(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 4 398 273 A1

(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 153(4) EPC

(43) Date of publication:
10.07.2024 Bulletin 2024/28

(21) Application number: **22863018.2**

(22) Date of filing: **05.08.2022**

(51) International Patent Classification (IPC):
H01F 1/147 $^{(2006.01)}$ ***H01F 41/02*** $^{(2006.01)}$

(86) International application number:
PCT/CN2022/110452

(87) International publication number:
WO 2023/029877 (09.03.2023 Gazette 2023/10)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

(30) Priority: **01.09.2021 CN 202111020063**

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(54) AMORPHOUS MAGNETIC POWDER CORE PRECURSOR PARTICLE, AMORPHOUS MAGNETIC POWDER CORE, PREPARATION METHOD THEREFOR, AND INDUCTOR

(57) Disclosed herein are an amorphous magnetic powder core precursor particle, an amorphous magnetic powder core, a preparation method therefor, and an inductor. The amorphous magnetic powder core precursor particle comprises an amorphous alloy particle and a coating layer covering the surface of the amorphous alloy particle; elements of the amorphous alloy particle are Fe, Si, Cr, and B. The preparation method comprises: adding an acid solution to the amorphous alloy particle for acidification to obtain an acidified particle, then passivating the acidified particle to obtain a passivated particle, and finally coating the passivated particle to obtain the amorphous magnetic powder core precursor particle. The amorphous magnetic powder core provided by the present application has high magnetic permeability and inductance, and still maintains a low loss characteristic under high-frequency use.

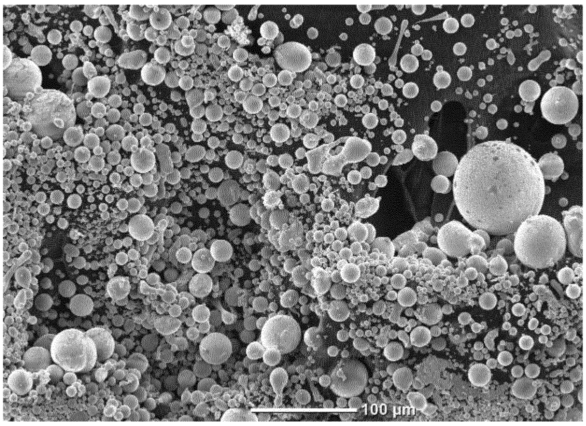

FIG. 1

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Description

TECHNICAL FIELD

[0001] Embodiments of the present application relate to the technical field of alloy soft magnetic materials and powder metallurgy, and for example, an amorphous magnetic powder core precursor particle, an amorphous magnetic powder core, a preparation method therefor, and an inductor.

BACKGROUND

[0002] Magnetic powder core, a novel composite soft magnetic material, possesses excellent soft magnetic properties and frequency characteristics, and has been the key component in the production of inductors, especially those used in high frequency and high power circuits. Lots of new challenges have been brought to the magnetic components by the utilization of the third generation of semiconductor materials with wide bandgap and high current density and the high frequency of electronic devices. The conventional magnetic powder cores such as Fe-Si-Al, Fe-Ni-Mo and Fe-Si alloy systems suffer from poor magnetic stability, high magnetic loss, heavy mass and low power, which cannot satisfy the development needs of magnetic components and are not applicable at high frequency.

[0003] Compared with conventional magnetic powder cores, the amorphous magnetic powder core has the advantages of constant magnetic permeability, high resistivity and low loss at high frequency, and has been widely used in various fields such as transformers, sensors and switch mode power supplies, etc. However, the soft magnetic core, made through tape wound or sheet lamination, has high loss when operating at high frequency, which is limited from high-frequency applications. However, the preparation method of crushing amorphous soft magnetic tape into powder, and insulating-coating and compression-molding the powder into magnetic powder core products provides a direction for further improving the performance of amorphous magnetic powder core.

[0004] CN107818854A discloses a preparation method for an iron-based amorphous soft magnetic powder core and an application, comprising the following steps: firstly preparing and screening an amorphous alloy powder with a target particle size, subjecting the amorphous alloy powder to passivation and insulation coating with a passivation agent and a binder respectively, then pressing the treated amorphous alloy powder into a magnetic powder core by cold pressing method, and finally subjecting the magnetic powder core to longitudinal magnetic field heat treatment to obtain a powder core with high superposition and low loss; however, no specific values for magnetic permeability are presented.

[0005] CN107967976A discloses an amorphous magnetic powder core precursor particle comprising an amorphous alloy particle with a composition of $Fe_aSi_bB_cP_dNb_eX_f$ and a coating layer on the surface of the amorphous alloy particle. Meanwhile, a material and a process for an amorphous magnetic powder core product using soft magnetic ferrite as an insulation coating agent are disclosed. The resulting amorphous magnetic ring sample has a magnetic permeability of 97u, which is higher than the performance of many current magnetic powder core products, but still has a long way from high-permeability Fe-Ni and Fe-Ni-Mo materials.

[0006] CN1080106_54A discloses a new spherical iron-based amorphous alloy powder and a preparation method for an amorphous magnetic powder core, comprising the following steps: preparing the new spherical iron-based amorphous alloy powder by gas atomization, subjecting the screened amorphous alloy powder to passivation and insulation coating in sequence with a passivation agent, an insulation agent and a binder, compression-molding the treated amorphous alloy powder by cold pressing method, and finally performing stress-relief annealing. CN104575913A discloses a preparation method for a low-loss amorphous powder core, wherein the amorphous powder core with magnetic permeability between 60 and 90 is prepared by adding a suitable high-temperature insulating material, selecting a suitable insulation coating method, and performing compression molding and high-temperature annealing process. However, under high frequency conditions, the magnetic permeability of the amorphous powder cores is low and the magnetic loss is high.

[0007] Currently, the powder-preparing technique of gas atomization-undercooling has been significantly improved, making spherical amorphous powders more readily available. The applications of amorphous magnetic powder core are greatly expanded, since, just like the common magnetic powder cores, various magnetic powder cores with different shapes and sizes can be produced by powder metallurgy molding technique. Meanwhile, the reduced powder size can lower the loss, especially in the high frequency MHz range. However, the smaller the powder size, the lower the magnetic permeability of the inductive material of the magnetic powder core, and to improve the magnetic permeability of metal powder core is an important approach to improve efficiency and reduce the core size, but many techniques are not practicable in this way so far.

SUMMARY

[0008] The following is a summary of the subject described in detail herein. This summary is not intended to limit the protection scope of the claims.

[0009] Embodiments of the present application provide an amorphous magnetic powder core precursor particle, an amorphous magnetic powder core, a preparation method therefor, and an inductor. The amorphous magnetic powder core provided in the present application not only has high magnetic permeability and inductance, but also maintains low loss characteristics at high frequency.

[0010] In a first aspect, embodiments of the present application provide an amorphous magnetic powder core precursor particle, wherein the amorphous magnetic powder core precursor particle comprises an amorphous alloy particle and a coating layer on the surface of the amorphous alloy particle; elements of the amorphous alloy particle are Fe, Si, Cr and B.

[0011] The amorphous magnetic powder core precursor particle provided in the present application contains the Cr element. As Cr has a lower potential than Fe, Cr is more susceptible to oxidation than Fe, thus delaying or preventing Fe from rusting, effectively improving the oxidation resistance of the amorphous magnetic powder core precursor, and thus ensuring that the amorphous magnetic powder core has a high magnetic permeability. In addition, the coating layer located on the surface of the amorphous alloy particle has an insulating effect and reduces the loss of amorphous magnetic powder core.

