# Trial decision

Invalidation No. 2014-800138

Kanagawa, Japan	
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The patent invalidation trial case of Patent No. 4568827 "Vapor-phase film formation method for an amorphous oxide thin film" between the parties above has resulted in the following trial decision.

Conclusion

The demand for trial of the case was groundless. The costs in connection with the trial shall be borne by the demandant.

Reason

No. 1 History of the procedures

The history of the procedures for the patent No. 4568827 of the case is outlined below.

Original application (Japanese Patent Application No. 2006-	510907)
Original filing date	February 28, 2005
Written application for exception to lack of novelty	August 22, 2006
Internal priority (Japanese Patent Application No. 2004-714	77)
Priority date	March 12, 2004
Internal priority (Japanese Patent Application No. 2004-325)	938)
Priority date	November 10, 2004
International application (PCT/JP2005/3273)	
International application date	February 28, 2005
Patent application (Japanese Patent Application No. 2010-68	3707)
Application date	March 24, 2010
Written request for examination:	March 25, 2010
Written amendment	March 30, 2010
Explanation of circumstances concerning accelerate	ed examination
	April 13, 2010
Written statement	April 19, 2010
Interview record	May 19, 2010
Notice of reasons for refusal (mailing date)	May 25, 2010
Written amendment and written opinion	June 21, 2010
Decision to grant a patent (mailing date)	July 13, 2010
Registration date	August 20, 2010
Demand for invalidation trial	August 28, 2014
Demandee: written reply	November 20, 2014
Notification of matters to be examined (mailing dat	e) December 25,
2014	
Demandant: oral proceedings statement brief	February 9, 2015
Demandee: oral proceedings statement brief	February 9, 2015
Demandee: written statement	dated February 17, 2015,
(received on February 18, 2015)	
Demandee: oral proceedings statement brief (2)	February 20, 2015
Oral proceedings	February 23, 2015
Demandant: written statement	February 26, 2015
Demandee: written statement	March 13, 2015 (date of
acceptance)	

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#### No. 2 The Invention

The invention according to claims 1 to 5 of the patent No. 4568827 (hereinafter referred to as "patent invention 1" to "patent invention 5") is recognized as follows.

#### "[Claim 1]

A vapor-phase film formation method for an amorphous oxide thin film, wherein a pulsed laser deposition method or an RF sputtering method is applied to an oxide thin film with a crystallized composition thereof expressed by a formula  $InGaO_3(ZnO)_m$  (m is a natural number of less than 6),

when depositing the thin film on a substrate using a polycrystal of the oxide as a target in an atmosphere containing an oxygen gas without intentionally adding impurity ions for enhancing electric resistance to the thin film in a state where a temperature of the substrate is not intentionally increased,

a semi-insulating transparent In-Ga-Zn-O thin film having an electron mobility of 0.1 cm<sup>2</sup>/(V.second) or more at room temperature and an electron carrier concentration of  $10^{16}$ /cm<sup>3</sup> or less at room temperature is formed by controlling the magnitude of oxygen partial pressure so that the formed thin film has an electron carrier concentration of  $10^{16}$ /cm<sup>3</sup> or less at room temperature.

[Claim 2]

A vapor-phase film formation method for an amorphous oxide thin film, wherein a pulsed laser deposition method or an RF sputtering method is applied to an oxide thin film with a crystallized composition thereof expressed by a formula  $InGaO_3(Zn_{1-x}Mg_xO)_m$  (m is a natural number of less than 6,  $0.80 \le x < 0.85$ ),

when depositing the thin film on a substrate using a polycrystal of the oxide as a target in an atmosphere containing an oxygen gas without intentionally adding impurity ions for enhancing electric resistance to the thin film in a state where a temperature of the substrate is not intentionally increased,

a semi-insulating transparent In-Ga-Zn-Mg-O thin film having an electron mobility of 0.1 cm<sup>2</sup>/(V.second) or more at room temperature and an electron carrier concentration of  $10^{16}$ /cm<sup>3</sup> or less at room temperature is formed by controlling the magnitude of oxygen partial pressure so that the formed thin film has an electron carrier concentration of  $10^{16}$ /cm<sup>3</sup> or less at room temperature.

[Claim 3]

The vapor-phase film formation method for an amorphous oxide thin film according to claim 1 or 2, wherein a glass substrate, a plastic substrate, or a plastic film is used as the substrate.

### [Claim 4]

The vapor-phase film formation method for an amorphous oxide thin film according to claim 1, wherein the pulsed laser deposition method is used to form the film in a vacuum atmosphere with an oxygen partial pressure of more than 5 Pa. [Claim 5]

The vapor-phase film formation method for an amorphous oxide thin film according to claim 1, wherein the RF sputtering method is used to form the film in a mixed atmosphere of an oxygen gas and an argon gas with an oxygen partial pressure of more than  $4x10^{-2}$  Pa."

