

[Document Name] DESCRIPTION

[Title of the Invention] VAPOR DEPOSITION MATERIAL AND METHOD FOR MANUFACTURING SAME

[Technical Field]

[0001]

The present invention relates to an evaporation material for use in a vacuum deposition method, and a method of producing such an evaporation material.

[Background Art]

[0002]

The vacuum deposition method is one type of deposition technology, and is a technology of forming a thin film by heating an evaporation material in a vacuum and the evaporation material, which became gas molecules, becoming adhered to a substrate. The vacuum deposition method is being broadly used for forming elements in electronic components, semiconductor devices, optical thin films, magnetic devices, LEDs, organic ELs, and LCDs. The vacuum deposition method can be used not only for depositing metals, but also for the deposition of non-metals such as oxides.

[0003]

Conventionally, when filling an evaporation material in a crucible and melting the evaporation material with an electron beam or the like, there was a problem in that the impurities contained in the evaporation material would become volatilized, a bumping phenomenon would occur, and particles would become adhered on the substrate. In relation to the problem of the bumping phenomenon, Patent Document 1 proposes a method of reducing impurities. Moreover, Patent Document 2 proposes a method of adding additive metals, and Patent Document 3 proposes a method of controlling the oxygen content of the outermost surface.

[Prior Art Documents]

[Patent Documents]

[0004]

[Patent Document 1] Japanese Unexamined Patent Application Publication No. H1-180961

[Patent Document 2] International Publication No. 2017/199873

[Patent Document 3] Japanese Unexamined Patent Application Publication No. 2000-212728

[Summary of the Invention]

[Problems to be Solved by the Invention]

[0005]

An object of the present invention is to provide an evaporation material for use in a vacuum deposition method capable of suppressing the bumping phenomenon upon melting the evaporation material.

[Means for Solving the Problems]

[0006]

In order to achieve the foregoing object, the first embodiment of the present invention provides an evaporation material for use in a vacuum deposition method, wherein the evaporation material comprises one or more types among Au, Ag, Pt, Pd and their alloys, micropores are formed on a surface of the evaporation material, and a number of the micropores having an equivalent circle diameter of 0.1 μm or more and 10.0 μm or less is one or more micropores per 500 μm^2 . Moreover, the second embodiment of the present invention provides an evaporation material for use in a vacuum deposition method, wherein the evaporation material comprises one or more types among Au, Ag, Pt, Pd and their alloys, and a hydrogen content in the evaporation material is 10 wtpm or less.

[Effect of the Invention]

[0007]

According to the present invention, it is possible to suppress the bumping phenomenon upon melting the evaporation material, and thereby reduce the particles that become adhered on the substrate. Accordingly, the present invention is able to contribute to improving the yield of products.

[Brief Description of the Drawings]

[0008]

[Fig. 1]

Fig. 1 is an image obtained from observing the surface of the evaporation material of Conventional Example 1 using an SEM (5000X).

[Fig. 2]

Fig. 2 is an image obtained from observing the surface of the evaporation material of Example 1-1 using an SEM (5000X).

[Fig. 3]

Fig. 3 is an image obtained from observing the surface of the evaporation material of Example 1-7 using an SEM (5000X).

[Best Mode for Carrying Out the Invention]

[0009]

An evaporation material for use in a vacuum deposition method is normally prepared by melting a raw material in a ceramic crucible made of alumina or in a carbon crucible, pouring the molten metal in a mold to form an ingot, machining the obtained ingot into an adequate shape (pellet form), and thereafter washing the surface with acid or an organic solvent. Moreover, a high purity product having a purity of 3N (99.9 wt%) or higher is used as the raw material, and, after the machining, the surface is chemically washed to remove adhering substances.

[0010]

Nevertheless, even when this kind of high purity raw material is employed and a washed evaporation material is used, there was a problem in that a bumping phenomenon occurs during evaporation (melting), and particles become adhered on the substrate. As a result of studying this kind of problem, the problem was considered to be a result of the raw material or impurities (volatile elements) having a high vapor pressure that got mixed in during the production process becoming gasified, during the melting process, within the evaporation material, and thereby causing the bumping phenomenon.

[0011]

Thus, as a result of intense study, the present inventors discovered that, by forming micropores on the surface of the evaporation material, the volatile elements existing within the evaporation material can be more easily volatilized, and the bumping phenomenon can thereby be suppressed. Based on this discovery, the first embodiment of the present invention provides an evaporation material wherein micropores are formed on a surface of the evaporation material, and a number of the micropores having an equivalent circle diameter of 0.1 μm or more and 10.0 μm or less is one or more micropores per 500 μm^2 .

