

TITLE OF THE INVENTION

SILVER ALLOY SPUTTERING TARGET FOR FORMING  
ELECTROCONDUCTIVE FILM, AND METHOD FOR MANUFACTURING SAME

BACKGROUND OF THE INVENTION

[Field of the Invention]

**[0001]** The present invention relates to a silver alloy sputtering target for forming an electroconductive film such as a reflective electrode film for an organic LED element, a wiring film for a touch panel, or the like, and a method for manufacturing such a sputtering target. More specifically, the present invention relates to a large-sized silver alloy sputtering target.

[Description of the Related Art]

**[0002]** Organic LED elements are light-emitting elements using the principle in which a voltage is applied between an anode and a cathode formed on either side of an organic LED light-emitting layer, positive holes and electrons are injected into an organic LED film from the anode and the cathode, respectively, to thereby emit light from the organic LED film when positive holes and electrons are combined in the organic LED light-emitting layer and have been recently receiving considerable attention as elements used for display devices. The organic LED element driving method includes the passive matrix type and the active matrix type. The driving method by the active

matrix type organic LED element can provide high-speed switching for each of pixels by providing one or more thin-film transistors, and thus, is advantageous for high contrast ratio and fineness.

**[0003]** Also, the light extraction method includes the bottom emission type that extracts light emitted from a transparent substrate and the top emission type that extracts light to the opposite side of the substrate. Since a high aperture ratio can be obtained in the top emission type, the top emission type is advantageous for obtaining higher luminance.

**[0004]** FIG. 2 shows an example of a configuration of a layer in a top emission structure where the reflective electrode is an anode. Here, in order to efficiently reflect light emitted from an organic LED layer, it is preferable that a reflective electrode film (described as a "reflective anode film" in FIG. 2) provides high reflectivity and high corrosion resistance. It is also preferable that the reflective electrode film has a low resistance as an electrode. Such materials known include Ag alloy and Al alloy. In order to obtain an organic LED element having higher luminance, Ag alloy is excellent in high visible light reflection. Here, a sputtering method is employed for forming a reflective electrode film for an organic LED element, and a silver alloy sputtering target is employed (Patent Document 1).

**[0005]** In addition to a reflective electrode film for an organic LED element, it has also been conventionally investigated to employ an Ag alloy film as an

electroconductive film for a lead-out wiring or the like for a touch panel. When a pure Ag is used as such a wiring film, a short-circuit malfunction readily occurs due to the occurrence of migration. Thus, it has been conventionally investigated to employ an Ag alloy film.

[Prior Art Documents]

[Patent Document]

**[0006]** [Patent Document 1] WO 2002/077317

#### SUMMARY OF THE INVENTION

[Problems to be solved by the Invention]

**[0007]** However, the following problems still remain in the conventional techniques described above.

Specifically, with increasing the size of a glass substrate during the production of an organic LED element, a large-sized silver alloy target used for forming a reflective electrode film has also come to be employed. Here, when a large-sized target is subjected to sputtering by applying high electric power thereto, a phenomenon called "splashing" generated by abnormal electrical discharge in the target occurs. Consequently, molten micro particles may be attached to the substrate to thereby cause a short circuit between wirings or electrodes, resulting in a decrease in the yield of the organic LED elements. A reflective electrode film for an organic LED element of the top emission type is an undercoat layer of an organic light-emitting layer, and thus, needs to have a high

flatness. Hence, the occurrence of splashing needs to be suppressed.

Also, it is desirable that a reflective electrode film for an organic LED element exhibits high reflectivity and it is required that a reflective electrode film for an organic LED element and an electroconductive film for a wiring film or the like of a touch panel exhibit excellent film corrosion resistance, excellent film heat resistance, and low electrical resistance.

**[0008]** The present invention has been made in view of the aforementioned circumstances, and an object of the present invention is to provide a silver alloy sputtering target for forming an electroconductive film, the sputtering target being capable of inhibiting splashing even when a large electric power is applied to the target in line with increased target size, having excellent corrosion resistance and heat resistance, and being capable of forming a low-electrical-resistance film, and a method for manufacturing such a sputtering target.

[Means for Solving the Problems]

**[0009]** The present inventors have found that splashing may be suppressed even when a large electric power is applied to a silver alloy sputtering target for forming an electroconductive film by setting the average grain diameter of the crystal grains thereof to be in the range of from 120 to 400  $\mu\text{m}$  by the specific manufacturing method. The present inventors have also found that film corrosion

resistance and film heat resistance can be improved by the addition of suitable amounts of Ga and Sn to Ag.

**[0010]** Also, the present inventors have found that splashing may be suppressed even when a large electric power is applied to a silver alloy sputtering target for forming an electroconductive film by the addition of suitable amounts of In, Ga, and Sn to Ag and by setting the average grain diameter of the crystal grains thereof to be in the range of from 120 to 250  $\mu\text{m}$ .

**[0011]** Thus, the present invention has been made in view of the aforementioned circumstances and has adopted the following structure in order to solve the aforementioned problems.

A silver alloy sputtering target for forming an electroconductive film according to a first aspect of the present invention is characterized in that the sputtering target includes a silver alloy having a component composition containing a total of 0.1 to 1.5% by mass of Ga and/or Sn and the balance composed of Ag and unavoidable impurities, wherein the average grain diameter of the crystal grains of the silver alloy is 120 to 400  $\mu\text{m}$  and the dispersion in the grain diameter of the crystal grains is 20% or less of the average grain diameter.

**[0012]** Since the silver alloy sputtering target for forming an electroconductive film includes a silver alloy having a component composition containing a total of 0.1 to 1.5% by mass of Ga and/or Sn and the balance composed of Ag and unavoidable impurities, wherein the average grain diameter of the crystal grains of the silver alloy is 120

to 400  $\mu\text{m}$  and the dispersion in the grain diameter of the crystal grains is 20% or less of the average grain diameter, abnormal electrical discharge and the occurrence of splashing can be suppressed even when a large electric power is applied to the target during sputtering. Also, an electroconductive film exhibiting excellent corrosion resistance, excellent heat resistance, and low electrical resistance may be obtained by sputtering the silver alloy sputtering target for forming an electroconductive film.

**[0013]** A silver alloy sputtering target for forming an electroconductive film according to a second aspect of the present invention is characterized in that the sputtering target includes a silver alloy having a component composition containing a total of 0.1 to 1.5% by mass of Ga and/or Sn, a total of 1.0% by mass or less of Cu and/or Mg, and the balance composed of Ag and unavoidable impurities, wherein the average grain diameter of the crystal grains of the silver alloy is 120 to 400  $\mu\text{m}$  and the dispersion in the grain diameter of the crystal grains is 20% or less of the average grain diameter.

Specifically, since the silver alloy sputtering target for forming an electroconductive film contains Cu and/or Mg in the above range, the coarsening of the crystal grains can be suppressed and the reduction in reflectivity due to corrosion of the film can be further suppressed.

**[0014]** A silver alloy sputtering target for forming an electroconductive film according to a third aspect of the present invention is characterized in that the sputtering target includes a silver alloy having a component

composition containing a total of 0.1 to 1.5% by mass of Ga and/or Sn, a total of 0.8% by mass or less of Ce and/or Eu, and the balance composed of Ag and unavoidable impurities, wherein the average grain diameter of the crystal grains of the silver alloy is 120 to 400  $\mu\text{m}$  and the dispersion in the grain diameter of the crystal grains is 20% or less of the average grain diameter.

Specifically, since the silver alloy sputtering target for forming an electroconductive film contains Ce and/or Eu in the above range, the coarsening of the crystal grains can be suppressed and the reduction in reflectivity due to corrosion of the film can be further suppressed.

**[0015]** A silver alloy sputtering target for forming an electroconductive film according to a fourth aspect of the present invention is characterized in that the sputtering target includes a silver alloy having a component composition containing 0.1 to 1.5% by mass of In, a total of 0.1 to 1.5% by mass of Ga and/or Sn, and the balance composed of Ag and unavoidable impurities, wherein the average grain diameter of the crystal grains of the silver alloy is 120 to 250  $\mu\text{m}$  and the dispersion in the grain diameter of the crystal grains is 20% or less of the average grain diameter.

**[0016]** Since the silver alloy sputtering target for forming an electroconductive film includes a silver alloy having a component composition containing 0.1 to 1.5% by mass of In, a total of 0.1 to 1.5% by mass of Ga and/or Sn, and the balance composed of Ag and unavoidable impurities, wherein the average grain diameter of the crystal grains of

the silver alloy is 120 to 250  $\mu\text{m}$  and the dispersion in the grain diameter of the crystal grains is 20% or less of the average grain diameter, abnormal electrical discharge and the occurrence of splashing can be suppressed even when a large electric power is applied to the target during sputtering. Also, an electroconductive film exhibiting excellent corrosion resistance, excellent heat resistance, and low electrical resistance may be obtained by sputtering the silver alloy sputtering target for forming an electroconductive film.

**[0017]** A silver alloy sputtering target for forming an electroconductive film according to a fifth aspect of the present invention is characterized in that the sputtering target includes a silver alloy having a component composition containing 0.1 to 1.5% by mass of In, a total of 0.1 to 1.5% by mass of Ga and/or Sn, a total of 1.0% by mass or less of Cu and/or Mg, and the balance composed of Ag and unavoidable impurities, wherein the average grain diameter of the crystal grains of the silver alloy is 120 to 250  $\mu\text{m}$  and the dispersion in the grain diameter of the crystal grains is 20% or less of the average grain diameter.

Specifically, since the silver alloy sputtering target for forming an electroconductive film contains Cu and/or Mg in the above range, the coarsening of the crystal grains can be suppressed and the reduction in reflectivity due to corrosion of the film can be further suppressed.

**[0018]** A silver alloy sputtering target for forming an electroconductive film according to a sixth aspect of the present invention is characterized in that the sputtering

target includes a silver alloy having a component composition containing 0.1 to 1.5% by mass of In, a total of 0.1 to 1.5% by mass of Ga and/or Sn, a total of 0.8% by mass or less of Ce and/or Eu, and the balance composed of Ag and unavoidable impurities, wherein the average grain diameter of the crystal grains of the silver alloy is 120 to 250  $\mu\text{m}$  and the dispersion in the grain diameter of the crystal grains is 20% or less of the average grain diameter.

Specifically, since the silver alloy sputtering target for forming an electroconductive film contains Ce and/or Eu in the above range, the coarsening of the crystal grains can be suppressed and the reduction in reflectivity due to corrosion of the film can be further suppressed.

**[0019]** A silver alloy sputtering target for forming an electroconductive film according to a seventh aspect of the present invention is characterized in that the surface of the target has an area equal to or greater than 0.25  $\text{m}^2$  according to any one of the first to sixth aspects of the present invention.

Specifically, the silver alloy sputtering target for forming an electroconductive film is suitable and the aforementioned effect is even more pronounced when the sputtering target is large in size.

**[0020]** A method for manufacturing a silver alloy sputtering target for forming an electroconductive film according to an eighth aspect of the present invention is a method for manufacturing the silver alloy sputtering target for forming an electroconductive film according to the first aspect of the present invention and is characterized

in that the method includes, in sequence, the steps of repeating hot upset forging 6 to 20 times for an ingot formed by melting and casting having a component composition containing a total of 0.1 to 1.5% by mass of Ga and/or Sn and the balance composed of Ag and unavoidable impurities; cold-rolling the forged ingot; subjecting the cold-rolled board to a heat treatment; and machining the heat-treated board.

Specifically, since the method for manufacturing the silver alloy sputtering target for forming an electroconductive film includes the step of repeating hot upset forging 6 to 20 times, the dispersion in the grain diameter of the crystal grains can be 20% or less of the average grain diameter even in the case of a large-sized target.

**[0021]** A method for manufacturing a silver alloy sputtering target for forming an electroconductive film according to a ninth aspect of the present invention is a method for manufacturing the silver alloy sputtering target for forming an electroconductive film according to the second aspect of the present invention and is characterized in that the method includes, in sequence, the steps of repeating hot upset forging 6 to 20 times for an ingot formed by melting and casting having a component composition containing a total of 1.5% by mass or less of Ga and/or Sn, a total of 1.0% by mass or less of Cu and/or Mg, and the balance composed of Ag and unavoidable impurities; cold-rolling the forged ingot; subjecting the

cold-rolled board to a heat treatment; and machining the heat-treated board.

Specifically, in the method for manufacturing the silver alloy sputtering target for forming an electroconductive film, an ingot formed by melting and casting further contains a total of 1.0% by mass or less of Cu and/or Mg. Thus, the silver alloy sputtering target according to the second aspect of the present invention in which the coarsening of the crystal grains is suppressed can be obtained.

**[0022]** A method for manufacturing a silver alloy sputtering target for forming an electroconductive film according to a tenth aspect of the present invention is a method for manufacturing the silver alloy sputtering target for forming an electroconductive film according to the third aspect of the present invention and is characterized in that the method includes, in sequence, the steps of repeating hot upset forging 6 to 20 times for an ingot formed by melting and casting having a component composition containing a total of 1.5% by mass or less of Ga and/or Sn, a total of 0.8% by mass or less of Ce and/or Eu, and the balance composed of Ag and unavoidable impurities; cold-rolling the forged ingot; subjecting the cold-rolled board to a heat treatment; and machining the heat-treated board.