It should be noted that "an electron mobility of  $0.1 \text{ cm}_2/(\text{V. second})$  or more at room temperature" is described in claim 2 in the scope of claims for patent, "cm<sub>2</sub>/(V.second)" does not exist as the unit of the electron mobility, and hence "cm<sup>2</sup>/(V.second)" is recognized as a correct notation described in claim 1 as the unit of the electron mobility. Therefore, "an electron mobility of  $0.1 \text{ cm}_2/(\text{V.second})$  or more at room temperature" described in claim 2 is recognized as an error in writing and "an electron mobility of  $0.1 \text{ cm}^2/(\text{V.second})$  or more at room temperature" is recognized to be correct. Accordingly, patent invention 2 is recognized as described above.

### No. 3 Argument of Demandant

1 Against this, the demandant demanded the trial decision stating that "the patent for the invention according to claims 1 to 5 of Japanese patent No. 4568827 is invalid. The costs in connection with the trial shall be borne by the demandee," and submitted the following Evidence A No. 1 - Evidence A No. 22 attached to the written demand for trial as a means of proof.

In addition, the demandant alleged at the oral proceedings dated February 23, 2015 except for the above written demand for trial, the fourth line of page 32 to the 12th line of page 33 and the 15th line of page 37 to the 14th line of page 38 of the oral proceedings statement brief dated February 9, 2015, as well as the attached Reference Material 4 and Reference Material 5.

Further, the demandant submitted the written statement dated February 26, 2015 and March 13, 2015.

• Evidence A No. 1: Japanese Unexamined Patent Application Publication No. H5-251705

• Evidence A No. 2: International Publication No. WO 03/098699

• Evidence A No. 3: National Publication of International Patent Application No. H11-505377

• Evidence A No. 4: Japanese Unexamined Patent Application Publication No. 2000-44236

• Evidence A No. 5: Japanese Unexamined Patent Application Publication No. 2002-289859

• Evidence A No. 6: Technology of the transparent conductive film, Japan Society for the Promotion of Science, transparent oxide light - electronic materials 166 committee, first edition second printing issued April 25, 2000, pp. 78-81, pp. 148-155

• Evidence A No. 7: M. ORITA et al., "Amorphous transparent conductive oxide  $InGaO_3(ZnO)_m$  (m $\leq$ 4): a Zn4s conductor," PHILOSOPHICAL MAGAZINE B, 2001, VOL. 81, No. 5, pp. 501-515

• Evidence A No. 8: The 47th Spring Meeting of The Japan Society of Applied Physics and Related Societies, 2000, lecture Proceedings, Vol 2, pp. 577, 28a-ZB-1

• Evidence A No. 9: Satoru Narushima et al., "A p-Type Amorphous Oxide Semiconductor and Room Temperature Fabrication of Amorphous Oxide p-n Heterojunction Diodes, "Adv. Mater., 2003, vol. 15, No. 17, September 3, pp. 1409-1413

• Evidence A No. 10: Kenji Nomura et al., "Thin-Film Transistor Fabricated in Single-Crystalline Transparent Oxide Semiconductor, "Science 300, 1269 (2003), pp. 1269-1272

• Evidence A No. 11: International Publication No. WO 03/040441

• Evidence A No. 12: Japanese Unexamined Patent Application Publication No. H8-245220

• Evidence A No. 13: Japanese Unexamined Patent Application Publication No. S63-239117

• Evidence A No. 14: National Publication of International Patent Application Publication No. 2007-529119 (National publication of international publication of Japanese Patent Application No. 2007-502848)

• Evidence A No. 15: Japanese Patent Application No. 2007-502848, notice of reasons for refusal dated June 2, 2010

• Evidence A No. 16: Japanese Patent Application No. 2007-502848, written amendment dated December 8, 2010

• Evidence A No. 17: Japanese Patent Application No. 2007-502848, decision of refusal dated September 12, 2011

• Evidence A No. 18: Japanese Patent Application No. 2007-502848, written demand for trial dated January 20, 2012

• Evidence A No. 19: Japanese Patent Application No. 2007-502848, written amendment dated January 20, 2012

• Evidence A No. 20: Appeal No. 2012-1120 (Japanese Patent Application No. 2007-502848), notice of reasons for refusal dated January 28, 2013

• Evidence A No. 21: Appeal No. 2012-1120 (Japanese Patent Application No. 2007-502848), written amendment dated July 29, 2013

• Evidence A No. 22: Appeal No. 2012-1120 (Japanese Patent Application No. 2007-502848), trial decision dated September 20, 2013

It should be noted that the demandee has recognized establishment of Evidence A No. 1 to Evidence A No. 22.