[0012]

As a result of causing the number of the micropores having an equivalent circle diameter of 0.1 μm or more and 10.0 μm or less to be one or more micropores per 500 μm^2 on the surface of the evaporation material, the impurities having a high vapor

pressure existing within the evaporation material can be more easily volatilized, and the bumping phenomenon can thereby be effectively suppressed. The number of micropores having an equivalent circle diameter of 0.1 μm or more and 10.0 μm or less is preferably 5 or more micropores per 500 μm^2 , more preferably 10 or more micropores per 500 μm^2 , and most preferably 20 or more micropores per 500 μm^2 . As the number of micropores is greater, the surface area of the evaporation material will increase, and the gas of volatile elements existing inside the evaporation material can more easily escape from the micropores, and the bumping phenomenon can more effectively be suppressed.

[0013]

In this disclosure, the number of micropores having an equivalent circle diameter of 0.1 μm or more and 10.0 μm or less was counted by observing the representative surface of the evaporation material using a scanning electron microscope (SEM) at a magnification of 5000X, and the number of micropores (equivalent circle diameter of 0.1 μm or more and 10.0 μm or less) existing within the range of an area (500 μm^2) was counted.

[0014]

Moreover, from a different perspective, as a result of intense study by the present inventors regarding the cause of the bumping phenomenon that occurs during evaporation (melting), the present inventors discovered that non-metal inclusions existing as impurities in the evaporation material, specifically hydrogen, are the cause of bumping. In light of the above, the present inventors discovered that, by reducing the amount of impurities, specifically hydrogen, as much as possible, the bumping phenomenon caused by the non-metal inclusions upon melting the evaporation material can be suppressed. Based on this discovery, the second embodiment provides an evaporation material wherein a hydrogen content in the evaporation material is 10 wtppm or less.

[0015]

By causing the content of hydrogen existing as an impurity in the evaporation material to be 10 wtppm or less, the bumping phenomenon that occurs upon melting the evaporation material can be effectively suppressed. Moreover, since carbon (C), oxygen (O), as well as phosphorus (P) and sulfur (S) also tend to form non-metal inclusions, preferably the C content is 10 wtppm or less, the O content is 100 wtppm

or less, and the total content of P and S is 10 wtppm or less. While these elements sometimes become a solid solution, they become dissociated during the melting process and become the cause of bumping. Since non-metal inclusions have a specific gravity that is lighter than the evaporation material (metal material) and tend to become dissociated, they become the cause of the spitting. In particular, hydrogen and oxygen become dissociated from metal at the early stage of melting, and carbon, sulfur and phosphorus cover the molten metal surface during evaporation and cause bumping to occur. Accordingly, it is important to intentionally exclude these non-metal inclusions.

[0016]

The evaporation material according to the first embodiment and the second embodiment mainly comprises a noble metal material, and in particular preferably comprises Au, Ag, Pt, or Pd, and in addition may comprise alloys with Ge, Si, Sn, As, and Sb (for instance, Au-Sn, Au-Ge). These materials are materials that are relatively used broadly in electronic components, semiconductor devices, optical thin films, magnetic devices, LEDs, organic ELs, and LCDs. In particular, since noble metal materials are expensive, there are cost advantages in being able to prevent unwanted scattering caused by the bumping phenomenon.

[0017]

The evaporation material according to the first embodiment and the second embodiment preferably has a purity of 3N (99.9 wt%) or higher, and more preferably a purity of 4N (99.99 wt%) or higher. By reducing the impurity content, the consequential bumping phenomenon can be suppressed. In this disclosure, gas components are excluded in the calculation of purity.

[0018]

In the first embodiment, since the bumping phenomenon caused by volatile elements such as As, Zn, Mg, Na, and K (elements having a vapor pressure that is higher than the vapor pressure of the evaporation material) existing within the evaporation material can be prevented by forming micropores, even if the purity is relatively high (even if the impurity content other than volatile elements is low), it does not mean that the bumping phenomenon can be suppressed.

Moreover, in the second embodiment, even if a so-called high purity product is used as the raw material, since gas components such as hydrogen, carbon, oxygen, sulfur, and phosphorus, which tend to form non-metal inclusions, are not considered as

impurities in the calculation of purity, and since these gas components could also get mixed in during the production process, even if a so-called high purity product is used as the raw material of the evaporation material, it does not mean that bumping can be automatically prevented.

[0019]

The evaporation material according to the first embodiment can be prepared in the following manner.

One or more types among carbon (C), sulfur (S), and phosphorus (P) are added in a trace amount to a raw material having a purity of 3N (99.9 wt%) or higher, the product is melted in the atmosphere, vacuum or inert gas atmosphere, and thereafter cast to prepare an ingot. Subsequently, the obtained ingot is cut and machined into a pellet form, and the surface thereof is thereafter washed with acid or an organic solvent.

[0020]

Next, pellets (evaporation material) to which carbon has been added are subject to heat treatment in an atmosphere containing oxygen, hydrogen or water vapor at a temperature of 400°C or higher and a temperature equal to or less than the melting point of the evaporation material. Here, micropores can be formed on the surface of the evaporation material when the carbon or the like added above which reacts with oxygen or hydrogen, becomes gas such as CO₂ or CH₄, and becomes dissociated so that such gas can be released from such micropores. Since the foregoing carbon or the like is released as a compound gas, ultimately it will hardly remain in the evaporation material. Note that, while carbon was mainly explained above, the same effect can also be yielded with sulfur or phosphorus.