Specifically, in the method for manufacturing the silver alloy sputtering target for forming an electroconductive film, an ingot formed by melting and casting further contains a total of 0.8% by mass or less of

Ce and/or Eu. Thus, the silver alloy sputtering target according to the third aspect of the present invention in which the coarsening of the crystal grains is suppressed can be obtained.

**[0023]** A method for manufacturing a silver alloy sputtering target for forming an electroconductive film according to an eleventh aspect of the present invention is a method for manufacturing the silver alloy sputtering target for forming an electroconductive film according to the fourth aspect of the present invention and is characterized in that the method includes, in sequence, the steps of repeating hot upset forging 6 to 20 times for an ingot formed by melting and casting having a component composition containing 0.1 to 1.5% by mass of In, a total of 0.1 to 1.5% by mass of Ga and/or Sn, and the balance composed of Ag and unavoidable impurities; cold-rolling the forged ingot; subjecting the cold-rolled board to a heat treatment; and machining the heat-treated board.

Specifically, since the method for manufacturing the silver alloy sputtering target for forming an electroconductive film includes the step of repeating hot upset forging 6 to 20 times, the dispersion in the grain diameter of the crystal grains can be 20% or less of the average grain diameter even in the case of a large-sized target.

**[0024]** A method for manufacturing a silver alloy sputtering target for forming an electroconductive film according to a twelfth aspect of the present invention is a method for manufacturing the silver alloy sputtering target

for forming an electroconductive film according to the fifth aspect of the present invention and is characterized in that the method includes, in sequence, the steps of repeating hot upset forging 6 to 20 times for an ingot formed by melting and casting having a component composition containing 0.1 to 1.5% by mass of In, a total of 0.1 to 1.5% by mass of Ga and/or Sn, a total of 1.0% by mass or less of Cu and/or Mg, and the balance composed of Ag and unavoidable impurities; cold-rolling the forged ingot; subjecting the cold-rolled board to a heat treatment; and machining the heat-treated board.

Specifically, in the method for manufacturing the silver alloy sputtering target for forming an electroconductive film, an ingot formed by melting and casting further contains a total of 1.0% by mass or less of Cu and/or Mg. Thus, the silver alloy sputtering target according to the fifth aspect of the present invention in which the coarsening of the crystal grains is suppressed can be obtained.

**[0025]** A method for manufacturing a silver alloy sputtering target for forming an electroconductive film according to a thirteenth aspect of the present invention is a method for manufacturing the silver alloy sputtering target for forming an electroconductive film according to the sixth aspect of the present invention and is characterized in that the method includes, in sequence, the steps of repeating hot upset forging 6 to 20 times for an ingot formed by melting and casting having a component composition containing 0.1 to 1.5% by mass of In, a total

of 0.1 to 1.5% by mass of Ga and/or Sn, a total of 0.8% by mass or less of Ce and/or Eu, and the balance composed of Ag and unavoidable impurities; cold-rolling the forged ingot; subjecting the cold-rolled board to a heat treatment; and machining the heat-treated board.

Specifically, in the method for manufacturing the silver alloy sputtering target for forming an electroconductive film, an ingot formed by melting and casting further contains a total of 0.8% by mass or less of Ce and/or Eu. Thus, the silver alloy sputtering target according to the sixth aspect of the present invention in which the coarsening of the crystal grains is suppressed can be obtained.

**[0026]** A method for manufacturing a silver alloy sputtering target for forming an electroconductive film according to a fourteenth aspect of the present invention is characterized in that the temperature of the hot upset forging is from 750 to 850 °C in any one of the eighth to thirteenth aspects of the present invention.

Specifically, in the method for manufacturing the silver alloy sputtering target for forming an electroconductive film, the temperature of the hot upset forging is from 750 to 850 °C. Thus, the dispersion in the grain diameter of the crystal grains can be 20% or less of the average grain diameter and the average grain diameter of the crystal grains can be 400 μm or less. Furthermore, in the method for manufacturing a silver alloy sputtering target for forming an electroconductive film containing 0.1

to 1.5% by mass of In, the average grain diameter of the crystal grains can be 250  $\mu\text{m}$  or less.

[Effects of the Invention]

**[0027]** According to the present invention, the following effects may be provided.

Since the silver alloy sputtering target for forming an electroconductive film of the present invention is constituted by a silver alloy containing the content of Ga and/or Sn in the above range, wherein the average grain diameter of the crystal grains of the silver alloy is 120 to 400  $\mu\text{m}$  and the dispersion in the grain diameter of the crystal grains is 20% or less of the average grain diameter, the occurrence of splashing can be suppressed during sputtering and an electroconductive film exhibiting excellent corrosion resistance, excellent heat resistance, and low electrical resistance can be obtained.

Since the silver alloy sputtering target for forming an electroconductive film of the present invention is constituted by a silver alloy containing the content of In and Ga and/or Sn in the above range, wherein the average grain diameter of the crystal grains of the silver alloy is 120 to 250  $\mu\text{m}$  and the dispersion in the grain diameter of the crystal grains is 20% or less of the average grain diameter, the occurrence of splashing can be suppressed during sputtering and an electroconductive film exhibiting excellent corrosion resistance, excellent heat resistance, and low electrical resistance can be obtained.

Furthermore, in the method for manufacturing a silver alloy sputtering target for forming an electroconductive film of the present invention, the occurrence of splashing can be suppressed even in the case of a large-sized target and a silver alloy sputtering target on which an excellent electroconductive film can be formed can be manufactured.

[Brief Description of the Drawings]

**[0028]** FIG. 1 is an explanatory diagram illustrating a hot forging method in a method for manufacturing a silver alloy sputtering target for forming an electroconductive film according to one embodiment of the present invention.

FIG. 2 is a diagram illustrating an example of a simple configuration of layers of an organic LED element having a top emission structure where the reflective electrode is an anode.

[Best Modes for Carrying Out the Invention]

**[0029]** Hereinafter, a description will be given of a silver alloy sputtering target for forming an electroconductive film according to one embodiment of the present invention and a method for manufacturing such a sputtering target with reference to FIG. 1. In this specification, a percentage represents percent by mass if not otherwise specified or unless a percentage represents a specific numerical value.

**[0030]** The silver alloy sputtering target for forming an electroconductive film of the present embodiment is constituted by a silver alloy having a component

composition containing a total of 0.1 to 1.5% by mass of Ga and/or Sn and the balance composed of Ag and unavoidable impurities, wherein the average grain diameter of the crystal grains of the silver alloy (hereinafter referred to as "silver alloy crystal grains") is 120 to 400  $\mu\text{m}$  and the dispersion in the grain diameter of the crystal grains is 20% or less of the average grain diameter.

**[0031]** The silver alloy sputtering target for forming an electroconductive film of the present embodiment may also be constituted by a silver alloy having a component composition containing a total of 0.1 to 1.5% by mass of Ga and/or Sn, a total of 1.0% by mass or less of Cu and/or Mg, and the balance composed of Ag and unavoidable impurities.

The sputtering target may also contain a total of 0.8% by mass or less of Ce and/or Eu instead of Cu and Mg.

**[0032]** Also, the silver alloy sputtering target for forming an electroconductive film of the present embodiment is constituted by a silver alloy having a component composition containing 0.1 to 1.5% by mass of In, a total of 0.1 to 1.5% by mass of Ga and/or Sn, and the balance composed of Ag and unavoidable impurities, wherein the average grain diameter of the crystal grains of the silver alloy (hereinafter referred to as "silver alloy crystal grains") is 120 to 250  $\mu\text{m}$  and the dispersion in the grain diameter of the crystal grains is 20% or less of the average grain diameter.

**[0033]** The silver alloy sputtering target for forming an electroconductive film of the present embodiment may also be constituted by a silver alloy having a component

composition containing 0.1 to 1.5% by mass of In, a total of 0.1 to 1.5% by mass of Ga and/or Sn, a total of 1.0% by mass or less of Cu and/or Mg, and the balance composed of Ag and unavoidable impurities.

The sputtering target may also contain a total of 0.8% by mass or less of Ce and/or Eu instead of Cu and Mg.

**[0034]** In the sputtering target of the present embodiment, the surface of the target (the surface of the target to be subjected to sputtering) has an area of 0.25 m<sup>2</sup> or greater. In the case of a rectangular target, at least one side thereof has a length of 500 mm or greater. From the viewpoint of handling of the target, the upper limit of the length is preferably 2500 mm. On the other hand, from the viewpoint of the upper limit of the size which is rollable by a rolling machine in a cold-rolling step, the upper limit of the width is preferably 1700 mm. From the viewpoint of replacement frequency of a target, the thickness of a target is preferably 6 mm or greater. From the viewpoint of discharging stability of magnetron sputtering, the thickness of a target is preferably 20 mm or less.

**[0035]** Ag has the effect of imparting low resistance to a reflective electrode film for an organic LED element or a wiring film for a touch panel formed by sputtering.

**[0036]** Ga, Sn, and In have the effect of improving the hardness of a target, so that warpage during machining can be suppressed. In particular, the warpage of a large-sized target of which the surface has an area of 0.25 m<sup>2</sup> or greater may be suppressed during machining. In addition,

the addition of suitable amounts of Ga, Sn, and In has the effect of improving the corrosion resistance and heat resistance of an electroconductive film formed by sputtering. This is because Ga, Sn, and In have the effect of finely dividing the crystal grains contained in an electroconductive film and reducing the surface roughness of the film. In addition, Ga, Sn, and In have the effect of increasing the strength of the crystal grains by forming solid solution in Ag, suppressing the coarsening of the crystal grains due to heating, suppressing an increase in the surface roughness of the film, and suppressing the reduction in reflectivity due to corrosion of the film. Thus, in a reflective electrode film or a wiring film formed by using the silver alloy sputtering target for forming an electroconductive film of the present embodiment, improvements in the corrosion resistance and heat resistance of the film contribute higher luminance of an organic LED element and an improvement in reliability of wirings for a touch panel or the like.

**[0037]** The reason why a total content of Ga and/or Sn is limited to the above range is because it is not preferable that the effect obtained by the addition of Ga and/or Sn may not be expected when a total content of Ga and/or Sn is less than 0.1% by mass, whereas the electrical resistance of the film increases and the corrosion resistance of the film formed by sputtering is further reduced when a total content of Ga and/or Sn exceeds 1.5% by mass. Thus, since the composition of the film depends on the composition of the target, a total content of Ga

and/or Sn contained in a silver alloy sputtering target is set to 0.1% to 1.5% by mass and is preferably set to 0.2% to 1.0% by mass.

**[0038]** The reason why the content of In is limited to the above range is because it is not preferable that the effect obtained by the addition of In may not be expected when the content of In is less than 0.1% by mass, whereas the electrical resistance of the film increases and the corrosion resistance of the film formed by sputtering is further reduced when the content of In exceeds 1.5% by mass. Thus, since the composition of the film depends on the composition of the target, the In content contained in a silver alloy sputtering target is set to 0.1% to 1.5% by mass and is preferably set to 0.2% to 1.0% by mass.

**[0039]** Cu and Mg have the effect of preventing the crystal grains from being coarsened by being solid-solved in Ag. In particular, the silver alloy crystal grains are readily and partially coarsened in the target in line with increased target size, resulting in induction of splashing during sputtering. Thus, a remarkable effect for suppressing the coarsening of the silver alloy crystal grains is achieved by the addition of Cu and Mg. Even in a film formed by sputtering, the addition of suitable amounts of Cu and Mg has the effect of suppressing an increase in the surface roughness of the film by suppressing the coarsening of the crystal grains due to heating and suppressing the reduction in reflectivity due to corrosion of the film.

**[0040]**        The reason why the content of Cu and Mg is limited to the above range is because the corrosion resistance of the film formed by sputtering is further reduced and the electrical resistance of the film increases when a total content of Cu and/or Mg exceeds 1.0% by mass. Thus, a total content of Cu and/or Mg exceeding 1.0% by mass is not preferable to be used for an electrode film or a wiring film. Since the composition of the film formed by sputtering depends on the composition of the target, a total content of Cu and/or Mg contained in a silver alloy sputtering target is set to 1.0% by mass or less and is preferably set to 0.3% to 0.8% by mass.

**[0041]**        Ce and Eu have the effect of preventing the crystal grains from being coarsened by forming an intermetallic compound between Ce/Eu and Ag and by segregating the intermetallic compound at the crystal grain boundaries. In particular, the silver alloy crystal grains are readily and partially coarsened in the target in line with increased target size, resulting in induction of splashing during sputtering. Thus, a remarkable effect for suppressing the coarsening of the silver alloy crystal grains is achieved by the addition of Ce and Eu. Even in a film formed by sputtering, the addition of suitable amounts of Ce and Eu has the effect of suppressing an increase in the surface roughness of the film by suppressing the coarsening of the crystal grains due to heating and suppressing the reduction in reflectivity due to corrosion of the film.

**[0042]** The reason why the content of Ce and Eu is limited to the above range is because it is not preferable that the amount of the deposited intermetallic compound between these elements and Ag increases in the target structure and the grain diameter of the precipitate is coarsened, resulting in an increase in abnormal electrical discharge during sputtering when the content of Ce and/or Eu exceeds 0.8% by mass. Thus, since the composition of the film formed by sputtering depends on the composition of the target, a total content of Ce and/or Eu contained in a silver alloy sputtering target is set to 0.8% by mass or less and is preferably set to 0.3% to 0.5% by mass.