2 When the argument of the demandant in the written demand for trial and the oral proceedings are summarized, regarding reasons for invalidation 1-5, it is recognized that the demandant approximately argued as follows.

(1) Reasons for invalidation 1: summary of reasons for invalidation 1 (Article 29(2) of the Patent Act)

As described in A to E below, the Invention according to claims 1 to 5 of the patent could be easily made by a person skilled in the art based on the invention described in Evidence A No. 1, Evidence A No. 3, Evidence A No. 4, Evidence A No. 5, Evidence A No. 6, Evidence A No. 7, Evidence A No. 8, Evidence A No. 9, Evidence A No. 10, Evidence A No. 11, and Evidence A No. 12 distributed in Japan or abroad before the priority date, and thus demandee should not be granted a patent for the Invention in accordance with the provisions of Article 29(2) of the Patent Act.

Accordingly, the Invention according to claims 1 to 5 of the patent falls under the provisions of Article 123(1)(ii) of the Patent Act and should be invalidated.

A The invention according to claim 1 could be easily made by a person skilled in the art based on the invention described in Evidence A No. 1, Evidence A No. 4, Evidence A No. 5, Evidence A No. 6, Evidence A No. 7, Evidence A No. 8, Evidence A No. 9, Evidence A No. 10, and Evidence A No. 11.

B The invention according to claim 2 could be easily made by a person skilled in the art based on the invention described in Evidence A No. 1, Evidence A No. 4, Evidence A No. 5, Evidence A No. 6, Evidence A No. 7, Evidence A No. 8, Evidence A No. 9, Evidence A No. 10, Evidence A No. 11, and Evidence A No. 12.

C The invention according to claim 3 could be easily made by a person skilled in the art based on the invention described in Evidence A No. 1, Evidence A No. 4, Evidence A No. 5, Evidence A No. 6, Evidence A No. 7, Evidence A No. 8, Evidence A No. 9, Evidence A No. 10, Evidence A No. 11, and Evidence A No. 12.

D The invention according to claim 4 could be easily made by a person skilled in the art based on the invention described in Evidence A No. 1, Evidence A No. 3, Evidence A No. 4, Evidence A No. 5, Evidence A No. 6, Evidence A No. 7, Evidence A No. 8, Evidence A No. 9, Evidence A No. 10, and Evidence A No. 11.

E The invention according to claim 5 could be easily made by a person skilled in the art based on the invention described in Evidence A No. 1, Evidence A No. 4, Evidence A No. 5, Evidence A No. 6, Evidence A No. 7, Evidence A No. 8, Evidence A No. 9, Evidence A No. 10, and Evidence A No. 11.

(2) Reasons for invalidation 2: summary of reasons for invalidation 2 (Article 29(2) of the Patent Act)

As described in A to E below, the Invention according to claims 1 to 5 of the patent could be easily made by a person skilled in the art based on the invention described in Evidence A No. 1, Evidence A No. 2, Evidence A No. 4, Evidence A No. 5, Evidence A No. 6, Evidence A No. 7, Evidence A No. 8, Evidence A No. 9, Evidence A No. 10, Evidence A No. 11, Evidence A No. 12, and Evidence A No. 13 distributed in Japan or abroad before the priority date, and thus demandee should not be granted a patent for the Invention in accordance with the provisions of Article 29(2) of the Patent Act.

Accordingly, the Invention according to claims 1 to 5 of the patent falls under the provisions of Article 123(1)(ii) of the Patent Act and should be invalidated.

A The invention according to claim 1 could be easily made by a person skilled in the art based on the invention described in Evidence A No. 1, Evidence A No. 2, Evidence A

No. 4, Evidence A No. 5, Evidence A No. 6, Evidence A No. 7, Evidence A No. 8, Evidence A No. 9, Evidence A No. 10, Evidence A No. 11, and Evidence A No. 13.

B The invention according to claim 2 could be easily made by a person skilled in the art based on the invention described in Evidence A No. 1, Evidence A No. 2, Evidence A No. 4, Evidence A No. 5, Evidence A No. 6, Evidence A No. 7, Evidence A No. 8, Evidence A No. 9, Evidence A No. 10, Evidence A No. 11, Evidence A No. 12, and Evidence A No. 13.

C The invention according to claim 3 could be easily made by a person skilled in the art based on the invention described in Evidence A No. 1, Evidence A No. 2, Evidence A No. 4, Evidence A No. 5, Evidence A No. 6, Evidence A No. 7, Evidence A No. 8, Evidence A No. 9, Evidence A No. 10, Evidence A No. 11, Evidence A No. 12, and Evidence A No. 13.

