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(54) MULTI-LAYER INDUCTION HEATING BODY, PREPARATION METHOD THEREFOR AND USE THEREOF

(57) A multi-layer induction heating body, a preparation method therefor and a use thereof. The multi-layer induction heating body has the structure of at least three layers, so that the multi-layer induction heating body has the functions of heating and temperature control at the same time, the heating process is uniform and stable, and the conditions of cracking, deformation and the like cannot occur. By providing a transition layer (2) between a first susceptor material layer (1) and a second susceptor material layer (3), the thermal stability of the multi-layer induction heating body is improved, thereby ensuring the stability and consistency of an induction heating sheet in the heating process, effectively solving the problem of mechanical, physical and chemical incompatibility of two susceptor materials, and facilitating full use of the temperature control characteristics of two susceptors. The arrangement of the transition layer (2) can also avoid the mutual effect of the first susceptor material layer (1) and the second susceptor material layer (3) in the heating process, thereby achieving accurate heating and temperature control.

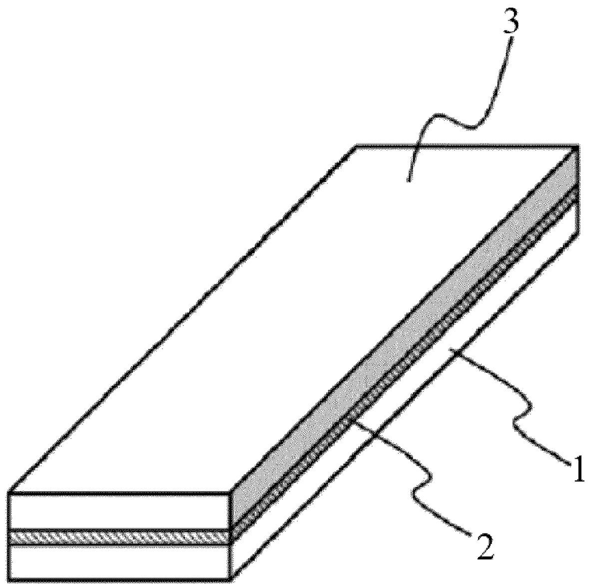

FIG. 1

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Description

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to Chinese patent application No. 202211000959.6, filed on August 19, 2022, and titled "MULTI-LAYER INDUCTION HEATING BODY, PREPARATION METHOD THEREFOR AND USE THEREOF", the content of which is hereby incorporated herein in its entirety by reference.

TECHNICAL FIELD

[0002] The present application relates to the technical field of induction heating materials, in particular to a multi-layer induction heating body, a preparation method thereof, and use thereof.

BACKGROUND

[0003] Iron-based alloys have high magnetic permeability and fast electromagnetic induction heating rate. Therefore, wireless temperature-controlled susceptors for induction heating aerosol-generating substrates generally adopt iron or iron-based alloys, most typically stainless-steel.

[0004] The susceptor made of single-material stainless-steel has the defect of low temperature-control precision, that is, the required temperature control range is usually much lower than the Curie temperature of the stainless-steel material, and a small change of the heating current in the temperature-control range corresponds to a large change of the susceptor temperature, which leads to low temperature-control precision, or even inaccurate temperature-control. In addition, since iron-based alloys have a high Curie temperature, when a single-layer stainless-steel strip is employed as a susceptor, it only functions to generate heat to form aerosol, and cannot to limit the maximum temperature based on the inherent properties of the material. Typically, 430L stainless-steel has a Curie temperature greater than or equal to 700°C, while the maximum temperature for generating aerosol is usually less than or equal to 350°C according to the national standard. Therefore, a temperature threshold control program needs to be integrated into the microcontroller, which makes the structure of the induction heating device complex.

SUMMARY

[0005] Therefore, the present application aims to address the issues that the single-material susceptors in the prior art show low temperature-control precision, and that the existing single-material heating bodies have a high Curie temperature, and only have a heating effect but no temperature self-limiting effect within the required controllable temperature range. Thereby, the present application provides a multi-layer induction heating body, a preparation method thereof, and use thereof.

[0006] In view of this, the present application provides the following technical solutions.

[0007] The present application provides a multi-layer induction heating body, including a first susceptor material layer, a second susceptor material layer, and a transition layer disposed between the first susceptor material layer and the second susceptor material layer.

[0008] Optionally, a thickness of the first susceptor material layer is in a range from 20 μm to 150 μm, and/or

a thickness of the second susceptor material layer is in a range from 20 μm to 150 μm, and/or
a thickness of the transition layer is in a range from 5 μm to 50 μm.

[0009] Optionally, the first susceptor material layer, the transition layer, and the second susceptor material layer are joined together by a sintering process.

[0010] Optionally, the multi-layer induction heating body further includes a protective layer disposed on an outer side of the first susceptor material layer and/or the second susceptor material layer away from the transition layer.

[0011] Optionally, a thickness of the protective layer is in a range from 1 μm to 10 μm.

[0012] Optionally, the multi-layer induction heating body is in a form of a sheet, a tube, a cup, or a pot.

[0013] Optionally, a material of the transition layer is a metal element, an alloy, a ceramic, or any combination thereof.

[0014] Optionally, a material of the first susceptor material layer is at least one of nickel and a nickel-chromium alloy, and/or

a material of the second susceptor material layer is at least one of iron and an iron-based alloy.

[0015] The present application further provides a method for preparing the multi-layer induction heating body as described above, including the following steps:

S1, according to raw material compositions of respective layers, preparing green bodies of the respective layers by a tape casting method;
S2, stacking the green bodies of the respective layers in sequence, and performing a hot isostatic pressing treatment to obtain a pre-sintered body; and
S3, de-binding and then sintering the pre-sintered body.

[0016] Optionally, the hot isostatic pressing treatment is performed at a temperature ranged from 65°C to 85°C and a pressure ranged from 5 MPa to 45 MPa for a time period ranged from 0.1 h to 1 h.

[0017] Optionally, the de-binding is performed at a temperature ranged from 250°C to 550°C for a time period ranged from 1 h to 10 h; and/or
the sintering is performed at a temperature ranged from 1100°C to 1400°C for a time period ranged from 0.5 h to 15 h.

[0018] Optionally, prior to preparing the green bodies of the respective layers by the tape casting method, the method further includes the following steps: adding a PVB binder and an alcohol solvent to powders of corresponding materials according to the raw material compositions of the respective layers, and performing ball milling in a ball mill tank to obtain corresponding slurries for the tape casting method.

[0019] Optionally, the ball milling is performed for a time period ranged from 2 h to 4 h to obtain the corresponding slurries for the tape casting method.

