

DESCRIPTION

INDIUM OXIDE-ZINC OXIDE-MAGNESIUM OXIDE TYPE SPUTTERING TARGET AND TRANSPARENT CONDUCTIVE FILM

Technical Field

[0001]

The present invention relates to a liquid crystal driving electrode substrate and an EL electrode substrate, and particularly to a transparent conductive film constituting a transparent electrode used for these electrode substrates. Also, the present invention relates to a sputtering target used to produce this transparent conductive film.

Background Art

[0002]

Studies concerning materials doped with Sn have been made as a transparent conductive film sputtering target so far. Particularly, ITO (indium tin oxide) is being widely used.

However, in the case of ITO, it is necessary to crystallize it to drop its specific resistance. Therefore, the film-formation of ITO must be carried out at high temperatures or it is necessary to carry out specified heat treatment after the film-formation.

[0003]

Also, there is the case where a problem arises that

when etching a crystallized ITO film, disorders owing to the use of a strong acid take place because aqua regia (mixture solution of nitric acid and hydrochloric acid) that is a strong acid is used as an etching solution. Specifically, there is the case where metal fine wire is used as gate wire and source/drain wire (or electrode) in liquid crystal displays using, for example, TFTs (Thin Film Transistor). In this case, a problem sometimes arises that these wire materials are broken or narrowed by aqua regia when an ITO film is subjected to etching processing.

[0004]

In light of this, there is a proposal as to a method in which amorphous ITO is formed by making hydrogen or water exist in sputtering gas and the formed amorphous ITO is etched by weak acid. However, ITO itself is crystalline, giving rise to the problem that when it is etched by a weak acid, etching residues are generated. Also, when hydrogen or water is made to exist in a dispersed state in sputtering gas when forming a film, there is a fear that a projection called a nodule is generated on the ITO sputtering target, causing abnormal discharge.

[0005]

The following Patent References are disclosed as an example of the patents concerning a sputtering target in which Zn is added as an additional metal other than Sn which is to be usually added in a transparent conductive film, and patents concerning conductive materials or transparent

conductive films.

For example, the following Patent Reference 1 discloses a target containing In and Zn as its major components and also a hexagonal layer compound represented by the formula $\text{In}_2\text{O}_3(\text{ZnO})_m$ ($m = 2$ to 20). According to this target, a transparent conductive film is obtained which is superior in moisture resistance to an ITO film and has the same conductivity and transmittance as an ITO film.

[0006]

Also, the following Patent Reference 2 discloses a liquid crystal display color filter provided with a liquid crystal driving transparent electrode containing an amorphous oxide in which the value of $\text{Zn}/(\text{Zn} + \text{In})$ showing an atomic ratio of a zinc element to an indium element is 0.2 to less than 0.9, the liquid crystal driving transparent electrode being resistant to cracks and peeling.

[0007]

Also, the following Patent Reference 3 discloses a conductive transparent base material comprising In and Zn wherein the value of $\text{In}/(\text{In} + \text{Zn})$ is 0.8 to 0.9, the base material being superior in etching characteristics and thermal stability of specific resistance.

[0008]

Moreover, among these disclosed Patent References 1 to 3, there are Patent references showing that a target free from the generation of nodules is obtained and a transparent conductive film which is superior in etching characteristics

and has the same specific resistance as ITO.

[0009]

Patent Reference 1: Publication of Japanese Patent Application Laid-Open (JP-A) No. 06-234565

Patent Reference 2: Publication of JP-A No. 07-120612

Patent Reference 3: Publication of JP-A No. 07-235219

Patent Reference 4: Publication of JP-A No. 08-264022

Disclosure of the Invention

Problem to be Solved by the Invention

[0010]

However, the amorphous transparent conductive film has no clear bandgap, namely, not so large bandgap, giving rise to the problem that there is the case where the conductive film is reduced in light transmittance at a shorter wavelength, particularly, a wavelength range from 400 to 450 nm.

[0011]

In the above Patent Reference 4, on the contrary, reflectance can be controlled and a highly transparent conductive film is produced by preparing a composition of a pseudo ternary oxide. However, this transparent conductive film has the problem that the conductivity of the sputtering target used to form this transparent conductive film is so low that it is difficult to carry out sputtering and the etching characteristics are not so much improved because the formed transparent conductive film is crystalline.

[0012]

The present invention has been made to solve the above problem and it is an object of the present invention to provide a target free from the generation of nodules in sputtering. Also, another object of the present invention is to provide an amorphous transparent conductive film which is superior in etching characteristics and transparency at a wavelength range particularly from 400 to 450 nm (having high light transmittance at a wavelength range from 400 to 450 nm).

Means for Solving the Problem

[0013]

Invention of a sputtering target

(1) In order to solve the above problem, the present invention provides a sputtering target comprising: indium oxide; zinc oxide; and magnesium oxide.

Magnesium oxide is further added to a sputtering target comprising indium oxide and zinc oxide to thereby obtain a target which is limited in the generation of nodules more efficiently in sputtering and is hence reduced in abnormal discharge.

[0014]

(2) The present invention also provides a sputtering target, wherein, when observing crystal peaks obtained by X-ray diffraction of the sputtering target comprising indium oxide, zinc oxide and magnesium oxide; said crystal peaks include peaks derived from: a hexagonal layer compound

constituted of indium oxide and zinc oxide and represented by the formula $\text{In}_2\text{O}_3(\text{ZnO})_m$ (where m denotes an integer from 3 to 20); and In_2MgO_4 constituted of indium oxide and magnesium oxide.

[0015]

The surface of the sputtering target is measured by X-ray diffraction, with the result that when the obtained crystal peaks are observed, it is essential that the crystal peaks include peaks derived from a specified hexagonal layer compound and In_2MgO_4 . Here, the specified hexagonal layer compound means those comprising indium oxide and zinc oxide and represented by the formula $\text{In}_2\text{O}_3(\text{ZnO})_m$ (here, m denotes an integer from 3 to 20). Also, the above In_2MgO_4 is constituted of indium oxide and magnesium oxide.

[0016]

Specific examples of the hexagonal layer compound constituted of indium oxide and zinc oxide include $\text{In}_2\text{Zn}_3\text{O}_6$, $\text{In}_2\text{Zn}_4\text{O}_7$ and $\text{In}_2\text{Zn}_5\text{O}_8$ and are represented by the formula $\text{In}_2\text{O}_3(\text{ZnO})_m$ (here, m denotes an integer from 3 to 20). Also, according to the mapping of EPMA (Electron Probe Microanalysis: X-ray microanalyzer), the size of crystal particles of these complex oxides is 10 μm or less, preferably 5 μm or less and more preferably 3 μm or less.