D The invention according to claim 4 could be easily made by a person skilled in the art based on the invention described in Evidence A No. 1, Evidence A No. 2, Evidence A No. 4, Evidence A No. 5, Evidence A No. 6, Evidence A No. 7, Evidence A No. 8, Evidence A No. 9, Evidence A No. 10, Evidence A No. 11, and Evidence A No. 13.

E The invention according to claim 5 could be easily made by a person skilled in the art based on the invention described in Evidence A No. 1, Evidence A No. 2, Evidence A No. 4, Evidence A No. 5, Evidence A No. 6, Evidence A No. 7, Evidence A No. 8, Evidence A No. 9, Evidence A No. 10, Evidence A No. 11, and Evidence A No. 13.

(3) Reasons for invalidation 3: summary of reasons for invalidation 3 (Article 29(2) of the Patent Act)

As described in A to E below, the Invention according to claims 1 to 5 of the patent could be easily made by a person skilled in the art based on the invention described in Evidence A No. 1, Evidence A No. 3, Evidence A No. 4, Evidence A No. 5, Evidence A No. 6, Evidence A No. 7, Evidence A No. 8, Evidence A No. 9, Evidence A No. 10, Evidence A No. 11, Evidence A No. 12, and Evidence A No. 13 distributed in Japan or abroad before the priority date, and thus demandee should not be granted a patent for the Invention in accordance with the provisions of Article 29(2) of the Patent Act.

Accordingly, the Invention according to claims 1 to 5 of the patent falls under the provisions of Article 123(1)(ii) of the Patent Act and should be invalidated.

A The invention according to claim 1 could be easily made by a person skilled in the art based on the invention described in Evidence A No. 1, Evidence A No. 3, Evidence A No. 4, Evidence A No. 5, Evidence A No. 6, Evidence A No. 7, Evidence A No. 8, Evidence A No. 9, Evidence A No. 10, Evidence A No. 11, and Evidence A No. 13.

B The invention according to claim 2 could be easily made by a person skilled in the art based on the invention described in Evidence A No. 1, Evidence A No. 3, Evidence A No. 4, Evidence A No. 5, Evidence A No. 6, Evidence A No. 7, Evidence A No. 8, Evidence A No. 9, Evidence A No. 10, Evidence A No. 11, Evidence A No. 12, and Evidence A No. 13.

C The invention according to claim 3 could be easily made by a person skilled in the art based on the invention described in Evidence A No. 1, Evidence A No. 3, Evidence A No. 4, Evidence A No. 5, Evidence A No. 6, Evidence A No. 7, Evidence A No. 8, Evidence A No. 9, Evidence A No. 10, Evidence A No. 11, Evidence A No. 12, and Evidence A No. 13.

D The invention according to claim 4 could be easily made by a person skilled in the art based on the invention described in Evidence A No. 1, Evidence A No. 3, Evidence A No. 4, Evidence A No. 5, Evidence A No. 6, Evidence A No. 7, Evidence A No. 8, Evidence A No. 9, Evidence A No. 10, Evidence A No. 11, and Evidence A No. 13.

E The invention according to claim 5 could be easily made by a person skilled in the art based on the invention described in Evidence A No. 1, Evidence A No. 3, Evidence A No. 4, Evidence A No. 5, Evidence A No. 6, Evidence A No. 7, Evidence A No. 8, Evidence A No. 9, Evidence A No. 10, Evidence A No. 11, and Evidence A No. 13.

(4) Reasons for invalidation 4: summary of reasons for invalidation 4 (Article 29(2) of the Patent Act)

As described in A to D below, the Invention according to claims 1, 3, 4, and 5 of the patent could be easily made by a person skilled in the art based on the invention described in Evidence A No. 1, Evidence A No. 4, Evidence A No. 5, Evidence A No. 6, Evidence A No. 7, Evidence A No. 9, Evidence A No. 10, and Evidence A No. 11

distributed in Japan or abroad before the priority date, and thus demandee should not be granted a patent for the Invention in accordance with the provisions of Article 29(2) of the Patent Act.

Accordingly, the Invention according to claims 1, 3, 4, and 5 of the patent falls under the provisions of Article 123(1)(ii) of the Patent Act and should be invalidated.

A The invention according to claim 1 could be easily made by a person skilled in the art based on the invention described in Evidence A No. 1, Evidence A No. 4, Evidence A No. 5, Evidence A No. 6, Evidence A No. 7, Evidence A No. 9, Evidence A No. 10, and Evidence A No. 11.

B The invention according to claim 3 could be easily made by a person skilled in the art based on the invention described in Evidence A No. 1, Evidence A No. 4, Evidence A No. 5, Evidence A No. 6, Evidence A No. 7, Evidence A No. 9, Evidence A No. 10, and Evidence A No. 11.

