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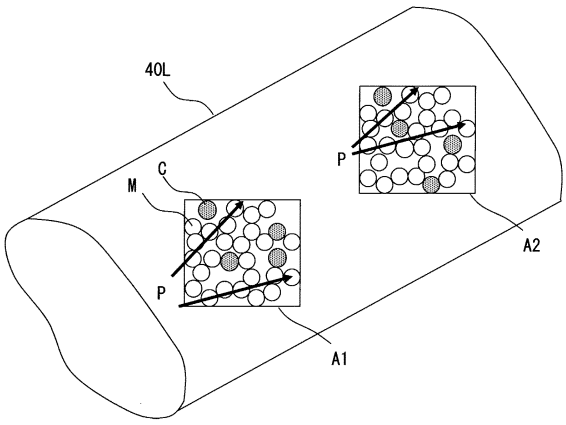
(54) CERAMIC HEATER, AND METHOD FOR MANUFACTURING CERAMIC HEATER

(57) A ceramic heater 11 comprising a heat-generation resistor body 40 embedded in a base, wherein the heat-generation resistor body includes a metal component and a ceramic component, and when ten different measurement parts A1,A2,A5,A6 of 10 um squares in a transverse cross-section of the heat-generation resistor body are measured, an average content of the metal component is not less than 35% by area but less than 50% by area, and a minimum content of the metal component is not less than 30% by area.

[FIG.4]



EP 4 322 707 A1

Description

TECHNICAL FIELD

[0001] The present invention relates to a ceramic heater used for, for example, a warm water washing toilet seat, a fan heater, an electric water heater, a 24-hour bath system, a soldering iron, a hair straightener, and the like, and a production method for the ceramic heater.

BACKGROUND ART

[0002] Conventionally, for example, in a warm water washing toilet seat, a heat exchange unit having a container (heat exchanger) made of resin is used, and in the heat exchange unit, a ceramic heater having an elongated pipe shape is provided for warming washing water contained in a heat exchanger.

[0003] As an example of the ceramic heater, a ceramic sheet printed with a heater wiring circuit serving as a heat-generation resistor body is wrapped around a cylindrical porcelain tube made of ceramic, and these are sintered to obtain a ceramic heater (see Patent Document 1).

[0004] Then, water flowing in a gap between the inner wall of the heat exchanger and the outer circumference of the ceramic heater is heated by the ceramic heater.

PRIOR ART DOCUMENT

PATENT DOCUMENT

[0005] Patent Document 1: Japanese Patent Application Laid-Open (kokai) No. H09-7739

SUMMARY OF THE INVENTION

PROBLEM TO BE SOLVED BY THE INVENTION

[0006] If the ceramic heater is downsized, the area of a part where heater wiring can be formed, of the ceramic sheet, is reduced. Therefore, in order to obtain the same amount of heat as in the conventional ceramic heater by one circuit, it is necessary to increase the wiring resistance, or ensure a wiring length equivalent to the conventional wiring length by reducing the wire-line width and increasing the number of times of folding.

[0007] Here, the wiring circuit of the heater is formed by printing an ink paste containing metal particles. Therefore, in consideration of blur in printing, there is a limitation in narrowing the wire-line width (e.g., about 0.3 mm). Thus, it is necessary to increase the wiring resistance, and for this purpose, ceramic particles such as alumina are added to the ink paste.

[0008] However, if many ceramic particles which are insulating materials are contained in wiring, ceramic particles are interposed between metal particles forming conduction paths so that conduction is hampered, thus causing a problem that disconnection becomes likely to occur.

[0009] Accordingly, an object of the present invention is to provide a ceramic heater in which the resistance of a heat-generation resistor body is increased while disconnection is suppressed, and a production method for the ceramic heater.

MEANS FOR SOLVING THE PROBLEM

[0010] In order to solve the above problem, a ceramic heater of the present invention is a ceramic heater comprising a heat-generation resistor body embedded in a base, wherein the heat-generation resistor body includes a metal component and a ceramic component, and when ten different measurement parts of 10 um squares in a transverse cross-section of the heat-generation resistor body are measured, an average content of the metal component is not less than 35% by area but less than 50% by area, and a minimum content of the metal component is not less than 30% by area.

[0011] With this ceramic heater, since the "average content of the metal component" which indicates the electric resistance of the entire heat-generation resistor body is set to such a level that the electric resistance increases, the resistance of the heat-generation resistor body can be increased.

[0012] In addition, since the "minimum content of the metal component" is set to such a level that the content of the ceramic component does not vary in each measurement part, occurrence of disconnection due to local formation of such an area where there is an excessively large amount of ceramic component can be suppressed.

[0013] Here, it is considered that, when the average content of the metal component is not less than 35% by area, the metal component aggregates and forms connection over the entirety in the heat-generation resistor body, thus stably exhibiting high conductivity.

[0014] In the ceramic heater of the present invention, a maximum content of the metal component may be not greater than 80% by area.

[0015] In this ceramic heater, variation in the content of the ceramic component in each measurement part described above is further reduced, so that disconnection can be further suppressed.

[0016] In the ceramic heater of the present invention, an electric resistivity of the heat-generation resistor body per area of 100 μm^2 at 25°C when a thickness thereof is 25 um mae be not less than 0.02 Ω.

[0017] In this ceramic heater, the electric resistance of the heat-generation resistor body can be assuredly increased.

[0018] A production method for a ceramic heater of the present invention is a production method for a ceramic heater, comprising: a ceramic base producing step of producing a ceramic base; and an application step of applying or printing an ink to be a heat-generation resistor body, around the ceramic base, wherein the ink contains

metal particles and ceramic particles, an average particle size of the metal particles is 0.5 to 2.0 um, and an average particle size of the ceramic particles is 0.2 to 2.0 um.