[0012] As a preferred technical solution of the present application, in the amorphous alloy particle, a mass fraction of element Si is 2-4wt%, preferably 2.2-3.8wt%; a mass fraction of element Cr is 2-3wt%, preferably 2.2-2.8wt%; a mass fraction of element B is 10-14wt%, preferably 11-13wt%; a remainder is Fe.

[0013] As Cr has a lower potential than Fe, Cr is more susceptible to oxidation than Fe, thus delaying or preventing Fe from rusting, effectively improving the oxidation resistance of the amorphous magnetic powder core precursor, and thus ensuring that the amorphous magnetic powder core has a high magnetic permeability; however, the excessively high Cr content will reduce the saturation characteristics of the material; accordingly, considering both rust prevention and electromagnetic performance, the Cr content should be controlled at 2-3wt%, and preferably 2.2-2.8wt%.

[0014] The radius of B is smaller than the radius of Fe, and the negative enthalpy of mixing is smaller than the radius of Fe. The appropriate addition of element B is conducive to enhancing the ability of amorphous formation, but the excessively high B content will reduce the saturation characteristics of the material, and the high hardness is not conducive to the subsequent compression molding.

[0015] For example, the mass fraction of element Si in the amorphous alloy particle may be 2wt%, 2.5wt%, 3wt%, 3.5wt% or 4wt%; the mass fraction of element Cr in the amorphous alloy particle may be 2wt%, 2.2wt%, 2.4wt%, 2.6wt%, 2.8wt% or 3wt%; the mass fraction of element Bin the amorphous alloy particle may be 10wt%, 10.5wt%, 11wt%, 11.5wt%, 12wt%, 12.5wt%, 13wt%, 13.5wt% or 14wt%; however, the mass fraction is not limited to the listed values, and other unlisted values within the numerical range are also applicable.

[0016] Preferably, the amorphous alloy particle has a particle size of 200-300 mesh; the amorphous alloy particle has a spherical shape.

[0017] As a preferred technical solution of the present application, the coating layer comprises an inorganic powder and a binder.

[0018] Preferably, the inorganic powder has a particle size of 250-550 nm, such as 250 nm, 280 nm, 300 nm, 320 nm, 350 nm, 380 nm, 400 nm, 420 nm, 450 nm, 480 nm, 500 nm, 530 nm or 550 nm; however, the particle size is not limited to the listed values, and other unlisted values within the numerical range are also applicable.

[0019] Preferably, the inorganic powder is an oxide powder.

[0020] Preferably, the inorganic powder comprises a nano oxide powder or a submicron oxide powder.

[0021] Preferably, the inorganic powder comprises any one or a combination of at least two of silica, a mica powder, zirconia or an aluminium oxide powder, and further preferably silica.

[0022] The inorganic powder inherently has a certain adsorption capacity and can be uniformly adhered to the amorphous alloy particle, which is conducive to the strengthening of the insulation layer and reduces the loss of the magnetic powder core.

[0023] Preferably, the binder is a polymer.

[0024] Preferably, the binder comprises any one or a combination of at least two of an epoxy resin, a silicone resin, an organosilicone resin, a polyamide resin or a phenolic resin, and further preferably an organosilicone resin.

[0025] In a second aspect, embodiments of the present application provide a preparation method for the amorphous magnetic powder core precursor particle according to the first aspect, and the preparation method comprises:
acidifying the amorphous alloy particle by adding an acidic solution to obtain an acidified particle, then passivating the acidified particle to obtain a passivated particle, and finally coating the passivated particle to obtain the amorphous magnetic powder core precursor particle.

[0026] In the present application, the amorphous alloy particle is prepared by high-pressure gas atomization with an atomization pressure of 80-100 kg/m^2, such as 80 kg/m^2, 85 kg/m^2, 90 kg/m^2, 95 kg/m^2 or 100 kg/m^2; however, the atomization pressure is not limited to the listed values, and other unlisted values within the numerical range are also applicable. An atomization gas is a protective gas, including nitrogen or argon.

[0027] Using the high-pressure gas atomization to prepare the amorphous alloy particle can avoid the defects of the conventional strip crushing process, such as impurity introduction, uneven composition and sharp edges, and besides, the gas atomization can prepare the spherical amorphous alloy particle with small particle size, which has smooth surface and no obvious holes or pits or other defects, reducing magnetic loss, and meanwhile, the spherical shape can improve the superimposed current.

[0028] By performing acidifying treatment before the passivation, the problem of slow reaction between the amorphous alloy particle and the passivation agent can be solved, and therefore, a dense passivation film can be formed on the surface of amorphous alloy particle, improving the insulation effect of amorphous alloy particle; additionally, the coating treatment further improves the insulation and stability of amorphous alloy particle. As a result, the amorphous magnetic powder core provided in the present application has high magnetic permeability and low magnetic loss at high frequency.

[0029] As a preferred technical solution of the present application, the acidifying is performed under stirring.

[0030] Preferably, the acidifying is performed for 5-60 min, and further preferably 10-50 min, such as 5 min, 10 min, 15 min, 20 min, 25 min, 30 min, 35 min, 40 min, 45 min, 50 min, 55 min or 60 min; however, the time is not limited to the listed values, and other unlisted values within the numerical range are also applicable.

[0031] Preferably, the acidic solution comprises a chromic acid solution and/or a potassium permanganate solution.

[0032] Preferably, the acidic solution has a mass fraction of 5-25wt%, and further preferably 10-20wt%, such as 5wt%, 10wt%, 15wt%, 20wt% or 25wt%; however, the mass fraction is not limited to the listed values, and other unlisted values within the numerical range are also applicable.

[0033] In the present application, the mass fraction of the acidic solution is particularly limited to 5-25wt%. When the mass fraction of the acidic solution exceeds 25wt%, the amorphous alloy particle will have surface damage due to the high acidity and fast reaction; when the mass fraction of the acidic solution is lower than 5wt%, the amorphous alloy particle cannot react on its surface, because the acidic solution has low acidity and poor activity and exerts no effect on the amorphous alloy particle surface.

[0034] Preferably, based on a mass of the amorphous alloy particle being 100%, the acidic solution has an addition amount of 0.005-0.04wt%, and further preferably 0.01-0.03wt%, such as 0.005wt%, 0.01wt%, 0.015wt%, 0.02wt%, 0.025wt%, 0.03wt%, 0.035wt% or 0.04wt%; however, the addition amount is not limited to the listed values, and other unlisted values within the numerical range are also applicable.

[0035] In the present application, the addition amount of the acidic solution is particularly limited to 0.005-0.04wt%. When the addition amount of the acidic solution exceeds 0.04wt%, the amorphous alloy particle will have surface damage due to the high acidity and fast reaction; when the addition amount of the acidic solution is lower than 0.005wt%, the amorphous alloy particle cannot react on its surface, because the acidic solution has low acidity and poor activity and exerts no effect on the amorphous alloy particle surface.

[0036] As a preferred technical solution of the present application, a passivation agent used for the passivating comprises any one or a combination of at least two of a phosphoric acid solution, a nitric acid solution, a boric acid solution, a sodium dihydrogen phosphate solution, an aluminum dihydrogen phosphate solution or a sodium dihydrogen phosphate solution, and preferably a phosphoric acid solution.

[0037] Preferably, the passivation agent has a mass fraction of 10-20wt%, and further preferably 12-18wt%, such as 10wt%, 12wt%, 14wt%, 16wt%, 18wt% or 20wt%; however, the mass fraction is not limited to the listed values, and other unlisted values within the numerical range are also applicable.