Here, Ga, Sn, In, Cu, Mg, Ce, and Eu are quantitatively analyzed by Inductively Coupled Plasma Spectrometry (ICP Spectrometry).

**[0043]** The average grain diameter of the silver alloy crystal grains in the sputtering target of the present embodiment is 120 to 400  $\mu\text{m}$  and preferably 150 to 350  $\mu\text{m}$ . The reason why the average grain diameter of the silver alloy crystal grains is limited to the above range is because, if the average grain diameter is smaller than 120  $\mu\text{m}$ , the dispersion in the crystal grain diameter increases and thus abnormal electrical discharge readily occurs during high-power sputtering, resulting in the occurrence of splashing. On the other hand, if the average grain diameter is greater than 400  $\mu\text{m}$ , the unevenness of the sputtering surface increases due to the differences between sputtering rates caused by the differences between crystal orientations of the crystal grains in association with the

abrasion of the target during sputtering. Consequently, abnormal electrical discharge readily occurs during high-power sputtering, resulting in the occurrence of splashing.

**[0044]** The average grain diameter of the silver alloy crystal grains in the In-containing sputtering target of the present embodiment is 120 to 250  $\mu\text{m}$  and preferably 150 to 220  $\mu\text{m}$ . The reason why the average grain diameter of the silver alloy crystal grains is limited to the above range is because, if the average grain diameter is smaller than 120  $\mu\text{m}$ , the dispersion in the crystal grain diameter increases and thus abnormal electrical discharge readily occurs during high-power sputtering, resulting in the occurrence of splashing. On the other hand, if the average grain diameter is greater than 250  $\mu\text{m}$ , the unevenness of the sputtering surface increases due to the differences between sputtering rates caused by the differences between crystal orientations of the crystal grains in association with the abrasion of the target during sputtering. Consequently, abnormal electrical discharge readily occurs during high-power sputtering, resulting in the occurrence of splashing.

**[0045]** Here, the average grain diameter of the silver alloy crystal grains is measured as follows.

Firstly, the rectangular samples having a length of about 10 mm on each side are uniformly obtained from sixteen points of the sputtering surface of the sputtering target. More specifically, the sputtering target is segmented into sixteen sections (four by four), and the

sample is obtained from the central portion of each of the sixteen sections.

The present embodiment bears in mind a large-sized target which has a sputtering surface of  $500 \times 500$  (mm) or greater, i.e., of which the target surface has an area of  $0.25 \text{ m}^2$  or greater. Thus, a description has been given of a method for obtaining samples from the rectangular target generally used as a large-sized target. However, it is of course that the present embodiment also provides the effect of suppressing the occurrence of splashing for the rounded target. At this time, the target is segmented into sixteen sections in the same manner as the method for obtaining samples in the large-sized rectangular target, and samples are uniformly obtained from sixteen points of the sputtering surface of the sputtering target.

**[0046]** Next, the sputtering surface of each sample piece is polished. The sputtering surface of each sample piece is polished by a waterproofing paper of #180 to #4000, and then, is polished by buffing using abrasive grains of  $1 \text{ }\mu\text{m}$  to  $3 \text{ }\mu\text{m}$ .

Furthermore, the polished sample piece is subjected to etching in a manner such that the grain boundaries can be seen by an optical microscope. Here, a mixed solution of hydrogen peroxide and aqueous ammonia is used as an etching solution. Each sample piece is immersed into the etching solution for 1-2 seconds at room temperature so as to form the grain boundaries. Next, a photograph of each sample is taken by an optical microscope at a magnification of 30x.

**[0047]** Four segments having a length of 60 mm are drawn on each photograph in longitudinal and transverse directions at the interval of 20 mm in a cross-shaped manner, and the number of crystal grains cut on each line is counted. The crystal grain at the edge of the segment is counted as 0.5. The average intercept length:  $L$  ( $\mu\text{m}$ ) is calculated using Formula:  $L = 60000/(M \cdot N)$  (here,  $M$  is the actual magnification and  $N$  is the average value of the number of cut crystal grains).

Next, the average grain diameter of samples:  $d$  ( $\mu\text{m}$ ) is calculated using Formula  $d = (3/2) \cdot L$  based on the calculated average intercept length:  $L$  ( $\mu\text{m}$ ).

**[0048]** The average value of the average grain diameters of samples obtained from sixteen points is the average grain diameter of the silver alloy crystal grains of the target. The average grain diameter of the silver alloy crystal grains in the sputtering target of the present invention is in the range of from 120 to 400  $\mu\text{m}$ . The average grain diameter of the silver alloy crystal grains in the In-containing sputtering target of the present invention is in the range of from 120 to 250  $\mu\text{m}$ .

**[0049]** If the dispersion in the grain diameter of the crystal grains of the silver alloy is 20% or less of the average grain diameter of the silver alloy crystal grains, the occurrence of splashing during sputtering may be surely suppressed.

Here, the maximum absolute value of the deviation between the average grain diameter of one point and the average grain diameter of sixteen points ( $|[(\text{average grain$

diameter of one point) - (average grain diameter of sixteen points)]]) is specified, and the dispersion in the grain diameter is calculated using the specified average grain diameter (specified average grain diameter) as follows:

$$\frac{|[(\text{specified average grain diameter}) - (\text{average grain diameter of sixteen points})]|}{(\text{average grain diameter of sixteen points})} \times 100 (\%)$$

**[0050]** As described above, since the silver alloy sputtering target for forming an electroconductive film of the present embodiment is constituted by a silver alloy having a component composition containing a total content of Ga and/or Sn in the above range and the balance composed of Ag and unavoidable impurities, wherein the average grain diameter of the crystal grains of the silver alloy is 120 to 400  $\mu\text{m}$  and the dispersion in the grain diameter of the crystal grains is 20% or less of the average grain diameter, abnormal electrical discharge and the occurrence of splashing can be suppressed even when a large electric power is applied to the target during sputtering.

Furthermore, since the silver alloy sputtering target for forming an electroconductive film of the present embodiment is constituted by a silver alloy having a component composition containing a total content of In and Ga and/or Sn in the above range and the balance composed of Ag and unavoidable impurities, wherein the average grain diameter of the crystal grains of the silver alloy is 120 to 250  $\mu\text{m}$  and the dispersion in the grain diameter of the crystal grains is 20% or less of the average grain diameter, abnormal electrical discharge and the occurrence of

splashing can be suppressed even when a large electric power is applied to the target during sputtering. Also, an electroconductive film exhibiting excellent corrosion resistance, excellent heat resistance, and low electrical resistance may be obtained by sputtering the silver alloy sputtering target for forming an electroconductive film. The sputtering target of the present embodiment is particularly effective when the target is a large-sized target having a width of 500 mm, a length of 500 mm and a thickness of 6 mm or greater.

**[0051]** Next, a description will be given of a method for manufacturing the silver alloy sputtering target for forming an electroconductive film of the present embodiment.

For manufacturing the silver alloy sputtering target for forming an electroconductive film of the present embodiment, Ag with the purity of 99.99% by mass or greater and Ga and Sn with the purity of 99.9% by mass or greater are used as raw materials. When In is used, In with the purity of 99.9% by mass or greater is used.

**[0052]** Firstly, Ag and Ga are melted under a high vacuum or an inert gas atmosphere, and then, a predetermined content of Sn is added to the obtained molten metal. Then, the resulting mixture is melted under a vacuum or an inert gas atmosphere, and thus, an Ag alloy ingot formed by melting and casting, which contains a total of 0.1 to 1.5% by mass of Ga and/or Sn and the balance composed of Ag and unavoidable impurities, is manufactured.

Also, Ag and Ga are melted under a high vacuum or an inert gas atmosphere, and then, a predetermined content of

In and Sn is added to the obtained molten metal. Then, the resulting mixture is melted under a vacuum or an inert gas atmosphere, and thus, an Ag alloy ingot formed by melting and casting, which contains 0.1 to 1.5% by mass of In, a total of 0.1 to 1.5% by mass of Ga and/or Sn, and the balance composed of Ag and unavoidable impurities, is manufactured.

**[0053]** Here, from the viewpoint of stabilizing the composition ratio between Ag and Ga/Sn or the composition ratio between Ag and In/Ga/Sn, it is preferable that Ag is melted under an atmosphere substituted by argon after the atmosphere is evacuated to a vacuum level, and after melting, Sn is added to molten metal of Ag and Ga under an argon atmosphere or In and Sn are added to molten metal of Ag and Ga under an argon atmosphere, respectively. Furthermore, Ga and Sn may also be added in the form of a previously manufactured mother alloy such as AgGa, AgSn, or AgGaSn.

**[0054]** Next, the ingot formed by melting and casting is subjected to hot forging in order to set the average grain diameter of the silver alloy crystal grains to a predetermined value. During hot forging, it is preferable that the ingot formed by melting and casting is heated to 750 °C to 850 °C for 1-3 hours and then is repeatedly subjected to upsetting and forging under the forging ratio of 1/1.2 to 1/2 for 6-20 times. Hot forging is more preferably free-forging. It is particularly preferable that hot forging is repeated while the forging direction is rotated by 90 degrees. More specifically, as shown in FIG.

1, when a cylindrical ingot 1 is used, the ingot is first forged into a square-shaped ingot 2.

[0055] Then, the square-shaped ingot 2 is repeatedly subjected to forging by rotating the forging direction by 90 degrees different from the previous forging direction. At this time, from the viewpoint of setting the average grain diameter of the silver alloy crystal grains of the entire ingot to a predetermined value, it is preferable that the square-shaped ingot 2 is subjected to forging by rotating it in all directions of the longitudinal direction, the lateral direction, and the height direction thereof (x, y, and z directions shown in FIG. 2). Here, all the arrows of the broken lines shown in FIG. 1 indicate the forging direction, the z direction is the casting direction, the x direction is any direction altered by 90 degrees relative to the z direction, and the y direction is the direction altered by 90 degrees relative to both the z direction and the x direction.

[0056] The process is preferably repeated in order to set the average grain diameter of the silver alloy crystal grains of the sputtering target of the present embodiment to the desired value and fall the dispersion in the grain diameter of the silver alloy crystal grains within the desired range. When the repeated number of times is less than six, the effect may become insufficient. On the other hand, even when the repeated number of times is greater than twenty, no further improvement in the effect of suppressing the dispersion in the grain diameter of the silver alloy crystal grains may be expected.

[0057] It is not preferable that the temperature during hot upset forging is less than 750 °C because the effect of suppressing the dispersion in the grain diameter is not sufficiently developed due to the presence of fine crystal, and also not preferable that the temperature during hot upset forging exceeds 850 °C because the effect of suppressing the dispersion in the grain diameter is not sufficiently developed due to the remaining of coarse crystal. In order to avoid rapid cooling of ridge sections and/or edge sections formed by hot forging, it is preferable that the ridge sections and/or edge sections of the ingot is hammered, that is, edge hammering is appropriately performed so as not to affect the forging of the ingot body.

[0058] Next, a forged ingot 3 is subjected to cold-rolling until the desired thickness is reached, and thus, the forged ingot is formed in a board 4. From the viewpoint of the effect of suppressing the dispersion in the grain diameter, it is preferable that the reduction per one pass during cold-rolling is 5% to 10%. From the viewpoint of making the diameter of the crystal grain finer while setting the total reduction to a predetermined value and maintaining the effect of suppressing the dispersion of the grain diameter, it is preferable that cold-rolling is repeatedly performed until the total reduction ((thickness of ingot prior to cold-rolling - thickness of ingot after cold-rolling)/thickness of ingot prior to cold-rolling) becomes 60% to 75%. The number of passes is preferably 10 to 20 so as to develop the effect described above.

**[0059]** From the viewpoint of controlling the average grain diameter at a predetermined level by means of recrystallization, it is preferable that heat treatment after cold-rolling is performed for 1 to 2 hours at the temperature of 550 °C to 650 °C.

The board 4 subjected to heat treatment is subjected to machining such as milling, electric discharge machining, or the like until the desired dimension is reached, and thus, the silver alloy sputtering target for forming an electroconductive film of the present embodiment may be manufactured. From the viewpoint of suppressing the occurrence of splashing during sputtering, it is preferable that the arithmetic average surface roughness (Ra) of the sputtering surface of the target subjected to machining is 0.2 to 2  $\mu\text{m}$ .

[Examples]

**[0060]** Next, a description will be given of the evaluation results of the actually produced silver alloy sputtering target for forming an electroconductive film of the present invention in Examples.

(Example 1)

(Manufacture of silver alloy sputtering target)

**[0061]** As raw materials, Ag with the purity of 99.99% by mass or greater and Ga with the purity of 99.9% by mass or greater were prepared. Ag and Ga were placed in a high frequency vacuum furnace at the mass ratio shown in Table 1. The total mass upon melting was about 300 kg.

**[0062]** The vacuum chamber was evacuated to vacuum and the atmosphere was substituted by Ar gas. Then, Ag and Ga were melted under an Ar-substituted atmosphere. The resulting alloy molten metal was casted into a graphite casting mold. Then, the shrinkage cavity formed in the upper part of the ingot manufactured by casting was removed. The weight of the sound part of the ingot ( $\varnothing$  290 × 370 mm) obtained was about 260 kg.