[0020] Further, the multi-layer induction heating body can be in a form of a sheet, and can further be in a form of a tube, a cup or a pot that is processed from the sheet form.

[0021] The present application further provides use of the multi-layer induction heating body as described above or the multi-layer induction heating body prepared by the method as described above in the field of magnetic induction heating.

[0022] Typically without limitation, in the multi-layer induction heating body provided in the present application, the first susceptor material layer and the second susceptor material layer are made of materials having different Curie temperatures, and at least one of the first susceptor material layer and the second susceptor material layer has the Curie temperature below 400°C. Optionally, the material of the first susceptor material layer has the Curie temperature ranging from 200°C to 400°C, optionally, 380°C or above. The material of the second susceptor material layer has the Curie temperature ranging from 400°C to 1000°C.

[0023] For example, the material of the first susceptor material layer can be a nickel element, a nickel-chromium alloy, a surface-treated nickel, a surface-treated nickel-chromium alloy, or the like. The Curie temperature of nickel is about 350°C. For example, the material of the second susceptor material layer can be iron or an iron-based alloy, such as ferritic stainless steel, typically ferritic stainless steel 430L with the Curie temperature of about 700 °C.

[0024] The transition layer is disposed between the first susceptor material layer and the second susceptor material layer. A material of the transition layer is a metal element, an alloy, a ceramic, or any combination thereof.

[0025] According to the multi-layer induction heating body provided in the present application, the transition layer between the first susceptor material layer and the second susceptor material layer preferably is a metal element, an alloy, or a composite metal that has high thermal conductivity and high electrical conductivity.

[0026] The material of the transition layer can be a weakly magnetic or non-magnetic metal, for example, austenitic stainless steel 316L.

[0027] The material of the transition layer can also be a magnetic metal material. For example, when the first susceptor material is nickel and the second susceptor material is 430L, the transition layer can be an iron-chromium-aluminum alloy. The iron-chromium aluminum alloy has a natural alumina protective film on the surface thereof, and has good chemical compatibility with most metals at high temperatures, and thus is very suitable as the material of the transition layer.

[0028] The material of the transition layer can also be ceramic. Considering good compatibility with metals at high temperatures, ceramic is an ideal material of the transition layer.

[0029] To improve the oxidation resistance and corrosion resistance of the multi-layer susceptor, a protective layer can be optionally disposed on one side or both sides of the multi-layer susceptor, and the material of the protective layer can be metal, ceramic, glass, or any combination thereof.

[0030] The multi-layer induction heating body provided in the present application can provide a characteristic temperature point. The temperature of the heating body can be controlled near this characteristic temperature by electronic control, and the characteristic temperature can be regulated and controlled according to the material compositions. Typically, the characteristic temperature can be regulated and controlled within a range from 150°C to 400°C.

[0031] Depending on compositions and electrical control matching, heating can be achieved in two temperature ranges between 150°C to 260°C and between 250°C to 400°C. Furthermore, wireless temperature control can be realized according to the one-to-one corresponding current-temperature relationship.

[0032] The multi-layer induction heating body provided in the present application can be used in scenarios requiring temperature-controlled induction heating, such as an induction heating aerosol-forming susceptor heating material for electronic cigarettes, an aerosol-forming susceptor heating material for medical atomization, a beauty apparatus, etc.

[0033] The temperature control logic of the multi-layer induction heating body provided in the present application is as follows:

[0034] In the initial heating stage, the multi-layer induction heating body is heated, and the electronic controller detects an initial current. As the temperature of the heating body increases, the magnetic reluctance of the heating body increases, and correspondingly the current detected by the electronic controller decreases. When the temperature of the heating body continues to rise and approaches the Curie temperature of the low Curie temperature material in the multi-layer induction heating body, the low Curie temperature material starts to lose magnetism gradually, resulting in a decrease of overall magnetic reluctance of the heating body. Correspondingly, the apparent current detected by the electronic controller gradually increases, and at this point, a minimum current turning point (I_1) appears. In the subsequent heating stage, the current detected by the electronic controller is in a one-to-one correspondence with the temperature of the heating body. A standard curve can be established based on the one-to-one correspondence, so that wireless temperature control can be realized. As the temperature continues to rise, the low Curie temperature material in the multi-layer induction heating body continues to lose magnetism. When the low Curie temperature susceptor material completely lose magnetism, another maximum current turning point (I_2) appears. As the current continues to increase, the electromagnetic induction heating is dominated by the high Curie temperature material. With the heating temperature continues to rise, the current decreases due to the increase of the magnetic reluctance of the high Curie temperature material. By regulating the metal phase compositions of the high Curie temperature material and the low Curie temperature material in the multi-layer induction heating body proposed in the present application, it can realize the adjustment of the characteristic current value I_1, the characteristic temperature value T_1, the temperature control standard curve and the highest threshold temperature T_2.

[0035] The temperature control logics in the prior art include two types:

[0036] One type involves the conventional physically bonded double-layer susceptor assembly, which includes a first susceptor material and a second susceptor material. During the preheating period of the susceptor assembly starting from room temperature, the resistance-temperature curve (as shown in FIG. 6, with reference to Chinese patent document CN112739229A) of the susceptor assembly has a minimum resistance value within a ±5°C temperature range around the Curie temperature of the second susceptor material. This minimum resistance value is used to calibrate a specific temperature to achieve the purpose of temperature control. In this type of susceptor assembly, the first susceptor material is primarily responsible for heating, while the second susceptor material acts as a temperature marker. At the Curie temperature of the second susceptor material, the magnetic properties of the second susceptor material change from ferromagnetic or ferrimagnetic to paramagnetic, accompanied by a temporary change in resistance of the material. By monitoring the corresponding change of the current induced by the induction source, it can be detected when the second susceptor material has reached its Curie temperature and therefore when the predetermined operating temperature has been reached. However, in this temperature control logic, only the temperature point of the Curie temperature of the second susceptor material can be calibrated, and temperature control over a temperature range cannot be achieved due to the material limitation and the single temperature point.

[0037] Another type involves the susceptor adopting a single stainless-steel sheet. During heating the susceptor material in an induction heating device, there is a strictly monotonic relationship between the temperature of the susceptor and the apparent ohmic resistance determined by the DC voltage supplied by the DC power and the DC current obtained from the DC power. Since each single value of the apparent ohmic resistance corresponds to a unique temperature, the temperature of the susceptor can be determined based on the apparent ohmic resistance according to the strict monotonic relationship without being contact with the induction heating device. This temperature control logic has high requirements on the change amount in the corresponding relationship between the apparent ohmic resistance of the stainless-steel sheet and the temperature. In the corresponding relationship of the currently common stainless-steel sheet, when the temperature range is certain, the change amount of the apparent ohmic resistance is usually too small, and the temperature cannot be accurately controlled.