[0021]

The evaporation material according to the second embodiment can be prepared in the following manner.

A metal raw material having a purity of 3N (99.9 wt%) or higher is melted in the atmosphere, vacuum or inert gas atmosphere, preferably in a vacuum, and thereafter cast to prepare an ingot. Here, since non-metal inclusions (hydrogen, carbon, oxygen, phosphorus, sulfur, and their compounds) contained in the raw material float to the surface during the melting process, the cast ingot is observed and the surface part with numerous non-metal inclusions is subject to acid cleaning or cut and removed. While this also depends on the amount of non-metal inclusions, the amount of the surface

part to be removed is preferably 1 μm or more.

[0022]

Meanwhile, by performing the casting process from the bottom of the crucible to avoid the inclusion of non-metal inclusions floating to the molten metal surface during the melting process and leaving a part of the molten metal within the crucible rather than tapping the entire amount of the molten metal, or otherwise removing the final molten metal, the foregoing acid cleaning or cutting and removal will not be required. Moreover, when tapping the molten metal by tilting the crucible, an ingate may be provided at the upper part of the crucible to remove foreign substances such as non-metal inclusions. Here, the ratio of unused molten metal to be left in the crucible is preferably 0.1 wt% or more, and more preferably 1 wt% or more. Moreover, non-metal inclusions can also be floated and removed based on zone melting or the like.

[0023]

Next, the ingot from which the non-metal inclusions have been removed is subject to a wire drawing (thinning) process. While machining oil is normally used during the wire drawing process, since machining oil may become the cause of contamination of carbon or the like, preferably the ingot is formed into a predetermined shape based on the wire drawing process without using machining oil. Moreover, heat treatment (degassing or softening treatment) may also be performed before or after and during the wire drawing process. While this will also depend on the material, the heat treatment temperature is normally 100°C or higher and equal to or lower than the melting point of the material.

[0024]

When granulating the ingot, the molten metal is dripped from the bottom of the crucible into water or an organic solvent. In the foregoing case also, since the final molten metal contains a large amount of foreign substances such as non-metal inclusions, such final molten metal must not be included in the product.

[0025]

The foreign substances that adhered to the surface can be removed by washing the surface with acid or an organic solvent after the wire drawing process or after the granulation process. Nevertheless, when acid or an organic solvent is used, the surface needs to be sufficiently washed with pure water or a volatile component to remove the oxidation or residual carbon on the surface. In particular, when acid is used,

since there are cases where hydrogen infiltrates the metal and forms a non-metal inclusion, the washing of the surface with pure water or a volatile component is preferably performed with care.

[Examples]

[0026]

The Examples and Comparative Examples of the present invention are now explained. The following Examples merely illustrate representative examples, and the present invention does not need to be limited by the following Examples, and should be interpreted based on the scope of the technical concept described in the specification.

[0027]

(Conventional Example 1)

A Au raw material having a purity of 4N (99.99 wt%) was melted in the atmosphere, subsequently cast to prepare an ingot, the obtained ingot was machined into pellet form based on thinning or the like, and thereafter washed to prepare Au pellets having a purity of 4N. As a result of observing the surface of these Au pellets with an SEM, the number of micropores was 0 micropores. A photo of the Conventional Example observed with the SEM is shown in Fig. 1. Note that, in the Conventional Example and the following Examples, the number of micropores having an equivalent circle diameter of 0.1 μm or more and 10.0 μm or less existing in the observed area (500 μm^2) was counted. Next, these Au pellets (evaporation material) were filled in a crucible of a vacuum deposition device, preheated with an electron beam, thereafter melted, and the bumping phenomenon was observed. As a result, the number of defects (particles) on the wafer caused by the bumping phenomenon was more than 500 defects (particles). The foregoing results are shown in Table 1.

[0028]

(Example 1-1)

Au pellets having a purity of 4N prepared by adding 10 wtppm of carbon were heated in an oxygen-containing atmosphere at 900°C. As a result of observing the surface of the Au pellets after heat treatment with an SEM, the number of micropores was 20 to 100 micropores. A photo of Example 1 observed with the SEM is shown in Fig. 2. Next, these Au pellets (evaporation material) were filled in a crucible of a vacuum deposition device, preheated with an electron beam, thereafter melted, and the bumping phenomenon was observed. As a result, the number of defects (particles) on the wafer

caused by the bumping phenomenon was 0 defects (particles).