[0017]

When a sputtering target contains neither the above hexagonal layer compound constituted of indium oxide and zinc oxide nor In_2MgO_4 , the bulk resistance of the sputtering target

sometimes exceeds 10 mΩcm. When the bulk resistance exceeds 10 mΩcm like this, this causes abnormal discharge in sputtering and the sputtering target may be broken.

[0018]

(3) The present invention also provides the sputtering target according to the above (1), comprising: a hexagonal layer compound constituted of indium oxide and zinc oxide; and In₂MgO₄ constituted of indium oxide and magnesium oxide.

[0019]

(4) The present invention also provides the sputtering target according to any one of the above (1) to (3), wherein $[In]/([In] + [Zn] + [Mg]) = 0.74$ to 0.94 , $[Zn]/([In] + [Zn] + [Mg]) = 0.05$ to 0.25 and $[Mg]/([In] + [Zn] + [Mg]) = 0.01$ to 0.20 , where [In] denotes the number of indium atoms per unit volume, [Zn] denotes the number of zinc atoms per unit volume and [Mg] denotes the number of magnesium atoms per unit volume.

[0020]

Indium composition

In the sputtering target in the present invention, $[In]/([In] + [Zn] + [Mg]) = 0.74$ to 0.94 . When the value of $[In]/([In] + [Zn] + [Mg])$ is less than 0.74, there is the case where the bulk resistance of the sputtering target is increased too much and the specific resistance of the formed transparent conductive film becomes large. On the other hand, when the value of $[In]/([In] + [Zn] + [Mg])$ exceeds 0.94, the specific resistance of the formed transparent conductive

film is increased and the transparent conductive film is crystallized, causing the generation of residues during etching.

[0021]

Zinc composition

In the sputtering target in the present invention, $[Zn]/([In] + [Zn] + [Mg]) = 0.05$ to 0.25 . When the value of $[Zn]/([In] + [Zn] + [Mg])$ is less than 0.05 , there is the case where the specific resistance of the formed transparent conductive film is increased too much and the transparent conductive film is crystallized. On the other hand, when the value of $[Zn]/([In] + [Zn] + [Mg])$ exceeds 0.25 , the specific resistance of the formed transparent conductive film is increased too much.

[0022]

Magnesium composition

In the sputtering target in the present invention, $[Mg]/([In] + [Zn] + [Mg]) = 0.01$ to 0.20 . When the value of $[Mg]/([In] + [Zn] + [Mg])$ is less than 0.01 , there is the case where the specific resistance of the formed transparent conductive film is increased too much, the transparent conductive film is crystallized, and also, the transmittance of the transparent conductive film is not increased. On the other hand, when the value of $[Mg]/([In] + [Zn] + [Mg])$ exceeds 0.25 , the specific resistance of the formed transparent conductive film is increased too much.

[0023]

(5) The present invention also provides the sputtering target according to any one of the above (1) to (4), further comprising a positive tetravalent metal oxide.

[0024]

The term "positive tetravalent" means that the atomic valence of the metal atom in the metal oxide is +4. When the positive tetravalent metal oxide is contained, the bulk resistance of the sputtering target is dropped, whereby abnormal discharge can be prevented.

[0025]

(6) The present invention also provides the sputtering target according to the above (5), wherein said positive tetravalent metal oxide is SnO_2 , ZrO_2 , GeO_2 or CeO_2 .

[0026]

Among these positive tetravalent metal oxides, SnO_2 , ZrO_2 , GeO_2 and CeO_2 are preferably used.

[0027]

(7) The present invention also provides the sputtering target according to the above (6), the sputtering target containing one or two or more metal oxides selected from the group M consisting of SnO_2 , ZrO_2 , GeO_2 , CeO_2 and Ga_2O_3 .

[0028]

(8) The present invention also provides the sputtering target according to the above (7), wherein the amount of said one or two or more metal oxides selected from said group M is given by the following equation: $[\text{M}]/[\text{All metals}] = 0.0001$ to 0.15 , where $[\text{M}]$ represents the number of metal atoms in

one or two or more metal oxides selected from said group M per unit volume, that is, the number of atoms of one or two or more types of Sn, Zr, Ge, Ce and Ga per unit volume and [All metals] represent all metals per unit volume, that is, the sum of the number of In, Zn and Mg atoms and number of atoms in one or two or more metal oxides selected from said group M per unit volume.

[0029]

In the sputtering target, the value of $[M]/[All\ metals]$ is 0.0001 to 0.15, preferably 0.0003 to 0.12 and more preferably 0.0005 to 0.1. When the value of $[M]/[All\ metals]$ is less than 0.0001, there is the case where the effect obtained by the addition of [M] is not produced, whereas when the value of $[M]/[All\ metals]$ exceeds 0.15, there is the case where the etching characteristics of the formed transparent conductive film are little improved.

[0030]

Invention of an amorphous transparent conductive film

(9) The present invention also provides an amorphous transparent conductive film comprising: indium oxide; zinc oxide; and magnesium oxide.

[0031]

Since the transparent conductive film contains indium oxide, zinc oxide and further magnesium oxide, a completely amorphous transparent conductive film is obtained. Making the transparent conductive film amorphous results in that almost no etching residue is generated during etching. Also,

since the transparent conductive film contains magnesium oxide, a reduction in light transmittance at a wavelength range from 400 to 450 nm can be prevented efficiently.

[0032]

(10) The present invention also provides the amorphous transparent conductive film according to the above (9), wherein $[In]/([In] + [Zn] + [Mg]) = 0.74$ to 0.94 , $[Zn]/([In] + [Zn] + [Mg]) = 0.05$ to 0.25 and $[Mg]/([In] + [Zn] + [Mg]) = 0.01$ to 0.20 , where $[In]$ denotes the number of indium atoms per unit volume, $[Zn]$ denotes the number of zinc atoms per unit volume and $[Mg]$ denotes the number of magnesium atoms per unit volume.

[0033]

Indium composition

In the transparent conductive film in the present invention, $[In]/([In] + [Zn] + [Mg]) = 0.74$ to 0.94 , preferably 0.7 to 0.92 and more preferably 0.75 to 0.9 . When the value of $[In]/([In] + [Zn] + [Mg])$ is less than 0.74 , there is the case where the specific resistance of the formed transparent conductive film becomes too large. On the other hand, when the value of $[In]/([In] + [Zn] + [Mg])$ exceeds 0.94 , there is the case where the transparent conductive film is easily crystallized and the specific resistance of the transparent conductive film becomes large.