[0038] Preferably, based on a mass of the acidified particle being 100%, the passivation agent has an addition amount of 0.01-0.06wt%, and further preferably 0.02-0.05wt%, such as 0.01wt%, 0.02wt%, 0.03wt%, 0.04wt%, 0.05wt% or 0.06wt%; however, the addition amount is not limited to the listed values, and other unlisted values within the numerical range are also applicable.

[0039] In the present application, the addition amount of the passivation agent is particularly limited to 0.01-0.06wt%. When the addition amount of the passivation agent exceeds 0.06wt%, the magnetic permeability of the obtained amorphous magnetic powder core will be reduced, because the excessively high addition amount of the passivation agent will lead to excessive non-magnetic materials generated; when the addition amount of the passivation agent is lower than 0.01wt%, the magnetic powder loss of the obtained amorphous magnetic powder core will be high, because the passivation layer cannot be compact and the passivated particle will be susceptible to oxidation with excessively low addition amount of the passivation agent.

[0040] Preferably, the coating specifically comprises: mixing the passivated particle with an insulating agent uniformly to obtain an insulating particle, and subsequently adding a binder to the insulating particle and mixing them to obtain the amorphous magnetic powder core precursor particle.

[0041] Preferably, the mixing is performed under ultrasound.

[0042] Preferably, the insulating agent is an inorganic powder.

[0043] Preferably, the inorganic powder has a particle size of 250-550 nm, such as 250 nm, 280 nm, 300 nm, 320 nm, 350 nm, 380 nm, 400 nm, 420 nm, 450 nm, 480 nm, 500 nm, 530 nm or 550 nm; however, the particle size is not limited to the listed values, and other unlisted values within the numerical range are also applicable..

[0044] Preferably, the inorganic powder is an oxide powder.

[0045] Preferably, the inorganic powder comprises a nano oxide powder or a submicron oxide powder.

[0046] Preferably, the inorganic powder comprises any one or a combination of at least two of silica, a mica powder, zirconia or an aluminium oxide powder, and further preferably silica.

[0047] Preferably, based on a mass of the passivated particle being 100%, the insulating agent has a mass fraction of 0.04-0.06wt%, and further preferably 0.045-0.055wt%, such as 0.04wt%, 0.045wt%, 0.05wt%, 0.055wt% or 0.06wt%; however, the mass fraction is not limited to the listed values, and other unlisted values within the numerical range are also applicable.

[0048] Preferably, the binder is a polymer.

[0049] Preferably, the binder comprises any one or a combination of at least two of an epoxy resin, a silicone resin, an organosilicone resin, a polyamide resin or a phenolic resin, and further preferably an organosilicone resin.

[0050] The organosilicone resin has high thermal stability, is not easy to decompose, and as a binder, can improve the stability of amorphous magnetic powder core precursor particle, and also can improve the molding performance of amorphous magnetic powder core precursor particle.

[0051] Preferably, the binder is diluted with a solvent.

[0052] Preferably, the solvent is acetone.

[0053] Preferably, based on a mass of the insulating particle being 100%, the binder has a mass fraction of 0. 1-0.5wt%, and further preferably 0.2-0.4wt%, such as 0. 1wt%, 0. 15wt%, 0.2wt%, 0.25wt%, 0.3wt%, 0.35wt%, 0.4wt%, 0.45wt% or 0.5wt%; however, the mass fraction is not limited to the listed values, and other unlisted values within the numerical range are also applicable.

[0054] In the present application, the addition amount of the binder is particularly limited to 0.1-0.5wt%. When the addition amount of the binder exceeds 0.5wt%, the obtained amorphous magnetic powder core will have low density and low magnetic permeability, because the non-magnetic materials will have a high proportion and the molding density will be low with the excessively high addition amount of the binder; when the addition amount of the binder is lower than 0.1wt%, the body of the amorphous magnetic powder core will have no strength nor fabricability, because the bonding of the amorphous magnetic powder core mainly depends on the effect of binder.

[0055] In a third aspect, embodiments of the present application provide an amorphous magnetic powder core, and the amorphous magnetic powder core is prepared from the amorphous magnetic powder core precursor particle according to the first aspect.

[0056] The amorphous magnetic powder core provided in the present application has high magnetic permeability and high inductance, and maintains high magnetic permeability and low loss characteristics at high frequency.

[0057] In a fourth aspect, embodiments of the present application provide a preparation method for the amorphous magnetic powder core according to the third aspect, and the preparation method comprises:

mixing the amorphous magnetic powder core precursor particle with a release agent uniformly, then adding them to a mold and subjecting to compression molding, and subsequently performing annealing to obtain the amorphous magnetic powder core.

[0058] The amorphous powder core precursor particle is pressed and annealed to remove internal stress and form an amorphous powder core with suitable density, thereby increasing the magnetic permeability of the amorphous magnetic powder core and reducing magnetic loss at the same time.

[0059] As a preferred technical solution of the present application, the compression molding is performed at 10-14 T/cm^2, such as 10 T/cm^2, 11 T/cm^2, 12 T/cm^2, 13 T/cm^2 or 14 T/cm^2; however, the pressure is not limited to the listed values, and other unlisted values within the numerical range are also applicable.

[0060] Preferably, the release agent is stearamide.

[0061] Preferably, based on a mass of the amorphous magnetic powder core precursor particle being 100wt%, the release agent has a mass fraction of 0.01-0.03wt%, such as 0.01wt%, 0.015wt%, 0.02wt%, 0.025wt% or 0.3wt%; however, the mass fraction is not limited to the listed values, and other unlisted values within the numerical range are also applicable.

[0062] Preferably, the annealing is performed at 530-630°C, such as 530°C, 540°C, 550°C, 560°C, 570°C, 580°C, 590°C, 600°C, 610°C, 620°C or 630°C; however, the temperature is not limited to the listed values, and other unlisted values within the numerical range are also applicable.

[0063] Preferably, the annealing is performed for 15-25 min, such as 15 min, 17 min, 20 min, 23 min or 25 min; however, the time is not limited to the listed values, and other unlisted values within the numerical range are also applicable.

[0064] Preferably, an atmosphere for the annealing comprises a nitrogen atmosphere or an argon atmosphere.

[0065] In a fifth aspect, embodiments of the present application provide an inductor, and the inductor comprises the amorphous magnetic powder core according to the third aspect.

[0066] Compared with the related art, the present application has the following beneficial effects:

the amorphous magnetic powder core provided in embodiments of the present application has high magnetic permeability and inductance, and maintains low loss characteristics at high frequency, wherein the magnetic permeability can reach about 140 and the magnetic loss (500 kHz@100 mT) can be as low as about 5500 mW/cm^3, facilitating the application at high frequency.

[0067] Other aspects can be understood upon reading and understanding the accompanying drawings and detailed description.

BRIEF DESCRIPTION OF DRAWINGS

[0068] The accompanying drawings are used to provide a further understanding of the technical solutions herein, and constitute part of the specification, and explain the technical solutions herein in conjunction with the examples of the present application, but do not constitute a limitation on the technical solutions herein.

FIG. 1 shows a scanning electron microscope image of an amorphous alloy particle in Example 1.

FIG. 2 shows a differential thermal analysis curve of an amorphous alloy particle in Example 1.

DETAILED DESCRIPTION

[0069] The technical solutions of the present application are further described below through specific examples. It should be apparent to those skilled in the art that the examples are merely used for a better understanding of the present application and should not be considered as a specific limitation on the present application.