[0029]

(Example 1-2)

Au pellets having a purity of 4N prepared by adding 5 wtppm of carbon were heated in a hydrogen-containing atmosphere at 600°C. As a result of observing the surface of the Au pellets after heat treatment with an SEM, the number of micropores was 10 to 30 micropores. Next, these Au pellets (evaporation material) were filled in a crucible of a vacuum deposition device, preheated with an electron beam, thereafter melted, and the bumping phenomenon was observed. As a result, the number of defects (particles) on the wafer caused by the bumping phenomenon was 1 to 5 defects (particles).

[0030]

(Example 1-3)

Au pellets having a purity of 5N prepared by adding 1 wtppm of carbon were heated in a water vapor-containing atmosphere at 400°C. As a result of observing the surface of the Au pellets after heat treatment with an SEM, the number of micropores was 1 to 10 micropores. Next, these Au pellets (evaporation material) were filled in a crucible of a vacuum deposition device, preheated with an electron beam, thereafter melted, and the bumping phenomenon was observed. As a result, the number of defects (particles) on the wafer caused by the bumping phenomenon was 20 to 30 defects (particles).

[0031]

(Example 1-4)

Au pellets having a purity of 4N prepared by adding 5 wtppm of sulfur were heated in the atmosphere at 1050°C. As a result of observing the surface of the Au pellets after heat treatment with an SEM, the number of micropores was 20 to 50 micropores. Next, these Au pellets (evaporation material) were filled in a crucible of a vacuum deposition device, preheated with an electron beam, thereafter melted, and the bumping phenomenon was observed. As a result, the number of defects (particles) on the wafer caused by the bumping phenomenon was 1 to 10 defects (particles).

[0032]

(Example 1-5)

Au pellets having a purity of 4N prepared by adding 5 wtppm of phosphorus were heated in the atmosphere at 700°C. As a result of observing the surface of the Au pellets after heat treatment with an SEM, the number of micropores was 20 to 50

micropores. Next, these Au pellets (evaporation material) were filled in a crucible of a vacuum deposition device, preheated with an electron beam, thereafter melted, and the bumping phenomenon was observed. As a result, the number of defects (particles) on the wafer caused by the bumping phenomenon was 1 to 10 defects (particles).

[0033]

(Example 1-6)

Pt pellets having a purity of 3N5 prepared by adding 3 wtppm of carbon were heated in a hydrogen-containing atmosphere at 1550°C. As a result of observing the surface of the Pt pellets after heat treatment with an SEM, the number of micropores was 20 to 50 micropores. Next, these Pt pellets (evaporation material) were filled in a crucible of a vacuum deposition device, preheated with an electron beam, thereafter melted, and the bumping phenomenon was observed. As a result, the number of defects (particles) on the wafer caused by the bumping phenomenon was 0 defects (particles).

[0034]

(Example 1-7)

Pt pellets having a purity of 4N prepared by adding 3 wtppm of carbon were heated in a water vapor-containing atmosphere at 1000°C. As a result of observing the surface of the Pt pellets after heat treatment with an SEM, the number of micropores was 5 to 10 micropores. A photo of Example 7 observed with the SEM is shown in Fig. 3. Next, these Pt pellets (evaporation material) were filled in a crucible of a vacuum deposition device, preheated with an electron beam, thereafter melted, and the bumping phenomenon was observed. As a result, the number of defects (particles) on the wafer caused by the bumping phenomenon was 5 to 10 defects (particles).

[0035]

(Example 1-8)

Ag pellets having a purity of 4N prepared by adding 1 wtppm of carbon were heated in an oxygen-containing atmosphere at 400°C. As a result of observing the surface of the Ag pellets after heat treatment with an SEM, the number of micropores was 1 to 5 micropores. Next, these Ag pellets (evaporation material) were filled in a crucible of a vacuum deposition device, preheated with an electron beam, thereafter melted, and the bumping phenomenon was observed. As a result, the number of defects (particles) on the wafer caused by the bumping phenomenon was 10 to 30 defects (particles).

[0036]

(Example 1-9)

Ag pellets having a purity of 4N prepared by adding 3 wtppm of carbon were heated in a water vapor-containing atmosphere at 900°C. As a result of observing the surface of the Ag pellets after heat treatment with an SEM, the number of micropores was 20 to 50 micropores. Next, these Ag pellets (evaporation material) were filled in a crucible of a vacuum deposition device, preheated with an electron beam, thereafter melted, and the bumping phenomenon was observed. As a result, the number of defects (particles) on the wafer caused by the bumping phenomenon was 0 defects (particles).

[0037]

(Example 1-10)

Pd pellets having a purity of 3N prepared by adding 3 wtppm of carbon were heated in a hydrogen-containing atmosphere at 1300°C. As a result of observing the surface of the Pd pellets after heat treatment with an SEM, the number of micropores was 20 to 50 micropores. Next, these Pd pellets (evaporation material) were filled in a crucible of a vacuum deposition device, preheated with an electron beam, thereafter melted, and the bumping phenomenon was observed. As a result, the number of defects (particles) on the wafer caused by the bumping phenomenon was 1 to 5 defects (particles).