[0038] The technical solutions provided in the present application have the following advantages:

The multi-layer induction heating body provided in the present application includes at least three layers of the first susceptor material layer, the second susceptor material layer and the transition layer, so that the multi-layer induction heating body has both heating function and temperature control function, with high temperature control accuracy, uniform and stable heating process, and the conditions of cracking, deformation and the like cannot occur. By disposing the transition layer between the first susceptor material layer and the second susceptor material layer, the thermal stability of the multi-layer induction heating body is significantly improved, thus ensuring the stability and consistency of the induction heating body in the heating process. The present application provides a novel method for preparing the multi-layer induction sheet based on a powder sintering process. The transition layer is added between the first susceptor and the second susceptor, which can effectively solve the mechanical, physical and chemical incompatibility between the two susceptor materials, and facilitates full utilization of the temperature control characteristics of the two susceptors. In addition, the transition layer can also avoid the interaction between the first susceptor material layer and the second susceptor material layer in the heating process, and thus realizing precise heating and temperature control.

[0039] In the multi-layer induction heating body provided in the present application, the transition layer is very thin, only ranging from 5 μm to 50 μm. As such, the direct heat exchange between the first susceptor and the second susceptor can be accelerated, which is beneficial for the first susceptor and the second susceptor to directly and quickly achieve heat balance. The first susceptor and the second susceptor are combined together as a whole, enabling the whole to reach heat balance quickly in the heating process, which is beneficial to precise temperature control.

[0040] In the multi-layer induction heating body provided in the present application, the thickness of each layer is limited, so as to prevent the transition layer from affecting the induction heating characteristics of the first susceptor material layer and the second susceptor material layer.

[0041] The multi-layer induction heating body provided in the present application is formed by a sintering process. As such, the two susceptor materials can be easily bonded together, and the range of the combination of the susceptor materials can be effectively expanded. Moreover, the interface bonding force between the two susceptor material layers can be improved, avoiding problems such as peeling of the interface microstructure, deformation and even cracking of the heating body due to the difference in physical characteristics of the two susceptor materials in the physical pressing process in the prior art, thereby greatly benefiting to maintaining the consistency of temperature control characteristics of the heating body in the heating process. In addition, in the multi-layer heating body in the prior art, the first susceptor material layer and the second susceptor material layer are generally tightly bonded, and if the multi-layer heating body is directly formed by sintering, the first susceptor material layer and the second susceptor material layer may interact with each other, and ultimately affecting the performance of the heating body. In the present application, by providing the transition layer, the interaction between the two susceptor material layers can be effectively avoided.

[0042] The multi-layer induction heating body provided in the present application further includes a protective layer disposed on the outer side of the first susceptor material layer and/or the second susceptor material layer away from the transition layer, so that the high temperature resistance and corrosion resistance of the multi-layer induction heating body can be improved.

[0043] The preparation method of the multi-layer induction heating body provided in the present application has simple and mature preparation process, is easy to realize, and greatly reduces the manufacturing cost.

BRIEF DESCRIPTION OF THE DRAWINGS

[0044] In order to more clearly describe the technical solutions in the embodiments of the present application or the prior art, the drawings to be used in the description of the embodiments or the prior art will be described briefly. Apparently, the drawings described below are merely for some embodiments of the present application. For ordinary skilled persons in the art, other drawings can also be obtained based on the following drawings without creative work.

FIG. 1 shows a schematic structural view of a multi-layer induction heating body provided in the present application.
FIG. 2 shows a current-temperature correspondence curve during an electromagnetic induction heating process of a heating body provided in Example 1 of the present application.
FIG. 3 shows a current-temperature correspondence curve during an electromagnetic induction heating process of a heating body provided in Example 2 of the present application.
FIG. 4 shows a current-temperature correspondence curve during an electromagnetic induction heating process of a heating body provided in Example 3 of the present application.
FIG. 5 shows a current-temperature correspondence curve during an electromagnetic induction heating process of a heating body provided in Example 4 of the present application.
FIG. 6 shows a resistance-temperature curve during an electromagnetic induction heating process of a susceptor prepared by conventional physically bonding in the prior art.

Reference signs:

[0045] 1: first susceptor material layer, 2: transition layer, 3: second susceptor material layer.

DETAILED DESCRIPTION

[0046] The following examples are provided to facilitate the understanding of the present application, neither to limit the best modes nor restrict the content or protection scope of the present application. Any product, which is the same as or similar to the present application, derived from the teachings of the present application or obtained by combining the features of the present application with those of other prior art, all falls within the protection scope of the present application.

[0047] In the examples, where specific experimental steps or conditions are not described, the processes can be carried out according to conventional experimental steps or conditions as described in literature in the field. The reagents or instruments for which manufacturers are not specified are all common products that can be purchased from the market.

Example 1

[0048] This example provides a multi-layer induction heating body, as shown in FIG. 1, including a three-layer composite metal sheet layer of a first susceptor material layer 1 (Ni powder)/a transition layer 2 (stainless steel 316L)/a second susceptor material layer 3 (stainless steel 430L). The preparation method thereof includes the following specific steps:

(1) 100 g of Ni powder was taken and added with 3 g of PVB binder and 40 g of alcohol solvent. The above materials were put into a ball mill tank and subjected to ball milling for 3 hours. After that, a resulting slurry was taken out, and then subjected to a tape casting process by using a doctor blade with a height of 80 μm to obtain a Ni green body.
(2) 40 g of stainless steel 316L powder was taken and added with 1.25 g of PVB binder and 18 g of alcohol solvent. The above materials were put into a ball mill tank and subjected to ball milling for 3 hours. After that, a resulting slurry was taken out, and then subjected to a tape casting process by using a doctor blade with a height of 30 μm to obtain a stainless steel 316L green body.
(3) 100 g of stainless steel 430L powder was taken and added with 3 g of PVB binder and 40 g of alcohol solvent. The above materials were put into a ball mill tank and subjected to ball milling for 3 hours. After that, a resulting slurry was taken out, and then subjected to a tape casting process by using a doctor blade with a height of 80 μm to obtain a stainless steel 430L green body.
(4) The Ni green body, the stainless steel 316L green body and the stainless steel 430L green body were stacked in sequence, and then subjected to a hot isostatic pressing treatment to obtain a composite green body, i.e., a pre-sintered body. The hot isostatic pressing treatment was performed at a temperature of 70°C and a pressure of 20 MPa for a period time of 10 minutes.
(5) The pre-sintered body was put into a vacuum furnace and subjected to de-binding and sintering, during which the temperature was raised to 450°C at a rate of 3°C/min and held at 450°C for 60 min, then raised to 1300°C at a rate of 5°C/min and held at 1300°C for 30 min. After that, the sintered body was cooled in the furnace.
(6) The sintered body was taken out from the furnace, and then cut into the desired finished product.