C The invention according to claim 4 could be easily made by a person skilled in the art based on the invention described in Evidence A No. 1, Evidence A No. 3, Evidence A No. 4, Evidence A No. 5, Evidence A No. 6, Evidence A No. 7, Evidence A No. 9, Evidence A No. 10, and Evidence A No. 11.

D The invention according to claim 5 could be easily made by a person skilled in the art based on the invention described in Evidence A No. 1, Evidence A No. 4, Evidence A No. 5, Evidence A No. 6, Evidence A No. 7, Evidence A No. 9, Evidence A No. 10, and Evidence A No. 11.

(5) Reasons for invalidation 5: summary of reasons for invalidation 5 (Article 36(4)(i) of the Patent Act)

The detailed description of the invention of the patent description does not satisfy the enablement requirement for the invention according to claims 1, 3, 4, and 5 of the patent. Therefore, the patent for the invention according to claims 1, 3, 4, and 5 of the patent was issued to the patent application that does not satisfy the requirements provided in Article 36(4)(i) of the Patent Act and hence falls under the provisions in Article 123(1)(iv) of the Patent Act and should be invalidated.

No. 4 Argument of Demandee

According to the written reply dated November 20, 2014, the demandee demanded the trial decision stating that "the demand for trial of the case was groundless. The costs in connection with the trial shall be borne by the demandant." According to the above written reply, the demandee demanded that reasons 1-5 for invalidation are not found.

In addition, the demandee submitted the following Evidence B No. 1 to Evidence B No. 3 attached to the written reply.

- Evidence B No. 1 "Nature"<Vol. 432, November 25, 2004, pp. 488-492>
- Evidence B No. 2 Japanese Patent No. 5219369

• Evidence B No. 3 "ZnO Thin Film Transistors for Flexible Electronics," Mat. Res. Soc. Symp. Proc., Vol. 769, 2003

It should be noted that the demandant has recognized the establishment of Evidence B No. 1 to Evidence B No. 3.

In addition, the demandee stated at the oral proceedings dated February 23, 2015 that regarding the above written reply, the oral proceedings statement brief dated February 9, 2015, the written statement dated February 17, 2015, and the oral proceedings statement brief (2) dated February 20, 2015, correcting "about  $10^{-7}$  amps of leakage current" on page 18 of the oral proceedings statement document to "about  $10^{-6}$  amps of leakage current."

Further, the demandee submitted the written statement dated March 13, 2015.

No. 5 Regarding the reasons for invalidation 1

1 Patent Invention 1

The patent invention 1 is as previously recognized in "No. 2 The Invention," and is reproduced as follows.

[Claim 1]

A vapor-phase film formation method for an amorphous oxide thin film, wherein

a pulsed laser deposition method or an RF sputtering method is applied to an oxide thin film with a crystallized composition thereof expressed by a formula  $InGaO_3(ZnO)_m$  (m is a natural number of less than 6),

when depositing the thin film on a substrate using a polycrystal of the oxide as a target in an atmosphere containing an oxygen gas without intentionally adding impurity ions for enhancing electric resistance to the thin film in a state where a temperature of the substrate is not intentionally increased,

a semi-insulating transparent In-Ga-Zn-O thin film having an electron mobility of 0.1 cm<sup>2</sup>/(V.second) or more at room temperature and an electron carrier concentration of  $10^{16}$ /cm<sup>3</sup> or less at room temperature is formed by controlling the magnitude of oxygen partial pressure so that the formed thin film has an electron carrier concentration of  $10^{16}$ /cm<sup>3</sup> or less at room temperature.

### 2 Matters described in Evidence A No. 1

Regarding "thin film transistor" (Title of the Invention), Evidence A No. 1 includes FIGS. 1 to 6 and the following matters (the underlines are added by the body and the same shall apply hereinafter.)

(A-1a) "[Claim 2] A thin film transistor comprising a gate electrode, a gate insulating film, a source electrode, a drain electrode, and a semiconductor layer, wherein the semiconductor layer has a carrier concentration of  $10^{18}$ .cm<sup>-3</sup> or less, and the semiconductor layer is a translucent film." ([Scope of claims])

(A-1b) "In view of the above circumstances, the present invention has been made, and an object of the present invention is to provide a thin film transistor capable of further increasing an aperture ratio thereof without being affected by light by using <u>a</u> <u>semiconductor made of transparent material having a band gap greater than that of</u> <u>amorphous silicon</u> as a semiconductor layer." ([0007])

(A-1c) "[Means for Solving the Problems] The invention according to claim 1 for solving the above problems of the prior art is a thin film transistor comprising a gate electrode, a gate insulating film, a source electrode, a drain electrode, and a semiconductor layer, wherein the semiconductor layer has an energy band gap between a conduction band and a valence band of 3eV or more, and the semiconductor layer is a translucent film." ([0008])

