

CHROMIUM-SILICON ALLOY SPUTTERING TARGET MATERIAL AND PREPARATION METHOD THEREOF

TECHNICAL FIELD

The present application relates to the field of target materials and preparation method thereof
5 and, for example, to a chromium-silicon alloy sputtering target material and a preparation
method thereof.

BACKGROUND

Physical Vapor Deposition (PVD) refers to a process of, under a vacuum condition, with a
low-voltage and large-current arc discharge technique, evaporating a material source and
10 ionizing both evaporated substances and gas by using gas discharge, and then depositing the
evaporated substances and reaction products thereof on a workpiece to form a film with a
special function via the acceleration action of an electric field. The PVD technology is the core
technology for the semiconductor chip manufacturing industry, the solar energy industry, the
LCD manufacturing industry and other industries, and mainly includes vacuum evaporation, arc
15 plasma plating, ion coating, molecular beam epitaxy, sputtering coating and the like.

The sputtering is one of the main techniques for preparing thin film materials. During a process
of sputtering, ions generated by an ion source are accelerated and gathered in vacuum to form
an ion beam flow with high speed energy and bombard the surface of a solid such that kinetic
energy exchange is generated between the ions and atoms on the surface of the solid, and thus
20 the atoms on the surface of the solid are separated from the solid and deposited on a substrate
surface. The bombarded solid is a raw material for preparing a thin film deposited by a
sputtering method, which is generally called as a sputtering target material.

The sputtering target material is generally obtained by powder metallurgy sintering molding
processes, because the sputtering target material prepared by the processes have unique
25 chemical compositions and mechanical and physical properties that cannot be obtained by
conventional fusion casting methods. Porous, semi-compact or fully-compact materials and
products can be directly prepared by using the powder metallurgy sintering molding process.
The powder metallurgy sintering molding process is divided into two methods, i.e., hot pressed
sintering (HP) and hot isostatic pressing (HIP). The HP process includes the steps of filling dry
30 powder into a mold, then placing the mold in a vacuum hot pressing furnace, and heating while

pressurizing from a uniaxial direction under a vacuum or inert condition to simultaneously complete molding and sintering. The HIP process is to place a product in a closed container, degas the powder blank in the sheath under certain temperature and vacuum degree to ensure the vacuum atmosphere in the sheath, then apply same pressure to different directions, apply high temperature at the same time, and sinter and densify the product under the high temperature and high pressure.

The chromium-silicon alloy sputtering target material is a novel sputtering target material, and is useful in the fields of electronic gate materials and electronic films as a good conductor for vacuum sputtering. In order to make the chromium-silicon alloy sputtering target material perform good performance during vacuum sputtering, the chromium-silicon alloy sputtering target material is required to have higher density, higher internal organization structure uniformity, lower oxygen content and better machining conditions. However, at present, there is no preparation method which can make the prepared chromium-silicon alloy sputtering target material meet the above requirements.

At present, there are some methods for preparing sputtering target materials in the existing art. For example, CN110257781A discloses a chromium-aluminum-silicon-nickel quaternary alloy target material and a preparation method thereof. The preparation method includes the following steps: uniformly mixing powders, filling the powders into a mold and then pre-pressing the powders by isostatic cool pressing, crushing the pre-pressed alloy block into metal particles, pre-alloying the metal particles through vacuum sintering, crushing the pre-alloyed block into metal powders, filling the metal powders into a sheath and then carrying out degassing treatment, carrying out hot isostatic pressing treatment, and machining. Although the chromium-aluminum-silicon-nickel quaternary alloy target material prepared by the preparation method has the advantages of being high in compactness, free of pores, free of looseness and segregation, small in grain size, uniform in tissue and the like and is suitable for sputtering hard coatings needed by various tools and molds, the process flow of the preparation method is too complicated, its application scope is limited, and the multi-step operation will increase the risk of oxidization of the product. CN105331939A discloses a silicon-containing alloy target and a preparation method thereof. The preparation method includes five steps of pre-alloy powder preparation, mold filling followed by cold isostatic pressing treatment, re-sheathing followed by degassing treatment, hot isostatic pressing treatment and machining treatment. Although the preparation method can be used for preparing target materials with low impurity element content, high purity, high density, fine crystal grains and uniform

microstructure, the preparation method requires at least two times of mold filling treatment and includes a pressing treatment comprising cold isostatic pressing combined with degassing and hot isostatic pressing, and thus has the defects of complex process, high energy consumption and high cost.