[0034]

Zinc composition

In the transparent conductive film in the present

invention, $[Zn]/([In] + [Zn] + [Mg]) = 0.05$ to 0.25 , preferably 0.07 to 0.25 and more preferably 0.08 to 0.22 . When the value of $[Zn]/([In] + [Zn] + [Mg])$ is less than 0.05 , there is the case where the transparent conductive film is easily crystallized and the specific resistance of the formed transparent conductive film is increased. On the other hand, when the value of $[Zn]/([In] + [Zn] + [Mg])$ exceeds 0.25 , the specific resistance of the formed transparent conductive film is increased too much.

[0035]

Magnesium composition

In the transparent conductive film in the present invention, $[Mg]/([In] + [Zn] + [Mg]) = 0.01$ to 0.2 , preferably 0.01 to 0.15 and more preferably 0.02 to 0.1 . When the value of $[Mg]/([In] + [Zn] + [Mg])$ is less than 0.01 , there is the case where the transmittance of the transparent conductive film is not increased, the transparent conductive film is easily crystallized and the specific resistance of the transparent conductive film is increased. When the value of $[Mg]/([In] + [Zn] + [Mg])$ exceeds 0.20 , the specific resistance of the formed transparent conductive film is increased too much.

When each content of In, Zn and Mg in the transparent conductive film is out of the above range, there is the case where the transparent conductive film fails to obtain desirable transparency, specific resistance and etching characteristics.

[0036]

(11) The present invention also provides the amorphous transparent conductive film according to the above (9) or (10), further comprising a positive tetravalent metal oxide.

[0037]

When the positive tetravalent metal oxide is contained in the transparent conductive film, the bulk resistance of the target is dropped, whereby the transparent conductive film can be formed in a stable discharge condition and therefore, more stable transparent conductive film is obtained.

[0038]

(12) The present invention also provides the amorphous transparent conductive film according to the above (11), wherein said positive tetravalent metal oxide is SnO_2 , ZrO_2 , GeO_2 or CeO_2 .

[0039]

Among these positive tetravalent metal oxides, SnO_2 , ZrO_2 , GeO_2 and CeO_2 are preferably used.

[0040]

(13) The present invention also provides the amorphous transparent conductive film according to the above (9) or (10), the conductive film containing one or two or more metal oxides selected from the group M consisting of SnO_2 , ZrO_2 , GeO_2 , CeO_2 and Ga_2O_3 .

[0041]

(14) The present invention also provides the amorphous

transparent conductive film according to the above (13), wherein the amount of said one or two or more metal oxides selected from said group M is given by the following equation: $[M]/[\text{All metals}] = 0.0001 \text{ to } 0.15$, where $[M]$ represents the number of metal atoms in one or two or more metal oxides selected from said group M per unit volume, that is, the number of atoms of one or two or more types of Sn, Zr, Ge, Ce and Ga per unit volume and $[\text{All metals}]$ represent all metals per unit volume, that is, the sum of the number of In, Zn and Mg atoms and number of atoms of one or two or more metal oxides selected from said group M per unit volume.

[0042]

In the transparent conductive film, the value of $[M]/[\text{All metals}]$ is 0.0001 to 0.15, preferably 0.0003 to 0.12 and more preferably 0.0005 to 0.1. When the value of $[M]/[\text{All metals}]$ is less than 0.0001, there is the case where the effect obtained by the addition of $[M]$ is not produced, whereas when the value of $[M]/[\text{All metals}]$ exceeds 0.15, there is the case where the etching characteristics of the formed transparent conductive film are little improved.

Effect of the Invention

[0043]

As mentioned above, the sputtering target of the present invention generates almost no nodule during sputtering.

Also, the amorphous transparent conductive film generates almost no residue by etching using a weak acid (for

example, an organic acid) and is also superior in transparency (light transmittance) at a wavelength range from 400 to 450 nm.

Brief Description of the Drawings

[0044]

Fig. 1 is a view showing the material parameters of the sputtering targets and transparent conductive films in Examples 1 to 9 and Comparative Examples 1 and 2.

Fig. 2 is a view showing the X-ray chart of a target 1 in Example 1.

Best Mode for Carrying Out the Invention

[0045]

Preferred embodiments of the present invention will be explained hereinbelow.

Example 1

[0046]

Target 1

An In_2O_3 powder having an average particle diameter of $1\mu\text{m}$ or less, a ZnO powder having an average particle diameter of $1\mu\text{m}$ or less and a MgO powder having an average particle diameter of $1\mu\text{m}$ or less were respectively weighed in a specified ratio and mixed. Then, the mixture was placed in a resin pot, to which was added water to carry out wet ball mill mixing using a hard ZrO_2 ball. At this time, the mixing

was carried out for 20 hours. The obtained mixed slurry was taken out, followed by filtration, drying and granulation. The obtained granulate was placed in a molder, which was set to a cold hydrostatic press where a pressure of 3 ton/cm² was applied to the granulate to mold, thereby obtaining a molded article.

[0047]

Then, the obtained molded article was sintered in the following manner. First, the molded article was placed in a sintering furnace and oxygen was flowed into the sintering furnace at a rate of 5 l/min. per a volume of 0.1 m³ in the sintering furnace. In this atmosphere, the above molded article was sintered at 1470°C for 5 hours. At this time, the temperature in the sintering furnace was raised at a rate of 1°C/min. to 1000°C and at a rate of 3°C/min. from 1000°C to 1470°C.

Thereafter, oxygen was stopped flowing and the temperature in the sintering furnace was dropped to 1300°C from 1470°C at a rate of 10°C/min. Then, Ar was made to flow into the sintering furnace at a rate of 10 l/min. per a volume of 0.1 m³ in the sintering furnace. In this atmosphere, the molded article was kept at 1300°C for 3 hours and then allowed to cool, thereby obtaining a sintered body.

[0048]

The relative density of the obtained sintered body was found in the following manner. First, measurement was made by the Archimedes method using water to calculate the relative

density from the theoretical density, to find that the relative density was 97%. This relative density is shown in Fig. 1. The theoretical density at this time was calculated from the weight percentages of In_2O_3 crystals (vicksbite type structure) without oxygen defect and an oxide of Zn and Mg.