[0049] When heated by electromagnetic induction with an electromagnetic heating frequency of 6.78 MHz, the multi-layer induction heating body provided in this example exhibits a monotonically stable current-temperature correspondence during heating, as shown in FIG. 2, where I_1 and I_2 are the current turning points, respectively corresponding to temperatures T_1 and T_2. A temperature range of the varied temperatures corresponding to the suddenly changed currents (i.e., the temperature range between T_1 and T_2 which respectively correspond to I_1 and I_2) can be used as the temperature control range of the heating body. Additionally, the heating body has a characteristic of being heated to a maximum temperature, as shown in FIG.2, and the current and the temperature do not continue to increase. This characteristic provides a temperature self-protection effect in a susceptor assembly.

Example 2

[0050] This example provides a multi-layer induction heating body, as shown in FIG. 1, including a three-layer composite metal sheet layer of a first susceptor material layer 1 (Ni powder)/a transition layer 2 ($La_{0.6}Sr_{0.4}Fe_{0.8}Sc_{0.2}O_3$)/a second susceptor material layer 3 (stainless steel 430L). The preparation method includes the following specific steps.

(1) 100 g of Ni powder was taken and added with 3 g of PVB binder and 40 g of alcohol solvent. The above materials were put into a ball mill tank and subjected to ball milling for 3 hours. After that, a resulting slurry was taken out, and then subjected to a tape casting process by using a doctor blade with a height of 80 μm to obtain a Ni green body.
(2) 50 g of $La_{0.6}Sr_{0.4}Fe_{0.8}Sc_{0.2}O_3$ powder was taken and added with 1.5 g of PVB binder and 20 g of alcohol solvent. The above materials were put into a ball mill tank and subjected to ball milling for 3 hours. After that, a resulting slurry was taken out, and then subjected to a tape casting process by using a doctor blade with a height of 50 μm to obtain an $La_{0.6}Sr_{0.4}Fe_{0.8}Sc_{0.2}O_3$ green body.
(3) 100 g of stainless steel 430L powder was taken and added with 3 g of PVB binder and 40 g of alcohol solvent. The above materials were put into a ball mill tank and subjected to ball milling for 3 hours. After that, a resulting slurry was taken out, and then subjected to a tape casting process by using a doctor blade with a height of 80 μm to obtain a stainless steel 430L green body.
(4) The Ni green body, the $La_{0.6}Sr_{0.4}Fe_{0.8}Sc_{0.2}O_3$ green body and the stainless steel 430L green body were stacked in sequence, and then subjected to a hot isostatic pressing treatment to obtain a composite green body, i.e., a pre-sintered body. The hot isostatic pressing treatment was performed at a temperature of 70°C and a pressure of 20 MPa for a period time of 10 min.
(5) The pre-sintered body was put into a vacuum furnace and subjected to de-binding and sintering, during which the temperature was raised to 450°C at a rate of 3°C/min and held at 450°C for 60 min, then raised to 1300°C at a rate of

5°C/min and held at 1300°C for 30 min. After that, the sintered body was cooled in the furnace.
(6) The sintered body was taken out from the furnace, and then cut into the desired finished product.

[0051] The heating body provided in this example exhibits a current-temperature correspondence curve during an electromagnetic induction heating process as shown in FIG. 3.

Example 3

[0052] This example provides a multi-layer induction heating body, which is different from Example 1 in that Ni powder is replaced with Ni alloy 1J36 powder.
[0053] The heating body provided in this example exhibits a current-temperature correspondence curve during an electromagnetic induction heating process as shown in FIG. 4.

Example 4

[0054] This example provides a multi-layer induction heating body, which is different from Example 1 in that stainless steel 430L is replaced with ferritic stainless steel 420.
[0055] The heating body provided in this example exhibits a current-temperature correspondence curve during an electromagnetic induction heating process as shown in FIG. 5.

Test Example (Test Example for Example 1)

[0056] The heating body provided in Example 1 of the present application was tested according to the following steps:

Step 1: the prepared induction metal sheet was cut into a standard size of 8.6 mm in width and 16 mm in length.
Step 2: a thermocouple was attached to the standard sized metal sheet to measure the temperature.
Step 3: the induction metal heating sheet attached with the thermocouple was positioned and secured at the center of an electromagnetic induction heating coil.
Step 4: the voltage of the electromagnetic induction heating coil was set to 7.5 V, and the current of the electromagnetic induction heating coil was respectively set to 2.7 A, 2.8 A, 2.85 A, 2.9 A, and 2.95 A. Stable temperatures of the thermocouple at different currents were recorded. A stable temperature was obtained after heating for 60 seconds.
Step 5: four induction metal heating sheets were tested by repeating steps 1 to 4, and the consistency of the induction metal heating sheets was evaluated.

[0057] The test results are as follows. For a single induction metal heating sheet, the current is in a one-to-one correspondence with the temperature of the induction metal heating sheet. For the different heating bodies, in which four heating sheets are randomly selected for consistency evaluation, the heating sheets exhibit good consistency. Under different currents, the temperatures of different metal sheets are controlled within a deviation of ±3°C. The test results are shown in the table below. The temperatures of other examples are also controlled within a deviation of ±3°C, and the test results are not specifically shown.

Table 1

Current level (A)	1# (°C)	2# (°C)	3# (°C)	4# (°C)	Consistency (temperature deviation) (°C)
2.7	301	303	305	301	303±2
2.8	320	322	318	321	320±2
2.85	333	338	336	335	336±3
2.9	347	348	346	348	347±1
2.95	360	357	358	360	359±1

[0058] Clearly, the above examples are only provided for the purpose of illustrating and are not intended to limit the implementation. For those skilled in the art, other variations or modifications can be made based on the above description. It is neither necessary nor possible to enumerate all possible embodiments. Any obvious modifications or variations derived from the above are all within the protection scope of the present invention.

Claims

1. A multi-layer induction heating body, comprising a first susceptor material layer, a second susceptor material layer, and a transition layer disposed between the first susceptor material layer and the second susceptor material layer.

2. The multi-layer induction heating body according to claim 1, wherein a thickness of the first susceptor material layer is in a range from 20 μm to 150 μm, and/or

   a thickness of the second susceptor material layer is in a range from 20 μm to 150 μm, and/or
   a thickness of the transition layer is in a range from 5 μm to 50 μm.