- 5 Although the preparation methods in the existing art all adopt the hot isostatic pressing process, these preparation methods have complex process flows, and have defects of high energy consumption, high cost, and high risk of oxidization of the product. Therefore, it is urgent to develop an effective method for preparing a chromium-silicon alloy sputtering target material.

SUMMARY

- 10 The following is a summary of the subject matter described herein in detail. This summary is not intended to limit the scope of the claims.

The object of the present application comprises providing a chromium-silicon alloy sputtering target material and a preparation method thereof. The preparation method includes: filling chromium-silicon alloy powder having a target mass proportion into a mold, sealing the mold,
15 and carrying out vibration compaction treatment, degassing treatment, hot isostatic pressing treatment and machining, to finally obtain the chromium-silicon alloy sputtering target material. The preparation method is simple in process, and only requires mold filling treatment for one time, which reduces the risk of oxidization of the product, ensures product purity, improves product processing efficiency, and facilitates large-scale mass production. The preparation also
20 has advantages of low energy consumption and low cost. The chromium-silicon alloy sputtering target material obtained by the preparation method has the characteristics of density of greater than 99% and oxygen content of less than 0.05%, which provides better performance guarantee for subsequent sputtering.

To achieve the object, the present application adopts technical solutions described below.

- 25 In a first aspect, the present application provides a method for preparing a chromium-silicon alloy sputtering target material, which includes the following steps:

(1) filling chromium-silicon alloy powder having a target mass proportion into a mold, sealing the mold, and compacting the mold by vibration;

(2) degassing the mold compacted in step (1);

(3) subjecting the mold degassed in step (2) to hot isostatic pressing treatment at a temperature of 1000 °C to 1350 °C, to obtain a crude chromium-silicon alloy sputtering target material; and

(4) machining the crude chromium-silicon alloy sputtering target material obtained in step (3), to obtain the chromium-silicon alloy sputtering target material.

5 In the preparation method provided in the present application, vibration compaction treatment is used to prepare an alloy blank before degassing treatment. On one hand, the prepared alloy blank has a relatively high tap density, which can meet density requirements before the degassing treatment. On the other hand, the vibration compaction treatment can simplify the process flow and reduce the risk of oxidization of the product, thereby improving product
10 processing efficiency and facilitating large-scale mass production. The processing also has advantages of low energy consumption and low cost. In the preparation method, a high temperature of 1000 °C to 1350 °C is used to carry out the hot isostatic pressing treatment, which can ensure that the chromium-silicon alloy sputtering target material is compressed isostatically in each direction and thus can meet the requirements of density greater than 99%
15 and oxygen content less than 0.05%.

In the present application, the hot isostatic pressing treatment is carried out at a temperature of 1000 °C to 1350 °C, for example, 1000 °C, 1050 °C, 1100 °C, 1150 °C, 1170 °C, 1200 °C, 1230 °C, 1250 °C, 1300 °C, 1350 °C, etc. However, the temperature is not limited to the values listed above, and other unlisted values within this value range are also applicable.

20 As an optional technical solution of the present application, the chromium-silicon alloy powder having a target mass proportion in step (1) is prepared in an atomization method.

Optionally, the atomization method includes any one or a combination of at least two of gas atomization, centrifugal atomization, vacuum atomization and ultrasonic atomization. A typical but non-limited example of the combination is a combination of gas atomization and vacuum
25 atomization, a combination of centrifugal atomization and vacuum atomization, a combination of centrifugal atomization and ultrasonic atomization, or a combination of vacuum atomization and ultrasonic atomization. The atomization method is optionally gas atomization.

The principle of gas atomization is that molten metal is broken into fine liquid drops by the impact of high-pressure gas flow, and then the fine liquid drops are condensed into solid powder.

30 The gas atomization method has the advantages of high powder sphericity, low gas impurity

content and the like, and becomes an important metal powder preparation method.