[0049]

Also, when the content of Zn and Mg in the sintered body was quantitatively analyzed by an ICP (Inductively Coupled Plasma) emission analysis method, it was confirmed that the charged composition when the raw material powders were mixed was kept also in the sintered body. The value of $[\text{In}]/([\text{In}] + [\text{Zn}] + [\text{Mg}])$, value of $[\text{Zn}]/([\text{In}] + [\text{Zn}] + [\text{Mg}])$ and value of $[\text{Mg}]/([\text{In}] + [\text{Zn}] + [\text{Mg}])$ which are specific atomic composition ratios and confirmed at this time are shown in Fig. 1.

[0050]

In Fig. 1, $[\text{In}]$ represents the number of indium atoms per unit volume in the sintered body, $[\text{Zn}]$ represents the number of zinc atoms per unit volume in the sintered body and $[\text{Mg}]$ represents the number of magnesium atoms per unit volume in the sintered body.

[0051]

Next, the sputtered surface of the above sintered body was polished by a grinding stone into the surface having a diameter of 100 mm and a thickness of 5 mm. Then, a backing plate was applied to the sputtered surface by using an In type alloy to produce a sputtering target 1. The bulk

resistance of the sputtering target 1 was found in the following manner: first, the specific resistance of the target 1 was measured using Loresta (manufactured by Mitsubishi Chemical Co., Ltd.) according to the four probe method, to find the bulk resistance based on the measured specific resistance by calculation. The value of the calculated bulk resistance is shown in Table 1.

[0052]

As to the form of zinc or magnesium contained in the target 1, it is more preferable that zinc and magnesium be dispersed in the form of a complex oxide of indium oxide-zinc oxide (for example, $\text{In}_2\text{Zn}_5\text{O}_8$, $\text{In}_2\text{Zn}_7\text{O}_{10}$, $\text{In}_2\text{Zn}_3\text{O}_6$ or $\text{In}_2\text{Zn}_4\text{O}_7$) than in the form of zinc oxide (ZnO) or magnesium oxide (MgO). Fig. 2 is a view showing an X-ray chart of the target 1. In Fig. 2, the ordinate indicates the intensity of diffracted X-rays and the abscissa indicates the angle of diffracted X-rays. The above hexagonal layer compounds comprising indium oxide and zinc oxide are preferably those represented by the formula $\text{In}_2\text{O}_3(\text{ZnO})_m$ (here, m is an integer of 3 to 20) such as $\text{In}_2\text{Zn}_3\text{O}_6$, $\text{In}_2\text{Zn}_4\text{O}_7$ or $\text{In}_2\text{Zn}_5\text{O}_8$.

[0053]

When a zinc atom or a magnesium atom is substituted for the indium site of indium oxide in the form of a solid solution and is dispersed at an atomic level in the indium oxide sintered body, the bulk resistance of the target 1 is increased too much and there is therefore a fear that stable discharge is not obtained in sputtering and therefore abnormal

discharge is induced.

[0054]

Indium oxide, zinc oxide and magnesium oxide in the sputtering target 1 are preferably dispersed in the form of hexagonal layer compounds including indium oxide and zinc oxide and in the form of In_2MgO_4 comprising indium oxide and magnesium oxide. When these oxides are dispersed in such forms, the bulk resistance of the target 1 does not become too large and therefore, stable discharge is obtained at the time of sputtering.

[0055]

It has been confirmed by X-ray diffraction that indium oxide, zinc oxide and magnesium oxide in the sputtering target 1 of this Example 1 are dispersed in the form of the aforementioned hexagonal layer compounds and in the form of In_2MgO_4 . In this case, the above forms of indium oxide, zinc oxide and magnesium oxide in the sputtering target 1 were confirmed based on the crystal peaks obtained by X-ray diffraction.

[0056]

The above hexagonal layer compounds including indium oxide and zinc oxide are preferably those represented by the formula $\text{In}_2\text{O}_3(\text{ZnO})_m$ (here, m is an integer of 3 to 20) such as $\text{In}_2\text{Zn}_3\text{O}_6$, $\text{In}_2\text{Zn}_4\text{O}_7$ or $\text{In}_2\text{Zn}_5\text{O}_8$.

[0057]

When these oxides are dispersed in such a form, the bulk resistance of the target 1 is less than $10\text{ m}\Omega\text{cm}$, enabling

stable sputtering. This target 1 was used to carry out sputtering without generation of nodules (Fig. 1).

[0058]

Transparent conductive film 1a

After the obtained target 1 was set to a DC sputtering device, a transparent conductive film 1a of 130 nm in film thickness was formed on a slide glass at 200°C. The specific resistance and light transmittance (400 nm, 450 nm) of the formed transparent conductive film 1a were measured. The measured values of specific resistance and light transmittance are shown in Fig. 1. Also, this transparent conductive film 1a was measured by X-ray diffraction, with the result that no peak was observed to find that the transparent conductive film was amorphous. Also, when this transparent conductive film 1a was etched using a weak acid, no residue was generated (Fig. 1).

[0059]

As mentioned above, in this Example 1, the transparent conductive film 1a was obtained which was improved in light transmittance at a wavelength of 400 to 450 nm though it was amorphous.

Example 2

[0060]

Target 2

An In_2O_3 powder having an average particle diameter of 1 μm or less, a ZnO powder having an average particle diameter

of 1 μm or less and a MgO powder having an average particle diameter of 1 μm or less were mixed, molded and sintered in the same manner as in the above Example 1 except that each proportion of these powders was different from that of Example 1, to obtain a sintered body. The relative density of the sintered body was found in the same manner as in Example 1. The obtained relative density is shown in Fig. 1.

[0061]

Also, when the content of Zn and Mg in the obtained sintered body was quantitatively analyzed by an ICP emission analysis method in the same manner as in Example 1, it was confirmed that the charged composition when the raw material powders were mixed was kept also in the sintered body. The specific values of the composition ratios in the sintered body confirmed at this time are shown in Fig. 1.

[0062]

Next, a backing plate was applied to the sputtered surface of the sintered body in the same manner as in the above Example 1 to produce a sputtering target 2. The bulk resistance of the sputtering target 2 was found in the same manner as in Example 1. The value of the calculated bulk resistance is shown in Fig. 1. This target 2 was used to carry out sputtering without generation of nodules (Fig. 1).

[0063]

It has been confirmed by X-ray diffraction that indium oxide, zinc oxide and magnesium oxide in the sputtering target 2 of this Example 2 are present in the form of hexagonal layer

compounds and in the form of In_2MgO_4 similarly to the case of Example 1.