ADVANTAGEOUS EFFECTS OF THE INVENTION

[0019] According to the present invention, it is possible to increase the resistance of a heat-generation resistor body of a ceramic heater while suppressing disconnection.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020]

[FIG. 1] Front view showing a ceramic heater according to an embodiment of the present invention.
[FIG. 2] Development view showing a ceramic sheet of the ceramic heater.
[FIG. 3] Development view schematically showing heater wiring circuits included in FIG. 2.
[FIG. 4] Schematic view showing measurement parts of a heat-generation resistor body according to the embodiment of the present invention, and conduction paths in the measurement parts.
[FIG. 5] Schematic view showing measurement parts of a heat-generation resistor body not corresponding to the present invention, and conduction paths in the measurement parts.
[FIG. 6] View showing an example in which a plurality of measurement parts are taken from the same transverse cross-section of a heat-generation resistor body.
[FIG. 7] Graph showing the actual relationship between the content of a metal component and the electric resistivity.
[FIG. 8] Graph showing a result of actually measuring the contents of metal components in heat-generation resistor bodies of the ceramic heater of the present invention and commercial ceramic heaters.
[FIG. 9] Table that follows FIG. 8.

MODES FOR CARRYING OUT THE INVENTION

[0021] Hereinafter, an embodiment of the present invention will be described with reference to the drawings.
[0022] FIG. 1 is a front view showing a ceramic heater 11 according to the embodiment of the present invention. FIG. 2 is a development view showing a ceramic sheet 19 of the ceramic heater 11. FIG. 3 is a development view schematically showing heater wiring circuits 40a, 40b included in FIG. 2.
[0023] The ceramic heater 11 according to the embodiment of the present invention can be used for warming washing water in a heat exchanger of a heat exchange unit of a warm water washing toilet seat, for example.
[0024] As shown in FIG. 1, the ceramic heater 11 includes a tubular base (ceramic base) 13 having a heat-generation resistor body 40 embedded therein, and a flange 30 which is joined to the outer circumference of the ceramic base 13 via a joining member 20 and which is made of ceramic and has a ring shape, or a ring shape with ends. The ceramic base 13 includes a cylindrical support body 17 made of ceramic, and a ceramic sheet 19 wrapped around the outer circumference of the support body 17. The support body 17 has a through hole 17h in an axial-line-O direction thereof. Then, in the heat exchanger, water flowing inside the through hole 17h is heated by the ceramic heater 11 and water in the gap between the inner wall of the heat exchanger and the outer circumference of the ceramic heater is also heated by the ceramic heater 11.
[0025] The support body 17 and the ceramic sheet 19 can be formed from alumina, for example. The ceramic sheet 19 does not completely cover the outer circumference of the support body 17, and a slit 13s extending along the axial-line-O direction of the support body 17 is formed at a wrap-meeting part 19a of the ceramic sheet 19.
[0026] Meanwhile, as shown in FIG. 2, at the ceramic sheet 19, a heat-generation resistor body 40 composed of a plurality of heater wiring circuits 40a, 40b having meandering pattern shapes is formed by printing or the like. Each heater wiring circuit 40a, 40b of the heat-generation resistor body 40 is formed such that folded portions 40m at both ends of a plurality of wiring portions 40L (see upper drawing in FIG. 3) mutually extending along the axial-line-O direction extend in the width direction and are connected to ends of the adjacent wiring portions 40L. The wiring portions at both ends of each heater wiring circuit 40a, 40b are connected integrally to the respective ones of three pad-shaped connection terminals 41, 42a, 42b at one end in the axial-line-O direction.
[0027] Specifically, as shown in FIG. 3, wiring portions 40L1, 40L2 at both ends of the heater wiring circuit 40a are respectively connected to the connection terminal 41 serving as a shared ground and the connection terminal 42a on the plus side. Similarly, wiring portions 40L3, 40L4 at both ends of the heater wiring circuit 40b are respectively connected to the connection terminal 41 and the connection terminal 42b on the plus side.
[0028] Then, the connection terminals 41, 42a, 42b are electrically connected respectively to three external terminals 43 (only two are shown in FIG. 1) formed at the outer circumferential surface (back surface in FIG. 2) of the ceramic sheet 19, through via-conductors or the like (not shown).
[0029] The heat-generation resistor body 40 and the connection terminals 41, 42a, 42b can be formed using tungsten as a main component, for example.
[0030] Next, with reference to FIG. 4 and FIG. 5, the heat-generation resistor body 40 (each heater wiring circuit 40a, 40b) will be described. FIG. 4 is a schematic view showing measurement parts A1, A2 of the heat-generation resistor body according to the embodiment

of the present invention, and conduction paths in the measurement parts A1, A2. FIG. 5 is a schematic view showing measurement parts A10, A20 of a heat-generation resistor body not corresponding to the present invention, and conduction paths in the measurement parts A10, A20.

[0031] The heat-generation resistor body 40 contains a metal component and a ceramic component. When ten different measurement parts of 10 um squares in a transverse cross-section of the heat-generation resistor body 40 are measured, the average content of the metal component is not less than 35% by area but less than 50% by area, and the minimum content of the metal component is not less than 30% by area.

[0032] Here, as shown in FIG. 4, the measurement parts A1, A2 are 10-um-square areas in the transverse cross-section of the heat-generation resistor body 40 (in FIG. 4, representing one wiring portion 40L of the heater wiring circuit 40a shown in FIG. 3). Then, for each measurement part A1, A2, ..., by an electron microscope (SEM), a secondary electron image (composition image) is binarized, and the area ratio (% by area) of a bright part corresponding to the metal component is calculated as the content of the metal component.

[0033] In addition, the "average content of the metal component" is the average value of the contents of the metal component in the ten measurement parts. The "minimum content of the metal component" is the smallest value of the contents of the metal component in the measurement parts. Similarly, a "maximum content of the metal component" described later is the highest value of the contents of the metal component in the measurement parts.