Optionally, gas used for the gas atomization includes any one or a combination of at least two of helium, nitrogen and argon. A typical but non-limited example of the combination is a combination of helium and argon, a combination of nitrogen and argon, a combination of helium and nitrogen, etc. The gas is optionally argon.

As an optional solution of the present application, the target mass proportion in step (1) is $40\% \leq \text{Si (wt\%)} \leq 70\%$. For example, Si (wt%) is 40%, 45%, 50%, 55%, 60%, 65%, 70%, etc. However, the target mass proportion is not limited to the values listed above, and other unlisted values within this value range are also applicable. The target mass proportion is optionally $40\% \leq \text{Si (wt\%)} \leq 55\%$.

Optionally, the chromium-silicon alloy powder having a target mass proportion in step (1) has a particle size of 150 μm to 400 μm , for example, 150 μm , 200 μm , 220 μm , 250 μm , 260 μm , 280 μm , 300 μm , 350 μm , 400 μm , etc. However, the particle size is not limited to the values listed above, and the other values unlisted in this value range are also applicable. The particle size is optionally 200 μm to 350 μm .

Optionally, the chromium-silicon alloy powder having a target mass proportion in step (1) has a purity of above 3N5, for example, 3N5, 3N6, 3N7, 3N8, 3N9, 4N, etc. However, the purity is not limited to the values listed above, and the other values unlisted in this value range are also applicable.

As an optional technical solution of the present application, the mold in step (1) is a stainless steel sheath.

Optionally, before the powder is filled into the mold in step (1), the method further includes a cleaning step.

Optionally, the cleaning is to clean an inner wall of the mold so as to ensure no pollution in the mold.

The stainless steel sheath in the present application is welded by argon arc welding. A stainless steel cover is welded firmly with the sheath to seal the sheath, which provides basic guarantee for subsequent degassing treatment.

As an optional solution of the present application, the compacting by vibration in step (1) is carried out for 3 min to 30 min, for example, 3min, 5min, 8min, 10min, 13min, 15min, 20min, 23min, 25min, 30min, etc. However, the vibration time is not limited to the values listed above, and the other values unlisted in this value range are also applicable. The vibration time is optionally 3 min to 15 min.

Optionally, the compacting by vibration in step (1) is carried out at an amplitude of 1 mm to 10 mm, for example, 1 mm, 2 mm, 3 mm, 4 mm, 5 mm, 6 mm, 7 mm, 8 mm, 9 mm, 10 mm, etc. However, the vibration amplitude is not limited to the values listed above, and the other values unlisted in this value range are also applicable. The vibration amplitude is optionally 3 mm and 7 mm.

Optionally, the compacting by vibration in step (1) is carried out at a frequency of 50 times/min to 400 times/min, for example, 50 times/min, 80 times/min, 100 times/min, 120 times/min, 150 times/min, 170 times/min, 200 times/min, 230 times/min, 250 times/min, 280 times/min, 300 times/min, 350 times/min, 400 times/min, etc. However, the vibration frequency is not limited to the values listed above, and the other values unlisted in this value range are also applicable. The vibration frequency is optionally 100 times/min to 300 times/min.

As an optional solution of the present application, the degassing in step (2) is carried out at a temperature of 400 °C to 600 °C, for example, 400 °C, 450 °C, 500 °C, 550 °C, 600 °C, etc. However, the temperature is not limited to the values listed above, and the other values unlisted in this value range are also applicable. The temperature is optionally 450 °C to 550 °C.

Optionally, the degassing in step (2) is carried out at a vacuum degree of 5E-3 Pa to 1.5E-3 Pa, for example, 5E-3Pa, 4.5E-3Pa, 4E-3Pa, 3.5E-3Pa, 3E-3Pa, 2.5E-3Pa, 2E-3Pa, 1.5E-3Pa, etc. However, the vacuum degree is not limited to the values listed above, and the other values unlisted in this value range are also applicable. The vacuum degree is optionally 4E-3 Pa to 2E-3 Pa.