[0064]

Transparent conductive film 2a

After the obtained target 2 was set to a DC sputtering device, a transparent conductive film 2a of 130 nm in film thickness was formed on a slide glass at 200°C in the same manner as in Example 1. The specific resistance and light transmittance (400 nm, 450 nm) of the formed transparent conductive film 2a were measured. The measured values of specific resistance and light transmittance are shown in Fig. 1. Also, this transparent conductive film 2a was measured by X-ray diffraction, with the result that no peak was observed to find that the transparent conductive film was amorphous. Also, when this transparent conductive film 2a was etched using a weak acid, no residue was generated (Fig. 1).

As mentioned above, in this Example 2, the transparent conductive film 2a was obtained which was improved in light transmittance at a wavelength of 400 to 450 nm though it was amorphous, in the same manner as in Example 1.

Example 3

[0065]

Target 3

An In_2O_3 powder having an average particle diameter of 1 μm or less, a ZnO powder having an average particle diameter of 1 μm or less and a MgO powder having an average particle

diameter of 1 μm or less were mixed, molded and sintered in the same manner as in the above Examples 1 and 2 except that each proportion of these powders was different from that of Examples 1 and 2, to obtain a sintered body. The relative density of the sintered body was found in the same manner as in Examples 1 and 2. The relative density obtained at this time is shown in Fig. 1.

[0066]

Also, when the content of Zn and Mg in the obtained sintered body was quantitatively analyzed by an ICP emission analysis method in the same manner as in the above Examples 1 and 2, it was confirmed that the charged composition when the raw material powders were mixed was kept also in the sintered body. The specific values of the composition ratios in the sintered body confirmed at this time are shown in Fig. 1.

[0067]

Next, a backing plate was applied to the sputtered surface of the sintered body in the same manner as in the above Examples 1 and 2 to produce a sputtering target 3. The bulk resistance of the sputtering target 3 was found in the same manner as in Examples 1 and 2. The value of the calculated bulk resistance is shown in Table 1. This target 3 was used to carry out sputtering without generation of nodules (Fig. 1).

[0068]

It has been confirmed by X-ray diffraction that indium

oxide, zinc oxide and magnesium oxide in the sputtering target 3 of this Example 3 are present in the form of hexagonal layer compounds and in the form of In_2MgO_4 similarly to the case of Examples 1 and 2.

[0069]

Transparent conductive film 3a

After the obtained target 3 was set to a DC sputtering device, a transparent conductive film 3a of 130 nm in film thickness was formed on a slide glass at 200°C in the same manner as in Examples 1 and 2. The specific resistance and light transmittance (400 nm, 450 nm) of the formed transparent conductive film 3a were measured. The measured values of specific resistance and light transmittance are shown in Fig. 1. Also, this transparent conductive film 3a was measured by X-ray diffraction, with the result that no peak was observed to find that the transparent conductive film was amorphous. Also, when this transparent conductive film 3a was etched using a weak acid, no residue was generated (Fig. 1).

As mentioned above, in this Example 3, the transparent conductive film 3a was obtained which was improved in light transmittance at a wavelength of 400 to 450 nm though it was amorphous, in the same manner as in the Examples 1 and 2.

Example 4

[0070]

Target 4

An In_2O_3 powder having an average particle diameter

of 1 μm or less, a ZnO powder having an average particle diameter of 1 μm or less and a MgO powder having an average particle diameter of 1 μm or less were mixed, molded and sintered in the same manner as in the above Examples 1 to 3 except that each proportion of these powders was different from that of Examples 1 to 3, to obtain a sintered body. The relative density of the sintered body was found in the same manner as in Examples 1 to 3. The relative density obtained at this time is shown in Fig. 1.

[0071]

Also, when the content of Zn and Mg in the obtained sintered body was quantitatively analyzed by an ICP emission analysis method in the same manner as in the above Examples 1 to 3, it was confirmed that the charged composition when the raw material powders were mixed was kept also in the sintered body. The specific values of the composition ratios in the sintered body confirmed at this time are shown in Fig. 1.

[0072]

Next, a backing plate was applied to the sputtered surface of the sintered body to produce a sputtering target 4 in the same manner as in the above Examples 1 to 3. The bulk resistance of the sputtering target 4 was found in the same manner as in Examples 1 to 3. The value of the calculated bulk resistance is shown in Table 1. This target 4 was used to carry out sputtering without generation of nodules (Fig. 1).

[0073]

It has been confirmed by X-ray diffraction that indium oxide, zinc oxide and magnesium oxide in the sputtering target 4 of this Example 4 are present in the form of hexagonal layer compounds and in the form of In_2MgO_4 similarly to the case of Examples 1 to 3.

[0074]

Transparent conductive film 4a

After the obtained target 2 was set to a DC sputtering device, a transparent conductive film 4a of 130 nm in film thickness was formed on a slide glass at 200°C in the same manner as in the above Example 1. The specific resistance and light transmittance (400 nm, 450 nm) of the formed transparent conductive film 4a were measured. The measured values of specific resistance and light transmittance are shown in Fig. 1. Also, this transparent conductive film 4a was measured by X-ray diffraction, with the result that no peak was observed to find that the transparent conductive film was amorphous. Also, when this transparent conductive film 4a was etched using a weak acid, no residue was generated (Fig. 1).

As mentioned above, in this Example 4, the transparent conductive film 4a was obtained which was improved in light transmittance at a wavelength of 400 to 450 nm though it was amorphous, in the same manner as in the Examples 1 to 3.

Example 5

[0075]

Target 5

The above powders were mixed in the same composition ratios as in the above Example 1, molded and sintered except that a SnO₂ powder was mixed in a specified ratio, to obtain a sintered body. The relative density of the sintered body was found in the same manner as in the above Examples 1 to 4. The relative density obtained at this time is shown in Fig. 1.

[0076]

Also, when the content of Zn, Mg and Sn in the obtained sintered body was quantitatively analyzed by an ICP emission analysis method in the same manner as in the above Examples 1 to 4, it was confirmed that the charged composition when the raw material powders were mixed was kept also in the sintered body. The specific values of the composition ratios in the sintered body confirmed at this time are shown in Fig. 1.

[0077]

In the patent of this case, M means the group consisting of Sn, Zr and Ge and in particular, M in Fig. 1 represents any one of Sn, Zr and Ge. Also, [M] represents the number of Sn, Zr or Ge atoms in unit volume in the sintered body.