[0038]

(Example 1-11)

Au-Sb pellets having a purity of 3N prepared by adding 5 wtppm of carbon were heated in a hydrogen-containing atmosphere at 800°C. As a result of observing the surface of the Au-Sb pellets after heat treatment with an SEM, the number of micropores was 5 to 10 micropores. Next, these Au-Sb pellets (evaporation material) were filled in a crucible of a vacuum deposition device, preheated with an electron beam, thereafter melted, and the bumping phenomenon was observed. As a result, the number of defects (particles) on the wafer caused by the bumping phenomenon was 1 to 10 defects (particles).

[0039]

(Example 1-12)

Au-As pellets having a purity of 3N prepared by adding 5 wtppm of carbon were heated in a hydrogen-containing atmosphere at 800°C. As a result of observing the surface of the Au-As pellets after heat treatment with an SEM, the number of micropores was 1 to 10 micropores. Next, these Au-As pellets (evaporation material) were filled in a

crucible of a vacuum deposition device, preheated with an electron beam, thereafter melted, and the bumping phenomenon was observed. As a result, the number of defects (particles) on the wafer caused by the bumping phenomenon was 1 to 10 defects (particles).

[0040]

[Table 1]

		Vapor deposition material	Purity	Additive	Additive amount (wtppm)	Heating atmosphere	Heating temperature (°C)	Number of micropores of 0.1 μm or more and 10 μm or less*(/500μm ²)	Number of particles caused by bumping phenomenon *
Conventional Example	1-1	Au	4N	-	-	-	-	0 micropores	More than 500 particles
	1-1	Au	4N	C	10	Containing O2	900	20 to 100 micropores	0 particles
	1-2	Au	4N	C	5	Containing H2	600	10 to 30 micropores	1 to 5 particles
	1-3	Au	5N	C	1	Containing water vapor	400	1 to 10 micropores	20 to 30 particles
	1-4	Au	4N	S	5	Atmosphere	1050	20 to 50 micropores	1 to 10 particles
Examples	1-5	Au	4N	P	5	Atmosphere	700	20 to 50 micropores	1 to 10 particles
	1-6	Pt	3N5	C	3	Containing H2	1550	20 to 50 micropores	0 particles
	1-7	Pt	4N	C	3	Containing water vapor	1000	5 to 10 micropores	5 to 10 particles
	1-8	Ag	4N	C	1	Containing O2	400	1 to 5 micropores	10 to 30 particles
	1-9	Ag	4N	C	3	Containing water vapor	900	20 to 50 micropores	0 particles
	1-10	Pd	3N	C	3	Containing H2	1300	20 to 50 micropores	1 to 5 particles
	1-11	Au-Sb	3N	C	5	Containing H2	800	5 to 10 micropores	1 to 10 particles
	1-12	Au-As	3N	C	5	Containing H2	800	1 to 10 micropores	1 to 10 particles
	*The number of micropores is an approximate figure contained in the foregoing range. The same applies to the number of particles.								

[0041]

(Example 2-1)

A Au raw material having a purity of 4N was melted via EB (electron beam) melting in

a vacuum using a Cu crucible to prepare an ingot. Next, the obtained ingot was observed and a surface part with numerous non-metal inclusions was cut and removed. Subsequently, a wire drawing process was performed to the ingot without using machining oil and the ingot was finished into a predetermined shape. As a result of analyzing the H content in this evaporation material using an inert gas fusion-gas chromatograph (manufactured by LECO), the H content was less than 1 wtppm. As a result of analyzing the C content in an oxygen stream using a non-dispersive infrared device (manufactured by HORIBA), the C content was less than 1 wtppm. Moreover, as a result of analyzing the O content using an inert gas fusion-gas chromatograph (manufactured by LECO), the O content was less than 10 wtppm. Furthermore, as a result of analyzing the contents of S and P content based on the GD-MS method, the total content was less than 1 wtppm. Note that the contents of H, C, O, S, and P were also analyzed using the same methods in the following Examples. Next, this evaporation material (Au) was filled in a crucible of a vacuum deposition device, preheated with an electron beam, thereafter melted, and the bumping phenomenon was observed. As a result, the number of defects (particles) on the wafer caused by the bumping phenomenon was 0 defects (particles), and the results were extremely favorable.

[0042]

(Example 2-2)

A Au raw material having a purity of 4N was melted in an Ar atmosphere using a high purity carbon crucible to prepare an ingot. Subsequently, a wire drawing process was performed to the ingot without using machining oil and the ingot was finished into a predetermined shape. As a result of analyzing the H content in this evaporation material, the H content was less than 1 wtppm. Moreover, the C content was 8 wtppm, the O content was less than 10 wtppm, and the total content of S and P was 3 wtppm. Next, this evaporation material (Au) was filled in a crucible of a vacuum deposition device, preheated with an electron beam, thereafter melted, and the bumping phenomenon was observed. As a result, the number of defects (particles) on the wafer caused by the bumping phenomenon was a few defects (particles), and the results were favorable.