In the present application, by increasing the vacuum degree of degassing treatment to 5E-3 Pa to 1.5E-3 Pa, the gas in the sheath can be fully removed, such that the gas can be discharged clean, thus further ensuring that the silicon powder is not oxidized by air, such that the product performance of the final chromium-silicon alloy sputtering target material is further improved. In addition, under the vacuum degree, the degassing effect can be better ensured, energy consumption can be minimized, and the cost of input can be reduced.

As an optional solution of the present application, the hot isostatic pressing treatment in step (3) is carried out at a pressure of 130 MPa to 180 MPa, for example, 130 MPa, 140 MPa, 150 MPa, 160 MPa, 170 MPa, 180 MPa, etc. However, the pressure is not limited to the values listed above, and the other values unlisted in this value range are also applicable. The pressure is optionally 140 MPa to 165 MPa.

Optionally, the hot isostatic pressing treatment in step (3) involves keeping at the temperature and pressure for 2 h to 6 h, for example, 2 h, 3 h, 4 h, 5 h, 6 h, etc. However, the time is not limited to the values listed above, and the other values unlisted in this value range are also applicable. The temperature and pressure is optionally kept for 3 h to 5 h.

Optionally, the hot isostatic pressing treatment in step (3) is carried out in a hot isostatic pressing furnace.

The hot isostatic pressing process provided in the present application is designed according to the great differences in the melting point, specific gravity and other physical properties between chromium and silicon, in combination with a measured chromium-silicon alloy composition chart. By keeping at a high temperature of 1000 °C to 1350 °C and a high pressure of 130 MPa to 180 MPa for 2 h to 6 h, not only the density of the chromium-silicon alloy sputtering target material is greatly increased, and the internal organization structure of the chromium-silicon alloy becomes more uniform, but also the energy consumption is reduced, thereby minimizing the cost.

As an optional technical solution of the present application, the preparation method includes the following steps.

(1) preparing chromium-silicon alloy powder having a target mass proportion of $40\% \leq \text{Si (wt\%)} \leq 70\%$ by using a gas atomization method, then filling the chromium-silicon alloy powder into a pre-treated stainless steel sheath, sealing the stainless steel sheath, and compacting the stainless steel sheath by vibration;

wherein the chromium-silicon alloy powder has a particle size of 150 μm to 400 μm , and a purity of above 3N5;

the compacting by vibration is performed for 3 min to 30 min, at a vibration amplitude of 1 mm to 10 mm, and at a vibration frequency of 50 times/min to 400 times/min;

(2) heating the mold compacted in step (1) to 400 °C to 600 °C, and degassing under a vacuum degree of 5E-3 Pa to 1.5E-3 Pa;

(3) placing the mold degassed in step (2) into a hot isostatic pressing furnace, heating the hot isostatic pressing furnace to 1000 °C to 1350 °C, pressurizing the hot isostatic pressing furnace to 130 MPa to 180 MPa, and keeping at the temperature and pressure for 2 h to 6 h to carry out hot isostatic pressing treatment, to obtain a crude chromium-silicon alloy sputtering target material; and

(4) machining the crude chromium-silicon alloy sputtering target material obtained in step (3) to obtain the chromium-silicon alloy sputtering target material.

10 In a second aspect, the present application provides a chromium-silicon alloy sputtering target material, which is prepared by using the preparation method described in the first aspect.

As an optional solution of the present application, the chromium-silicon alloy sputtering target material has a density of greater than 99%, for example, 99.2%, 99.5%, 99.6%, 99.8%, 99.9%, etc. However, the density is not limited to the values listed above, and the other values unlisted in this value range are also applicable.

As an optional solution of the present application, the chromium-silicon alloy sputtering target has an oxygen content of less than 0.05%, for example, 0.005%, 0.01%, 0.02%, 0.03%, 0.04%, etc. However, the oxygen content is not limited to the values listed above, and the other values unlisted in this value range are also applicable.

20 Compared with the existing art, the present application has the following beneficial effects.

(1) In the method for preparing a chromium-silicon alloy sputtering target material in the present application, the alloy blank is prepared through vibration compaction treatment before degassing treatment, and only one time of mold filling treatment is required. Therefore, the preparation method has advantages of simple process, low energy consumption and low cost.