[0078]

Next, a backing plate was applied to the sputtered surface of the sintered body to produce a sputtering target 5 in the same manner as in the above Examples 1 to 4. The

bulk resistance of the sputtering target 5 was found in the same manner as in Examples 1 to 4. The value of the calculated bulk resistance is shown in Table 1. This target 5 was used to carry out sputtering without generation of nodules (Fig. 1).

[0079]

It has been confirmed by X-ray diffraction that indium oxide, zinc oxide and magnesium oxide in the sputtering target 5 of this Example 5 are present in the form of hexagonal layer compounds and in the form of In_2MgO_4 similarly to the case of Examples 1 to 4.

[0080]

Transparent conductive film 5a

After the obtained target 5 was set to a DC sputtering device, a transparent conductive film 5a of 130 nm in film thickness was formed on a slide glass at 200°C in the same manner as in the above Examples 1 to 4. The specific resistance and light transmittance (400 nm, 450 nm) of the formed transparent conductive film 5a were measured. The measured values of specific resistance and light transmittance are shown in Fig. 1. Also, this transparent conductive film 5a was measured by X-ray diffraction, with the result that no peak was observed to find that the transparent conductive film was amorphous. Also, when this transparent conductive film 5a was etched using a weak acid, no residue was generated (Fig. 1).

As mentioned above, in this Example 5, the transparent

conductive film 5a was obtained which was improved in light transmittance at a wavelength of 400 to 450 nm though it was amorphous, in the same manner as in the Examples 1 to 4.

Example 6

[0081]

Target 6

An In_2O_3 powder having an average particle diameter of 1 μm or less, a ZnO powder having an average particle diameter of 1 μm or less, a MgO powder having an average particle diameter of 1 μm or less and a SnO_2 powder were mixed, molded and sintered in the same manner as in the above Example 5 except that each proportion of these powders was different from that of Example 5, to obtain a sintered body. The relative density of the sintered body was found in the same manner as in the above Examples 1 to 5. The relative density obtained at this time is shown in Fig. 1.

[0082]

Also, when the content of Zn, Mg and Sn in the obtained sintered body was quantitatively analyzed by an ICP emission analysis method in the same manner as in the above Example 5, it was confirmed that the charged composition when the raw material powders were mixed was kept also in the sintered body. The specific values of the composition ratios in the sintered body confirmed at this time are shown in Fig. 1.

[0083]

Next, a backing plate was applied to the sputtered

surface of the sintered body to produce a sputtering target 6 in the same manner as in the above Examples 1 to 5. The bulk resistance of the sputtering target 6 was found in the same manner as in the above Examples 1 to 5. The value of the calculated bulk resistance is shown in Table 1. This target 6 was used to carry out sputtering without generation of nodules (Fig. 1).

[0084]

It has been confirmed by X-ray diffraction that indium oxide, zinc oxide and magnesium oxide in the sputtering target 6 of this Example 6 are present in the form of hexagonal layer compounds and in the form of In_2MgO_4 similarly to the case of Examples 1 to 5.

[0085]

Transparent conductive film 6a

After the obtained target 6 was set to a DC sputtering device, a transparent conductive film 6a of 130 nm in film thickness was formed on a slide glass at 200°C in the same manner as in the above Examples 1 to 5. The specific resistance and light transmittance (400 nm, 450 nm) of the formed transparent conductive film 6a were measured. The measured values of specific resistance and light transmittance are shown in Fig. 1. Also, this transparent conductive film 6a was measured by X-ray diffraction, with the result that no peak was observed to find that the transparent conductive film was amorphous. Also, when this transparent conductive film 6a was etched using a weak acid,

no residue was generated (Fig. 1).

As mentioned above, in this Example 6, the transparent conductive film 6a was obtained which was improved in light transmittance at a wavelength of 400 to 450 nm though it was amorphous, in the same manner as in the Examples 1 to 5.

Example 7

[0086]

Target 7

An In_2O_3 powder having an average particle diameter of $1\mu\text{m}$ or less, a ZnO powder having an average particle diameter of $1\mu\text{m}$ or less, a MgO powder having an average particle diameter of $1\mu\text{m}$ and a SnO_2 powder were mixed, molded and sintered in the same manner as in the above Examples 5 and 6 except that each proportion of these powders was different from that of Examples 5 and 6, to obtain a sintered body. The relative density of the sintered body was found in the same manner as in Examples 1 to 6. The relative density obtained at this time is shown in Fig. 1.

[0087]

Also, when the content of Zn, Mg and Sn in the obtained sintered body was quantitatively analyzed by an ICP emission analysis method in the same manner as in the above Examples 5 and 6, it was confirmed that the charged composition when the raw material powders were mixed was kept also in the sintered body. The specific values of the composition ratios in the sintered body confirmed at this time are shown in Fig.

1.

[0088]

Next, a backing plate was applied to the sputtered surface of the sintered body to produce a sputtering target 7 in the same manner as in the above Examples 1 to 6. The bulk resistance of the sputtering target 7 was found in the same manner as in Examples 1 to 6. The value of the calculated bulk resistance is shown in Table 1. This target 7 was used to carry out sputtering without generation of nodules (Fig. 1).

[0089]

It has been confirmed by X-ray diffraction that indium oxide, zinc oxide and magnesium oxide in the sputtering target 7 of this Example 7 are present in the form of hexagonal layer compounds and in the form of In_2MgO_4 similarly to the case of Examples 1 to 6.

[0090]

Transparent conductive film 7a

After the obtained target 7 was set to a DC sputtering device, a transparent conductive film 7a of 130 nm in film thickness was formed on a slide glass at 200°C in the same manner as in the above Examples 1 to 6. The specific resistance and light transmittance (400 nm, 450 nm) of the formed transparent conductive film 7a were measured. The measured values of specific resistance and light transmittance are shown in Fig. 1. Also, this transparent conductive film 7a was measured by X-ray diffraction, with

the result that no peak was observed to find that the transparent conductive film was amorphous. Also, when this transparent conductive film 7a was etched using a weak acid, no residue was generated (Fig. 1).

As mentioned above, in this Example 7, the transparent conductive film 7a was obtained which was improved in light transmittance at a wavelength of 400 to 450 nm though it was amorphous, in the same manner as in the Examples 1 to 6.

Example 8

[0091]

Target 8

The above powders were mixed in the same composition ratios as in the above Example 4, molded and sintered except that a ZrO_2 powder was further mixed in a specified ratio, to obtain a sintered body. The relative density of the sintered body was found in the same manner as in the above Examples 1 to 7. The relative density obtained at this time is shown in Fig. 1.