Example 1

[0070] This example provides a preparation method for an amorphous magnetic powder core, and the preparation method specifically comprises the following steps.

(1) A Fe-Si-Cr-B amorphous alloy particle with a particle size of 200 meshes was obtained by high-pressure gas atomization and screening, wherein a mass fraction of Fe was 82%, a mass fraction of Si was 3.5%, a mass fraction of Cr was 2.5% and a mass fraction of B was 12%. By characterizing the morphology of the amorphous alloy particle with scanning electron microscopy, as shown in FIG. 1, it can be seen that the amorphous alloy particle has a spherical shape, smooth surface and no obvious holes or pits or other defects; by analyzing the thermal transitions of the amorphous alloy particle with differential thermal analyzer, as shown in FIG. 2, it can be seen from the differential thermal analysis that the amorphous alloy particle has an exothermic peak at 450-480°C, i.e., the crystallization temperature, indicating that the prepared amorphous alloy particle is amorphous.

(2) The amorphous alloy particle obtained in step (1) was added with a chromic acid solution with a mass fraction of 15wt% and acidified for 30 min under stirring to obtain an acidified particle. In this step, an addition amount of the chromic acid solution was 0.02wt% of a mass of the amorphous alloy particle.

(3) The acidified particle obtained in step (2) was added with a phosphoric acid solution with a mass fraction of 15wt% and passivated, and stirred thoroughly until dry to obtain a passivated particle. In this step, an addition amount of the phosphoric acid solution was 0.03wt% of a mass of the acidified particle.

(4) The passivated particle obtained in step (3) was subjected to coating treatment; firstly, the passivated particle was uniformly mixed with an insulating agent of silica with a particle size of 500 nm under ultrasound to obtain an insulating particle, wherein an addition amount of silica was 0.05wt% of a mass of the passivated particle; subsequently, the insulating particle was added with an acetone solution of methyl silicone resin and mixed uniformly, and stirred thoroughly until dry to obtain an amorphous magnetic powder core precursor particle, wherein an addition amount of the acetone solution of methyl silicone resin was 0.3wt% of the insulating particle.

(5) The amorphous magnetic powder core precursor particle obtained in step (4) was added with zinc stearate, wherein an addition amount of the stearamide was 0.02wt% of a mass of the amorphous magnetic powder core precursor particle, mixed uniformly, and compressed into a magnetic ring ($\Phi 8\times 3.9\times 3.2$mm) at 12 T/cm^2, which had an external diameter of 8 mm, an internal diameter of 3.9 mm and a height of 3.2 mm; then, the magnetic ring was placed in a tube furnace under nitrogen protected and annealed at 580°C for 20 min to obtain the amorphous magnetic powder core.

Example 2

[0071] This example provides a preparation method for an amorphous magnetic powder core, and the preparation method specifically comprises the following steps.

(1) A Fe-Si-Cr-B amorphous alloy particle with a particle size of 300 meshes was obtained by high-pressure gas atomization and screening, wherein a mass fraction of Fe was 84%, a mass fraction of Si was 2.2%, a mass fraction of Cr was 2.8% and a mass fraction of B was 11%.

(2) The amorphous alloy particle obtained in step (1) was added with a chromic acid solution with a mass fraction of 10wt% and acidified for 50 min under stirring to obtain an acidified particle. In this step, an addition amount of the chromic acid solution was 0.03wt% of a mass of the amorphous alloy particle.

(3) The acidified particle obtained in step (2) was added with a phosphoric acid solution with a mass fraction of 12wt% and passivated, and stirred thoroughly until dry to obtain a passivated particle. In this step, an addition amount of the phosphoric acid solution was 0.05wt% of a mass of the acidified particle.

(4) The passivated particle obtained in step (3) was subjected to coating treatment; firstly, the passivated particle was uniformly mixed with an insulating agent of silica with a particle size of 250 nm under ultrasound to obtain an insulating particle, wherein an addition amount of silica was 0.055wt% of a mass of the passivated particle; subsequently, the insulating particle was added with an acetone solution of methyl silicone resin and mixed uniformly, and stirred thoroughly until dry to obtain an amorphous magnetic powder core precursor particle, wherein an addition amount of the acetone solution of methyl silicone resin was 0.2wt% of the insulating particle.

(5) The amorphous magnetic powder core precursor particle obtained in step (4) was added with zinc stearate, wherein an addition amount of the stearamide was 0.01wt% of a mass of the amorphous magnetic powder core precursor particle, mixed uniformly, and subjected to compression molding at 10 T/cm^2 (Φ8×3.9×3.2mm); then, the product was placed in a tube furnace under nitrogen protected and annealed at 530°C for 25 min to obtain the amorphous magnetic powder core.

Example 3

[0072] This example provides a preparation method for an amorphous magnetic powder core, and the preparation method specifically comprises the following steps.

(1) A Fe-Si-Cr-B amorphous alloy particle with a particle size of 200 meshes was obtained by high-pressure gas atomization and screening, wherein a mass fraction of Fe was 81%, a mass fraction of Si was 3.8%, a mass fraction of Cr was 2.2% and a mass fraction of B was 13%.

(2) The amorphous alloy particle obtained in step (1) was added with a potassium permanganate solution with a mass fraction of 20wt% and acidified for 10 min under stirring to obtain an acidified particle. In this step, an addition amount of the chromic acid solution was 0.01wt% of a mass of the amorphous alloy particle.

(3) The acidified particle obtained in step (2) was added with a phosphoric acid solution with a mass fraction of 18wt% and passivated, and stirred thoroughly until dry to obtain a passivated particle. In this step, an addition amount of the phosphoric acid solution was 0.02wt% of a mass of the acidified particle.

(4) The passivated particle obtained in step (3) was subjected to coating treatment; firstly, the passivated particle was uniformly mixed with an insulating agent of silica with a particle size of 550 nm under ultrasound to obtain an insulating particle, wherein an addition amount of silica was 0.045wt% of a mass of the passivated particle; subsequently, the insulating particle was added with an acetone solution of methyl silicone resin and mixed uniformly, and stirred thoroughly until dry to obtain an amorphous magnetic powder core precursor particle, wherein an addition amount of the acetone solution of methyl silicone resin was 0.4wt% of the insulating particle.

(5) The amorphous magnetic powder core precursor particle obtained in step (4) was added with zinc stearate, wherein an addition amount of the stearamide was 0.03wt% of a mass of the amorphous magnetic powder core precursor particle, mixed uniformly, and subjected to compression molding at 14 T/cm^2 (Φ8×3.9×3.2mm); then, the product was placed in a tube furnace under nitrogen protected and annealed at 630°C for 15 min to obtain the amorphous magnetic powder core.

Example 4

[0073] This example provides a preparation method for an amorphous magnetic powder core, and the preparation method specifically comprises the following steps.

(1) A Fe-Si-Cr-B amorphous alloy particle with a particle size of 200 meshes was obtained by high-pressure gas atomization and screening, wherein a mass fraction of Fe was 85%, a mass fraction of Si was 2%, a mass fraction of Cr was 3% and a mass fraction of B was 10%.

(2) The amorphous alloy particle obtained in step (1) was added with a potassium permanganate solution with a mass fraction of 5wt% and acidified for 60 min under stirring to obtain an acidified particle. In this step, an addition amount of the chromic acid solution was 0.04wt% of a mass of the amorphous alloy particle.

(3) The acidified particle obtained in step (2) was added with a phosphoric acid solution with a mass fraction of 10wt% and passivated, and stirred thoroughly until dry to obtain a passivated particle. In this step, an addition amount of the phosphoric acid solution was 0.06wt% of a mass of the acidified particle.

