 2 oder 3, das das Bilden einer geschmolzenen Bindung (53) durch Laserschweißen umfasst, welche eine Beziehung von $t \geq 0{,}78 \times S$ erfüllt, zwischen einer Höhe in Millimetern, t, eines ungeschmolzenen Teils der Edelmetallspitze (52a) und einer horizontalen Schnittfläche in mm^2, S, der Edelmetallspitze (52a).

5. Verfahren nach Anspruch 1, wobei die geschmolzene Bindung (53) eine gekrümmte Form hat, die einen Krümmungsradius von 0,3 bis 1,0 mm hat.

6. Zündkerze, umfassend:

eine Mittelelektrode (3);
einen Isolator (2), der darin die Mittelelektrode (3) in einem Zustand hält, bei dem ein Spitzenendteil (51) der Mittelelektrode (3) daraus hervorragt;
ein Metallgehäuse (1), das den Isolator (2) darin hält; eine Masseelektrode (4), die an dem Metallgehäuse (1) befestigt ist, wobei die Masseelektrode (4) eine innere Seitenfläche (4a) hat, die eine Breite hat, welche kleiner ist, während sie zu einer Spitzenendseite fortschreitet, in einem Teil der inneren Seitenfläche (4a), die zwischen einem Paar von verjüngten Flächen (4b) positioniert ist;
einen Entladeteil (52), in dem eine Edelmetallspitze (52a) an der inneren Seitenfläche (4a) der Grundelektrode (4) durch Laserschweißen befestigt ist, um so einen Durchmesser von 0,8 mm oder weniger und eine Höhe von 0,5 mm oder mehr zu erreichen, wobei ein Entladungsspalt (6) zwischen dem Entladungsteil (52) und dem Spitzenendteil (51) der Mittelelektrode (3) gebildet ist;
eine geschmolzene Bindung (53), in der die Edelmetallspitze (52a) und die Grundelektrode (4) miteinander verschmolzen sind, **dadurch gekennzeichnet, dass** sich die geschmolzene Bindung (53) von der inneren Seitenfläche (4a) bis zu den verjüngten Flächen (4b) erstreckt, wobei die geschmolzene Bindung (53) eine gekrümmte Form (R) an einer Ecke hat, die zwischen der inneren Seitenfläche (4a) und den verjüngten Flächen (4b) gebildet ist.

7. Zündkerze nach Anspruch 6, wobei die geschmolzene Bindung (53) eine gekrümmte Form hat, die einen Krümmungsradius von 0,3 bis 1,0 mm hat.

8. Zündkerze nach Anspruch 6 oder 7, wobei die Edelmetallspitze (52a) so geschweißt ist, dass ein ungeschmolzener Teil der Edelmetallspitze (52a) um 0,3 mm oder mehr von der geschmolzenen Bindung (53) vorragt.

9. Zündkerze nach Anspruch 6, 7 oder 8, wobei die Edelmetallspitze (52a) eine Beziehung von $t \geq 0{,}78 \times S$ erfüllt, zwischen einer Höhe in mm, t, des ungeschmolzenen Teils und einer horizontalen Schnittfläche in mm^2, S.

10. Zündkerze nach einem der Ansprüche 6 bis 9, wobei die Edelmetallspitze (52a) eine Legierung umfasst, die aus der Gruppe bestehend aus einer Pt-Ni-Legierung, einer Pt-Rh-Legierung, einer Pt-Rh-Ni-Legierung, einer Ir-Pt-Legierung, einer Ir-Rh-Legierung, einer Ir-Pt-Rh-Ni-Legierung und einer Ir-Ru-Rh-Ni-Legierung ausgewählt ist.

11. Zündkerze nach einem der Ansprüche 6 bis 10, wobei die geschmolzene Bindung (53) eine Form hat, bei der ein Mittelteil auf einer Seite des Metallgehäuses (1) nach innen vertieft ist, wenn er von einer Spitzenendfläche der Edelmetallspitze (52a) betrachtet wird, und ein Mindestabstand zwischen einer äußeren peripheren Kante der geschmolzenen Bindung (53) im vertieften Teil und einer äußeren peripheren Fläche der Edelmetallspitze (52a) 0,25 mm oder mehr beträgt.