3. The multi-layer induction heating body according to claim 1, wherein the first susceptor material layer, the transition layer, and the second susceptor material layer are joined together by a sintering process.

4. The multi-layer induction heating body according to claim 1, wherein the multi-layer induction heating body further comprises a protective layer disposed on an outer side of the first susceptor material layer and/or the second susceptor material layer away from the transition layer.

5. The multi-layer induction heating body according to claim 4, wherein a thickness of the protective layer is in a range from 1 μm to 10 μm.

6. The multi-layer induction heating body according to claim 1, wherein the multi-layer induction heating body is in a form of a sheet, a tube, a cup, or a pot.

7. The multi-layer induction heating body according to claim 6, wherein a material of the transition layer is a metal element, an alloy, a ceramic or any combination thereof.

8. The multi-layer induction heating body according to any one of claims 1 to 7, wherein a material of the first susceptor material layer is at least one of nickel and a nickel-chromium alloy, and/or
   a material of the second susceptor material layer is at least one of iron and an iron-based alloy.

9. The multi-layer induction heating body according to any one of claims 1 to 7, wherein the first susceptor material layer and the second susceptor material layer are made of materials having different Curie temperatures, and at least one of the first susceptor material layer and the second susceptor material layer has the Curie temperature below 400°C.

10. The multi-layer induction heating body according to claim 9, wherein the material of the first susceptor material layer has the Curie temperature ranging from 200°C to 400°C.

11. The multi-layer induction heating body according to claim 10, wherein the material of the first susceptor material layer has the Curie temperature of 380°C or above, and/or the material of the second susceptor material layer has the Curie temperature ranging from 400°C to 1000°C.

12. The multi-layer induction heating body according to any one of claims 1 to 7, wherein the multi-layer induction heating body has a monotonically stable current-temperature correspondence in a temperature range between 150°C and 400°C during an electromagnetic induction heating process.

13. The multi-layer induction heating body according to any one of claims 1 to 7, wherein the multi-layer induction heating body has a monotonically stable current-temperature correspondence in two temperature ranges between 150°C and 260°C and between 250°C and 400°C during an electromagnetic induction heating process.

14. A method for preparing the multi-layer induction heating body according to any one of claims 1 to 13, comprising following steps:

   S1, according to raw material compositions of respective layers, preparing green bodies of the respective layers by a tape casting method;
   S2, stacking the green bodies of the respective layers in sequence, and performing a hot isostatic pressing treatment to obtain a pre-sintered body; and
   S3, de-binding and then sintering the pre-sintered body.

15. The method for preparing the multi-layer induction heating body according to claim 14, wherein the hot isostatic pressing treatment is performed at a temperature ranged from 65°C to 85°C and a pressure ranged from 5 MPa to 45 MPa for a time period ranged from 0.1 h to 1 h; and/or

the de-binding is performed at a temperature ranged from 250°C to 550°C for a time period ranged from 1 h to 10 h; and/or
the sintering is performed at a temperature ranged from 1100°C to 1400°C for a time period ranged from 0.5 h to 15 h.

16. The method for preparing the multi-layer induction heating body according to claim 14 or 15, wherein prior to preparing the green bodies of the respective layers by the tape casting method, the method further comprises following steps: adding a PVB binder and an alcohol solvent to powders of corresponding materials according to the raw material compositions of the respective layers, and performing ball milling in a ball mill tank to obtain corresponding slurries for the tape casting method.

17. The method for preparing the multi-layer induction heating body according to claim 16, wherein the ball milling is performed for a time period ranged from 2 h to 4 h to obtain the corresponding slurries for the tape casting method.

18. Use of the multi-layer induction heating body according to any one of claims 1 to 13 or the multi-layer induction heating body prepared by the method according to any one of claims 14 to 17 in the field of magnetic induction heating.

19. The use of the multi-layer induction heating body in the field of magnetic induction heating according to claim 18, wherein the use is for an induction heating aerosol-forming susceptor heating material for electronic cigarettes, an aerosol-forming susceptor heating material for medical atomization, or a beauty apparatus.

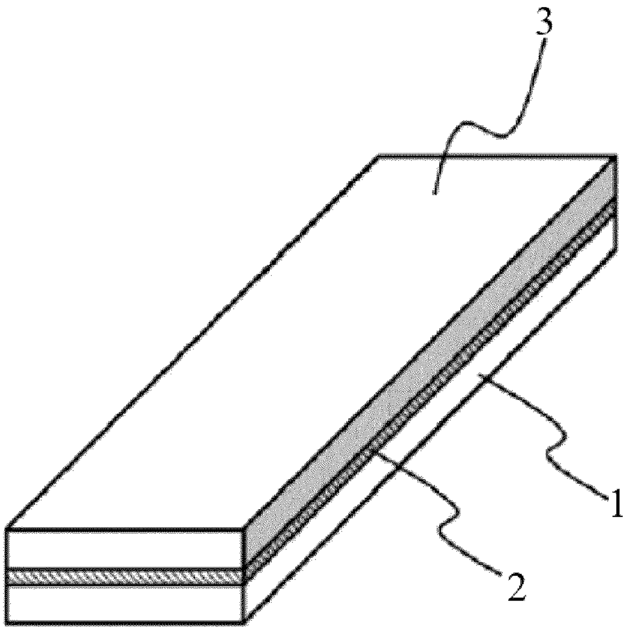
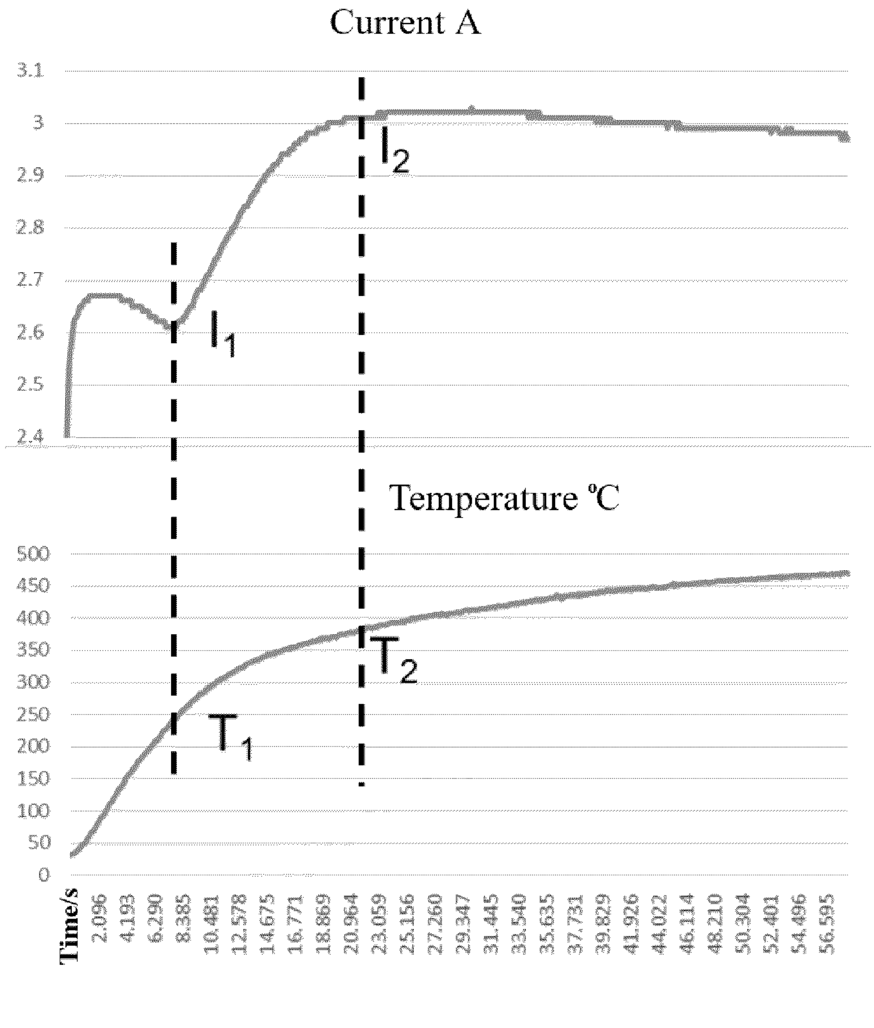