**[0063]** The obtained ingot was heated at the temperature of 800 °C for 1 hour, and then was forged by repeating the rotation of the forging direction by 90 degrees in all directions (the z direction: the casting direction, the x direction: any direction altered by 90 degrees relative to the z direction, and the y direction: the direction altered by 90 degrees relative to both the z direction and the x direction). At the forging ratio per one time of 1/1.2 to 1/2, upsetting and forging were repeated nineteen times while changing the forging direction. The ingot was flattened at twentieth forging and was formed to obtain the size of about 600 × 910 × 45 (mm).

**[0064]** After forging, the ingot was subjected to cold-rolling, and thus, the ingot was formed in a board with the size of about 1200 × 1300 × 16 (mm). The reduction per one pass during cold-rolling was 5% to 10%, and the number of passes was 13. The total reduction during cold-rolling was 70%.

After rolling, the board was heated at the temperature of 640 °C for 1 hour, and was subjected to recrystallization processing.

Next, the board was subjected to machining until the size of 1000 × 1200 × 12 (mm) was reached, whereby the sputtering target in Example 1 of the present invention was obtained.

(Evaluation of sputtering target)

**[0065]** (1) Warpage after machining

The warpage of the sputtering target in Example 1 was measured after machining. The result was shown in Table 2.

**[0066]** (2) Average grain diameter of silver alloy crystal grains

As described in the present embodiments, sixteen samples were uniformly obtained from sixteen points of the sputtering target in Example 1 manufactured as described above with the size of 1000 × 1200 × 12 (mm). Then, the average grain diameter of the surface viewed from the sputtering surface of each sample was measured, and thus, the average grain diameter of the silver alloy crystal grains, which is the average value of the average grain diameters of the samples, and the dispersion in the average grain diameter of the silver alloy crystal grains and the average grain diameter of the silver alloy crystal grains were calculated. The results of the measurement of the dispersion in the average grain diameter are shown in Table 1. Consequently, in the sputtering target in Example 1, the average grain diameter of the silver alloy crystal grains was in the range of from 120 to 400 μm, and the

dispersion in the grain diameter of the silver alloy crystal grains was 20% or less of the average grain diameter of the silver alloy crystal grains.

**[0067]** (3) Measurement of the number of times abnormal electrical discharge occurred during sputtering

A disk having the diameter of 152.4 mm and the thickness of 6 mm was cut out from the arbitrary portion of the sputtering target in Example 1 with the size of 1000 × 1200 × 12 (mm), and was soldered to a copper backing plate. The soldered sputtering target was used as the target for evaluation of splashing during sputtering, and the number of times abnormal electrical discharge occurred during sputtering was measured. The result is shown in Table 2.

**[0068]** In the measurement of the number of times abnormal electrical discharge occurred, the soldered target for evaluation was attached to a normal magnetron sputtering apparatus, and the atmosphere was evacuated to a pressure of  $1 \times 10^{-4}$  Pa. Then, the soldered target was subjected to sputtering under the condition that Ar gas pressure was 0.5 Pa, the electric power applied was DC 1000 W, and the target-to-substrate distance was 60 mm. The number of times abnormal electrical discharge occurred during sputtering was measured as the number of times abnormal electrical discharge occurred for 30 minutes elapsed from the start of discharging by means of the arc counting function of the DC power source (model number: RPDG-50A) manufactured by MKS Instruments, Inc. The result is shown in Table 2. In the sputtering target in Example 1,

the number of times abnormal electrical discharge occurred was as many as ten or less.

**[0069]** (4) Evaluation of basic properties as electroconductive film

(4-1) The surface roughness of film

Using the target for evaluation shown in (3), sputtering was performed under the same condition as that shown in (2), and a film having the thickness of 100 nm is formed on a glass substrate having the size of 20 × 20 (mm) to thereby obtain a silver alloy film. Furthermore, in order to evaluate heat resistance, the silver alloy film was subject to heat treatment at the temperature of 250 °C for 10 minutes. Then, the average surface roughness (Ra) of the silver alloy film was measured by an atomic force microscope. The result is shown in Table 2. The average surface roughness Ra of the film of the sputtering target in Example 1 was 1 nm or less.

**[0070]** (4-2) Reflectivity

In order to evaluate corrosion resistance, the silver alloy film formed in the same manner as (4-1) was kept in a constant temperature and high humidity chamber at the temperature of 80 °C and the humidity of 85% for 100 hours and then the reflectivity of the silver alloy film was measured by a spectrophotometer. The result is shown in Table 2. Consequently, the absolute reflectivity of the silver alloy film of the sputtering target in Example 1 at the wavelength of 550 nm was 90% or greater.

**[0071]** (4-3) Specific resistance of film

The result of measuring the specific resistance of the silver alloy film formed in the same manner as (4-1) is shown in Table 2. Consequently, the specific resistance of the silver alloy film in the sputtering target in Example 1 was as low as  $3.34 \mu\Omega\cdot\text{cm}$ .

**[0072]** (Examples 2 to 9 and Comparative Examples 1 to 5)

The sputtering targets in Examples 2 to 9 and Comparative Examples 1 to 5 were manufactured in the same manner as that in Example 1 so as to obtain the sputtering targets in Examples 2 to 9 and Comparative Examples 1 to 5 except that the component compositions and the manufacturing conditions were set as described in Table 1. Then, the aforementioned various evaluations were conducted as in Example 1. These results are shown in Tables 1 and 2.

**[0073]** (Conventional Examples 1 and 2)

As in Example 1, Ag and Ga were melted under the component compositions of Ga and Sn described in Table 1. The resulting alloy molten metal was casted into a graphite casting mold to thereby manufacture an ingot with the size of about  $400 \times 400 \times 150$  (mm). Furthermore, the ingot was subjected to hot rolling after being heated at the temperature of  $600^\circ\text{C}$  for 1 hour to thereby manufacture the sputtering target in Conventional Example 1. As in Conventional Example 1, the cast ingot was subjected to hot rolling and then subjected to heat treatment at the temperature of  $600^\circ\text{C}$  for 2 hours to thereby manufacture the sputtering target in Conventional Example 2. As in the evaluation in Example 1, various evaluations for the

sputtering targets in Conventional Examples 1 and 2 were conducted. These results are shown in Tables 1 and 2.

**[0074]** (Reference Example 1)

Ag with the blending proportion of Ga described in Table 1 (the total weight used was 7 kg) were melted. The resulting alloy molten metal was casted into a graphite casting mold to thereby manufacture an ingot with the size of  $\phi 80 \times 110$  (mm). The obtained ingot was subjected to upsetting and forging as the same number of times (five times) as that in Comparative Example 7, the reduction during cold-rolling, and heat treatment to thereby obtain a board with the size of  $220 \times 220 \times 11$  (mm). As in Examples and Comparative Examples, the aforementioned various evaluations were conducted in Reference Example 1. These results are shown in Tables 1 and 2. Since the sputtering target in Reference Example 1 has the size smaller than that of the sputtering targets manufactured in Examples and Comparative Examples, no evaluation was conducted for the warpage of the sputtering target in Reference Example 1 after machining.

**[0075]** [Table 1]

|                        | Ga (% BY MASS) | Sn (% BY MASS) | FORGING TEMPERATURE (°C) | THE NUMBER OF TIMES UPSET FORGING PERFORMED | TOTAL PRESSURE REDUCTION RATIO DURING COLD-ROLLING (%), NOTE THAT HOT-ROLLING WAS USED IN CONVENTIONAL EXAMPLES | HEAT TREATMENT CONDITION AFTER COLD-ROLLING, NOTE THAT HOT-ROLLING WAS USED IN CONVENTIONAL EXAMPLES | AVERAGE PARTICLE DIAMETER ( $\mu\text{m}$ ) | DISPERSION IN PARTICLE DIAMETER (%) |
|------------------------|----------------|----------------|--------------------------|---------------------------------------------|-----------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------|---------------------------------------------|-------------------------------------|
| EXAMPLE 1              | 0.1            | 0              | 800                      | 20                                          | 70                                                                                                              | 640°C, 1 HOUR                                                                                        | 330                                         | 14                                  |
| EXAMPLE 2              | 0.5            | 0              | 750                      | 15                                          | 70                                                                                                              | 600°C, 1 HOUR                                                                                        | 300                                         | 16                                  |
| EXAMPLE 3              | 1              | 0              | 850                      | 6                                           | 75                                                                                                              | 580°C, 1 HOUR                                                                                        | 270                                         | 19                                  |
| EXAMPLE 4              | 1.5            | 0              | 800                      | 10                                          | 60                                                                                                              | 560°C, 1 HOUR                                                                                        | 240                                         | 16                                  |
| EXAMPLE 5              | 0              | 0.1            | 800                      | 20                                          | 70                                                                                                              | 600°C, 1 HOUR                                                                                        | 340                                         | 12                                  |
| EXAMPLE 6              | 0              | 0.5            | 750                      | 15                                          | 70                                                                                                              | 600°C, 1 HOUR                                                                                        | 250                                         | 16                                  |
| EXAMPLE 7              | 0              | 1              | 800                      | 10                                          | 75                                                                                                              | 600°C, 1 HOUR                                                                                        | 220                                         | 18                                  |
| EXAMPLE 8              | 0              | 1.5            | 750                      | 6                                           | 70                                                                                                              | 600°C, 1 HOUR                                                                                        | 200                                         | 18                                  |
| EXAMPLE 9              | 0.5            | 0.3            | 800                      | 15                                          | 65                                                                                                              | 600°C, 1 HOUR                                                                                        | 190                                         | 15                                  |
| COMPARATIVE EXAMPLE 1  | 0.05*          | 0              | 800                      | 15                                          | 65                                                                                                              | 600°C, 1 HOUR                                                                                        | 410*                                        | 19                                  |
| COMPARATIVE EXAMPLE 2  | 0              | 1.7*           | 800                      | 15                                          | 65                                                                                                              | 600°C, 1 HOUR                                                                                        | 230                                         | 18                                  |
| COMPARATIVE EXAMPLE 3  | 0.5            | 0              | 700                      | 15                                          | 65                                                                                                              | 600°C, 1 HOUR                                                                                        | 280                                         | 29*                                 |
| COMPARATIVE EXAMPLE 4  | 0              | 0.5            | 900                      | 15                                          | 65                                                                                                              | 600°C, 1 HOUR                                                                                        | 450*                                        | 35*                                 |
| COMPARATIVE EXAMPLE 5  | 0.5            | 0              | 800                      | 5*                                          | 65                                                                                                              | 600°C, 1 HOUR                                                                                        | 300                                         | 36*                                 |
| CONVENTIONAL EXAMPLE 1 | 0.5            | 0              |                          |                                             | 89                                                                                                              |                                                                                                      | 350                                         | 115*                                |
| CONVENTIONAL EXAMPLE 2 | 0              | 0.5            |                          |                                             | 89                                                                                                              | 600°C, 2 HOURS                                                                                       | 430*                                        | 32*                                 |
| REFERENCE EXAMPLE 1    | 0.5            | 0              | 800                      | 5                                           | 65                                                                                                              | 600°C, 1 HOUR                                                                                        | 260                                         | 12                                  |

MARK \* REPRESENTS A VALUE DEPARTING FROM THE CONDITION OF THE PRESENT INVENTION.

[0076] [Table 2]

|                           | THE NUMBER<br>OF TIMES<br>ABNORMAL<br>ELECTRICAL<br>DISCHARGE<br>OCCURRED | WARPAGE<br>AFTER<br>MACHINING<br>(mm) | SURFACE<br>ROUGHNESS<br>OF FILM<br>AFTER HEAT<br>TREATMENT<br>(Ra: nm) | ABSOLUTE<br>REFLECTIVITY AT<br>WAVELENGTH OF 550<br>nm AFTER KEPT IN<br>CONSTANT<br>TEMPERATURE AND<br>CONSTANT HUMIDITY<br>(%) | SPECIFIC<br>RESISTANCE<br>OF FILM<br>( $\mu\Omega \cdot \text{cm}$ ) |
|---------------------------|---------------------------------------------------------------------------|---------------------------------------|------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------|
| EXAMPLE 1                 | 5                                                                         | 0.7                                   | 1                                                                      | 94.3                                                                                                                            | 3.34                                                                 |
| EXAMPLE 2                 | 6                                                                         | 0.8                                   | 0.9                                                                    | 95.8                                                                                                                            | 4.12                                                                 |
| EXAMPLE 3                 | 7                                                                         | 0.7                                   | 0.8                                                                    | 95.3                                                                                                                            | 5.16                                                                 |
| EXAMPLE 4                 | 6                                                                         | 0.4                                   | 0.8                                                                    | 94.8                                                                                                                            | 6.13                                                                 |
| EXAMPLE 5                 | 5                                                                         | 0.8                                   | 0.9                                                                    | 93.9                                                                                                                            | 3.38                                                                 |
| EXAMPLE 6                 | 4                                                                         | 0.7                                   | 0.8                                                                    | 95.5                                                                                                                            | 4.30                                                                 |
| EXAMPLE 7                 | 6                                                                         | 0.6                                   | 0.7                                                                    | 95.2                                                                                                                            | 5.39                                                                 |
| EXAMPLE 8                 | 7                                                                         | 0.7                                   | 0.7                                                                    | 95.5                                                                                                                            | 6.46                                                                 |
| EXAMPLE 9                 | 7                                                                         | 0.5                                   | 0.9                                                                    | 95.8                                                                                                                            | 5.86                                                                 |
| COMPARATIVE<br>EXAMPLE 1  | 24                                                                        | 1.4                                   | 2                                                                      | 87.5                                                                                                                            | 4.27                                                                 |
| COMPARATIVE<br>EXAMPLE 2  | 8                                                                         | 0.4                                   | 0.7                                                                    | 88.5                                                                                                                            | 7.93                                                                 |
| COMPARATIVE<br>EXAMPLE 3  | 22                                                                        | 0.6                                   | 0.8                                                                    | 95.3                                                                                                                            | 5.25                                                                 |
| COMPARATIVE<br>EXAMPLE 4  | 28                                                                        | 0.7                                   | 0.7                                                                    | 95.2                                                                                                                            | 5.27                                                                 |
| COMPARATIVE<br>EXAMPLE 5  | 26                                                                        | 0.7                                   | 0.7                                                                    | 95.5                                                                                                                            | 5.20                                                                 |
| CONVENTIONAL<br>EXAMPLE 1 | 85                                                                        | 1.3                                   | 0.7                                                                    | 95.2                                                                                                                            | 5.16                                                                 |
| CONVENTIONAL<br>EXAMPLE 2 | 39                                                                        | 0.8                                   | 0.8                                                                    | 95.8                                                                                                                            | 5.26                                                                 |
| REFERENCE<br>EXAMPLE 1    | 5                                                                         |                                       | 0.7                                                                    | 95.3                                                                                                                            | 5.23                                                                 |