Revendications

1. Procédé pour produire une bougie d'allumage, ladite bougie d'allumage comprenant :

une électrode centrale (3) ;
un isolant (2) qui maintient ladite électrode centrale (3) à l'intérieur de ce dernier dans un état dans lequel une partie d'extrémité de pointe (51) de ladite électrode centrale (3) fait saillie de ce dernier ;
une coque métallique (1) qui maintient ledit isolant (2) à l'intérieur de cette dernière ;
une électrode de masse (4) qui est fixée sur ladite coque métallique (1), ladite électrode de masse (4) ayant une face latérale interne (4a) ayant une largeur qui est plus petite au fur et à mesure qu'elle avance vers un côté d'extrémité de pointe, dans une partie de la face latérale interne (4a) positionnée entre une paire de faces progressivement rétrécies (4b) ; et
une partie de décharge (52) qui est reliée à ladite face latérale interne (4a) de ladite électrode de masse (4) par soudage au laser afin d'atteindre un diamètre de 0,8 mm ou inférieur et une hauteur de 0,5 mm ou supérieure, un entrefer de décharge (6) étant formé entre ladite partie de décharge (52) et ladite partie d'extrémité de pointe (51) de ladite électrode centrale (3), **caractérisé en ce que** ledit procédé comprend les étapes consistant à :

former lesdites faces progressivement rétrécies (4b) avant que ladite partie de décharge (52) ne soit soudée au laser sur ladite face latérale interne (4a), former ladite liaison en fusion (53) par soudage au laser afin de s'étendre de ladite face latérale interne (4a) vers lesdites faces progressivement rétrécies (4b), ladite liaison en fusion

(53) ayant une forme incurvée (R) au niveau d'un coin formé entre ladite face latérale interne (4a) et lesdites faces progressivement rétrécies (4b).

2. Procédé selon la revendication 1, qui comprend l'étape consistant à former ladite partie de décharge (52) en reliant une pointe de métal noble (52a) à ladite face latérale interne (4a) après que ladite pointe de métal noble (52a) contenant principalement un métal noble a été positionnée afin de déterminer une distance minimum entre ladite pointe (52a) et chacune desdites faces progressivement rétrécies (4b) et une face d'extrémité de pointe (4c) de ladite électrode de masse (4) de 0,1 à 0,8 mm.

3. Procédé selon la revendication 1 ou 2, qui comprend l'étape consistant à former une liaison en fusion (53) par soudage au laser, en laissant ladite pointe de métal noble (52a) avec une partie non fondue ayant une hauteur de 0,3 mm ou supérieure.

4. Procédé selon la revendication 1, 2 ou 3, qui comprend l'étape consistant à former une liaison en fusion (53) par soudage au laser, satisfaisant une relation de $t \geq 0{,}78 \times S$, entre une hauteur en mm, t d'une partie non fondue de ladite pointe de métal noble (52a) et une surface transversale horizontale en mm^2, S de ladite pointe de métal noble (52a).

5. Procédé selon la revendication 1, dans lequel ladite liaison en fusion (53) a une forme incurvée qui a un rayon de courbure de l'ordre de 0,3 à 1,0 mm.

6. Bougie d'allumage comprenant :

une électrode centrale (3) ;
un isolant (2) qui maintient ladite électrode centrale (3) à l'intérieur de ce dernier dans un état dans lequel une partie d'extrémité de pointe (51) de ladite électrode centrale (3) fait saillie de ce dernier ;
une coque métallique (1) qui maintient ledit isolant (2) à l'intérieur de cette dernière ;
une électrode de masse (4) qui est fixée sur ladite coque métallique (1), ladite électrode de masse (4) ayant une face latérale interne (4a) ayant une largeur qui est inférieure au fur et à mesure qu'elle avance vers un côté d'extrémité de pointe, dans une partie de la face latérale interne (4a) positionnée entre une paire de faces progressivement rétrécies (4b) ;
une partie de décharge (52) dans laquelle une pointe de métal noble (52a) est reliée à ladite face latérale interne (4a) de ladite électrode de masse (4) par soudage au laser afin d'atteindre un diamètre de 0,8 mm ou inférieur et une hauteur de 0,5 mm ou supérieure, un entrefer de décharge (6) étant formé entre ladite partie de décharge (52) et ladite partie d'extrémité de pointe (51) de ladite électrode centrale (3) ; et
une liaison en fusion (53) dans laquelle ladite pointe de métal noble (52a) et ladite électrode de masse (4) sont fondues ensemble, **caractérisée en ce que** ladite liaison en fusion (53) s'étend à partir de ladite face latérale interne (4a) jusqu'auxdites faces progressivement rétrécies (4b), ladite liaison en fusion (53) ayant une forme incurvée (R) au niveau d'un coin formé entre ladite face latérale interne (4a) et lesdites faces progressivement rétrécies (4b).