3
1
2

FIG. 1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3.1
3
2.9
2.8
2.7
2.6
2.5
2.4
I_2
I_1
Temperature ºC
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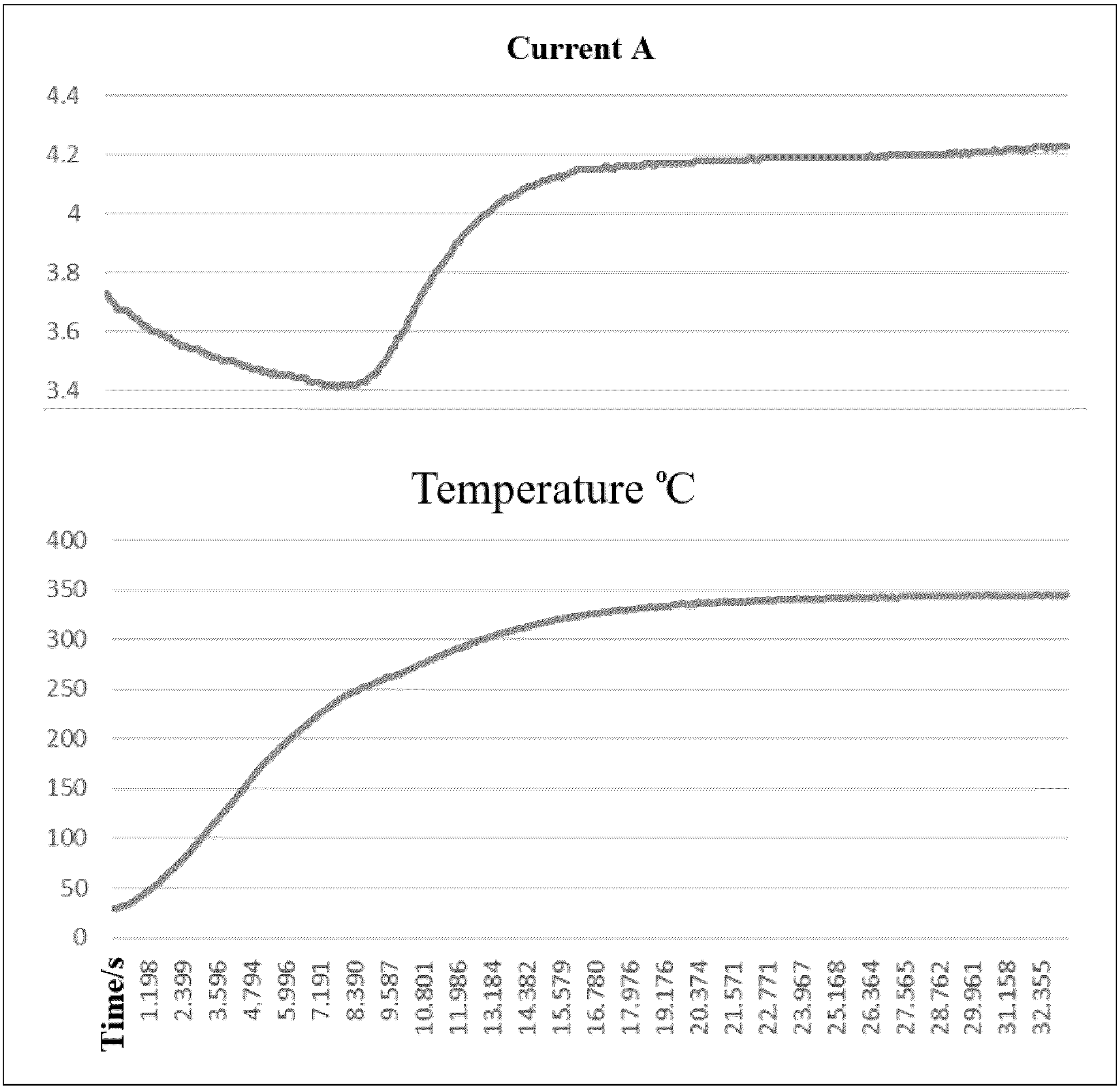
450
400
350
300
250
200
150
100
50
0
T_1
T_2
Time/s
2.096
4.193
6.290
8.385
10.481
12.578
14.675
16.771
18.869
20.964
23.059
25.156
27.260
29.347
31.445
33.540
35.635
37.731
39.829
41.926
44.022
46.114
48.210
50.304
52.401
54.496
56.595