[0034] Normally, the heat-generation resistor body 40 is formed by printing an ink paste containing metal particles and ceramic particles. The ceramic particles such as alumina increases the wiring resistance, but if many ceramic particles are contained, the ceramic particles are interposed between the metal particles forming conduction paths so that conduction is hampered and disconnection becomes likely to occur.

[0035] Accordingly, as shown in FIG. 4, metal particles M and ceramic particles C are uniformly mixed in each measurement part A1, A2 (i.e., the content of the ceramic component does not vary in each measurement part A1, A2), whereby the metal particles M connect to each other without being separated by the ceramic particles C in each measurement part A1, A2 and thus conduction paths P are assuredly formed.

[0036] Thus, the content of the ceramic component in the heat-generation resistor body is increased so that the resistance is increased, while disconnection can be suppressed. In particular, if the wire-line width of the heat-generation resistor body 40 (wiring portion 40L) becomes smaller, disconnection is more likely to occur when there is a part where many ceramic particles are contained locally, but such disconnection can also be suppressed.

[0037] In FIG. 4, for convenience sake, conduction paths P along the cross-sections of the measurement parts A1, A2 are shown, but in actuality, conduction paths are formed so as to pass the cross-section of each measurement part A1, A2 toward the backward direction of the drawing sheet. However, it is considered that the arrangement state of the metal particles M and the ceramic particles C is three-dimensionally isotropic (the arrangement states in the cross-section of each measurement part A1, A2 and in the backward direction of the drawing sheet perpendicular to the cross-section are the same). Therefore, for convenience in illustration in the drawing, conduction paths P along the cross-sections of the measurement parts A1, A2 are shown.

[0038] On the other hand, as shown in FIG. 5, a case where metal particles M and ceramic particles C are not uniformly mixed in each measurement part A1, A2 (i.e., the content of the ceramic component greatly varies in each measurement part A1, A2) will be considered.

[0039] In this case, in a measurement part A10, the ratio of the ceramic particles C is great (there are four particles in the measurement part) and therefore the metal particles M are separated by the ceramic particles C, so that a conduction path is not formed and disconnection B occurs. Meanwhile, in a measurement part A20, the ratio of the ceramic particles C is small (there is one particle in the measurement part) and therefore the metal particles M connect to each other without being separated by the ceramic particles C, so that a conduction path P is formed.

[0040] From the above, as an index indicating the electric resistance of the entire heat-generation resistor body, the "average content of the metal component" described above is defined, and is set so as to increase the electric resistance.

[0041] In addition, as an index for ensuring that the content of the ceramic component in each measurement part does not vary and occurrence of disconnection due to local formation of such an area where there is an excessively large amount of ceramic component is suppressed, the "minimum content of the metal component" described above is defined, to suppress disconnection. For example, in the measurement part A10 in FIG. 5, the "minimum content of the metal component" is smaller than the prescribed range of the present invention.

[0042] In the present invention, if the maximum content of the metal component is not greater than 80% by area, variation in the content of the ceramic component in each measurement part described above is further reduced, so that disconnection can be further suppressed.

[0043] In the present invention, if the electric resistivity of the heat-generation resistor body 40 per area of 100 μm^2 at 25°C when the thickness thereof is 25 um is not less than 0.02 Ω, the electric resistance of the heat-generation resistor body can be assuredly increased. For the electric resistivity, the heat-generation resistor body 40 is cut and the resistance is measured, the width, the thickness, and the length of the cut part are measured, and then the resistance value per area of 100 μm^2 when the

thickness is 25 um is calculated.

[0044] In the present embodiment, as a method for controlling the average content of the metal component and the minimum content of the metal component in the above ranges, for example, the particle sizes of the metal particles and the ceramic particles contained in a resistor body ink for forming the heat-generation resistor body 40 are made fine. By making the particle sizes of the respective particles fine, the degree of dispersion when the respective particles are mixed is increased, whereby variation in the content of the ceramic component can be reduced.

[0045] Specifically, for example, in a case of performing measurement using a particle size distribution by laser diffraction and scattering, an average particle size φ of the metal particles can be set at 0.5 to 2.0 um, and an average particle size φ of the ceramic particles can be set at 0.2 to 2.0 um.

[0046] As the metal particles, tungsten powder and molybdenum powder can be used in combination. Examples of the ceramic particles include alumina.

[0047] By adjusting the sintering temperature for forming the heat-generation resistor body 40, in particular, by suppressing excessive grain growth or excessive sintering of the metal component, variation in the content of the ceramic component can be reduced.

[0048] The resistor body ink can be produced as follows, for example. First, the metal particles and the ceramic particles are weighed and put into a pot, and a solvent is further added. Then, the particles are crushed into fine powder by a ball mill. Further, resin (binder) is added into the ball mill, to be further mixed and crushed. Thereafter, the extra solvent is removed through exposure to air. Thus, a slurry ink is obtained.

[0049] The ceramic heater 11 can be produced as follows, for example.

[0050] First, from slurry of ceramic powder such as alumina, a member to be the support body 17 is extrusion-molded, and then is calcined. In addition, from the same slurry as above, a green sheet to be the ceramic sheet 19 is formed, and on the surface thereof, the above resistor body ink to be the heat-generation resistor body 40 and the connection terminals 41, 42a, 42b as shown in FIG. 2 is printed and dried. Then, on the printed surface of the green sheet, another green sheet is laminated and pressed, whereby the heat-generation resistor body 40 and the connection terminals 41, 42a, 42b are embedded between both green sheets. Further, in one surface of the laminated body of both green sheets, via holes are provided and are filled with via-conductors. Directly above these, conductive pastes to be the external terminals 43 are printed and dried.

[0051] Then, a ceramic paste is applied on the opposite surface of the laminated body of both green sheets, the laminated body is wrapped around the support body 17, and the entire body is sintered.

[0052] In addition, ceramic powder such as alumina is pressure-molded by a mold and then sintered, thus obtaining the flange 30.