(4) The passivated particle obtained in step (3) was subjected to coating treatment; firstly, the passivated particle was uniformly mixed with an insulating agent of silica with a particle size of 500 nm under ultrasound to obtain an insulating particle, wherein an addition amount of silica was 0.04wt% of a mass of the passivated particle; subsequently, the insulating particle was added with an acetone solution of methyl silicone resin and mixed uniformly, and stirred thoroughly until dry to obtain an amorphous magnetic powder core precursor particle, wherein an addition amount of the acetone solution of methyl silicone resin was 0.5wt% of the insulating particle.

(5) The amorphous magnetic powder core precursor particle obtained in step (4) was added with stearamide, wherein an addition amount of the stearamide was 0.02wt% of a mass of the amorphous magnetic powder core precursor particle, mixed uniformly, and subjected to compression molding at 12 T/cm^2 (Φ8×3.9×3.2mm); then, the product was placed in a tube furnace under nitrogen protected and annealed at 580°C for 20 min to obtain the amorphous magnetic powder core.

Example 5

[0074] This example provides a preparation method for an amorphous magnetic powder core, and the preparation method specifically comprises the following steps.

(1) A Fe-Si-Cr-B amorphous alloy particle with a particle size of 200 meshes was obtained by high-pressure gas atomization and screening, wherein a mass fraction of Fe was 80%, a mass fraction of Si was 4%, a mass fraction of Cr was 2% and a mass fraction of B was 14%.

(2) The amorphous alloy particle obtained in step (1) was added with a chromic acid solution with a mass fraction of 25wt% and acidified for 5 min under stirring to obtain an acidified particle. In this step, an addition amount of the chromic acid solution was 0.005wt% of a mass of the amorphous alloy particle.

(3) The acidified particle obtained in step (2) was added with a phosphoric acid solution with a mass fraction of 20wt% and passivated, and stirred thoroughly until dry to obtain a passivated particle. In this step, an addition amount of the phosphoric acid solution was 0.01wt% of a mass of the acidified particle.

(4) The passivated particle obtained in step (3) was subjected to coating treatment; firstly, the passivated particle was uniformly mixed with an insulating agent of silica with a particle size of 500 nm under ultrasound to obtain an insulating particle, wherein an addition amount of silica was 0.06wt% of a mass of the passivated particle; subsequently, the insulating particle was added with an acetone solution of methyl silicone resin and mixed uniformly, and stirred thoroughly until dry to obtain an amorphous magnetic powder core precursor particle, wherein an addition amount of the acetone solution of methyl silicone resin was 0.1wt% of the insulating particle.

(5) The amorphous magnetic powder core precursor particle obtained in step (4) was added with stearamide, wherein an addition amount of the stearamide was 0.02wt% of a mass of the amorphous magnetic powder core precursor particle, mixed uniformly, and subjected to compression molding at 12 T/cm^2 (Φ8×3.9×3.2mm); then, the product was placed in a tube furnace under nitrogen protected and annealed at 580°C for 20 min to obtain the amorphous magnetic powder core.

Example 6

[0075] This example provides a preparation method for an amorphous magnetic powder core, and the preparation method specifically comprises the following steps.

(1) A Fe-Si-Cr-B amorphous alloy particle with a particle size of 200 meshes was obtained by high-pressure gas atomization and screening, wherein a mass fraction of Fe was 82%, a mass fraction of Si was 3.5%, a mass fraction of Cr was 2.5% and a mass fraction of B was 12%.

(2) The amorphous alloy particle obtained in step (1) was added with a chromic acid solution with a mass fraction of 15wt% and acidified for 30 min under stirring to obtain an acidified particle. In this step, an addition amount of the chromic acid solution was 0.01wt% of a mass of the amorphous alloy particle.

(3) The acidified particle obtained in step (2) was added with a phosphoric acid solution with a mass fraction of 15wt% and passivated, and stirred thoroughly until dry to obtain a passivated particle. In this step, an addition amount of the phosphoric acid solution was 0.05wt% of a mass of the acidified particle.

(4) The passivated particle obtained in step (3) was subjected to coating treatment; firstly, the passivated particle was uniformly mixed with an insulating agent of silica with a particle size of 500 nm under ultrasound to obtain an insulating particle, wherein an addition amount of silica was 0.05wt% of a mass of the passivated particle; subsequently, the insulating particle was added with an acetone solution of methyl silicone resin and mixed uniformly, and stirred thoroughly until dry to obtain an amorphous magnetic powder core precursor particle, wherein an addition amount of the acetone solution of methyl silicone resin was 0.2wt% of the insulating particle.

(5) The amorphous magnetic powder core precursor particle obtained in step (4) was added with stearamide, wherein an addition amount of the stearamide was 0.02wt% of a mass of the amorphous magnetic powder core precursor particle, mixed uniformly, and compressed into a magnetic ring (Φ8×3.9×3.2mm) at 14 T/cm^2, which had an external diameter of 8 mm, an internal diameter of 3.9 mm and a height of 3.2 mm; then, the magnetic ring was placed in a tube furnace under nitrogen protected and annealed at 530°C for 20 min to obtain the amorphous magnetic powder core.

Example 7

[0076] This example provides a preparation method for an amorphous magnetic powder core, and the preparation method specifically comprises the following steps.

(1) A Fe-Si-Cr-B amorphous alloy particle with a particle size of 200 meshes was obtained by high-pressure gas atomization and screening, wherein a mass fraction of Fe was 84%, a mass fraction of Si was 4%, a mass fraction of Cr was 2% and a mass fraction of B was 10%.

(2) The amorphous alloy particle obtained in step (1) was added with a potassium permanganate solution with a mass fraction of 15wt% and acidified for 30 min under stirring to obtain an acidified particle. In this step, an addition amount of the chromic acid solution was 0.01wt% of a mass of the amorphous alloy particle.

(3) The acidified particle obtained in step (2) was added with a phosphoric acid solution with a mass fraction of 15wt% and passivated, and stirred thoroughly until dry to obtain a passivated particle. In this step, an addition amount of the phosphoric acid solution was 0.05wt% of a mass of the acidified particle.

(4) The passivated particle obtained in step (3) was subjected to coating treatment; firstly, the passivated particle was uniformly mixed with an insulating agent of silica with a particle size of 500 nm under ultrasound to obtain an insulating particle, wherein an addition amount of silica was 0.05wt% of a mass of the passivated particle; subsequently, the insulating particle was added with an acetone solution of methyl silicone resin and mixed uniformly, and stirred thoroughly until dry to obtain an amorphous magnetic powder core precursor particle, wherein an addition amount of the acetone solution of methyl silicone resin was 0.2wt% of the insulating particle.

(5) The amorphous magnetic powder core precursor particle obtained in step (4) was added with stearamide, wherein an addition amount of the stearamide was 0.02wt% of a mass of the amorphous magnetic powder core precursor particle, mixed uniformly, and compressed into a magnetic ring (Φ8×3.9×3.2mm) at 14 T/cm^2, which had an external

diameter of 8 mm, an internal diameter of 3.9 mm and a height of 3.2 mm; then, the magnetic ring was placed in a tube furnace under nitrogen protected and annealed at 550°C for 20 min to obtain the amorphous magnetic powder core.

Example 8

[0077] This example differs from Example 1 in that in step (1), for the Fe-Si-Cr-B amorphous alloy particle, a mass fraction of Fe was 79.5%, a mass fraction of Si was 3.5%, a mass fraction of Cr was 5% and a mass fraction of B was 12%. Other process parameters and operating steps are the same as in Example 1.