FIG. 2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3.6
3.4
Temperature ℃
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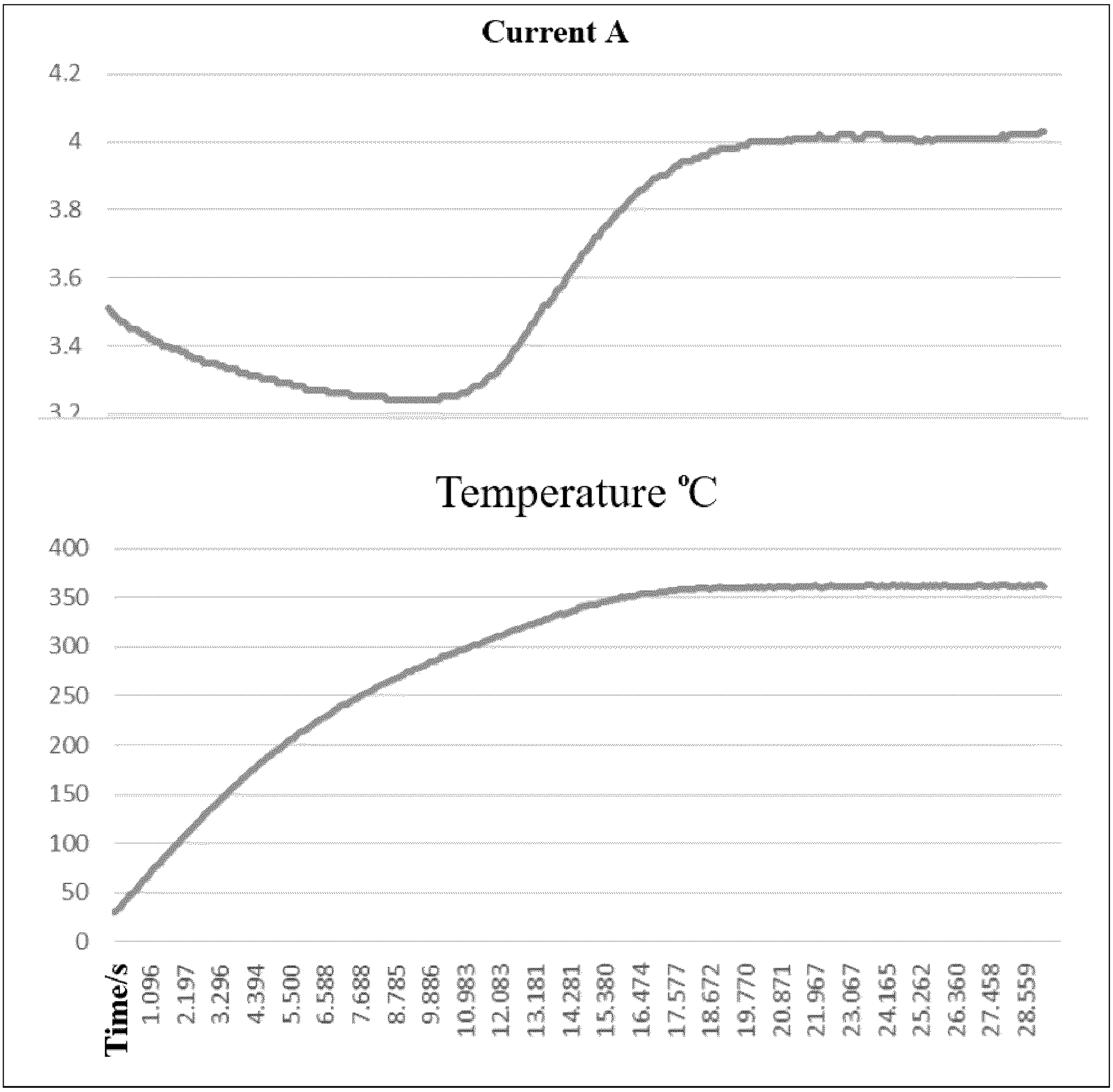
250
200
150
100
50
0
Time/s
1.198
2.399
3.596
4.794
5.996
7.191
8.390
9.587
10.801
11.986
13.184
14.382
15.579
16.780
17.976
19.176
20.374
21.571
22.771
23.967
25.168
26.364
27.565
28.762
29.961
31.158
32.355

FIG. 3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3.8
3.6
3.4
3.2
Temperature ºC
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350
300
250
200
150
100
50
0
Time/s
1.096
2.197
3.296
4.394
5.500
6.588
7.688
8.785
9.886
10.983
12.083
13.181
14.281
15.380
16.474
17.577
18.672
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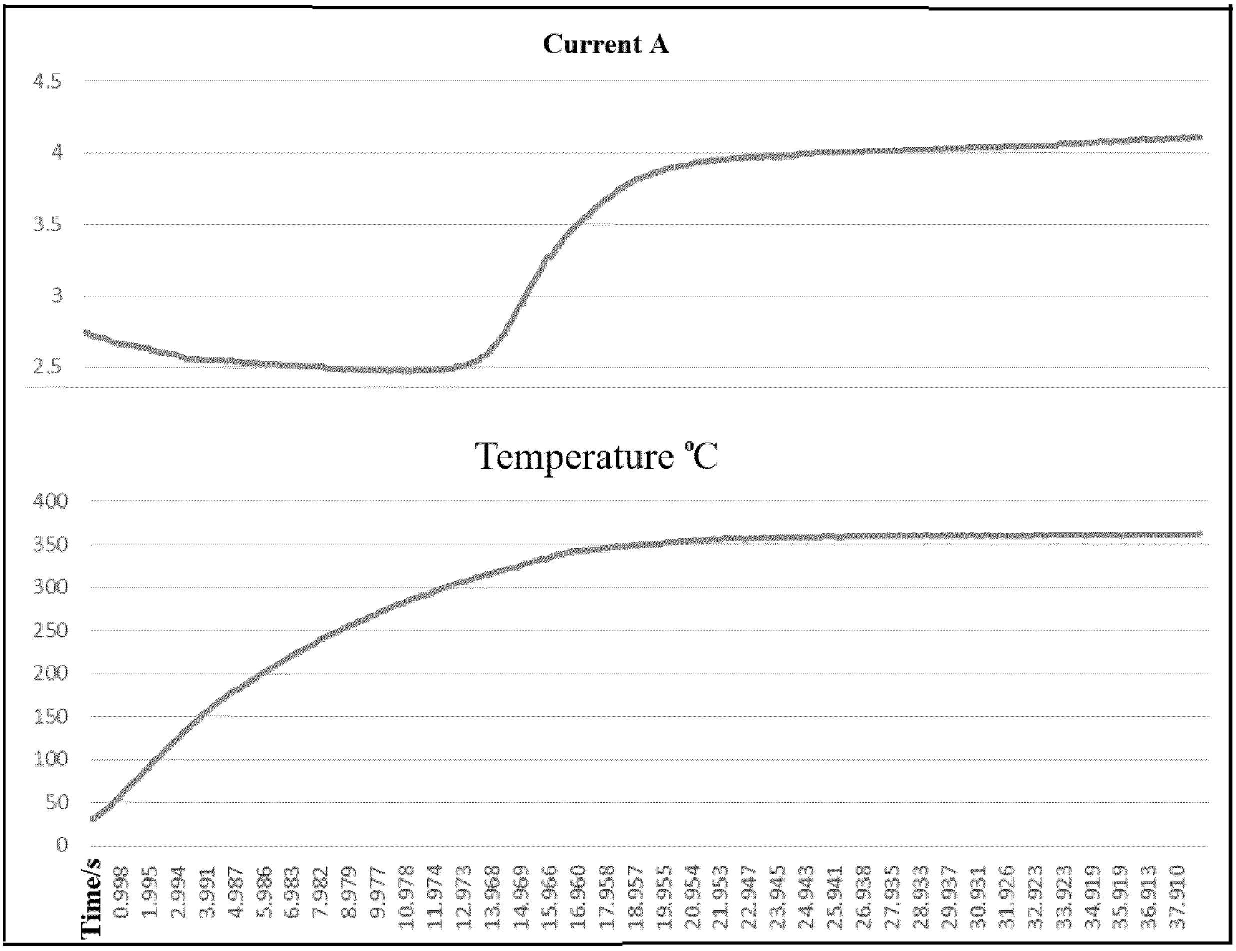
20.871
21.967
23.067
24.165
25.262
26.360
27.458
28.559