[0077] As can be seen from Table 1, in Examples 1 to 9, the average grain diameter of the silver alloy crystal grains was 190 to 340  $\mu\text{m}$  and the dispersion in the grain diameter was 12 to 19%. These were preferable ranges. In contrast, in Comparative Example 1 in which Ga was 0.05% by mass, the average grain diameter was 410  $\mu\text{m}$  and has fallen outside a desired range. Also, in Comparative Example 3 in which the temperature of hot forging was 700  $^{\circ}\text{C}$ , the dispersion in the grain diameter was as high as 29%. In Comparative Example 4 in which the temperature of hot

forging was 900 °C, the average grain diameter was as high as 450  $\mu\text{m}$  and the dispersion in the grain diameter was also as high as 35%.

**[0078]** As can be seen from Table 2, in Examples 1 to 9, good results were obtained for the number of times abnormal electrical discharge occurred, the warpage after machining, the surface roughness of the film, the absolute reflectivity at the wavelength of 550 nm, and the specific resistance of the film. In contrast, in Comparative Example 1 in which Ga was 0.05% by mass, the warpage after machining was as high as 1.4 mm, the surface roughness of the film was also as high as 2  $\mu\text{m}$ , and the absolute reflectivity at the wavelength of 550 nm was as small as 87.5%. In Comparative Example 2 in which Sn was 1.7% by mass, the absolute reflectivity at the wavelength of 550 nm was as small as 88.5%. In Comparative Examples 1 and 3 to 5 and Conventional Examples 1 and 2, the number of times abnormal electrical discharge occurred was as many as twenty two or more. Furthermore, in Comparative Example 2 in which Sn was 1.7% by weight, the specific resistance of the film was as high as 7.93  $\mu\Omega\cdot\text{cm}$ .

**[0079]** (Examples 10 to 20 and Comparative Example 6)

The sputtering targets in Examples 10 to 20 and Comparative Example 6 were manufactured in the same manner as that in Example 1 so as to obtain the sputtering targets in Examples 10 to 20 and Comparative Example 6 except that the component compositions of Ga/Sn and Cu/Mg and the manufacturing conditions were set as described in Table 3.

Then, the aforementioned various evaluations were conducted as in Example 1. These results are shown in Tables 3 and 4.

[0080] [Table 3]

|                       | Ga (% BY MASS) | Sn (% BY MASS) | Cu, Mg (% BY MASS) | FORGING TEMPERATURE (°C) | THE NUMBER OF TIMES UPSET FORGING PERFORMED | TOTAL PRESSURE REDUCTION RATIO DURING COLD-ROLLING (%). NOTE THAT HOT-ROLLING WAS USED IN CONVENTIONAL EXAMPLES | HEAT TREATMENT CONDITION AFTER COLD-ROLLING. NOTE THAT HOT-ROLLING WAS USED IN CONVENTIONAL EXAMPLES | AVERAGE PARTICLE DIAMETER (μm) | DISPERSION IN PARTICLE DIAMETER (%) |
|-----------------------|----------------|----------------|--------------------|--------------------------|---------------------------------------------|-----------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------|--------------------------------|-------------------------------------|
| EXAMPLE 10            | 0.5            | 0              | Mg 0.2             | 800                      | 15                                          | 65                                                                                                              | 600°C, 1 HOUR                                                                                        | 160                            | 13                                  |
| EXAMPLE 11            | 0.5            | 0              | Mg 1.0             | 800                      | 15                                          | 65                                                                                                              | 600°C, 1 HOUR                                                                                        | 140                            | 14                                  |
| EXAMPLE 12            | 0.5            | 0              | Cu 0.1             | 800                      | 15                                          | 65                                                                                                              | 600°C, 1 HOUR                                                                                        | 170                            | 13                                  |
| EXAMPLE 13            | 0.5            | 0              | Cu 0.8             | 800                      | 15                                          | 65                                                                                                              | 600°C, 1 HOUR                                                                                        | 130                            | 13                                  |
| EXAMPLE 14            | 0              | 0.5            | Mg 0.1             | 800                      | 15                                          | 65                                                                                                              | 600°C, 1 HOUR                                                                                        | 170                            | 14                                  |
| EXAMPLE 15            | 0              | 0.5            | Mg 0.7             | 800                      | 15                                          | 65                                                                                                              | 600°C, 1 HOUR                                                                                        | 140                            | 12                                  |
| EXAMPLE 16            | 0              | 0.5            | Cu 0.3             | 800                      | 15                                          | 65                                                                                                              | 600°C, 1 HOUR                                                                                        | 160                            | 14                                  |
| EXAMPLE 17            | 0              | 0.5            | Cu 0.6             | 800                      | 15                                          | 65                                                                                                              | 600°C, 1 HOUR                                                                                        | 160                            | 16                                  |
| EXAMPLE 18            | 0.2            | 0.2            | Mg 0.4, Cu 0.2     | 800                      | 15                                          | 65                                                                                                              | 600°C, 1 HOUR                                                                                        | 130                            | 12                                  |
| EXAMPLE 19            | 0.2            | 0.2            | Mg 0.1, Cu 0.5     | 800                      | 15                                          | 65                                                                                                              | 600°C, 1 HOUR                                                                                        | 150                            | 11                                  |
| EXAMPLE 20            | 0.5            | 0              | Mg 0.05            | 800                      | 15                                          | 65                                                                                                              | 600°C, 1 HOUR                                                                                        | 260                            | 17                                  |
| COMPARATIVE EXAMPLE 6 | 0              | 0.5            | Mg 1.7*            | 800                      | 15                                          | 65                                                                                                              | 600°C, 1 HOUR                                                                                        | 120                            | 12                                  |

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[0081] [Table 4]

|                          | THE NUMBER<br>OF TIMES<br>ABNORMAL<br>ELECTRICAL<br>DISCHARGE<br>OCCURRED | WARPAGE<br>AFTER<br>MACHINING<br>(mm) | SURFACE<br>ROUGHNESS<br>OF FILM<br>AFTER<br>HEAT<br>TREATMENT<br>(Ra: nm) | ABSOLUTE<br>REFLECTIVITY<br>AT WAVELENGTH<br>OF 550 nm<br>AFTER KEPT<br>IN CONSTANT<br>TEMPERATURE<br>AND CONSTANT<br>HUMIDITY (%) | SPECIFIC<br>RESISTANCE<br>OF FILM<br>( $\mu \Omega \cdot \text{cm}$ ) |
|--------------------------|---------------------------------------------------------------------------|---------------------------------------|---------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------|
| EXAMPLE 10               | 3                                                                         | 0.6                                   | 0.7                                                                       | 96.9                                                                                                                               | 4.59                                                                  |
| EXAMPLE 11               | 4                                                                         | 0.6                                   | 0.7                                                                       | 95.4                                                                                                                               | 6.26                                                                  |
| EXAMPLE 12               | 1                                                                         | 0.7                                   | 0.8                                                                       | 96.7                                                                                                                               | 4.35                                                                  |
| EXAMPLE 13               | 0                                                                         | 0.5                                   | 0.6                                                                       | 96.4                                                                                                                               | 5.80                                                                  |
| EXAMPLE 14               | 5                                                                         | 0.6                                   | 0.8                                                                       | 95.5                                                                                                                               | 4.47                                                                  |
| EXAMPLE 15               | 4                                                                         | 0.6                                   | 0.6                                                                       | 96.7                                                                                                                               | 5.73                                                                  |
| EXAMPLE 16               | 2                                                                         | 0.5                                   | 0.7                                                                       | 96.2                                                                                                                               | 4.92                                                                  |
| EXAMPLE 17               | 4                                                                         | 0.5                                   | 0.7                                                                       | 96.2                                                                                                                               | 5.53                                                                  |
| EXAMPLE 18               | 1                                                                         | 0.6                                   | 0.7                                                                       | 96.7                                                                                                                               | 5.27                                                                  |
| EXAMPLE 19               | 4                                                                         | 0.5                                   | 0.7                                                                       | 96.6                                                                                                                               | 5.27                                                                  |
| EXAMPLE 20               | 7                                                                         | 0.5                                   | 0.9                                                                       | 96.4                                                                                                                               | 4.21                                                                  |
| COMPARATIVE<br>EXAMPLE 6 | 2                                                                         | 0.5                                   | 0.6                                                                       | 88.4                                                                                                                               | 7.81                                                                  |

[0082] As can be seen from Table 3, in Examples 10 to 20, the average grain diameter of the silver alloy crystal grains was 130 to 260  $\mu\text{m}$  and the dispersion in the grain diameter was 11 to 17%. These were preferable ranges.

As can be seen from Table 4, in Examples 10 to 20, good results were obtained for the number of times abnormal electrical discharge occurred, the warpage after machining, the surface roughness of the film, the absolute reflectivity at the wavelength of 550 nm, and the specific resistance of the film. In contrast, in Comparative Example 6 in which Mg was 1.7% by weight, other properties were at good levels but the absolute reflectivity at the

wavelength of 550 nm was as low as 88.4% and the specific resistance of the film was as high as 7.81  $\mu\Omega\cdot\text{cm}$ .

**[0083]** (Examples 21 to 28 and Comparative Example 7)

The sputtering targets in Examples 21 to 28 and Comparative Example 7 were manufactured in the same manner as that in Example 1 so as to obtain the sputtering targets in Examples 21 to 28 and Comparative Example 7 except that the component compositions of Ga/Sn and Ce/Eu and the manufacturing conditions were set as described in Table 5. Then, the aforementioned various evaluations were conducted as in Example 1. These results are shown in Tables 5 and 6.

**[0084]** [Table 5]

|                       | Ga (% BY MASS) | Sn (% BY MASS) | Ca, Eu (% BY MASS) | FORGING TEMPERATURE (°C) | THE NUMBER OF TIMES UPSET FORGING PERFORMED | TOTAL PRESSURE REDUCTION RATIO DURING COLD-ROLLING (%). NOTE THAT HOT-ROLLING WAS USED IN CONVENTIONAL EXAMPLES | HEAT TREATMENT CONDITION AFTER COLD-ROLLING, NOTE THAT HOT-ROLLING WAS USED IN CONVENTIONAL EXAMPLES | AVERAGE PARTICLE DIAMETER (μm) | DISPERSION IN PARTICLE DIAMETER (%) |
|-----------------------|----------------|----------------|--------------------|--------------------------|---------------------------------------------|-----------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------|--------------------------------|-------------------------------------|
| EXAMPLE 21            | 0              | 0.4            | Ce0.05             | 800                      | 15                                          | 65                                                                                                              | 600°C, 1 HOUR                                                                                        | 210                            | 16                                  |
| EXAMPLE 22            | 0              | 0.4            | Ce0.7              | 800                      | 15                                          | 65                                                                                                              | 600°C, 1 HOUR                                                                                        | 150                            | 14                                  |
| EXAMPLE 23            | 0.5            | 0              | Eu 0.07            | 800                      | 15                                          | 65                                                                                                              | 600°C, 1 HOUR                                                                                        | 210                            | 18                                  |
| EXAMPLE 24            | 0.5            | 0              | Eu 0.8             | 800                      | 15                                          | 65                                                                                                              | 600°C, 1 HOUR                                                                                        | 130                            | 15                                  |
| EXAMPLE 25            | 0.3            | 0              | Ce0.2, Eu0.1       | 800                      | 15                                          | 65                                                                                                              | 600°C, 1 HOUR                                                                                        | 160                            | 16                                  |
| EXAMPLE 26            | 0.4            | 0.3            | Ce0.5, Eu0.05      | 800                      | 15                                          | 65                                                                                                              | 600°C, 1 HOUR                                                                                        | 160                            | 18                                  |
| EXAMPLE 27            | 0.2            | 0.2            | Ce0.08, Eu0.5      | 800                      | 15                                          | 65                                                                                                              | 600°C, 1 HOUR                                                                                        | 150                            | 17                                  |
| EXAMPLE 28            | 0.5            | 0              | Ce0.01             | 800                      | 15                                          | 65                                                                                                              | 600°C, 1 HOUR                                                                                        | 270                            | 16                                  |
| COMPARATIVE EXAMPLE 7 | 0.5            | 0              | Eu0.9*             | 800                      | 15                                          | 65                                                                                                              | 600°C, 1 HOUR                                                                                        | 120                            | 19                                  |