[0053] The ceramic base 13 and the flange 30 produced as described above are heated at a glass melting temperature or higher in a state in which a solid joining material 20 (glass) to be the joining member 20 is placed in a gap between the ceramic base 13 and the flange 30, whereby the flange 30 is joined to the outer circumference of the ceramic base 13.

[0054] The production method for the ceramic heater of the present invention includes a ceramic base producing step of producing a ceramic base, and an application step of applying (printing) an ink to be a heat-generation resistor body, around the ceramic base. The above ink contains metal particles and ceramic particles, an average particle size of the metal particles is 0.5 to 2.0 um, and an average particle size of the ceramic particles is 0.2 to 2.0 μm.

[0055] It should be understood that the present invention is not limited to the above embodiment and incorporates various modifications and equivalents within the idea and the scope of the present invention.

[0056] The kinds of the metal component and the ceramic component composing the heat-generation resistor body are not limited to the above ones.

[0057] The number of heater wiring circuits and the shape thereof are also not limited.

[0058] Regarding each measurement part in a transverse cross-section of the heat-generation resistor body, measurement parts may be taken from different transverse cross-sections, or as shown in FIG. 6, a plurality of measurement parts A5, A6 may be taken from the same transverse cross-section.

[Examples]

[Example 1]

[0059] Using tungsten powder and molybdenum powder as metal particles and using alumina powder as ceramic particles, resistor body inks in which the average particle size φ of the metal particles was 1.3 um and the average particle size φ of the ceramic particles was 0.5 um, were produced. The blend ratio of the metal particles was variously changed for the respective resistor body inks.

[0060] Each resistor body ink was printed in a predetermined heat generation pattern and was dried, and then was sintered at such a temperature that the metal particles were not oxidized. Then, the electric resistivity at 25°C when the thickness was 25 um was measured by a usual method.

[0061] The obtained result is shown in FIG. 7. The content of the metal component is the area ratio (% by area) when ten different measurement parts of 10 um squares in the transverse cross-section of the heat-generation resistor body were measured as described above.

[0062] As shown in FIG. 7, when the content of the metal component is less than approximately 50% by ar-

ea, the electric resistivity sharply increases. On the basis of this result, the average content of the metal component in the present invention is set to be less than 50% by area.

[Example 2]

[0063] For a ceramic heater (Example) produced in the same manner as in Example 1 and commercial ceramic heaters (Comparative examples 1 to 3), the "average content of the metal component", the "minimum content of the metal component", and the "maximum content of the metal component" were measured by the above method. In addition, a max-min difference of the content of the metal component = (maximum content of metal component) - (minimum content of metal component) was calculated.

[0064] The obtained results are shown in FIG. 8 and FIG. 9.

[0065] FIG. 8 shows a result of actually measuring the contents of the metal components of the heat-generation resistor bodies in Comparative examples 1, 2, 3 and Example. A result of measurements at ten points randomly selected in each sample is plotted on the left side in each sample, and a result of measurements for an area containing a large amount of metal component and an area containing a small amount of metal component, which were intentionally selected visually in each sample, were plotted on the right side in each sample.

[0066] FIG. 9 shows a result of calculating the average content, the maximum content, and the minimum content of the metal component, and the max-min difference of the content of the metal component in each of Comparative examples 1, 2, 3 and Example on the basis of the measurement result shown in FIG. 8.

[0067] In Comparative examples 1, 2, the "average contents of the metal components" were not less than 50% by area and therefore were greater than that in Example. Thus, the resistances of the heat-generation resistor bodies of the ceramic heaters could not be increased.

[0068] In Comparative example 3, the "average content of the metal component" was great equivalently to that in Example, but the "minimum content of the metal component" was less than 30% by area and therefore less than that in Example. Thus, it is considered that disconnection is likely to occur.

[Description of Reference Numerals]

[0069]

11 ceramic heater
40 heat-generation resistor body
A1,A2,A5,A6 measurement part

Claims

1. A ceramic heater comprising a heat-generation resistor body embedded in a base, wherein

   the heat-generation resistor body includes a metal component and a ceramic component, and
   when ten different measurement parts of 10 um squares in a transverse cross-section of the heat-generation resistor body are measured, an average content of the metal component is not less than 35% by area but less than 50% by area, and a minimum content of the metal component is not less than 30% by area.

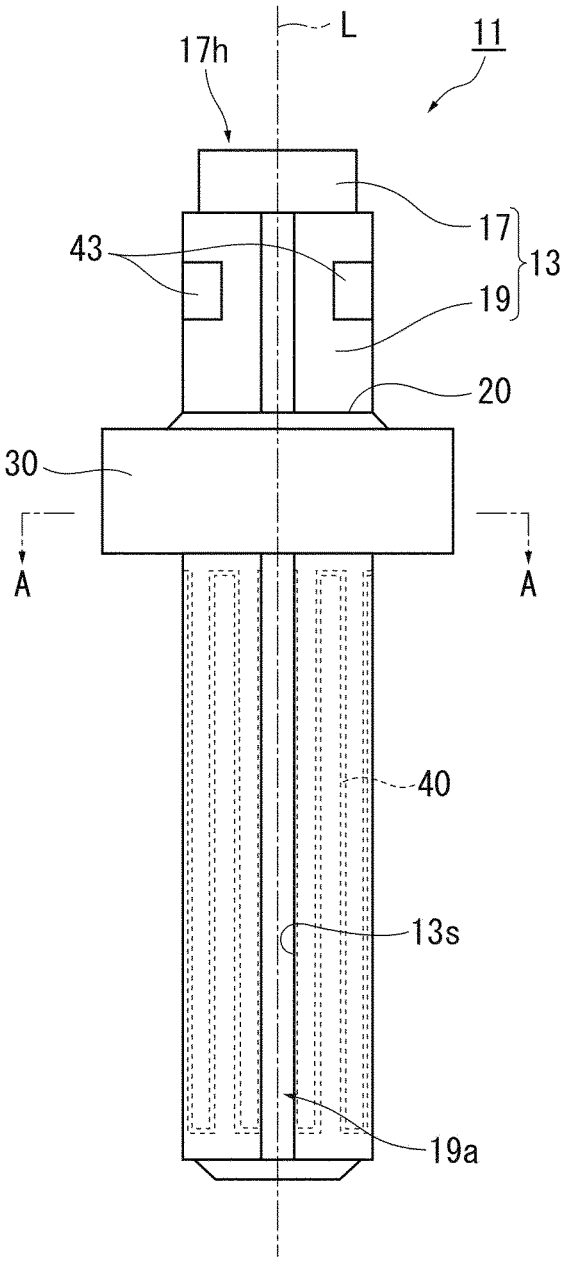
2. The ceramic heater according to claim 1, wherein a maximum content of the metal component is not greater than 80% by area.