FIG. 4


Current A
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4
3.5
3
2.5
Temperature ℃
400
350
300
250
200
150
100
50
0
Time/s
0.998
1.995
2.994
3.991
4.987
5.986
6.983
7.982
8.979
9.977
10.978
11.974
12.973
13.968
14.969
15.966
16.960
17.958
18.957
19.955
20.954
21.953
22.947
23.945
24.943
25.941
26.938
27.935
28.933
29.937
30.931
31.926
32.923
33.923
34.919
35.919
36.913
37.910

FIG. 5

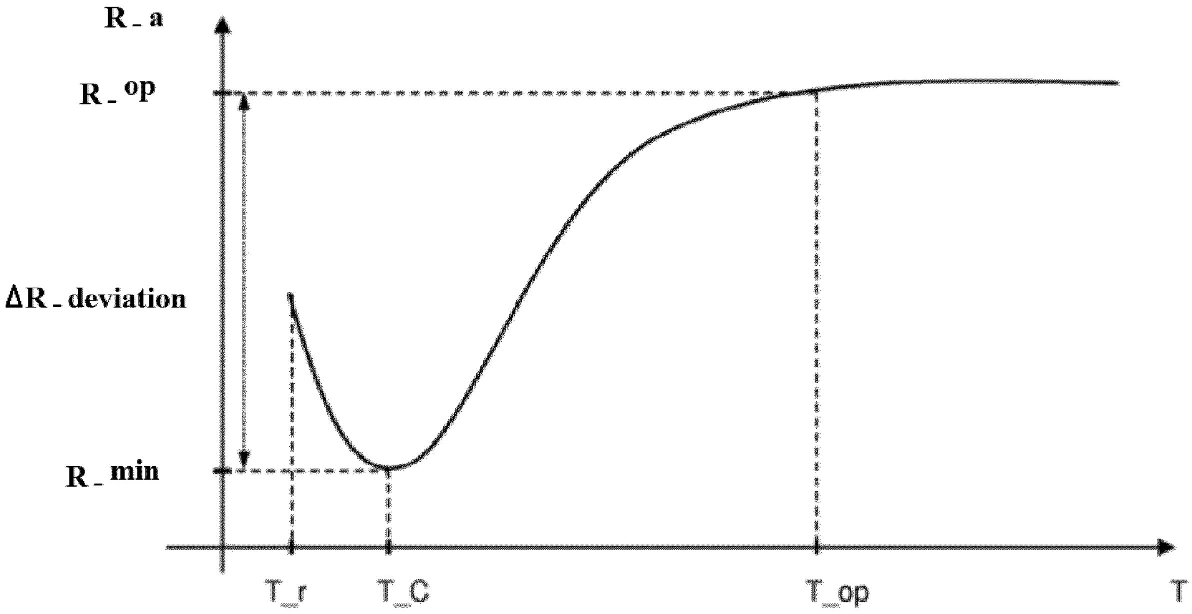
R_a
R_op
ΔR_deviation
R_min
T_r
T_C
T_op
T

FIG. 6

INTERNATIONAL SEARCH REPORT

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A. CLASSIFICATION OF SUBJECT MATTER

A24F 40/465(2020.01)i; A24F 40/70(2020.01)i; B22F 7/02(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)

IPC:A24F,B22F

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

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

CNTXT, VEN, CNKI: 加热, 多层, 雾化, 感应, 感受器, lay?, heat+,

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
PX	CN 115299653 A (SHENZHEN SMOORE TECHNOLOGY LTD.) 08 November 2022 (2022-11-08) entire document	1-19
X	CN 112739229 A (PHILIP MORRIS PRODUCTS S.A.) 30 April 2021 (2021-04-30) description, paragraphs 116-117, and figures 3 and 5	1, 2, 6-8
Y	CN 112739229 A (PHILIP MORRIS PRODUCTS S.A.) 30 April 2021 (2021-04-30) description, paragraphs 116-117, and figures 3 and 5	3-5, 9-19
Y	CN 109875123 A (SHENZHEN FIRST UNION TECHNOLOGY CO., LTD.) 14 June 2019 (2019-06-14) description, paragraphs 43-51	3-5, 9-19
X	CN 113974210 A (HUBEI CHINA TOBACCO INDUSTRY CO., LTD.) 28 January 2022 (2022-01-28) entire document	1-2, 6-8
A	CN 110461177 A (PHILIP MORRIS PRODUCTS S.A.) 15 November 2019 (2019-11-15) entire document	1-19

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

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- "A" document defining the general state of the art which is not considered to be of particular relevance
- "D" document cited by the applicant in the international application
- "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
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- "&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
15 September 2023	**15 September 2023**

Name and mailing address of the ISA/CN	Authorized officer
China National Intellectual Property Administration (ISA/CN) **China No. 6, Xitucheng Road, Jimenqiao, Haidian District, Beijing 100088**	Telephone No.

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C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	CN 216651319 U (SHENZHEN INNOKIN TECHNOLOGY CO., LTD.) 03 June 2022 (2022-06-03) entire document	1-19
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		MX 2019011326 A	21 October 2019
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		HUE 060578 T2	28 March 2023
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		WO 2018178216 A1	04 October 2018
		ZA 201905575 B	27 January 2021
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		AR 111392 A1	10 July 2019
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		AU 2018246293 A1	21 November 2019
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Information on patent family members

International application No.
PCT/CN2023/095852

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