Example 9

[0078] This example differs from Example 1 in that in step (1), for the Fe-Si-Cr-B amorphous alloy particle, a mass fraction of Fe was 83.5%, a mass fraction of Si was 3.5%, a mass fraction of Cr was 1% and a mass fraction of B was 12%. Other process parameters and operating steps are the same as in Example 1.

Example 10

[0079] This example differs from Example 1 in that in step (2), the amorphous alloy particle obtained in step (1) was added with a chromic acid solution with a mass fraction of 30wt% and acidified for 30 min under stirring to obtain an acidified particle. Other process parameters and operating steps are the same as in Example 1.

Example 11

[0080] This example differs from Example 1 in that in step (2), the amorphous alloy particle obtained in step (1) was added with a chromic acid solution with a mass fraction of 3wt% and acidified for 30 min under stirring to obtain an acidified particle. Other process parameters and operating steps are the same as in Example 1.

Example 12

[0081] This example differs from Example 1 in that in step (2), an addition amount of the chromic acid solution was 0.05wt% of a mass of the amorphous alloy particle. Other process parameters and operating steps are the same as in Example 1.

Example 13

[0082] This example differs from Example 1 in that in step (2), an addition amount of the chromic acid solution was 0.002wt% of a mass of the amorphous alloy particle. Other process parameters and operating steps are the same as in Example 1.

Example 14

[0083] This example differs from Example 1 in that in step (3), an addition amount of the phosphoric acid solution was 0.08wt% of a mass of the acidified particle. Other process parameters and operating steps are the same as in Example 1.

Example 15

[0084] This example differs from Example 1 in that in step (3), an addition amount of the phosphoric acid solution was 0.005wt% of a mass of the acidified particle. Other process parameters and operating steps are the same as in Example 1.

Example 16

[0085] This example differs from Example 1 in that in step (4), an addition amount of the acetone solution of methyl silicone resin was 0.7wt% of a mass of the insulating particle. Other process parameters and operating steps are the same as in Example 1.

Example 17

[0086] This example differs from Example 1 in that in step (4), an addition amount of the acetone solution of methyl silicone resin was 0.05wt% of a mass of the insulating particle. Other process parameters and operating steps are the same as in Example 1.

Comparative Example 1

[0087] This comparative example differs from Example 1 in that in step (1), a Fe-Si-B amorphous alloy particle with a particle size of 200 meshes was obtained by high-pressure gas atomization and screening, wherein a mass fraction of Fe was 84.5%, a mass fraction of Si was 3.5%, and a mass fraction of B was 12%. Other process parameters and operating steps are the same as in Example 1.

Comparative Example 2

[0088] This comparative example differs from Example 1 in that the amorphous alloy particle obtained in step (1) was directly subjected to the passivation treatment in step (3). Other process parameters and operating steps are the same as in Example 1.

Comparative Example 3

[0089] This comparative example differs from Example 1 in that in step (4), the passivated particle obtained in step (3) was subjected to coating treatment with adding an acetone solution of methyl silicone resin, and stirred thoroughly until dry to obtain an amorphous magnetic powder core precursor particle, wherein an addition amount of the acetone solution of methyl silicone resin was 0.3wt% of the insulating particle. Other process parameters and operating steps are the same as in Example 1.

[0090] The performance test results of the amorphous magnetic powder cores prepared in Examples 1-17 and Comparative Examples 1-3 are shown in Table 1.

Table 1

	Magnetic Permeability	Inductance L (μH)	Loss @ 100 mT unit: mW/cm^3		
			50 kHz	500 kHz	1 MHz
Example 1	139.8	7.06	244.43	5530.5	15890.4
Example 2	142.5	7.20	253.22	5021.4	15298.3
Example 3	145.3	7.34	267.82	5209.3	15373.2
Example 4	136.3	6.88	304.21	5308.8	15569.2
Example 5	158.4	8.00	311.13	5792.8	15749.5
Example 6	169.31	8.55	308.33	5886.2	15070.3
Example 7	153.9	7.77	256.21	5543.9	15321.4
Example 8	127.2	6.43	390.41	6025.6	18249.3
Example 9	125.6	6.35	387.62	6227.9	18364.8
Example 10	114.2	5.78	366.91	7193.5	17442.8
Example 11	156.7	7.91	341.57	7023.1	17651.4
Example 12	144.8	7.31	388.95	7297.6	18182.8
Example 13	139.6	7.05	397.01	6534.9	18386.7
Example 14	130.3	7.79	366.98	7298.3	17543.9
Example 15	143.6	7.25	376.89	7328.1	18025.6
Example 16	128.6	6.98	371.13	6569.2	17227.9
Example 17	153.2	7.74	389.92	6199.5	18193.5

(continued)

	Magnetic Permeability	Inductance L (μH)	Loss @ 100 mT unit: mW/cm^3		
			50 kHz	500 kHz	1 MHz
Comparative Example 1	107.3	5.42	355.32	4908.2	14023.1
Comparative Example 2	100.9	5.10	308.24	5021.4	15207.6
Comparative Example 3	112.4	5.68	311.09	4883.7	14903.8

[0091] As can be seen from the data in Table 1:

(1) The amorphous magnetic powder cores of Examples 1-7 all have high magnetic permeability and high inductance, and can maintain low loss characteristics at high frequency, indicating that the amorphous magnetic powder cores obtained by the amorphous magnetic powder core preparation method provided in the present application have excellent performance.

(2) The magnetic permeability and inductance of the amorphous magnetic powder cores of Examples 8 and 9 are lower than those of Example 1, and the magnetic loss is higher than that of Example 1 at low or high frequency, the reason of which is that in Example 8, the Cr content of the amorphous magnetic powder core precursor particle is too high, and in Example 9, the Cr content of the amorphous magnetic powder core precursor particle is too low. As Cr has a lower potential than Fe, Cr is more susceptible to oxidation than Fe, thus delaying or preventing Fe from rusting, effectively improving the oxidation resistance of the amorphous magnetic powder core precursor, and thus ensuring that the amorphous magnetic powder core has a high magnetic permeability; however, the excessively high Cr content will reduce the saturation characteristics of the material.

(3) The magnetic loss of the amorphous magnetic powder cores of Examples 10 and 11 is higher than that of Example 1 at low or high frequency, the reason of which is that in Example 10, the mass fraction of the acidic solution is too high and in Example 11, the mass fraction of the acidic solution is too low. When the mass fraction of the acidic solution is too high, the high acidity and fast reaction will lead to surface damage of the amorphous alloy particle; when the mass fraction of the acidic solution is too low, the acidic solution will have low acidity and poor activity and thus have no effect on the surface of the amorphous alloy particle.

(4) The magnetic loss of the amorphous magnetic powder cores of Examples 12 and 13 is higher than that of Example 1 at low or high frequency, the reason of which is that in Example 12, the addition amount of the acidic solution is too high and in Example 13, the addition amount of the acidic solution is too low. When the addition amount of the acidic solution is too high, the high acidity and fast reaction will lead to surface damage of the amorphous alloy particle; when the addition amount of the acidic solution is too low, the acidic solution will have low acidity and poor activity and thus have no effect on the surface of the amorphous alloy particle.