3. The ceramic heater according to claim 1 or 2, wherein
   an electric resistivity of the heat-generation resistor body per area of 100 μm^2 at 25°C when a thickness thereof is 25 um is not less than 0.02 Ω.

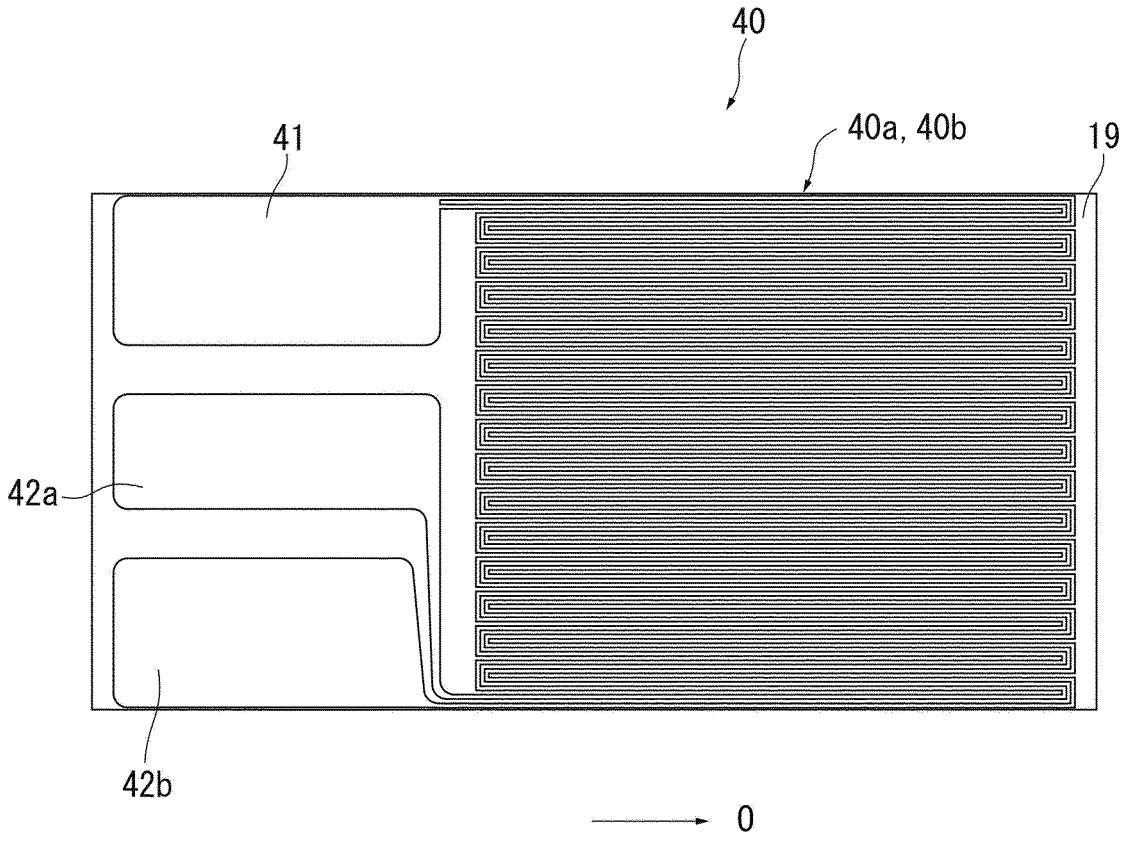
4. A production method for a ceramic heater, comprising:

   a ceramic base producing step of producing a ceramic base; and
   an application step of applying or printing an ink to be a heat-generation resistor body, around the ceramic base, wherein
   the ink contains metal particles and ceramic particles, an average particle size of the metal particles is 0.5 to 2.0 um, and an average particle size of the ceramic particles is 0.2 to 2.0 um.