[0092]

Also, when the content of Zn, Mg and Zr in the obtained sintered body was quantitatively analyzed by an ICP emission analysis method in the same manner as in the above Examples 1 to 7, it was confirmed that the charged composition when the raw material powders were mixed was kept also in the sintered body. The specific values of the composition ratios in the sintered body confirmed at this time are shown in Fig.

1.

[0093]

Next, a backing plate was applied to the sputtered surface of the sintered body to produce a sputtering target 8 in the same manner as in the above Examples 1 to 7. The bulk resistance of the sputtering target 8 was found in the same manner as in the above Examples 1 to 7. The value of the calculated bulk resistance is shown in Table 1. This target 8 was used to carry out sputtering without generation of nodules (Fig. 1).

[0094]

It has been confirmed by X-ray diffraction that indium oxide, zinc oxide and magnesium oxide in the sputtering target 8 of this Example 8 are present in the form of hexagonal layer compounds and in the form of In_2MgO_4 similarly to the case of Examples 1 to 7.

[0095]

Transparent conductive film 8a

After the obtained target 8 was set to a DC sputtering device, a transparent conductive film 8a of 130 nm in film thickness was formed on a slide glass at 200°C in the same manner as in the above Examples 1 to 7. The specific resistance and light transmittance (400 nm, 450 nm) of the formed transparent conductive film 8a were measured. The measured values of specific resistance and light transmittance are shown in Fig. 1. Also, this transparent conductive film 8a was measured by X-ray diffraction, with

the result that no peak was observed to find that the transparent conductive film was amorphous. Also, when this transparent conductive film 8a was etched using a weak acid, no residue was generated (Fig. 1).

As mentioned above, in this Example 8, the transparent conductive film 8a was obtained which was improved in light transmittance at a wavelength of 400 to 450 nm though it was amorphous, in the same manner as in the Examples 1 to 7.

Example 9

[0096]

Target 9

The above powders were mixed in the same composition ratios as in the above Example 8, molded and sintered except that a GeO_2 powder was mixed in place of a ZrO_2 powder, to obtain a sintered body. The relative density of the sintered body was found in the same manner as in the above Examples 1 to 8. The relative density obtained at this time is shown in Fig. 1.

[0097]

Also, when the content of Zn, Mg and Ge in the obtained sintered body was quantitatively analyzed by an ICP emission analysis method in the same manner as in the above Examples 1 to 8, it was confirmed that the charged composition when the raw material powders were mixed was kept also in the sintered body. The specific values of the composition ratios in the sintered body confirmed at this time are shown in Fig.

1.

[0098]

Next, a backing plate was applied to the sputtered surface of the sintered body to produce a sputtering target 9 in the same manner as in the above Examples 1 to 8. The bulk resistance of the sputtering target 9 was found in the same manner as in the above Examples 1 to 8. The value of the calculated bulk resistance is shown in Table 1. This target 9 was used to carry out sputtering without generation of nodules (Fig. 1).

[0099]

It has been confirmed by X-ray diffraction that indium oxide, zinc oxide and magnesium oxide in the sputtering target 9 of this Example 9 are present in the form of hexagonal layer compounds and in the form of In_2MgO_4 similarly to the case of Examples 1 to 8.

[0100]

Transparent conductive film 9a

After the obtained target 9 was set to a DC sputtering device, a transparent conductive film 9a of 130 nm in film thickness was formed on a slide glass at 200°C in the same manner as in the above Examples 1 to 8. The specific resistance and light transmittance (400 nm, 450 nm) of the formed transparent conductive film 9a were measured. The measured values of specific resistance and light transmittance are shown in Fig. 1. Also, this transparent conductive film 9a was measured by X-ray diffraction, with

the result that no peak was observed to find that the transparent conductive film was amorphous. Also, when this transparent conductive film 9a was etched using a weak acid, no residue was generated (Fig. 1).

As mentioned above, in this Example 9, the transparent conductive film 9a was obtained which was improved in light transmittance at a wavelength of 400 to 450 nm though it was amorphous, in the same manner as in the Examples 1 to 8.

Example 10

[0101]

No particular limitation is imposed on the sputtering target of the present invention insofar as three components, specifically, indium oxide, zinc oxide and magnesium oxide are contained in each specified ratio. Therefore, for example, the powder mixture consisting of the above three components were mixed, molded and sintered using a known method, whereby the sputtering target can be produced.

[0102]

The sputtering target of the present invention preferably contains components other than the above three components to the extent that the effect of the present invention is not impaired. For example, in the above Examples 5 to 9, the sputtering targets contain SnO_2 , ZrO_2 or GeO_2 in each specified ratio besides the above three components. However, it is preferable that the sputtering target contain Ga_2O_3 , GeO_2 or the like in addition to the aforementioned

components. Also, it is preferable that two or more components selected from SnO_2 , ZrO_2 , GeO_2 , Ga_2O_3 and CeO_2 be contained besides the above three components.

[0103]

When Ga_2O_3 was added in the target, it is preferably dispersed in the form of a complex oxide such as InGaMgO_4 , $\text{InGaMg}_2\text{O}_5$, InGaMgZnO_5 , $\text{InGaMgZn}_2\text{O}_6$, $\text{In}_2\text{Ga}_2\text{ZnO}_7$, InGaZnO_4 , $\text{InGaZn}_2\text{O}_4$, $\text{InGaZn}_3\text{O}_6$, $\text{InGaZn}_4\text{O}_7$, $\text{InGaZn}_5\text{O}_8$, $\text{InGaZn}_6\text{O}_9$ or $\text{InGaZn}_7\text{O}_{10}$.

[0104]

When the sputtering target of this Example 10 contains the aforementioned components such as SnO_2 , ZrO_2 , GeO_2 , Ga_2O_3 or CeO_2 besides the three components, namely, indium oxide, zinc oxide and magnesium oxide, the sputtering target of this Example 10 produces the same action effect as the sputtering targets of the aforementioned Examples 1 to 9. Also, the transparent conductive film formed using the sputtering target like this produces the same action effect as the transparent conductive films of the above Examples 1 to 9.

[0105]

"Comparative Example 1"

ITO target

A commercially available ITO target, specifically, a sputtering target constituted of indium oxide and tin oxide was used to carry out the same treatment and operation as in the above Examples 1 to 9.