(5) The magnetic loss of the amorphous magnetic powder cores of Examples 14 and 15 is higher than that of Example 1 at low or high frequency, and the magnetic permeability of the amorphous magnetic powder core of Example 14 is lower than that of Example 1, the reason of which is that in Example 14, the addition amount of the passivation agent is too high and in Example 15, the addition amount of the passivation agent is too low. When the addition amount of the passivation agent is too high, excessive non-magnetic materials will be generated, resulting in decreased magnetic permeability of the amorphous magnetic powder core; when the addition amount of the passivation agent is too low, the passivation layer cannot be compact and the passivated particle will be susceptible to oxidation, resulting in high magnetic powder loss of the amorphous magnetic powder core.

(6) The magnetic loss of the amorphous magnetic powder cores of Examples 16 and 17 is higher than that of Example 1 at low or high frequency, and the magnetic permeability of the amorphous magnetic powder core of Example 16 is lower than that of Example 1, the reason of which is that in Example 16, the addition amount of the binder is too high and in Example 17, the addition amount of the binder is too low. When the addition amount of the binder is too high, the non-magnetic materials will have a high proportion and the molding density will be low, and thus the obtained amorphous magnetic powder core will have low density and low magnetic permeability; when the addition amount of the binder is too low, the body of the amorphous magnetic powder core will have no strength nor fabricability, the reason of which is that the bonding of the amorphous magnetic powder core mainly depends

on the effect of binder.

(7) The magnetic permeability and inductance of the amorphous powder cores of Comparative Examples 1-3 are lower than those of Example 1, and the magnetic loss is higher than that of Example 1 at low or high frequency, the reason of which is that no Cr is contained in the amorphous powder core precursor particle in Comparative Example 1, the acid treatment process is skipped in Comparative Example 2, and the insulation process of the inorganic powder is skipped in Comparative Example 3. As can be seen from the data of Comparative Examples 1-3, the appropriate addition of Cr, the acid treatment process and the inorganic powder insulation process play an important role for the amorphous magnetic powder core in improving magnetic permeability and inductance and reducing magnetic loss.

[0092] The applicant declares that although the specific examples of the present application are described above, the protection scope of the present application is not limited thereto, and it should be apparent to those skilled in the art that any variation or substitution, which is obvious to those skilled in the art within the technical scope disclosed in the present application, shall falls within the protection scope and disclosure scope of the present application.

Claims

1. An amorphous magnetic powder core precursor particle, which comprises an amorphous alloy particle and a coating layer on the surface of the amorphous alloy particle; elements of the amorphous alloy particle are Fe, Si, Cr and B.

2. The amorphous magnetic powder core precursor particle according to claim 1, wherein mass percentages of the elements of the amorphous alloy particle are as follows:

Si	2-4wt%;
Cr	2-3wt%;
B	10-14wt%; and

a remainder of Fe.

3. The amorphous magnetic powder core precursor particle according to claim 2, wherein the mass percentages of the elements of the amorphous alloy particle are as follows:

Si	2.2-3.8wt%;
Cr	2.2-2.8wt%;
B	11-13wt%; and

a remainder of Fe.

4. The amorphous magnetic powder core precursor particle according to any one of claims 1 to 3, wherein the amorphous alloy particle has a particle size of 200-300 mesh.

5. The amorphous magnetic powder core precursor particle according to any one of claims 1 to 4, wherein the amorphous alloy particle has a spherical shape.

6. The amorphous magnetic powder core precursor particle according to any one of claims 1 to 5, wherein the coating layer comprises an inorganic powder and a binder;

   preferably, the inorganic powder has a particle size of 250-550 nm;
   preferably, the inorganic powder is an oxide powder;
   preferably, the inorganic powder comprises a nano oxide powder or a submicron oxide powder;
   preferably, the inorganic powder comprises any one or a combination of at least two of silica, a mica powder, zirconia or an aluminium oxide powder, and further preferably silica;
   preferably, the binder is a polymer;
   preferably, the binder comprises any one or a combination of at least two of an epoxy resin, a silicone resin,

an organosilicone resin, a polyamide resin or a phenolic resin, and further preferably an organosilicone resin.

7. A preparation method for the amorphous magnetic powder core precursor particle according to any one of claims 1 to 6, comprising
acidifying the amorphous alloy particle by adding an acidic solution to obtain an acidified particle, then passivating the acidified particle to obtain a passivated particle, and finally coating the passivated particle to obtain the amorphous magnetic powder core precursor particle.

8. The preparation method according to claim 7, wherein the acidifying is performed under stirring.

9. The preparation method according to claim 7 or 8, wherein the acidifying is performed for 5-60 min, and further preferably 10-50 min.

10. The preparation method according to any one of claims 7 to 9, wherein the acidic solution comprises a chromic acid solution and/or a potassium permanganate solution;

preferably, the acidic solution has a mass fraction of 5-25wt%, and further preferably 10-20wt%;
preferably, based on a mass of the amorphous alloy particle being 100%, the acidic solution has an addition amount of 0.005-0.04wt%, and further preferably 0.01-0.03wt%.

11. The preparation method according to any one of claims 7 to 10, wherein a passivation agent used for the passivating comprises any one or a combination of at least two of a phosphoric acid solution, a nitric acid solution, a boric acid solution, a sodium dihydrogen phosphate solution, an aluminum dihydrogen phosphate solution or a sodium dihydrogen phosphate solution, and preferably a phosphoric acid solution;

preferably, the passivation agent has a mass fraction of 10-20wt%, and further preferably 12-18wt%;
preferably, based on a mass of the acidified particle being 100%, the passivation agent has an addition amount of 0.01-0.06wt%, and further preferably 0.02-0.05wt%;
preferably, the coating specifically comprises:

mixing the passivated particle with an insulating agent uniformly to obtain an insulating particle, and subsequently adding a binder to the insulating particle and mixing them to obtain the amorphous magnetic powder core precursor particle;
preferably, the mixing is performed under ultrasound;
preferably, the insulating agent is an inorganic powder;
preferably, the inorganic powder has a particle size of 250-550 nm;
preferably, the inorganic powder is an oxide powder;
preferably, the inorganic powder comprises a nano oxide powder or a submicron oxide powder;
preferably, the inorganic powder comprises any one or a combination of at least two of silica, a mica powder, zirconia or an aluminium oxide powder, and further preferably silica;
preferably, based on a mass of the passivated particle being 100%, the insulating agent has a mass fraction of 0.04-0.06wt%, and further preferably 0.045-0.055wt%;
preferably, the binder is a polymer;
preferably, the binder comprises any one or a combination of at least two of an epoxy resin, a silicone resin, an organosilicone resin, a polyamide resin or a phenolic resin, and further preferably an organosilicone resin;
preferably, the binder is diluted with a solvent;
preferably, the solvent is acetone;
preferably, based on a mass of the insulating particle being 100%, the binder has a mass fraction of 0.1-0.5wt%, and further preferably 0.2-0.4wt%.

12. An amorphous magnetic powder core, which is prepared from the amorphous magnetic powder core precursor particle according to any one of claims 1 to 6.

13. A preparation method for the amorphous magnetic powder core according to claim 12, comprising
mixing the amorphous magnetic powder core precursor particle with a release agent uniformly, then adding them to a mold and subjecting to compression molding, and subsequently performing annealing to obtain the amorphous magnetic powder core.

14. The preparation method according to claim 13, wherein the mixing is performed under ultrasound and stirring;

preferably, the compression molding is performed at 10-14 T/cm^2 ;
preferably, the release agent is stearamide;
preferably, based on a mass of the amorphous magnetic powder core precursor particle being 100wt%, the release agent has a mass fraction of 0.01-0.03wt%;
preferably, the annealing is performed at 530-630°C;
preferably, the annealing is performed for 15-25 min;
preferably, an atmosphere for the annealing comprises a nitrogen atmosphere or an argon atmosphere.