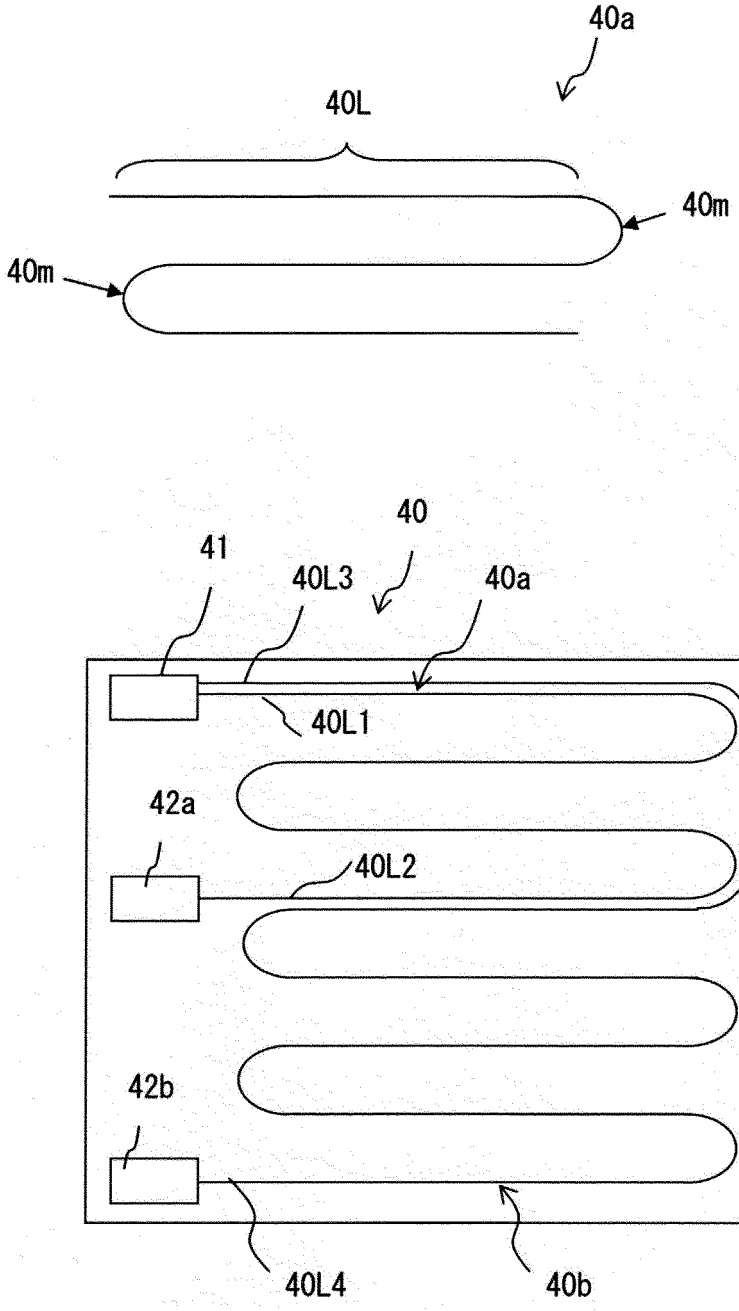
[FIG.1]



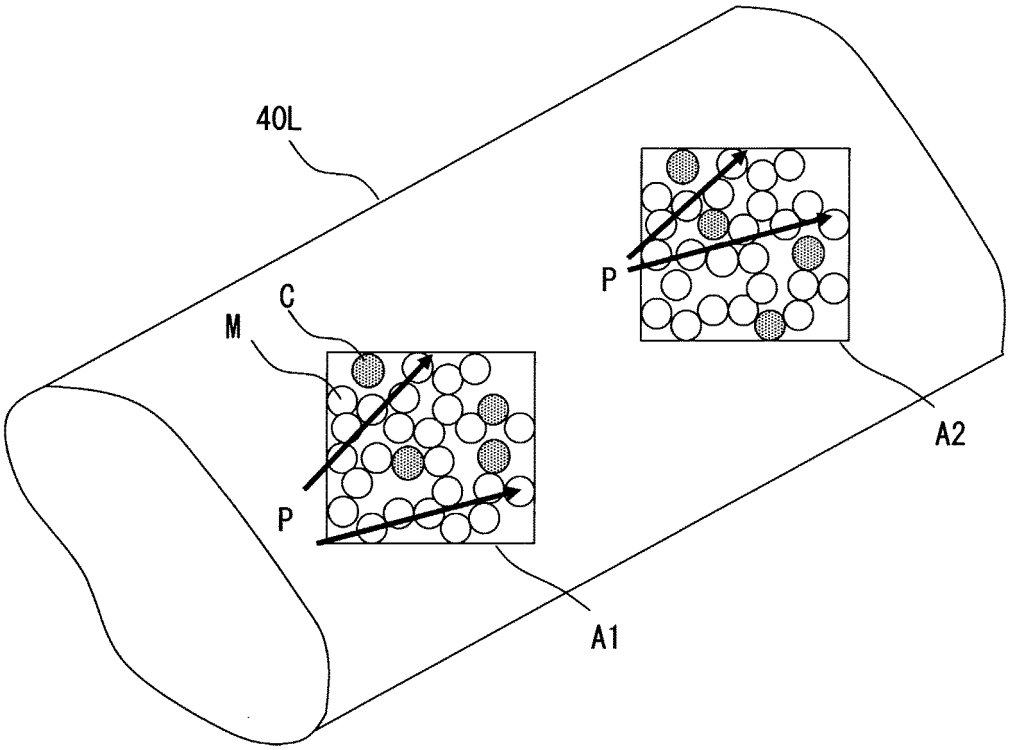
[FIG.2]



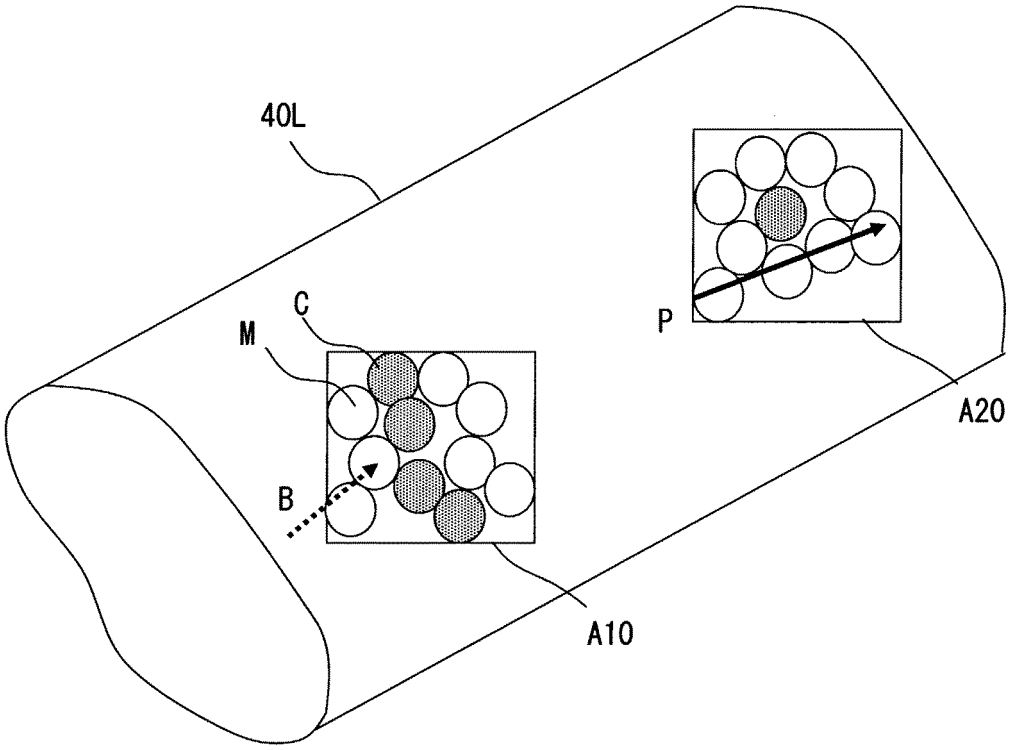
[FIG.3]