25 (2) The preparation method can reduce the risk of oxidization of the product, ensure product purity, improve product processing efficiency, and facilitate large-scale mass production.

(3) The chromium-silicon alloy sputtering target material obtained in the present application has the characteristics of density of greater than 99% and oxygen content of less than 0.05%, which

can provide better performance guarantee for subsequent sputtering.

Other aspects can be understood after the detailed description and the drawings are read and understood.

BRIEF DESCRIPTION OF DRAWINGS

- 5 FIG. 1 is a flowchart of a method for preparing a chromium-silicon alloy sputtering target material according to the present application.

DETAILED DESCRIPTION

- 10 Solutions of the present application are further described below through specific examples in conjunction with the drawings. Those who skilled in the art should understand that the examples are merely used for helping to understand the present application and should not be regarded as the specific limitations to the present application.

FIG. 1 is a flowchart of a method for preparing a chromium-silicon alloy sputtering target material according to the present application. The preparation method includes the following steps.

- 15 (1) Fill chromium-silicon alloy powder having a target mass proportion into a mold, seal the mold, and compacted the mold by vibration.
- (2) Degas the mold compacted in step (1).
- (3) Subject the mold degassed in step (2) to hot isostatic pressing treatment at a temperature of 1000 °C to 1350 °C to obtain a crude chromium-silicon alloy sputtering target material.
- 20 (4) Machine the crude chromium-silicon alloy sputtering target material obtained in step (3) to obtain a chromium-silicon alloy sputtering target material with a qualified dimension.

The present application will be described below in detail through the following examples.

Example 1

- 25 This example provides a method for preparing a chromium-silicon alloy sputtering target material. The preparation method includes the following steps.

(1) Chromium-silicon alloy powder with a target mass proportion of Si (wt%) = 40% was prepared by using a gas atomization method, where the particle size of the chromium-silicon alloy powder was 250 μm , and the purity thereof was 3N6. Then the chromium-silicon alloy powder was filled into a pre-cleaned stainless steel sheath. A stainless steel cover was welded with the sheath using argon arc welding to seal the sheath. The mold was compacted by vibration, where the vibration time was 20 min, the vibration amplitude was 5 mm, and the vibration frequency was 250 times/min.

(2) The mold compacted in step (1) was heated to 450 $^{\circ}\text{C}$, and degassed under a vacuum degree of $2\text{E-}3$ Pa.

(3) The mold degassed in step (2) was placed into a hot isostatic pressing furnace. The hot isostatic pressing furnace was heated to 1100 $^{\circ}\text{C}$ and pressurized to 175 MPa, and kept at the temperature and pressure for 4 h to carry out hot isostatic pressing treatment, to obtain a crude chromium-silicon alloy sputtering target material.

(4) The crude chromium-silicon alloy sputtering target material obtained in step (3) was machined to obtain a chromium-silicon alloy sputtering target material.

Example 2

(1) Chromium-silicon alloy powder with a target mass proportion of Si (wt%) = 45% was prepared by using a gas atomization method, where the particle size of the chromium-silicon alloy powder was 400 μm , and the purity thereof was 3N5. Then the chromium-silicon alloy powder was filled into a pre-cleaned stainless steel sheath. A stainless steel cover was welded with the sheath using argon arc welding to seal the sheath. The mold was compacted by vibration, where the vibration time was 30 min, the vibration amplitude was 10 mm, and the vibration frequency was 50 times/min.

(2) The mold compacted in step (1) was heated to 450 $^{\circ}\text{C}$, and degassed under a vacuum degree of $1.5\text{E-}3$ Pa.

(3) The mold degassed in step (2) was placed into a hot isostatic pressing furnace. The hot isostatic pressing furnace was heated to 1125 $^{\circ}\text{C}$ and pressurized to 140 MPa, and kept at the temperature and pressure for 6 h to carry out hot isostatic pressing treatment, to obtain a crude chromium-silicon alloy sputtering target material.

(4) The crude chromium-silicon alloy sputtering target material obtained in step (3) was machined to obtain a chromium-silicon alloy sputtering target material.