[0043]

(Example 2-3)

A Au raw material having a purity of 3N was melted in the atmosphere using a high purity alumina crucible to prepare an ingot. The obtained ingot was cast by leaving roughly 1% of Au within the crucible. Next, the obtained ingot was observed and a surface part with numerous non-metal inclusions was cut and removed. Subsequently, a wire drawing process was performed to the ingot using machining oil and the ingot was finished into a predetermined shape. Subsequently, the ingot was washed with dilute acid, thereafter washed with acetone, and then dried. As a result of analyzing the H content in this evaporation material, the H content was less than 10 wtppm. Moreover, the C content was 2 wtppm, the O content was 20 wtppm, and the total content of S and P was 8 wtppm. Next, this evaporation material (Au) was filled in a crucible of a vacuum deposition device, preheated with an electron beam, thereafter melted, and the bumping phenomenon was observed. As a result, the number of defects (particles) on the wafer caused by the bumping phenomenon was a few dozen defects (particles), and the results were somewhat favorable.

[0044]

(Example 2-4)

A Pt raw material having a purity of 4N was melted via EB melting in a vacuum using a Cu crucible to prepare an ingot. Next, the obtained ingot was observed and a surface part with numerous non-metal inclusions was cut and removed. Subsequently, a wire drawing process was performed to the ingot while performing heat treatment at 1000°C and the ingot was finished into a predetermined shape. Subsequently, the ingot was used as is as the evaporation material without washing the surface thereof. As a result of analyzing the H content in this evaporation material, the H content was less than 1 wtppm. Moreover, the C content was less than 1 wtppm, the O content was less than 10 wtppm, and the total content of S and P was less than 1 wtppm. Next, this evaporation material (Pt) was filled in a crucible of a vacuum deposition device, preheated with an electron beam, thereafter melted, and the bumping phenomenon was observed. As a result, the number of defects (particles) on the wafer caused by the bumping phenomenon was 0 defects (particles), and the results were extremely favorable.

[0045]

(Example 2-5)

A Pt raw material having a purity of 3N was melted in the atmosphere vacuum using a

commercially available carbon crucible to prepare an ingot. Next, the obtained ingot was observed and a surface part with numerous non-metal inclusions was cut and removed. Subsequently, a wire drawing process was performed to the ingot while performing heat treatment at 1000°C and the ingot was finished into a predetermined shape. Subsequently, the ingot was washed with pure water and dried, and used as the evaporation material. As a result of analyzing the H content in this evaporation material, the H content was 6 wtppm. Moreover, the C content was 10 wtppm, the O content was 70 wtppm, and the total content of S and P was 6 wtppm. Next, this evaporation material (Pt) was filled in a crucible of a vacuum deposition device, preheated with an electron beam, thereafter melted, and the bumping phenomenon was observed. As a result, the number of defects (particles) on the wafer caused by the bumping phenomenon was a few dozen defects (particles), and the results were somewhat favorable.

[0046]

(Example 2-6)

A Pd raw material having a purity of 4N was melted via EB melting in a vacuum using a Cu crucible to prepare an ingot. The obtained ingot was observed and a surface part with numerous non-metal inclusions was cut and removed. Next, a wire drawing process was performed to the ingot without using machining oil and the ingot was finished into a predetermined shape. Subsequently, the ingot was subject to vacuum degassing at 1000°C and used as the evaporation material. The H content in this evaporation material was 1 wtppm. Moreover, the C content was less than 1 wtppm, the O content was 10 wtppm, and the total content of S and P was less than 1 wtppm. Next, this evaporation material (Pd) was filled in a crucible of a vacuum deposition device, preheated with an electron beam, thereafter melted, and the bumping phenomenon was observed. As a result, the number of defects (particles) on the wafer caused by the bumping phenomenon was 0 defects (particles), and the results were extremely favorable.

[0047]

(Example 2-7)

A Pd raw material having a purity of 4N was melted in a vacuum using a high purity alumina crucible to prepare an ingot, the molten metal was removed from the bottom of the crucible and drawn, and cut into a predetermined shape. However, by leaving

about 1% of the molten metal within the crucible rather than tapping the entire amount of the molten metal, the non-metal inclusions remaining at the bottom of the crucible were removed. The H content in this evaporation material was 8 wtppm. Moreover, the C content was 1 wtppm, the O content was 100 wtppm, and the total content of S and P was 1 wtppm. Next, this evaporation material (Pd) was filled in a crucible of a vacuum deposition device, preheated with an electron beam, thereafter melted, and the bumping phenomenon was observed. As a result, the number of defects (particles) on the wafer caused by the bumping phenomenon was a few defects (particles), and the results were favorable.