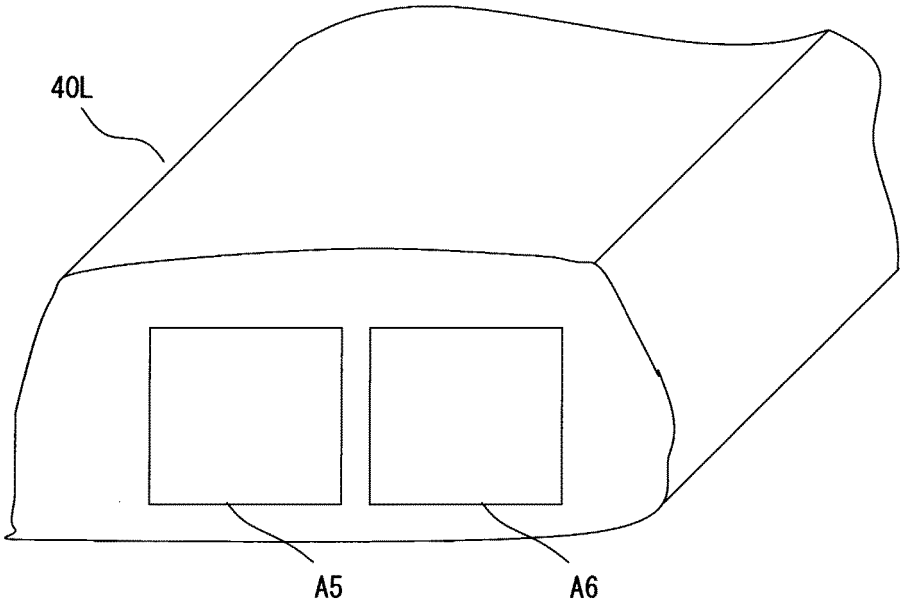
[FIG.4]



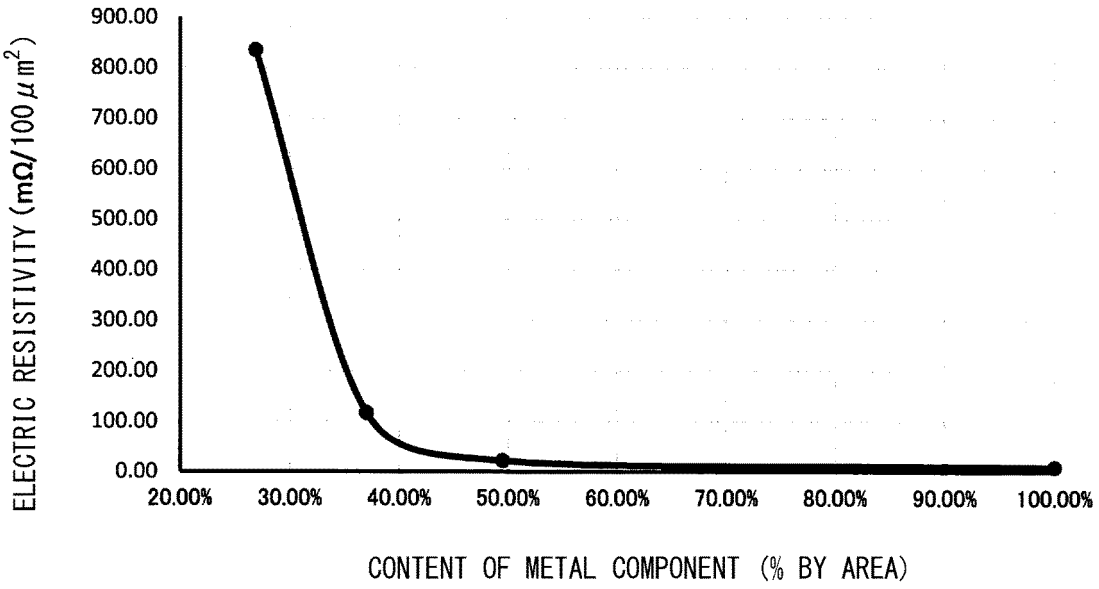
[FIG.5]



[FIG.6]



[FIG.7]