Example 3

5 (1) Chromium-silicon alloy powder with a target mass proportion of Si (wt%) = 50% was prepared by using a gas atomization method, where the particle size of the chromium-silicon alloy powder was 150 μm , and the purity thereof was 3N7. Then the chromium-silicon alloy powder was filled into a pre-cleaned stainless steel sheath. A stainless steel cover was welded with the sheath using argon arc welding to seal the sheath. The mold was compacted by vibration, where the vibration time was 15 min, the vibration amplitude was 3 mm, and the
10 vibration frequency was 400 times/min.

(2) The mold compacted in step (1) was heated to 450 °C, and degassed under a vacuum degree of $5\text{E-}3$ Pa.

(3) The mold degassed in step (2) was placed into a hot isostatic pressing furnace. The hot isostatic pressing furnace was heated to 1150 °C and pressurized to 150 MPa, and kept at the
15 temperature and pressure for 2 h to carry out hot isostatic pressing treatment, to obtain a crude chromium-silicon alloy sputtering target material.

(4) The crude chromium-silicon alloy sputtering target material obtained in step (3) was machined to obtain a chromium-silicon alloy sputtering target material.

Comparative example 1

20 In this comparative example, the process conditions were the same to those in the example 1 except that the temperature of the hot isostatic pressing treatment in step (3) was changed into 1400 °C.

Comparative example 2

25 In this comparative example, the process conditions were the same to those in the example 1 except that the temperature of the hot isostatic pressing treatment in step (3) was changed into 900 °C.

The density, internal organization structure uniformity and oxygen content of the

chromium-silicon alloy sputtering target materials obtained in the above examples and comparative examples were tested, and results are specifically shown in Table 1.

Table 1

Group	Density	Internal Organization Structure Uniformity	Oxygen Content
Example 1	99.7%	the product is uniform and dense microcosmically, without any void or stratification structure	0.03
Example 2	99.5%	the product is uniform and dense microcosmically, without any void or stratification structure	0.04
Example 3	99.4%	the product is uniform and dense microcosmically, without any void or stratification structure	0.04
Comparative example 1	95.1%	the product has voids microcosmically, and is brittle and easy to crack	0.12
Comparative example 2	83.6%	the product has voids and stratification structure microcosmically	0.15

It can be seen from Table 1 that a chromium-silicon alloy sputtering target material with density greater than 99% and oxygen content less than 0.05% can be prepared by the preparation method of the present application, and the product is uniform and dense microcosmically and meets performance requirements for sputtering. Moreover, the preparation method of the present application only requires mold filling treatment for one time and has a simple process flow, which reduces the risk of oxidization of the product, improves product processing efficiency, and facilitates large-scale mass production.

The applicant has stated that although the detailed structure characteristics of the present application are described through the embodiments described above, the present application is not limited to the detailed structure characteristics described above, which means that implementation of the present application does not necessarily depend on the detailed structure characteristics described above.

Though the preferred embodiments of the present application have been described above in detail, the present application is not limited to the above-described embodiments, and various simple modifications can be made to the technical solutions of the present application without departing from the scope of the present application.

In addition, it is to be noted that if not in collision, the specific technical features described in

the above specific embodiments may be combined in any suitable manner. In order to avoid unnecessary repetition, the present application does not further specify any of various possible combination manners.

What is claimed is:

1. A method for preparing a chromium-silicon alloy sputtering target material, comprising the following steps:

5 (1) filling chromium-silicon alloy powder having a target mass proportion into a mold, sealing the mold, and compacting the mold by vibration;

(2) degassing the mold compacted in step (1);

(3) subjecting the mold degassed in step (2) to hot isostatic pressing treatment at a temperature of 1000 °C to 1350 °C to obtain a crude chromium-silicon alloy sputtering target material; and

10 (4) machining the crude chromium-silicon alloy sputtering target material obtained in step (3) to obtain the chromium-silicon alloy sputtering target material.

2. The preparation method of claim 1, wherein the hot isostatic pressing treatment in step (3) is performed at a pressure of 130 MPa to 180 MPa, and is optionally 140 MPa to 165 MPa.

3. The production method of claim 1 or 2, wherein the hot isostatic pressing treatment in step (3) involves keeping at the temperature and pressure for 2 h to 6 h, and is optionally 3 h to 5 h.