[0048]

(Example 2-8)

A Pd raw material having a purity of 3N was melted in an Ar atmosphere using a commercially available carbon crucible to prepare an ingot, the molten metal was removed from the bottom of the crucible and drawn, and cut into a predetermined shape. However, by leaving about 0.1% of the molten metal within the crucible rather than tapping the entire amount of the molten metal, the non-metal inclusions remaining at the bottom of the crucible were removed. The H content in this evaporation material was 10 wtppm. Moreover, the C content was 10 wtppm, the O content was 100 wtppm, and the total content of S and P was 10 wtppm. Next, this evaporation material (Pd) was filled in a crucible of a vacuum deposition device, preheated with an electron beam, thereafter melted, and the bumping phenomenon was observed. As a result, the number of defects (particles) on the wafer caused by the bumping phenomenon was a few dozen defects (particles), and the results were somewhat favorable.

[0049]

(Example 2-9)

A Ag raw material having a purity of 4N was melted via EB melting in a vacuum using a Cu crucible to prepare an ingot. Next, the obtained ingot was observed and a surface part with numerous non-metal inclusions was cut and removed. Subsequently, a wire drawing process was performed to the ingot without using machining oil and the ingot was finished into a predetermined shape. The H content in this evaporation material was less than 1 wtppm. Moreover, the C content was less than 1 wtppm, the O content was 10 wtppm, and the total content of S and P was 2 wtppm. Next, this evaporation material (Ag) was filled in a crucible of a vacuum deposition device, preheated with an

electron beam, thereafter melted, and the bumping phenomenon was observed. As a result, the number of defects (particles) on the wafer caused by the bumping phenomenon was 0 defects (particles), and the results were extremely favorable.

[0050]

(Example 2-10)

A Ag raw material having a purity of 3N was melted in the atmosphere using a high purity carbon crucible to prepare an ingot. Subsequently, a wire drawing process was performed to the ingot without using machining oil and the ingot was finished into a predetermined shape. The H content in this evaporation material was 7 wtpm. Moreover, the C content was 10 wtpm, the O content was 50 wtpm, and the total content of S and P was 10 wtpm. Next, this evaporation material (Ag) was filled in a crucible of a vacuum deposition device, preheated with an electron beam, thereafter melted, and the bumping phenomenon was observed. As a result, the number of defects (particles) on the wafer caused by the bumping phenomenon was a few dozen defects (particles), and the results were somewhat favorable.

[0051]

(Example 2-11)

A Au-Sn raw material having a purity of 4N was melted in a vacuum using a high purity carbon crucible to prepare an ingot, the molten metal was removed from the bottom of the crucible and drawn, and cut into a predetermined shape. However, by leaving about 0.1% of the molten metal within the crucible rather than tapping the entire amount of the molten metal, the non-metal inclusions remaining at the bottom of the crucible were removed. As a result of analyzing the H content in this evaporation material, the H content was 1 wtpm. Moreover, the C content was 10 wtpm, the O content was 10 wtpm, and the total content of S and P was 5 wtpm. Next, this evaporation material (Au-Sn) was filled in a crucible of a vacuum deposition device, preheated with an electron beam, thereafter melted, and the bumping phenomenon was observed. As a result, the number of defects (particles) on the wafer caused by the bumping phenomenon was a few defects (particles), and the results were favorable.

[0052]

(Example 2-12)

A Au-Sn raw material having a purity of 3N was melted in the atmosphere using a low purity carbon crucible to prepare an ingot, the molten metal was removed from the

bottom of the crucible and drawn, and cut into a predetermined shape. However, by leaving about 1% of the molten metal within the crucible rather than tapping the entire amount of the molten metal, the non-metal inclusions remaining at the bottom of the crucible were removed. As a result of analyzing the H content in this evaporation material, the H content was 5 wtppm. Moreover, the C content was 10 wtppm, the O content was 90 wtppm, and the total content of S and P was 9 wtppm. Next, this evaporation material (Au-Sn) was filled in a crucible of a vacuum deposition device, preheated with an electron beam, thereafter melted, and the bumping phenomenon was observed. As a result, the number of defects (particles) on the wafer caused by the bumping phenomenon was a few dozen defects (particles), and the results were somewhat favorable.

[0053]

The foregoing results are shown in Table 2.

[Table 2]

(wtppm)

Example	H	C	O	P+S	Evaluation result
2-1	<1	<1	<10	<1	◎
2-2	<1	8	<10	3	○
2-3	10	2	20	8	△
2-4	<1	<1	<10	<1	◎
2-5	6	10	70	6	△
2-6	1	<1	10	<1	◎
2-7	8	1	100	1	○
2-8	10	10	100	10	△
2-9	<1	<1	10	2	◎
2-10	7	10	50	10	△
2-11	1	10	10	5	○
2-12	5	10	90	9	△

◎: Extremely favorable; ○: Favorable △: Somewhat favorable

[0054]

(Comparative Example 2-1)

A Au raw material having a purity of 3N was melted in the atmosphere using a low purity carbon crucible to prepare an ingot. Next, a wire drawing process was performed to the obtained ingot and the ingot was finished into a predetermined shape without subjecting the surface part of the ingot to acid cleaning or cutting and removal. Note that machining oil was used for the wire drawing process. Subsequently, the surface of the ingot was washed with acid, dried, and thereafter used as the evaporation material. The H content in this evaporation material was 12 wtppm. Moreover, the C content was 25 wtppm, the O content was 110 wtppm, and the total content of S and P was 15 wtppm. Next, this evaporation material (Au) was filled in a crucible of a vacuum deposition device, preheated with an electron beam, thereafter melted, and the bumping phenomenon was observed. As a result, the number of defects (particles) on the wafer caused by the bumping phenomenon was hundreds of defects (particles).