(A-1d) "[Operation] According to the invention of claim 1, the thin film transistor is such that <u>the semiconductor layer has an energy band gap between a conduction band</u> and a valence band of 3eV or more, and the semiconductor layer is a translucent film, and hence conductivity is unlikely to be changed even when light is transmitted therethrough." ([0010])

(A-1e) "...the intra-film oxygen concentration is adjusted and <u>an ITO film</u> to be a semiconductor active layer 8 is deposited to a film thickness of <u>approximately 500</u> <u>angstroms by sputtering</u>. More specifically, this can be achieved by sputtering at an oxygen gas concentration of 1% or more at film deposition. At this time, <u>when the carrier concentration of the ITO film is  $10^{18}$  cm<sup>-3</sup> or less, the degeneracy is resolved to provide an ITO film (semiconductor active layer 8) as the semiconductor." ([0015]-[0016])</u>

(A-1f) "In general, an oxide transparent conductive film such as ITO can change the electrical conductivity of the film by changing the intra-film oxygen content. This is because carriers are generated by deviation from the stoichiometric composition (oxygen deficiency)." ([0019])

(A-1g) "The oxygen concentration dependence at sputtering of electrical resistivity of the ITO (Indium Tin Oxide) film has characteristics as shown in FIG. 2. Thus, if the percentage of the oxygen gas ( $O_2/Ar+O_2$ ) is 1% or more in the reactive sputtering using an Ar gas and an oxygen gas, electrical resistivity ( $\rho[\Omega.cm]$ ) of the ITO film can be increased, and hence <u>control can be made to reduce the conductivity of the ITO film.</u>" ([0020])

(A-1h) "The thin film transistor of the first embodiment has effects such that the conductivity can be reduced by controlling the intra-film carrier concentration to be  $10^{18}$  cm<sup>-3</sup> or less by increasing the intra-film oxygen content of the ITO film used for the conventional transparent electrode, and the element characteristics can be improved without being affected by light by using the ITO film as the semiconductor active layer <u>8.</u>" ([0022])

3 Judgment by the body regarding the patent invention 1

When the above excerpts (A-1a) to (A-1h) are summarized, it is recognized that Evidence A No. 1 describes the following invention (hereinafter referred to as "Cited Invention 1".)

"A vapor-phase film formation method for a semiconductor layer of a thin film transistor, wherein the thin film transistor comprises a gate electrode, a gate insulating film, a source electrode, a drain electrode, and a semiconductor layer; and the

<sup>(1)</sup> Cited Invention 1

semiconductor layer has a carrier concentration of  $10^{18}$ .cm<sup>-3</sup> or less, and the semiconductor layer is a translucent film; wherein

the percentage of the oxygen gas  $(O_2/Ar+O_2)$  at film deposition is 1% or more in the reactive sputtering using an Ar gas and an oxygen gas, and the intra-film oxygen content of the ITO (Indium Tin Oxide) film as an oxide transparent conductive film used for the conventional transparent electrode is increased, whereby the number of carriers generated by deviation from the stoichiometric composition (oxygen deficiency) of the deposited ITO film is reduced; the carrier concentration of the ITO film is controlled to  $10^{18}$ .cm<sup>-3</sup> or less; and the degeneracy is resolved to reduce the conductivity, thereby to provide the ITO film (semiconductor active layer) as a semiconductor."

#### (2) Comparison

A The patent invention 1 is compared with the Cited Invention 1.

B "ITO (Indium Tin Oxide) film" in the Cited Invention 1 and "an oxide thin film with a crystallized composition thereof expressed by a formula  $InGaO_3(ZnO)_m$  (m is a natural number of less than 6)" in the patent invention 1 are common in that both films are "oxide thin films."

C In addition, "ITO film (semiconductor active layer) as a semiconductor" in the Cited Invention 1 and "transparent In-Ga-Zn-O thin film" in the patent invention 1 are common in that both films are "transparent oxide thin films."

D Therefore, the film formation method wherein "the percentage of the oxygen gas  $(O_2/Ar+O_2)$  at film deposition is 1% or more in the reactive sputtering using an Ar gas and an oxygen gas, and the intra-film oxygen content of the ITO (Indium Tin Oxide) film as an oxide transparent conductive film used for the conventional transparent electrode is increased, whereby the number of carriers generated by deviation from the stoichiometric composition (oxygen deficiency) of the deposited ITO film is reduced; the carrier concentration of the ITO film is controlled to  $10^{18}$ .cm<sup>-3</sup> or less; and the degeneracy is resolved to reduce the conductivity, thereby to provide the ITO film (semiconductor active layer) as a semiconductor" in the Cited Invention 1 and the method wherein "when depositing the thin film on a substrate using a polycrystal of the oxide as a target in an atmosphere containing an oxygen gas without intentionally adding impurity ions for enhancing electric resistance to the thin film in a state where a