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[0085] [Table 6]

|                          | THE NUMBER<br>OF TIMES<br>ABNORMAL<br>ELECTRICAL<br>DISCHARGE<br>OCCURRED | WARPAGE<br>AFTER<br>MACHINING<br>(mm) | SURFACE<br>ROUGHNESS<br>OF FILM<br>AFTER<br>HEAT<br>TREATMENT<br>(Ra: nm) | ABSOLUTE<br>REFLECTIVITY AT<br>WAVELENGTH OF<br>550 nm<br>AFTER KEPT IN<br>CONSTANT<br>TEMPERATURE AND<br>CONSTANT<br>HUMIDITY (%) | SPECIFIC<br>RESISTANCE<br>OF FILM<br>( $\mu\Omega\cdot\text{cm}$ ) |
|--------------------------|---------------------------------------------------------------------------|---------------------------------------|---------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------|
| EXAMPLE 21               | 3                                                                         | 0.7                                   | 0.8                                                                       | 96.0                                                                                                                               | 4.19                                                               |
| EXAMPLE 22               | 4                                                                         | 0.5                                   | 0.7                                                                       | 96.5                                                                                                                               | 5.48                                                               |
| EXAMPLE 23               | 4                                                                         | 0.6                                   | 0.9                                                                       | 96.1                                                                                                                               | 4.34                                                               |
| EXAMPLE 24               | 8                                                                         | 0.7                                   | 0.7                                                                       | 96.9                                                                                                                               | 5.60                                                               |
| EXAMPLE 25               | 4                                                                         | 0.9                                   | 0.7                                                                       | 96.0                                                                                                                               | 4.40                                                               |
| EXAMPLE 26               | 3                                                                         | 0.5                                   | 0.8                                                                       | 96.8                                                                                                                               | 5.76                                                               |
| EXAMPLE 27               | 3                                                                         | 0.6                                   | 0.7                                                                       | 96.4                                                                                                                               | 5.20                                                               |
| EXAMPLE 28               | 5                                                                         | 0.6                                   | 0.9                                                                       | 96.5                                                                                                                               | 4.22                                                               |
| COMPARATIVE<br>EXAMPLE 7 | 12                                                                        | 0.8                                   | 0.7                                                                       | 95.8                                                                                                                               | 5.99                                                               |

[0086] As can be seen from Table 5, in Examples 21 to 28, the average grain diameter of the silver alloy crystal grains was 130 to 270  $\mu\text{m}$  and the dispersion in the grain diameter was 15 to 18%. These were preferable ranges.

As can be seen from Table 6, in Examples 21 to 28, good results were obtained for the number of times abnormal electrical discharge occurred, the warpage after machining, the surface roughness of the film, the absolute reflectivity at the wavelength of 550 nm, and the specific resistance of the film. In contrast, in Comparative Example 7 in which Eu was 0.9% by weight, other properties were at good levels but the number of times abnormal electrical discharge occurred was as many as twelve.

[0087] (Example 29)

(Manufacture of silver alloy sputtering target)

As raw materials, Ag with the purity of 99.99% by mass or greater, In with the purity of 99.9% by mass or

greater, and Ga with the purity of 99.9% by mass or greater were prepared. Ag, In, and Ga were placed as raw materials in a high frequency vacuum furnace at the mass ratio shown in Table 7. The total mass upon melting was about 300 kg.

**[0088]** The vacuum chamber was evacuated to vacuum and the atmosphere was substituted by Ar gas. Ag and Ga were melted under an Ar-substituted atmosphere and then In is added to the resulting mixture. The resulting alloy molten metal was casted into a graphite casting mold. Then, the shrinkage cavity formed in the upper part of the ingot manufactured by casting was removed. The weight of the sound part of the ingot ( $\phi$  290 × 370 mm) obtained was about 260 kg.

**[0089]** As in Example 1, the obtained ingot was heated and then was forged.

**[0090]** As in Example 1, the forged ingot was subjected to cold-rolling.

After rolling, the board was heated at the temperature of 580 °C for 1 hour, and was subjected to recrystallization processing.

Next, the board was subjected to machining until the size of 1000 × 1200 × 12 (mm) was reached, whereby the sputtering target in Example 29 of the present invention was obtained.

**[0091]** (Evaluation of sputtering target)

As in Example 1, the aforementioned various evaluations (1) to (4) for the sputtering target in Example 29 were conducted. The results are shown in Tables 7 and 8.

**[0092]** (Examples 30 to 42 and Comparative Examples 8 to 14)

The sputtering targets in Examples 30 to 42 and Comparative Examples 8 to 14 were manufactured in the same manner as that in Example 29 so as to obtain the sputtering targets in Examples 30 to 42 and Comparative Examples 8 to 14 except that the component compositions and the manufacturing conditions were set as described in Table 7. Then, the aforementioned various evaluations were conducted as in Example 29. These results are shown in Tables 7 and 8.

**[0093]** (Conventional Examples 3 and 4)

As in Example 29, In, Ga, and Sn were melted under the component compositions of In, Ga, and Sn described in Table 7. The resulting alloy molten metal was casted into a graphite casting mold to thereby manufacture an ingot with the size of about 400 × 400 × 150 (mm). Furthermore, the ingot was subjected to hot rolling after being heated at the temperature of 600 °C for 1 hour to thereby manufacture the sputtering target in Conventional Example 3. As in Conventional Example 3, the cast ingot was subjected to hot rolling and then subjected to heat treatment at the temperature of 600 °C for 2 hours to thereby manufacture the sputtering target in Conventional Example 4. As in the evaluation in Example 29, the aforementioned various evaluations for the sputtering targets in Conventional Examples 3 and 4 were conducted. These results are shown in Tables 7 and 8.

**[0094]** (Reference Example 2)

Ag with the blending proportion of In and Ga described in Table 7 (the total weight used was 7 kg) were melted. The resulting alloy molten metal was casted into a graphite casting mold to thereby manufacture an ingot with the size of  $\phi 80 \times 110$  (mm). The obtained ingot was subjected to upsetting and forging as the same number of times (five times) as that in Comparative Example 7, the reduction during cold-rolling, and heat treatment to thereby obtain a board with the size of  $220 \times 220 \times 11$  (mm). As in Examples and Comparative Examples, the aforementioned various evaluations were conducted in Reference Example 2. These results are shown in Tables 7 and 8. Since the sputtering target in Reference Example 2 has the size smaller than that of the sputtering targets manufactured in Examples and Comparative Examples, no evaluation was conducted for the warpage of the sputtering target in Reference Example 2 after machining.

[0095] [Table 7]

|                        | In (% BY MASS) | Ga (% BY MASS) | Sn (% BY MASS) | FORGING TEMPERATURE (°C) | THE NUMBER OF TIMES UPSET FORGING PERFORMED | TOTAL PRESSURE REDUCTION RATIO DURING COLD-ROLLING (%). NOTE THAT HOT-ROLLING WAS USED IN CONVENTIONAL EXAMPLES | HEAT TREATMENT CONDITION AFTER COLD-ROLLING. NOTE THAT HOT-ROLLING WAS USED IN CONVENTIONAL EXAMPLES | AVERAGE PARTICLE DIAMETER ( $\mu$ m) | DISPERSION IN PARTICLE DIAMETER (%) |
|------------------------|----------------|----------------|----------------|--------------------------|---------------------------------------------|-----------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------|--------------------------------------|-------------------------------------|
| EXAMPLE 29             | 0.1            | 0.2            | 0              | 800                      | 20                                          | 70                                                                                                              | 580°C, 1 HOUR                                                                                        | 210                                  | 14                                  |
| EXAMPLE 30             | 0.5            | 0.2            | 0              | 750                      | 6                                           | 75                                                                                                              | 600°C, 1 HOUR                                                                                        | 170                                  | 16                                  |
| EXAMPLE 31             | 1              | 0.2            | 0              | 850                      | 15                                          | 70                                                                                                              | 580°C, 2 HOURS                                                                                       | 190                                  | 13                                  |
| EXAMPLE 32             | 1.5            | 0.2            | 0              | 800                      | 10                                          | 60                                                                                                              | 600°C, 2 HOURS                                                                                       | 180                                  | 16                                  |
| EXAMPLE 33             | 0.5            | 0.1            | 0              | 800                      | 15                                          | 65                                                                                                              | 640°C, 1 HOUR                                                                                        | 250                                  | 15                                  |
| EXAMPLE 34             | 0.5            | 0.5            | 0              | 750                      | 20                                          | 70                                                                                                              | 600°C, 1 HOUR                                                                                        | 160                                  | 12                                  |
| EXAMPLE 35             | 0.5            | 1              | 0              | 850                      | 10                                          | 75                                                                                                              | 580°C, 1 HOUR                                                                                        | 140                                  | 16                                  |
| EXAMPLE 36             | 0.5            | 1.5            | 0              | 800                      | 10                                          | 60                                                                                                              | 560°C, 1 HOUR                                                                                        | 130                                  | 20                                  |
| EXAMPLE 37             | 0.5            | 0              | 0.1            | 800                      | 20                                          | 70                                                                                                              | 600°C, 1 HOUR                                                                                        | 210                                  | 14                                  |
| EXAMPLE 38             | 0.5            | 0              | 0.5            | 750                      | 15                                          | 70                                                                                                              | 600°C, 1 HOUR                                                                                        | 180                                  | 14                                  |
| EXAMPLE 39             | 0.5            | 0              | 1              | 850                      | 6                                           | 75                                                                                                              | 600°C, 1 HOUR                                                                                        | 160                                  | 16                                  |
| EXAMPLE 40             | 0.5            | 0              | 1.5            | 800                      | 10                                          | 60                                                                                                              | 600°C, 1 HOUR                                                                                        | 120                                  | 15                                  |
| EXAMPLE 41             | 0.5            | 0.2            | 0.2            | 800                      | 15                                          | 65                                                                                                              | 600°C, 1 HOUR                                                                                        | 180                                  | 15                                  |
| EXAMPLE 42             | 0.3            | 0.5            | 0.5            | 800                      | 15                                          | 65                                                                                                              | 600°C, 1 HOUR                                                                                        | 140                                  | 13                                  |
| COMPARATIVE EXAMPLE 8  | 0.05*          | 0.2            | 0              | 800                      | 15                                          | 65                                                                                                              | 600°C, 1 HOUR                                                                                        | 260*                                 | 14                                  |
| COMPARATIVE EXAMPLE 9  | 1.7*           | 0              | 0.2            | 800                      | 15                                          | 65                                                                                                              | 600°C, 1 HOUR                                                                                        | 120                                  | 15                                  |
| COMPARATIVE EXAMPLE 10 | 0.5            | 0.05*          | 0              | 800                      | 15                                          | 65                                                                                                              | 600°C, 1 HOUR                                                                                        | 290*                                 | 15                                  |
| COMPARATIVE EXAMPLE 11 | 0.5            | 0              | 1.8*           | 800                      | 15                                          | 65                                                                                                              | 600°C, 1 HOUR                                                                                        | 130                                  | 16                                  |
| COMPARATIVE EXAMPLE 12 | 0.5            | 0              | 0.3            | 700                      | 15                                          | 65                                                                                                              | 600°C, 1 HOUR                                                                                        | 180                                  | 23*                                 |
| COMPARATIVE EXAMPLE 13 | 0.5            | 0              | 0.3            | 900                      | 15                                          | 65                                                                                                              | 600°C, 1 HOUR                                                                                        | 300*                                 | 22*                                 |
| COMPARATIVE EXAMPLE 14 | 0.5            | 0.3            | 0              | 800                      | 5*                                          | 65                                                                                                              | 600°C, 1 HOUR                                                                                        | 180                                  | 26*                                 |
| CONVENTIONAL EXAMPLE 3 | 0.5            | 0.2            | 0              |                          |                                             | 89                                                                                                              |                                                                                                      | 140                                  | 86*                                 |
| CONVENTIONAL EXAMPLE 4 | 0.5            | 0              | 0.2            |                          |                                             | 89                                                                                                              |                                                                                                      | 330*                                 | 28*                                 |
| REFERENCE EXAMPLE 2    | 0.5            | 0.2            | 0              | 800                      | 5                                           | 65                                                                                                              | 600°C, 1 HOUR                                                                                        | 160                                  | 14                                  |

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[0096]