[0055]

(Comparative Example 2-2)

A Pt raw material having a purity of 3N was melted in the atmosphere using a low purity carbon crucible to prepare an ingot. Next, a wire drawing process was performed to the obtained ingot and the ingot was finished into a predetermined shape without subjecting the surface part of the ingot to acid cleaning or cutting and removal. Note that machining oil was used for the wire drawing process. Subsequently, the surface of the ingot was washed with acetone, dried, and thereafter used as the evaporation material. The H content in this evaporation material was 11 wtppm. Moreover, the C content was 110 wtppm, the O content was 120 wtppm, and the total content of S and P was 11 wtppm. Next, this evaporation material (Pt) was filled in a crucible of a vacuum deposition device, preheated with an electron beam, thereafter melted, and the bumping phenomenon was observed. As a result, the number of defects (particles) on the wafer caused by the bumping phenomenon was hundreds of defects (particles).

[0056]

(Comparative Example 2-3)

A Pd raw material having a purity of 3N was melted under weak reduced pressure using a low purity carbon crucible to prepare an ingot, the molten metal was removed from the bottom of the crucible and drawn, and cut into a predetermined shape.

However, the entire amount of the molten metal was tapped. The H content in this evaporation material was 20 wtppm. Moreover, the C content was 20 wtppm, the O content was 250 wtppm, and the total content of S and P was 20 wtppm. Next, this evaporation material (Pd) was filled in a crucible of a vacuum deposition device, preheated with an electron beam, thereafter melted, and the bumping phenomenon was observed. As a result, the number of defects (particles) on the wafer caused by the bumping phenomenon was hundreds of defects (particles).

[0057]

The foregoing results are shown in Table 3.

[Table 3]

Comparative Example	(wtppm)				
	H	C	O	P+S	Evaluation result
2-1	12	25	110	15	×
2-2	11	110	120	11	×
2-3	20	20	250	20	×

×: Unfavorable

[Industrial Applicability]

[0058]

According to the present invention, it is possible to suppress the bumping phenomenon upon melting the evaporation material, and thereby reduce the particles that become adhered on the substrate. The evaporation material according to this embodiment can be broadly used for forming elements in electronic components, semiconductor devices, optical thin films, magnetic devices, LEDs, organic ELs, and LCDs using the vacuum deposition method.

CLAIMS

[Claim 1]

An evaporation material, wherein the evaporation material comprises one or more types among Au, Ag, Pt, Pd and their alloys, micropores are formed on a surface of the evaporation material, and a number of the micropores having an equivalent circle diameter of 0.1 μm or more and 10.0 μm or less is one or more micropores per 500 μm^2 .

[Claim 2]

The evaporation material according to claim 1, wherein a purity of the evaporation material is 3N (99.9 wt%) or higher.

[Claim 3]

An evaporation material, wherein the evaporation material comprises one or more types among Au, Ag, Pt, Pd and their alloys, and a hydrogen content in the evaporation material is 10 wtppm or less.

[Claim 4]

The evaporation material according to claim 3, wherein a carbon content in the evaporation material is 10 wtppm or less.

[Claim 5]

The evaporation material according to claim 3 or claim 4, wherein an oxygen content in the evaporation material is 100 wtppm or less.

[Claim 6]

The evaporation material according to any one of claims 3 to 5, wherein a total content of sulfur and phosphorus in the evaporation material is 10 wtppm or less.

[Claim 7]

A method of producing the evaporation material according to any one of claims 3 to 6, wherein a raw material is melted and cast to form an ingot and the ingot is thereafter subject to a wire drawing process to prepare an evaporation material, or a raw material is melted and thereafter granulated to prepare an evaporation material, wherewith a surface part thereof is cut and removed after the wire drawing process or after the granulation process.

[Claim 8]

A method of producing the evaporation material according to any one of claims 3 to 6,

wherein a raw material is melted and cast to form an ingot and the ingot is thereafter subject to a wire drawing process to prepare an evaporation material, or a raw material is melted and thereafter granulated to prepare an evaporation material, wherewith, after melting the raw material, 0.1 wt% or more of a molten metal thereof is left within a crucible to prepare a cast ingot, or granulated.

[Claim 9]

The method of producing the evaporation material according to claim 7 or claim 8, wherein heat treatment is performed before or after and during the wire drawing process.