temperature of the substrate is not intentionally increased, a semi-insulating transparent In-Ga-Zn-O thin film having an electron mobility of  $0.1 \text{ cm}^2/(\text{V.second})$  or more at room temperature and an electron carrier concentration of  $10^{16}/\text{cm}^3$  or less at room temperature is formed by controlling the magnitude of oxygen partial pressure so that the formed thin film has an electron carrier concentration of  $10^{16}/\text{cm}^3$  or less at room temperature" in the patent invention 1 are common in that both methods are such that "when depositing the thin film on a substrate in an atmosphere containing an oxygen gas, the magnitude of oxygen partial pressure is controlled to reduce the electron carrier concentration of the formed thin film, thereby to form a transparent oxide thin film."

E Considering the above, the corresponding features and the different features between the patent invention 1 and the Cited Invention 1 are as follows.

#### <Corresponding feature>

A vapor-phase film formation method for an oxide thin film wherein

when depositing the thin film on a substrate in an atmosphere containing an oxygen gas, the magnitude of oxygen partial pressure is controlled to reduce the electron carrier concentration of the formed thin film, thereby to form a transparent oxide thin film.

#### <The different feature>

• Different feature 1-1: The transparent oxide thin film to be formed differs such that in the case of the patent invention 1, the transparent oxide thin film is ""an oxide thin film with a crystallized composition thereof expressed by a formula  $InGaO_3(ZnO)_m$  (m is a natural number of less than 6)" formed by "a pulsed laser deposition method or an RF sputtering method" "using a polycrystal of the oxide as a target, in a state where a temperature of the substrate is not intentionally increased, without intentionally adding impurity ions for enhancing electric resistance to the thin film" and is "an amorphous oxide thin film," which is "semi-insulating transparent In-Ga-Zn-O thin film," wherein "the electron carrier concentration of the formed thin film at room temperature is  $10^{16}$ /cm<sup>3</sup> or less," and "the electron mobility at room temperature is  $0.1 \text{ cm}^2/(\text{V.second})$  or more,"" while in the case of Cited Invention 1, the transparent oxide thin film is ""an ITO film which is an oxide transparent electrode," wherein "the carrier concentration is controlled to  $10^{18} \text{ cm}^{-3}$  or less.""

(3) Judgment of the different feature

• Regarding the different feature 1-1

A <Technical findings concerning the transparent oxide thin film before the priority date of the subject patent>

(A) Evidence A No. 1 describes the following matters.

(A-1e) (reproduced) "... the intra-film oxygen concentration is adjusted and an ITO film to be a semiconductor active layer 8 is deposited to a film thickness of approximately 500 angstroms by sputtering. More specifically, this can be achieved by sputtering at an oxygen gas concentration of 1% or more at film deposition. At this time, when the carrier concentration of the ITO film is 10<sup>18</sup>.cm<sup>-3</sup> or less, the degeneracy is resolved to provide an ITO film (semiconductor active layer 8) as the semiconductor." ([0015]-[0016])

(A-1f) (reproduced) "<u>In general, an oxide transparent conductive film such as ITO can change the electrical conductivity of the film by changing the intra-film oxygen content.</u> This is because carriers are generated by deviation from the stoichiometric composition (oxygen deficiency)." ([0019])

(A-1h) (reproduced) "<u>The thin film transistor of the first embodiment has effects such</u> that the conductivity can be reduced by controlling the intra-film carrier concentration to be  $10^{18}$ .cm<sup>-3</sup> or less by increasing the intra-film oxygen content of the ITO film used for the conventional transparent electrode, and the element characteristics can be improved without being affected by light by using the ITO film as the semiconductor active layer 8." ([0022])

(B) Evidence A No. 5 describes the following matters.

(A-5a) "Here, the ZnO film is widely used for the transparent conductive film, but <u>the</u> ZnO film used for the semiconductor active layer of the thin film transistor of the present invention is such that the carrier concentration thereof is controlled to  $10^{18}$ .cm<sup>-3</sup> or less. In the conductive oxide film such as a ZnO film, generally, the composition is slightly reductively deviated from the stoichiometric composition, and thereby intrinsic defects such as oxygen vacancies form a donor level. Thus, the carrier concentration reaches approximately  $10^{18}$  to  $10^{19}$  cm<sup>-3</sup>. When the carrier concentration is increased to more than  $10^{18}$ .cm<sup>-3</sup>, the Fermi level reaches the conductor and enters into a state of degeneracy. Then, the ZnO film acts like a metal. On the contrary, when the carrier

concentration is reduced to  $10^{18}$ .cm<sup>-3</sup> or less, the state of degeneracy is resolved. Then, the ZnO film can be used for the semiconductor active layer." ([0036])