[Table 8]

|                           | THE NUMBER<br>OF TIMES<br>ABNORMAL<br>ELECTRICAL<br>DISCHARGE<br>OCCURRED | WARPAGE<br>AFTER<br>MACHINING<br>(mm) | SURFACE<br>ROUGHNESS<br>OF FILM<br>AFTER<br>HEAT<br>TREATMENT<br>(Ra: nm) | ABSOLUTE<br>REFLECTIVITY AT<br>WAVELENGTH OF<br>550 nm<br>AFTER KEPT IN<br>CONSTANT<br>TEMPERATURE AND<br>CONSTANT<br>HUMIDITY (%) | SPECIFIC<br>RESISTANCE<br>OF FILM<br>( $\mu \Omega \cdot \text{cm}$ ) |
|---------------------------|---------------------------------------------------------------------------|---------------------------------------|---------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------|
| EXAMPLE 29                | 1                                                                         | 1                                     | 0.8                                                                       | 96.4                                                                                                                               | 3.85                                                                  |
| EXAMPLE 30                | 2                                                                         | 0.6                                   | 0.7                                                                       | 96.2                                                                                                                               | 4.68                                                                  |
| EXAMPLE 31                | 1                                                                         | 0.7                                   | 0.7                                                                       | 95.8                                                                                                                               | 5.67                                                                  |
| EXAMPLE 32                | 3                                                                         | 0.4                                   | 0.7                                                                       | 94.0                                                                                                                               | 6.67                                                                  |
| EXAMPLE 33                | 2                                                                         | 0.8                                   | 0.8                                                                       | 95.3                                                                                                                               | 4.44                                                                  |
| EXAMPLE 34                | 1                                                                         | 0.9                                   | 0.7                                                                       | 96.0                                                                                                                               | 5.35                                                                  |
| EXAMPLE 35                | 4                                                                         | 0.7                                   | 0.8                                                                       | 96.0                                                                                                                               | 6.41                                                                  |
| EXAMPLE 36                | 5                                                                         | 0.5                                   | 0.7                                                                       | 94.0                                                                                                                               | 6.80                                                                  |
| EXAMPLE 37                | 3                                                                         | 0.6                                   | 0.8                                                                       | 95.8                                                                                                                               | 4.46                                                                  |
| EXAMPLE 38                | 4                                                                         | 0.7                                   | 0.7                                                                       | 96.0                                                                                                                               | 5.33                                                                  |
| EXAMPLE 39                | 5                                                                         | 0.4                                   | 0.7                                                                       | 95.5                                                                                                                               | 6.44                                                                  |
| EXAMPLE 40                | 3                                                                         | 0.5                                   | 0.7                                                                       | 93.8                                                                                                                               | 6.80                                                                  |
| EXAMPLE 41                | 3                                                                         | 0.5                                   | 0.7                                                                       | 96.2                                                                                                                               | 5.12                                                                  |
| EXAMPLE 42                | 2                                                                         | 0.7                                   | 0.7                                                                       | 96.3                                                                                                                               | 6.04                                                                  |
| COMPARATIVE<br>EXAMPLE 8  | 22                                                                        | 1.9                                   | 1.7                                                                       | 92.3                                                                                                                               | 3.78                                                                  |
| COMPARATIVE<br>EXAMPLE 9  | 3                                                                         | 0.5                                   | 0.7                                                                       | 89.1                                                                                                                               | 7.07                                                                  |
| COMPARATIVE<br>EXAMPLE 10 | 25                                                                        | 0.6                                   | 1.9                                                                       | 94.5                                                                                                                               | 4.33                                                                  |
| COMPARATIVE<br>EXAMPLE 11 | 5                                                                         | 0.7                                   | 0.7                                                                       | 87.7                                                                                                                               | 7.97                                                                  |
| COMPARATIVE<br>EXAMPLE 12 | 27                                                                        | 0.6                                   | 0.8                                                                       | 95.7                                                                                                                               | 4.89                                                                  |
| COMPARATIVE<br>EXAMPLE 13 | 27                                                                        | 0.7                                   | 0.8                                                                       | 96.1                                                                                                                               | 4.87                                                                  |
| COMPARATIVE<br>EXAMPLE 14 | 25                                                                        | 0.5                                   | 0.7                                                                       | 96.3                                                                                                                               | 4.87                                                                  |
| CONVENTIONAL<br>EXAMPLE 3 | 45                                                                        | 1.2                                   | 0.8                                                                       | 95.8                                                                                                                               | 4.66                                                                  |
| CONVENTIONAL<br>EXAMPLE 4 | 38                                                                        | 0.8                                   | 0.8                                                                       | 96.4                                                                                                                               | 4.68                                                                  |
| REFERENCE<br>EXAMPLE 2    | 4                                                                         |                                       | 0.7                                                                       | 95.6                                                                                                                               | 4.66                                                                  |

[0097] As can be seen from Table 7, in Examples 29 to 42, the average grain diameter of the silver alloy crystal grains was 120 to 250  $\mu\text{m}$  and the dispersion in the grain diameter was 12 to 20%. These were preferable ranges. In contrast, in Comparative Example 8 in which In was 0.05% by

weight, the average grain diameter was 260  $\mu\text{m}$  and has fallen outside a desired range. Also, in Comparative Example 12 in which the temperature of hot forging was 700  $^{\circ}\text{C}$ , the dispersion in the grain diameter was as high as 23%. In Comparative Example 13 in which the temperature of hot forging was 900  $^{\circ}\text{C}$ , the average grain diameter was as high as 300  $\mu\text{m}$  and the dispersion in the grain diameter was also as high as 22%.

[0098] In Comparative Example 14 in which the number of times upset forging performed was five, the dispersion in the grain diameter was as high as 26%. In Conventional Example 3, the dispersion in the grain diameter was as high as 86%. Furthermore, in Conventional Example 4, the average grain diameter was as high as 330  $\mu\text{m}$  and the dispersion in the grain diameter was also as high as 28%.

In Reference Example 2, evaluation was conducted for the small-sized target as compared with a large-sized target for which the present invention becomes particularly effective. Despite the fact that the small-sized target was manufactured under the substantially same condition as that in Comparative Example 14 in which the number of times hot upset forging performed was five, the dispersion in the grain diameter was preferably 14%.

[0099] As can be seen from Table 8, in Examples 29 to 42, good results were obtained for the number of times abnormal electrical discharge occurred, the warpage after machining, the surface roughness of the film, the absolute reflectivity at the wavelength of 550 nm, and the specific resistance of the film. In contrast, in Comparative

Example 8 in which In was 0.05% by mass, the warpage after machining was as high as 1.9 mm and the surface roughness of the film was also as high as 1.7  $\mu\text{m}$ . In Comparative Example 9 in which In was 1.7% by mass, the absolute reflectivity at the wavelength of 550 nm was as small as 89.1%. In Comparative Examples 8, 10, and 12 to 14 and Conventional Examples 3 and 4, the number of times abnormal electrical discharge occurred was as many as twenty two or more. Furthermore, in Comparative Example 9 in which In was 1.7% by weight and in Comparative Example 11 in which Sn was 1.8% by weight, the specific resistance of the film was as high as 7  $\mu\Omega\cdot\text{cm}$ .

**[0100]** (Examples 43 to 52 and Comparative Example 15)

The sputtering targets in Examples 43 to 52 and Comparative Example 15 were manufactured in the same manner as that in Example 29 so as to obtain the sputtering targets in Examples 43 to 52 and Comparative Example 15 except that the component compositions of In, Ga/Sn, and Cu/Mg and the manufacturing conditions were set as described in Table 9. Then, the aforementioned various evaluations were conducted as in Example 29. These results are shown in Tables 9 and 10.

**[0101]** [Table 9]

|                        | In (% BY MASS) | Ga (% BY MASS) | Sn (% BY MASS) | Cu, Mg (% BY MASS) | FORGING TEMPERATURE (°C) | THE NUMBER OF TIMES UPSET FORGING PERFORMED | TOTAL PRESSURE REDUCTION RATIO DURING COLD-ROLLING (%). NOTE THAT HOT-ROLLING WAS USED IN CONVENTIONAL EXAMPLES | HEAT TREATMENT CONDITION AFTER COLD-ROLLING. NOTE THAT HOT-ROLLING WAS USED IN CONVENTIONAL EXAMPLES | AVERAGE PARTICLE DIAMETER (μm) | DISPERSION IN PARTICLE DIAMETER (%) |
|------------------------|----------------|----------------|----------------|--------------------|--------------------------|---------------------------------------------|-----------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------|--------------------------------|-------------------------------------|
| EXAMPLE 43             | 0.5            | 0.2            | 0              | Mg0.1              | 800                      | 20                                          | 70                                                                                                              | 580°C, 1HOUR                                                                                         | 170                            | 13                                  |
| EXAMPLE 44             | 0.5            | 0.2            | 0              | Mg0.5              | 750                      | 15                                          | 70                                                                                                              | 600°C, 1HOUR                                                                                         | 160                            | 13                                  |
| EXAMPLE 45             | 0.5            | 0.2            | 0              | Mg1.0              | 850                      | 6                                           | 75                                                                                                              | 580°C, 2HOURS                                                                                        | 150                            | 17                                  |
| EXAMPLE 46             | 0.5            | 0              | 0.2            | Cu0.1              | 800                      | 10                                          | 60                                                                                                              | 600°C, 2HOURS                                                                                        | 170                            | 15                                  |
| EXAMPLE 47             | 0.5            | 0              | 0.2            | Cu0.5              | 800                      | 20                                          | 70                                                                                                              | 640°C, 1HOUR                                                                                         | 130                            | 12                                  |
| EXAMPLE 48             | 0.5            | 0              | 0.2            | Cu1.0              | 750                      | 15                                          | 70                                                                                                              | 600°C, 1HOUR                                                                                         | 150                            | 14                                  |
| EXAMPLE 49             | 0.3            | 0.3            | 0              | Mg0.6, Cu0.1       | 800                      | 15                                          | 65                                                                                                              | 600°C, 1HOUR                                                                                         | 160                            | 15                                  |
| EXAMPLE 50             | 0.4            | 0              | 0.2            | Mg0.2, Cu0.5       | 800                      | 15                                          | 65                                                                                                              | 600°C, 1HOUR                                                                                         | 130                            | 17                                  |
| EXAMPLE 51             | 0.2            | 0.2            | 0.2            | Mg0.2, Cu0.3       | 800                      | 15                                          | 65                                                                                                              | 600°C, 1HOUR                                                                                         | 140                            | 16                                  |
| EXAMPLE 52             | 0.5            | 0.2            | 0              | Mg0.05             | 800                      | 15                                          | 65                                                                                                              | 600°C, 1HOUR                                                                                         | 180                            | 16                                  |
| COMPARATIVE EXAMPLE 15 | 0.5            | 0              | 0.2            | Mg1.7*             | 800                      | 15                                          | 65                                                                                                              | 600°C, 1HOUR                                                                                         | 120                            | 15                                  |

MARK \* REPRESENTS A VALUE DEPARTING FROM THE CONDITION OF THE PRESENT INVENTION

[0102] [Table 10]

|                           | THE NUMBER<br>OF TIMES<br>ABNORMAL<br>ELECTRICAL<br>DISCHARGE<br>OCCURRED | WARPAGE<br>AFTER<br>MACHINING<br>(mm) | SURFACE<br>ROUGHNESS<br>OF FILM<br>AFTER<br>HEAT<br>TREATMENT<br>(Ra: nm) | ABSOLUTE<br>REFLECTIVITY AT<br>WAVELENGTH OF<br>550 nm<br>AFTER KEPT IN<br>CONSTANT<br>TEMPERATURE AND<br>CONSTANT<br>HUMIDITY (%) | SPECIFIC<br>RESISTANCE<br>OF FILM<br>( $\mu\Omega\cdot\text{cm}$ ) |
|---------------------------|---------------------------------------------------------------------------|---------------------------------------|---------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------|
| EXAMPLE 43                | 1                                                                         | 0.9                                   | 0.7                                                                       | 97.1                                                                                                                               | 4.80                                                               |
| EXAMPLE 44                | 3                                                                         | 0.8                                   | 0.7                                                                       | 97.0                                                                                                                               | 5.64                                                               |
| EXAMPLE 45                | 5                                                                         | 0.7                                   | 0.6                                                                       | 95.2                                                                                                                               | 6.70                                                               |
| EXAMPLE 46                | 2                                                                         | 0.4                                   | 0.7                                                                       | 96.0                                                                                                                               | 4.84                                                               |
| EXAMPLE 47                | 0                                                                         | 0.8                                   | 0.7                                                                       | 97.2                                                                                                                               | 5.68                                                               |
| EXAMPLE 48                | 3                                                                         | 0.8                                   | 0.7                                                                       | 94.7                                                                                                                               | 6.73                                                               |
| EXAMPLE 49                | 3                                                                         | 0.7                                   | 0.7                                                                       | 97.0                                                                                                                               | 5.86                                                               |
| EXAMPLE 50                | 5                                                                         | 0.7                                   | 0.6                                                                       | 96.3                                                                                                                               | 5.90                                                               |
| EXAMPLE 51                | 2                                                                         | 0.5                                   | 0.7                                                                       | 97.3                                                                                                                               | 5.48                                                               |
| EXAMPLE 52                | 4                                                                         | 0.6                                   | 0.7                                                                       | 96.7                                                                                                                               | 4.70                                                               |
| COMPARATIVE<br>EXAMPLE 15 | 4                                                                         | 0.5                                   | 0.6                                                                       | 89.8                                                                                                                               | 8.20                                                               |

[0103] As can be seen from Table 9, in Examples 43 to 52, the average grain diameter of the silver alloy crystal grains was 130 to 180  $\mu\text{m}$  and the dispersion in the grain diameter was 12 to 17%. These were preferable ranges.