900.00
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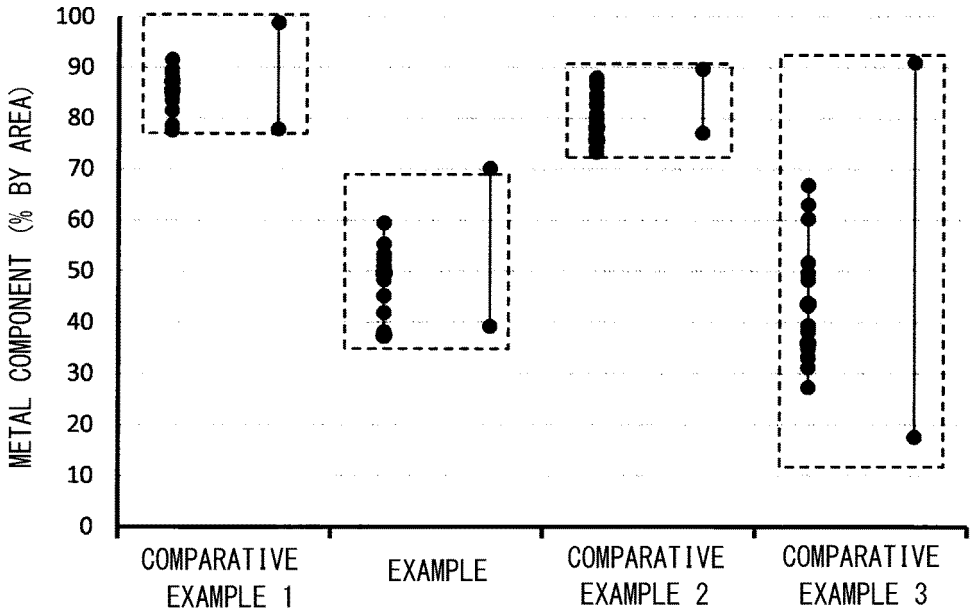
ELECTRIC RESISTIVITY (mΩ/100μm²)
20.00%
30.00%
40.00%
50.00%
60.00%
70.00%
80.00%
90.00%
100.00%
CONTENT OF METAL COMPONENT (% BY AREA)

[FIG.8]


100
90
80
70
60
50
40
30
20
10
0
METAL COMPONENT (% BY AREA)
COMPARATIVE EXAMPLE 1
EXAMPLE
COMPARATIVE EXAMPLE 2
COMPARATIVE EXAMPLE 3

[FIG.9]

	COMPARATIVE EXAMPLE 1	EXAMPLE	COMPARATIVE EXAMPLE 2	COMPARATIVE EXAMPLE 3
AVERAGE CONTENT OF METAL COMPONENT (% BY AREA)	85.7	49.8	80.6	43.9
MAXIMUM CONTENT OF METAL COMPONENT (% BY AREA)	98.9	70.2	89.7	91.0
MINIMUM CONTENT OF METAL COMPONENT (% BY AREA)	77.7	37.4	73.3	17.6
MAX-MIN DIFFERENCE OF CONTENT OF METAL COMPONENT (% BY AREA)	21.2	32.8	16.3	73.4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2022/017033

A. CLASSIFICATION OF SUBJECT MATTER

H05B 3/12(2006.01)i; ***H05B 3/18***(2006.01)i; ***H05B 3/48***(2006.01)i
FI: H05B3/12; H05B3/18; H05B3/48

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)

H05B3/12; H05B3/18; H05B3/48

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

Published examined utility model applications of Japan 1922-1996
Published unexamined utility model applications of Japan 1971-2022
Registered utility model specifications of Japan 1996-2022
Published registered utility model applications of Japan 1994-2022

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.
A	JP 11-135239 A (NGK SPARK PLUG CO LTD) 21 May 1999 (1999-05-21) paragraphs [0023], [0028]-[0029], fig. 1-4	1-3
X		4
A	JP 8-315967 A (NGK SPARK PLUG CO LTD) 29 November 1996 (1996-11-29) entire text, all drawings	1-4
A	JP 2019-135713 A (NGK SPARK PLUG CO LTD) 15 August 2019 (2019-08-15) entire text, all drawings	1-4
A	JP 9-7739 A (KYOCERA CORP) 10 January 1997 (1997-01-10) entire text, all drawings	1-4

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

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"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
13 June 2022	**21 June 2022**
Name and mailing address of the ISA/JP **Japan Patent Office (ISA/JP)** **3-4-3 Kasumigaseki, Chiyoda-ku, Tokyo 100-8915** **Japan**	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2022/017033

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

(1) The number of inventions of the international application in which the following claims are set forth is 2.
Claims 1-4

(2) Due to the following reasons, this international application is considered not to comply with the requirements of unity of invention.

(Invention 1) Claims 1-3

Claims 1-3 have the special technical feature in that "when 10 measurement sites of different 10 μm-square pixels in the cross-section of the heating resistor are measured, the average content of the metal component is 35-50 area% (exclusive of 50) and the minimum content of the metal component is 30 area% or more," and are thus classified as invention 1.

(Invention 2) Claim 4

Claims 4 and claim 1 classified as invention 1 share the common technical feature in that the "heating resistor includes a metal component and a ceramic component." However, said technical feature does not make a contribution over the prior art in light of the disclosure of document 1, and thus cannot be said to be a special technical feature. Furthermore, there are no other same or corresponding special technical features between these inventions.

In addition, claim 4 is not dependent on claim 1. Furthermore, claim 4 is not substantially identical to or similarly closely related to any of the claims classified as invention 1.

Therefore, claim 4 cannot be classified as invention 1.

In addition, claim 4 have the special technical feature in that the "ink contains metal particles and ceramic particles, wherein the metal particles have an average particle diameter of 0.5-2.0 μ, and the ceramic particles have an average particle diameter of 0.2-2.0 μm," and are thus classified as invention 2.

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☑ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

Form PCT/ISA/210 (continuation of first sheet) (January 2015)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/JP2022/017033

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
JP 11-135239 A	21 May 1999	US 6084220 A column 6, lines 22-41, column 7, line 30 to column 9, line 28, fig. 1-4 EP 914021 A2 EP 1524882 A2	
JP 8-315967 A	29 November 1996	(Family: none)	
JP 2019-135713 A	15 August 2019	EP 3522681 A1 CN 110121222 A	
JP 9-7739 A	10 January 1997	(Family: none)	

Form PCT/ISA/210 (patent family annex) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP H097739 A **[0005]**