7. Bougie d'allumage selon la revendication 6, dans laquelle ladite liaison en fusion (53) a une forme incurvée qui a un rayon de courbure de l'ordre de 0,3 à 1,0 mm.

8. Bougie d'allumage selon la revendication 6 ou 7, dans laquelle ladite pointe de métal noble (52a) est soudée de sorte qu'une partie non fondue de ladite pointe de métal noble (52a) fait saillie de 0,3 mm ou plus de ladite liaison en fusion (53).

9. Bougie d'allumage selon la revendication 6, 7 ou 8, dans laquelle ladite pointe de métal noble (52a) satisfait une relation de $t \geq 0{,}78 \times S$, entre une hauteur en mm, t de ladite partie non fondue et une surface transversale horizontale en mm^2, S.

10. Bougie d'allumage selon l'une quelconque des revendications 6 à 9, dans laquelle ladite pointe de métal noble (52a) comprend un alliage sélectionné dans le groupe comprenant un alliage de Pt-Ni, un alliage de Pt-Rh, un alliage de Pt-Rh-Ni, un alliage de Ir-Pt, un alliage de Ir-Rh, un alliage de Ir-Pt-Rh-Ni et un alliage de Ir-Ru-Rh-Ni.

11. Bougie d'allumage selon l'une quelconque des revendications 6 à 10, dans laquelle ladite liaison en fusion (53) a une forme dans laquelle une partie centrale sur un côté de ladite coque métallique (1) est évidée vers l'intérieur, comme observé à partir d'une face d'extrémité de pointe de ladite pointe de métal noble (52a), et une distance minimum entre un bord périphérique externe de ladite liaison en fusion (53) dans ladite partie évidée et une face périphérique externe de ladite pointe de métal noble (52a) est de 0,25 mm ou plus.