As can be seen from Table 10, in Examples 43 to 52, good results were obtained for the number of times abnormal electrical discharge occurred, the warpage after machining, the surface roughness of the film, the absolute reflectivity at the wavelength of 550 nm, and the specific resistance of the film. In contrast, in Comparative Example 15 in which Mg was 1.7% by weight, other properties were at good levels but the absolute reflectivity at the wavelength of 550 nm was as slightly low as 89.8% and the specific resistance of the film was as high as 8.20  $\mu\Omega\cdot\text{cm}$ .

**[0104]** (Examples 53 to 62 and Comparative Example 16)

The sputtering targets in Examples 53 to 62 and Comparative Example 16 were manufactured in the same manner as that in Example 29 so as to obtain the sputtering targets in Examples 53 to 62 and Comparative Example 16 except that the component compositions of In, Ga/Sn, and Ce/Eu and the manufacturing conditions were set as described in Table 11. Then, the aforementioned various evaluations were conducted as in Example 29. These results are shown in Tables 11 and 12.

**[0105]** [Table 11]

|                        | In (% BY MASS) | Ga (% BY MASS) | Sn (% BY MASS) | Ce, Eu (% BY MASS) | FORGING TEMPERATURE (°C) | THE NUMBER OF TIMES UPSET FORGING PERFORMED | TOTAL PRESSURE REDUCTION RATIO DURING COLD-ROLLING (%). NOTE THAT HOT-ROLLING WAS USED IN CONVENTIONAL EXAMPLES | HEAT TREATMENT CONDITION AFTER COLD-ROLLING. NOTE THAT HOT-ROLLING WAS USED IN CONVENTIONAL EXAMPLES | AVERAGE PARTICLE DIAMETER (μm) | DISPERSION IN PARTICLE DIAMETER (%) |
|------------------------|----------------|----------------|----------------|--------------------|--------------------------|---------------------------------------------|-----------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------|--------------------------------|-------------------------------------|
| EXAMPLE 53             | 0.5            | 0.3            | 0              | Ce0.05             | 800                      | 10                                          | 70                                                                                                              | 580°C, 1 HOUR                                                                                        | 180                            | 15                                  |
| EXAMPLE 54             | 0.5            | 0.3            | 0              | Ce0.1              | 750                      | 20                                          | 75                                                                                                              | 600°C, 1 HOUR                                                                                        | 140                            | 14                                  |
| EXAMPLE 55             | 0.5            | 0.3            | 0              | Ce0.8              | 850                      | 6                                           | 65                                                                                                              | 580°C, 2 HOURS                                                                                       | 170                            | 18                                  |
| EXAMPLE 56             | 0.5            | 0              | 0.3            | Eu0.05             | 800                      | 15                                          | 70                                                                                                              | 600°C, 2 HOURS                                                                                       | 150                            | 15                                  |
| EXAMPLE 57             | 0.5            | 0              | 0.3            | Eu0.1              | 800                      | 20                                          | 70                                                                                                              | 640°C, 1 HOUR                                                                                        | 140                            | 13                                  |
| EXAMPLE 58             | 0.5            | 0              | 0.3            | Eu0.8              | 750                      | 10                                          | 60                                                                                                              | 600°C, 1 HOUR                                                                                        | 170                            | 15                                  |
| EXAMPLE 59             | 0.5            | 0.3            | 0              | Eu0.3              | 800                      | 15                                          | 65                                                                                                              | 600°C, 1 HOUR                                                                                        | 130                            | 15                                  |
| EXAMPLE 60             | 0.5            | 0              | 0.3            | Ce0.1              | 800                      | 15                                          | 65                                                                                                              | 600°C, 1 HOUR                                                                                        | 150                            | 14                                  |
| EXAMPLE 61             | 0.4            | 0.2            | 0.2            | Ce0.08, Eu0.1      | 800                      | 15                                          | 65                                                                                                              | 600°C, 1 HOUR                                                                                        | 140                            | 16                                  |
| EXAMPLE 62             | 0.5            | 0.3            | 0              | Ce0.01             | 800                      | 15                                          | 65                                                                                                              | 600°C, 1 HOUR                                                                                        | 200                            | 19                                  |
| COMPARATIVE EXAMPLE 16 | 0.5            | 0              | 0.4            | Eu0.9*             | 800                      | 15                                          | 65                                                                                                              | 600°C, 1 HOUR                                                                                        | 120                            | 16                                  |

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[0106] [Table.12]

|                           | THE NUMBER<br>OF TIMES<br>ABNORMAL<br>ELECTRICAL<br>DISCHARGE<br>OCCURRED | WARPAGE<br>AFTER<br>MACHINING<br>(mm) | SURFACE<br>ROUGHNESS<br>OF FILM<br>AFTER HEAT<br>TREATMENT<br>(Ra: nm) | ABSOLUTE<br>REFLECTIVITY AT<br>WAVELENGTH OF<br>550 nm AFTER<br>KEPT IN<br>CONSTANT<br>TEMPERATURE<br>AND CONSTANT<br>HUMIDITY (%) | SPECIFIC<br>RESISTANCE<br>OF FILM<br>( $\mu\Omega\cdot\text{cm}$ ) |
|---------------------------|---------------------------------------------------------------------------|---------------------------------------|------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------|
| EXAMPLE 53                | 5                                                                         | 0.9                                   | 0.7                                                                    | 97.1                                                                                                                               | 4.93                                                               |
| EXAMPLE 54                | 4                                                                         | 0.6                                   | 0.6                                                                    | 97.2                                                                                                                               | 4.99                                                               |
| EXAMPLE 55                | 10                                                                        | 0.7                                   | 0.7                                                                    | 96.8                                                                                                                               | 6.20                                                               |
| EXAMPLE 56                | 4                                                                         | 0.5                                   | 0.7                                                                    | 96.2                                                                                                                               | 5.00                                                               |
| EXAMPLE 57                | 5                                                                         | 0.9                                   | 0.7                                                                    | 96.7                                                                                                                               | 5.05                                                               |
| EXAMPLE 58                | 9                                                                         | 0.7                                   | 0.6                                                                    | 96.4                                                                                                                               | 6.26                                                               |
| EXAMPLE 59                | 6                                                                         | 0.6                                   | 0.7                                                                    | 96.8                                                                                                                               | 5.39                                                               |
| EXAMPLE 60                | 7                                                                         | 0.5                                   | 0.6                                                                    | 97.0                                                                                                                               | 5.05                                                               |
| EXAMPLE 61                | 6                                                                         | 0.6                                   | 0.7                                                                    | 97.3                                                                                                                               | 5.20                                                               |
| EXAMPLE 62                | 5                                                                         | 0.6                                   | 0.7                                                                    | 96.5                                                                                                                               | 4.82                                                               |
| COMPARATIVE<br>EXAMPLE 16 | 12                                                                        | 0.8                                   | 0.6                                                                    | 95.5                                                                                                                               | 6.88                                                               |

[0107] As can be seen from Table 11, in Examples 53 to 62, the average grain diameter of the silver alloy crystal grains was 130 to 200  $\mu\text{m}$  and the dispersion in the grain diameter was 13 to 18%. These were preferable ranges.

As can be seen from Table 12, in Examples 53 to 62, good results were obtained for the number of times abnormal electrical discharge occurred, the warpage after machining, the surface roughness of the film, the absolute reflectivity at the wavelength of 550 nm, and the specific resistance of the film. In contrast, in Comparative Example 16 in which Eu was 0.9% by weight, other properties were at good levels but the number of times abnormal electrical discharge occurred was as many as twelve.

**[0108]** As described above, the silver alloy sputtering targets for forming an electroconductive film in Examples 1 to 62 of the present invention suppress the occurrence of abnormal electrical discharge. It can be seen that these sputtering targets are subject to sputtering to thereby obtain reflective electrode films for an organic LED, which exhibit excellent properties such as high reflectivity and the small surface roughness of the reflection film. It can also be seen that these reflective electrode films for an organic LED exhibit excellent properties such as low specific resistance and thus are preferably used for a wiring film for a touch panel.

**[0109]** The technical scope of the present invention is not limited to the aforementioned embodiments and Examples, but the present invention may be modified in various ways without departing from the scope or teaching of the present invention.

[Reference Numerals]

**[0110]** 1: cylindrical ingot, 2: squared ingot, 3: forged ingot, 4: board

WHAT IS CLAIMED IS:

1. A silver alloy sputtering target for forming an electroconductive film comprising:

a silver alloy having a component composition containing a total of 0.1 to 1.5% by mass of Ga and/or Sn and the balance composed of Ag and unavoidable impurities,

wherein the average grain diameter of the crystal grains of the silver alloy is 120 to 400  $\mu\text{m}$ , and

wherein the dispersion in the grain diameter of the crystal grains is 20% or less of the average grain diameter.

2. The silver alloy sputtering target for forming an electroconductive film according to claim 1, wherein a total of 1.0% by mass or less of Cu and/or Mg is contained instead of some of the Ag.

3. The silver alloy sputtering target for forming an electroconductive film according to claim 1, wherein a total of 0.8% by mass or less of Ce and/or Eu is contained instead of some of the Ag.

4. A silver alloy sputtering target for forming an electroconductive film comprising:

a silver alloy having a component composition containing a total of 0.1 to 1.5% by mass of Ga and/or Sn, 0.1 to 1.5% by mass of In, and the balance composed of Ag and unavoidable impurities,

wherein the average grain diameter of the crystal grains of the silver alloy is 120 to 250  $\mu\text{m}$ , and

wherein the dispersion in the grain diameter of the crystal grains is 20% or less of the average grain diameter.

5. The silver alloy sputtering target for forming an electroconductive film according to claim 4, wherein 0.1 to 1.5% by mass of In and a total of 1.0% by mass or less of Cu and/or Mg are contained instead of some of the Ag.

6. The silver alloy sputtering target for forming an electroconductive film according to claim 4, wherein 0.1 to 1.5% by mass of In and a total of 0.8% by mass or less of Ce and/or Eu are contained instead of some of the Ag.

7. The silver alloy sputtering target for forming an electroconductive film according to claim 1, wherein the surface of the target has an area equal to or greater than 0.25  $\text{m}^2$ .

8. A method for manufacturing the silver alloy sputtering target for forming an electroconductive film according to claim 1, the method in sequence:

repeating hot upset forging 6 to 20 times for an ingot formed by melting and casting having a component composition containing a total of 0.1 to 1.5% by mass of Ga and/or Sn and the balance composed of Ag and unavoidable impurities;

cold-rolling the forged ingot;

subjecting the cold-rolled board to a heat treatment; and  
machining the heat-treated board.

9. A method for manufacturing the silver alloy sputtering target for forming an electroconductive film according to claim 2, the method comprising in sequence:

repeating hot upset forging 6 to 20 times for an ingot formed by melting and casting having a component composition containing a total of 0.1 to 1.5% by mass of Ga and/or Sn, a total of 1.0% by mass or less of Cu and/or Mg, and the balance composed of Ag and unavoidable impurities;

cold-rolling the forged ingot;

subjecting the cold-rolled board to a heat treatment; and

machining the heat-treated board.

10. A method for manufacturing the silver alloy sputtering target for forming an electroconductive film according to claim 3, the method comprising in sequence:

repeating hot upset forging 6 to 20 times for an ingot formed by melting and casting having a component composition containing a total of 0.1 to 1.5% by mass of Ga and/or Sn, a total of 0.8% by mass or less of Ce and/or Eu, and the balance composed of Ag and unavoidable impurities;

cold-rolling the forged ingot;

subjecting the cold-rolled board to a heat treatment; and

machining the heat-treated board.

11. A method for manufacturing the silver alloy sputtering target for forming an electroconductive film according to claim 4, the method comprising in sequence:

repeating hot upset forging 6 to 20 times for an ingot formed by melting and casting having a component composition containing a total of 0.1 to 1.5% by mass of Ga and/or Sn, 0.1 to 1.5% by mass of In, and the balance composed of Ag and unavoidable impurities;

cold-rolling the forged ingot;

subjecting the cold-rolled board to a heat treatment; and

machining the heat-treated board.

12. A method for manufacturing the silver alloy sputtering target for forming an electroconductive film according to claim 5, the method comprising in sequence:

repeating hot upset forging 6 to 20 times for an ingot formed by melting and casting having a component composition containing a total of 0.1 to 1.5% by mass of Ga and/or Sn, 0.1 to 1.5% by mass of In, a total of 1.0% by mass or less of Cu and/or Mg, and the balance composed of Ag and unavoidable impurities;

cold-rolling the forged ingot;

subjecting the cold-rolled board to a heat treatment; and

machining the heat-treated board.

13. A method for manufacturing the silver alloy sputtering target for forming an electroconductive film according to claim 6, the method comprising in sequence:

repeating hot upset forging 6 to 20 times for an ingot formed by melting and casting having a component composition containing a total of 0.1 to 1.5% by mass of Ga and/or Sn, 0.1 to 1.5% by mass of In, a total of 0.8% by mass or less of Ce and/or Eu, and the balance composed of Ag and unavoidable impurities;

cold-rolling the forged ingot;

subjecting the cold-rolled board to a heat treatment; and

machining the heat-treated board.

14. A method for manufacturing the silver alloy sputtering target for forming an electroconductive film according to claim 8, wherein the temperature of the hot upset forging is from 750 °C to 850 °C.