15 4. The preparation method of claim 1, wherein the chromium-silicon alloy powder having a target mass proportion in step (1) is prepared in an atomization method;

optionally, the atomization method comprises any one or a combination of at least two of gas atomization, centrifugal atomization, vacuum atomization and ultrasonic atomization, and is optionally gas atomization;

20 optionally, gas used for the gas atomization comprises any one or a combination of at least two of helium, nitrogen and argon, and is optionally argon.

5. The preparation method of claim 1 or 2, wherein the target mass proportion in step (1) is $40\% \leq \text{Si (wt\%)} \leq 70\%$, and is optionally $40\% \leq \text{Si (wt\%)} \leq 55\%$;

25 optionally, the chromium-silicon alloy powder having a target mass proportion in step (1) has a particle size of 150 micron (μm) to 400 μm , optionally 200 μm to 350 μm ;

optionally, the chromium-silicon alloy powder having a target mass proportion in step (1) has a purity of above 3N5.

6. The preparation method of any one of claims 1 to 5, wherein the mold in step (1) is a stainless steel sheath;

optionally, before filling the powder into a mold in step (1), the method further comprises a cleaning step;

5 optionally, the cleaning is to clean an inner wall of the mold so as to ensure no pollution in the mold.

7. The preparation method of any one of claims 1 to 6, wherein compacting by vibration in step (1) is performed for 3 min to 30 min, optionally 3 min to 15 min;

10 optionally, compacting by vibration in step (1) is performed at a vibration amplitude of 1 mm to 10 mm, optionally 3 mm and 7 mm;

optionally, compacting by vibration in step (1) is performed at a vibration frequency of 50 times/min to 400 times/min, optionally 100 times/min to 300 times/min.

8. The preparation method of any one of claims 1 to 7, wherein degassing in step (2) is performed at a temperature of 400 °C to 600 °C, optionally 450 °C to 550 °C;

15 optionally, degassing in step (2) is performed at a vacuum degree of 5×10^{-3} Pa to 1.5×10^{-3} Pa, and optionally 4×10^{-3} Pa to 2×10^{-3} Pa.

9. The preparation method of any one of claims 1 to 8, wherein the hot isostatic pressing treatment in step (3) is carried out in a hot isostatic pressing furnace.

20 10. The preparation method of any one of claims 1 to 9, wherein the preparation method comprises the following steps:

(1) preparing chromium-silicon alloy powder having a target mass proportion of $40\% \leq \text{Si (wt\%)} \leq 70\%$ by using a gas atomization method, then filling the chromium-silicon alloy powder into a pre-treated stainless steel sheath, sealing the stainless steel sheath, and compacting the stainless steel sheath by vibration;

25 wherein the chromium-silicon alloy powder has a particle size of 150 μm to 400 μm , and a purity of above 3N5;

compacting by vibration is performed for 3 min to 30 min, at a vibration amplitude of 1 mm to 10 mm, and at a vibration frequency of 50 times/min to 400 times/min;

(2) heating the mold compacted in step (1) to 400 °C to 600 °C, and degassing under a vacuum degree of 5E-3 Pa to 1.5E-3 Pa;

(3) placing the mold degassed in step (2) into a hot isostatic pressing furnace, heating the hot isostatic pressing furnace to 1000 °C to 1350 °C and pressurizing the hot isostatic pressing furnace to 130 MPa to 180 MPa, and keeping at the temperature and pressure for 2 h to 6 h to carry out hot isostatic pressing treatment, to obtain a crude chromium-silicon alloy sputtering target material; and

(4) machining the crude chromium-silicon alloy sputtering target material obtained in step (3) to obtain the chromium-silicon alloy sputtering target material.

10 11. A chromium-silicon alloy sputtering target material prepared by the preparation method of any one of claims 1 to 10.

12. The chromium-silicon alloy sputtering target material of claim 11, wherein the chromium-silicon alloy sputtering target material has a density of greater than 99%.

15 13. The chromium-silicon alloy sputtering target material of claim 11 or 12, wherein the chromium-silicon alloy sputtering target has an oxygen content of less than 0.05%.