15. An inductor, comprising the amorphous magnetic powder core according to claim 12.

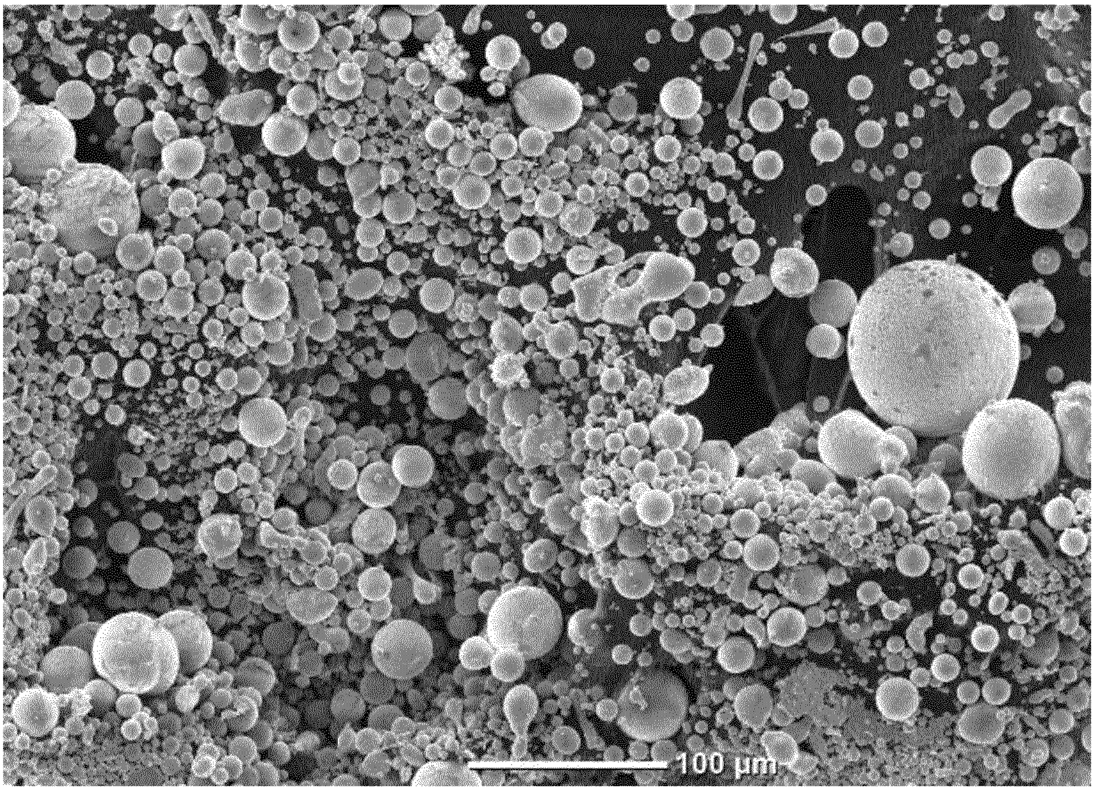

FIG. 1

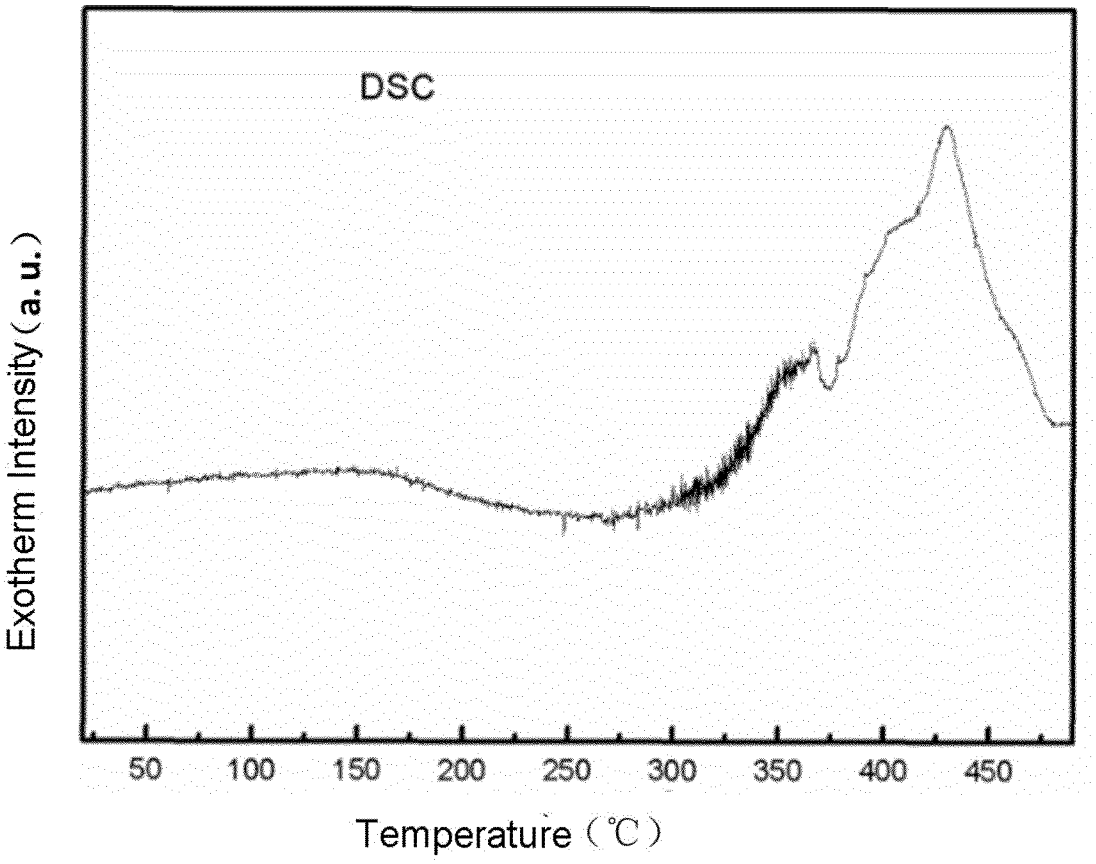
DSC
Exotherm Intensity（a. u.）
50
100
150
200
250
300
350
400
450
Temperature（℃）

FIG. 2

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2022/110452

A. CLASSIFICATION OF SUBJECT MATTER

H01F 1/147(2006.01)i; H01F 41/02(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)

H01F

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)

CNKI, CNPAT, WPI, IEEE: 非晶, 合金, 铁, 硅, 铬, 硼, 包覆, 颗粒, 酸化, 钝化, powder core, amorphous, particle, iron, silicon, chromium, boron, Fe, Si, Cr, B

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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X	JP 2016015357 A (SEIKO EPSON CORP.) 28 January 2016 (2016-01-28) description, paragraphs [0075]-[0130]	1-5, 12, 15
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Y	CN 111383810 A (HENGDIAN GROUP DMEGC MAGNETICS CO., LTD.) 07 July 2020 (2020-07-07) description, paragraphs [0004]-[0014]	6, 13-14
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☐ Further documents are listed in the continuation of Box C. ☑ See patent family annex.

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"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 **14 September 2022**	Date of mailing of the international search report **28 September 2022**
Name and mailing address of the ISA/CN **China National Intellectual Property Administration (ISA/CN)** **No. 6, Xitucheng Road, Jimenqiao, Haidian District, Beijing 100088, China** Facsimile No. **(86-10)62019451**	Authorized officer Telephone No.

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

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2022/110452

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