The relative density, composition ratios and bulk

resistance of the ITO target were found in the same method as in the above Examples 1 to 9. The calculated relative density, composition ratio and bulk resistance of the ITO target are shown in Fig. 1. [X] in Fig. 1 represents the number of Sn or Zn atoms per unit volume in the target. Also, when this ITO target was used to carry out sputtering, nodules were generated (Fig. 1).

[0106]

Transparent conductive film

After this ITO target was set to a DC sputtering device, a transparent conductive film of 130 nm in film thickness was formed on a slide glass at 200°C in the same manner as in the above Examples 1 to 9. The specific resistance and light transmittance (400 nm, 450 nm) of the formed transparent conductive film were measured. The measured values of specific resistance and light transmittance are shown in Fig. 1. Also, when this transparent conductive film was etched using a weak acid, residues were generated (Fig. 1).

[0107]

As mentioned above, when the transparent conductive film of Comparative Example 1 was etched using a weak acid, etching residues were generated.

[0108]

"Comparative Example 2"

IZO target

A commercially available IZO (indium-zinc oxide: "IZO": trademark) target, specifically, a sputtering target

constituted of indium oxide and zinc oxide was used to carry out the same treatment and operation as in the above Examples 1 to 9.

The relative density, composition ratios and bulk resistance of the IZO target were found in the same method as in the above Examples 1 to 9. The calculated relative density, composition ratio and bulk resistance of the IZO target are shown in Fig. 1. Also, when this IZO target was used to carry out sputtering, nodules were generated (Fig. 1).

[0109]

Transparent conductive film

After this IZO target was set to a DC sputtering device, a transparent conductive film of 130 nm in film thickness was formed on a slide glass at 200°C in the same manner as in the above Examples 1 to 9. The specific resistance and light transmittance (400 nm, 450 nm) of the formed transparent conductive film were measured. The measured values of specific resistance and light transmittance are shown in Fig. 1. Also, when this transparent conductive film was etched using a weak acid, no residue was generated (Fig. 1).

As mentioned above, the light transmittance of the transparent conductive film of Comparative Example 2 at a wavelength of 400 nm to 450 nm was not so high.

CLAIMS

1. A sputtering target comprising:

indium oxide;

zinc oxide; and

magnesium oxide.

2. The sputtering target according to claim 1, wherein, when observing crystal peaks obtained by X-ray diffraction of the sputtering target comprising indium oxide, zinc oxide and magnesium oxide;

said crystal peaks include peaks derived from:

a hexagonal layer compound constituted of indium oxide and zinc oxide and represented by the formula $\text{In}_2\text{O}_3(\text{ZnO})_m$ (where m denotes an integer from 3 to 20); and

In_2MgO_4 constituted of indium oxide and magnesium oxide.

3. The sputtering target according to claim 1, comprising:

a hexagonal layer compound constituted of indium oxide and zinc oxide and represented by the formula $\text{In}_2\text{O}_3(\text{ZnO})_m$ (where m denotes an integer from 3 to 20); and

In_2MgO_4 constituted of indium oxide and magnesium oxide.

4. The sputtering target according to anyone of claims 1 to 3, wherein $[\text{In}]/([\text{In}] + [\text{Zn}] + [\text{Mg}]) = 0.74$ to 0.94 , $[\text{Zn}]/([\text{In}] + [\text{Zn}] + [\text{Mg}]) = 0.05$ to 0.25 and $[\text{Mg}]/([\text{In}] + [\text{Zn}] + [\text{Mg}]) = 0.01$ to 0.20 , where $[\text{In}]$ denotes the number of indium atoms per unit volume, $[\text{Zn}]$ denotes the number of

zinc atoms per unit volume and [Mg] denotes the number of magnesium atoms per unit volume.

5. The sputtering target according to any one of claims 1 to 4, further comprising a positive tetravalent metal oxide.

6. The sputtering target according to claim 5, wherein said positive tetravalent metal oxide is SnO_2 , ZrO_2 , GeO_2 or CeO_2 .

7. The sputtering target according to any one of claims 1 to 4, the sputtering target containing one or two or more metal oxides selected from the group M consisting of SnO_2 , ZrO_2 , GeO_2 , CeO_2 and Ga_2O_3 .

8. The sputtering target according to claim 7, wherein the amount of said one or two or more metal oxides selected from said group M is given by the following equation: $[M]/[\text{All metals}] = 0.0001 \text{ to } 0.15$, where [M] represents the number of metal atoms in one or two or more metal oxides selected from said group M per unit volume, that is, the number of atoms of one or two or more types of Sn, Zr, Ge, Ce and Ga per unit volume and [All metals] represent all metals per unit volume, that is, the sum of the number of In, Zn and Mg atoms and number of atoms in one or two or more metal oxides selected from said group M per unit volume.

9. An amorphous transparent conductive film comprising:

indium oxide;
zinc oxide; and
magnesium oxide.

10. The amorphous transparent conductive film according to claim 9, wherein $[In]/([In] + [Zn] + [Mg]) = 0.74$ to 0.94 , $[Zn]/([In] + [Zn] + [Mg]) = 0.05$ to 0.25 and $[Mg]/([In] + [Zn] + [Mg]) = 0.01$ to 0.20 , where $[In]$ denotes the number of indium atoms per unit volume, $[Zn]$ denotes the number of zinc atoms per unit volume and $[Mg]$ denotes the number of magnesium atoms per unit volume.

11. The amorphous transparent conductive film according to claim 9 or 10, further comprising a positive tetravalent metal oxide.

12. The amorphous transparent conductive film according to claim 11, wherein said positive tetravalent metal oxide is SnO_2 , ZrO_2 , GeO_2 or CeO_2 .

13. The amorphous transparent conductive film according to claim 9 or 10, the conductive film containing one or two or more metal oxides selected from the group M consisting of SnO_2 , ZrO_2 , GeO_2 , CeO_2 and Ga_2O_3 .

14. The amorphous transparent conductive film according to claim 13, wherein the amount of said one or two or more metal oxides selected from said group M is given by the following equation: $[M]/[All\ metals] = 0.0001$ to 0.15 , where $[M]$ represents the number of metal atoms in one or two or more metal oxides selected from said group M per unit volume, that is, the number of atoms of one or two or more types of Sn, Zr, Ge, Ce and Ga per unit volume and $[All\ metals]$ represent all metals per unit volume, that is, the sum of the number of In, Zn and Mg atoms and number of atoms of one or two or

more metal oxides selected from said group M per unit volume.