FIG. 1

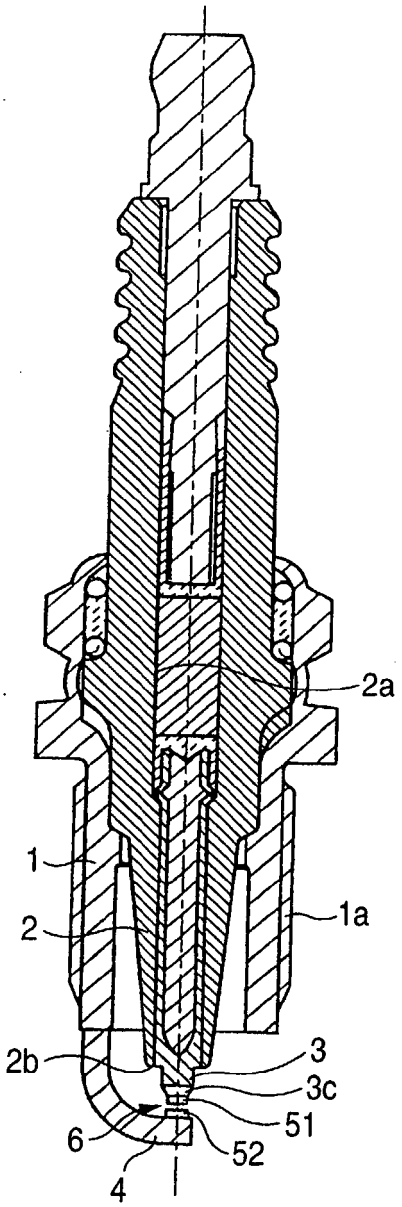


FIG. 2E

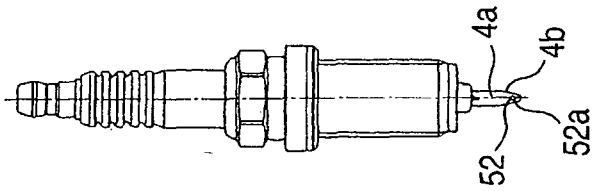


FIG. 2D

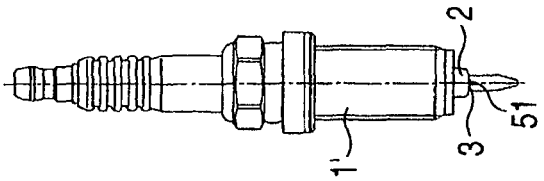


FIG. 2C

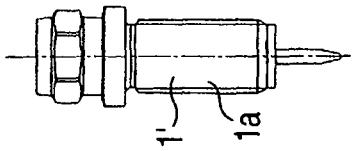


FIG. 2B

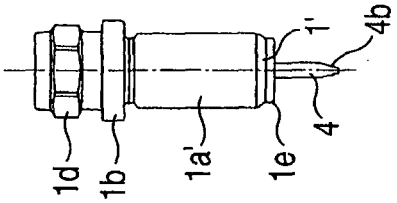


FIG. 2A

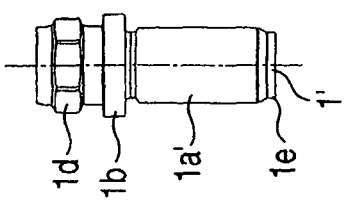


FIG. 3

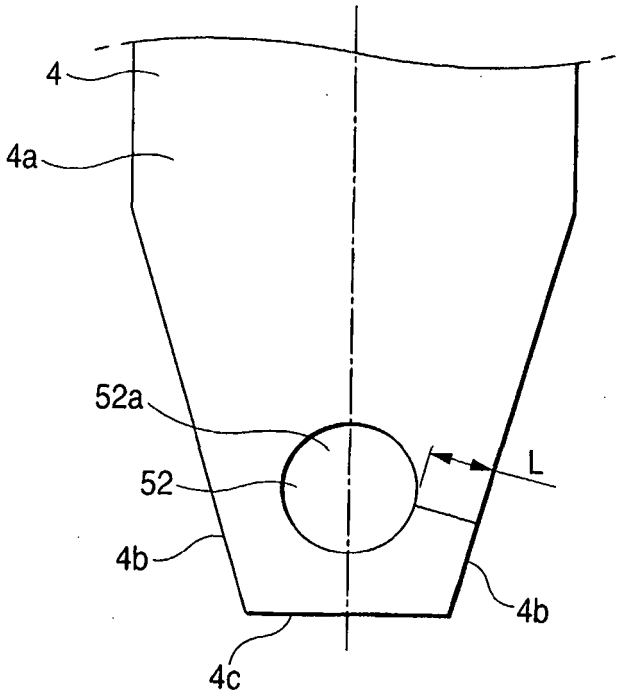


FIG. 4

DISTANCE L (mm)	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
OXIDATION RATE	×	○	○	◎	◎	◎	○	○	○	×	×

◎ : OXIDATION RATE IS SMALLER THAN 30%
○ : OXIDATION RATE IS 30 TO 50%
× : OXIDATION RATE IS LARGER THAN 50%

FIG. 5A

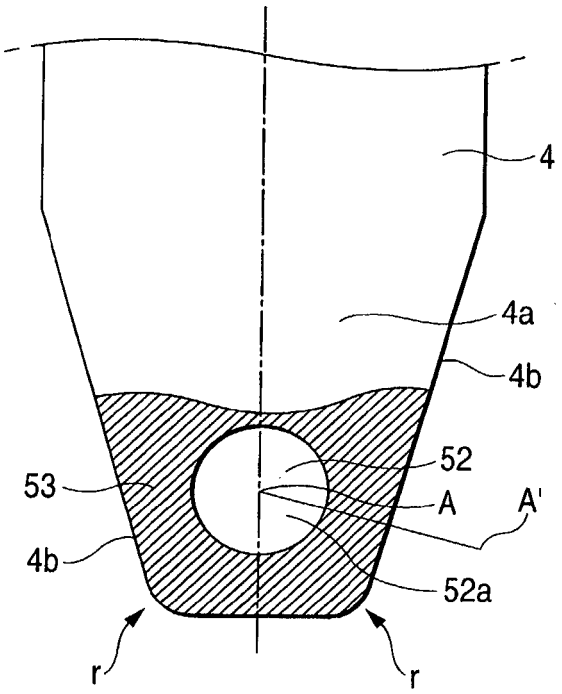


FIG. 5B

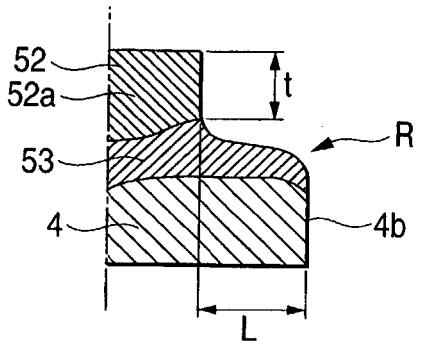
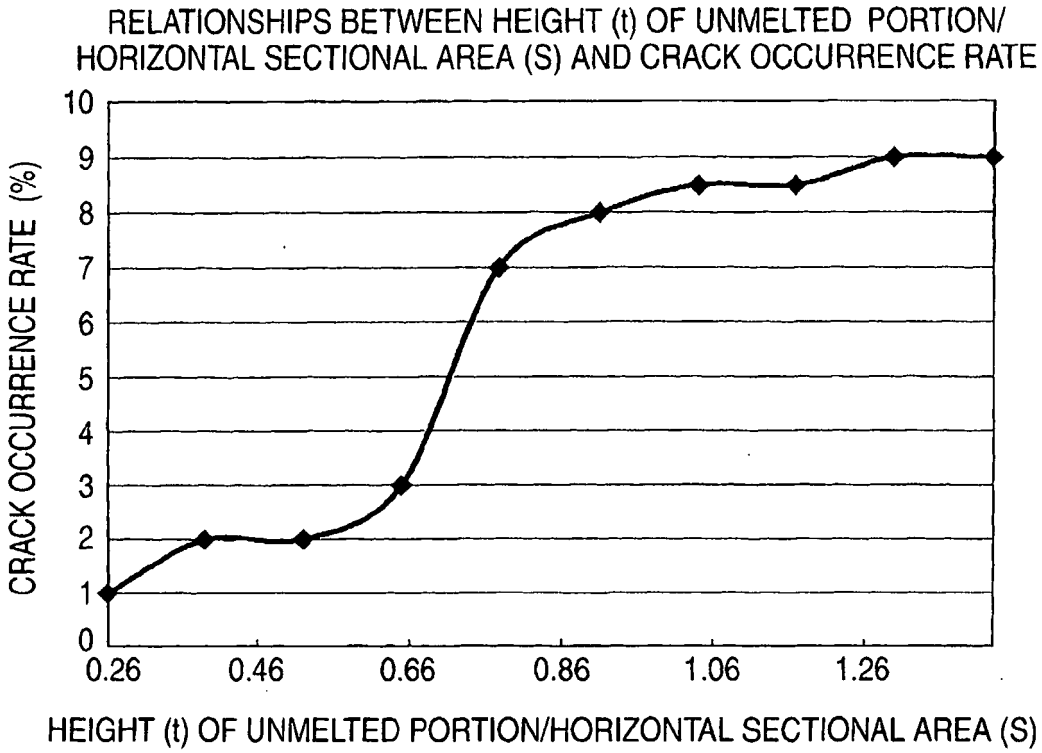


FIG. 6


RELATIONSHIPS BETWEEN HEIGHT (t) OF UNMELTED PORTION/
HORIZONTAL SECTIONAL AREA (S) AND CRACK OCCURRENCE RATE
CRACK OCCURRENCE RATE (%)
10
9
8
7
6
5
4
3
2
1
0
0.26
0.46
0.66
0.86
1.06
1.26
HEIGHT (t) OF UNMELTED PORTION/HORIZONTAL SECTIONAL AREA (S)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2002237365 A **[0002]**
- US 20020105254 A1 **[0002]**