(A5-b) "To make an electrode transparent to visible light, the electrode may be made to be a transparent conductive film. The <u>transparent conductive film</u> as the electrode may be made of any material as long as the film is transparent to visible light and a low resistivity can be obtained. For example, an oxide material such as an <u>indium oxide</u> (In<sub>2</sub>O<sub>3</sub>), a tin oxide (SnO<sub>2</sub>), and a ZnO, and the oxide material doped with impurities may be used as the transparent conductive film material. The oxide material (oxide semiconductor) such as In<sub>2</sub>O<sub>3</sub>, SnO<sub>2</sub>, and ZnO is originally an n-type degenerate semiconductor having a low resistivity of approximately  $10^{-1}$  to  $10^{-3}\Omega$  cm. By doping such an oxide material with impurities, the carrier density can be increased to approximately  $10^{-3}$  to  $10^{-4}\Omega$  cm. More specifically, for example, In<sub>2</sub>O<sub>3</sub> doped with tin (Sn) (generally referred to as ITO (Indium Tin Oxide), SnO<sub>2</sub> doped with antimony (Sb) or fluorine (F), ZnO doped with In, ZnO doped with gallium (Ga) (generally referred to as GZO), ZnO doped with AI (generally referred to as AZO), or the like may be used as the transparent conductive film material." ([0039])

(A-5c) "The ZnO film as the semiconductor active layer 4 was formed at a substrate temperature of 450°C by pulsed laser deposition. The ZnO film was formed to a thickness of approximately 500 Å. <u>By adjusting the oxygen concentration in the ZnO film, the carrier density and the electrical conductivity of the ZnO film was adjusted to a predetermined value.</u>" ([0067])

(C) Evidence A No. 6 describes the following matters.

(A6-a) "As a typical electrically conductive oxide thin film having some sufficient conductivity,  $\underline{\text{In}_2O_3}^{(1), 2)}$ ,  $\underline{\text{Sn}O_2}^{(3), 4)}$ ,  $\underline{\text{Zn}O}^{(5), 6)}$ ,  $\underline{\text{CdO}}^{(7), 8)}$ ,  $\underline{\text{CdIn}_2O_4}^{(9)}$ ,  $\underline{\text{Cd}_2\text{Sn}O_4}^{(10), 11)}$ ,  $\underline{\text{Zn}_2\text{Sn}O_4}$ ,  $\underline{\text{In}_2O_3}$ - $\underline{\text{Zn}O}$  system<sup>12)</sup> and the like are reported. These oxide semiconductors have a band gap of 3eV or more. Thus, light absorption due to interband transition of electrons occurs in an ultraviolet region with an energy of 350 to 400 nm or more and does not occur in a visible light region. This is because the photon energy in the visible region is insufficient to excite electrons in the valence band up to the conduction band over the band gap. Thus, the oxide semiconductors become transparent in the visible region." (on the sixth line from the bottom of page 79 to the first line of page 80)

(A6-b) "In addition, the composition is slightly reductively deviated from the stoichiometric composition, and thereby intrinsic defects such as oxygen vacancies form a donor level. Thus, the conduction electron density (carrier concentration) reaches approximately  $10^{18}$  to  $10^{19}$  cm<sup>-3</sup>. In the band structure of these conductive oxides, the valence band is mainly composed of the 2p orbital of oxygen atom and the conduction band is composed of the s orbital of metal atom (see 4-2-2). When the carrier density is increased to more than  $10^{18}$  cm<sup>-3</sup>, the Fermi level reaches the conduction band and enters into a state called degeneracy." (on the second line to the seventh line of page 80)

(A6-c) "Further, by adding Sn (ITO)<sup>1),13)</sup> to In<sub>2</sub>O<sub>3</sub>, Sb<sup>14),15)</sup>, F<sup>16) to 18)</sup> to SnO<sub>2</sub>, In<sup>19)</sup>, Ga (GZO)<sup>20)</sup>, Al (AZO)<sup>21),22)</sup> to ZnO, and the like, as the dopant, the conduction electron density can be increased to  $10^{20}$  to  $20^{21}$  cm<sup>-3</sup>, and the specific resistance can be reduced to approximately  $10^{-3}$  to  $10^{-4}\Omega$ . cm. For example, when tetravalent Sn is subjected to substitutional solid solution in the trivalent In site in the case of the ITO (indium tin oxide), or trivalent Ga or Al is subjected to substitutional solid solution in the divalent Zn site in the case of GZO or AZO, these impurity dopants can release one carrier per atom." (on the 17th to 23rd lines of page 80)

(A6-d) "Of <u>the electrically conductive oxide thin films doped with these impurities</u>, the <u>Sn-doped In<sub>2</sub>O<sub>3</sub> (ITO) thin film</u> is the most excellent in both high transmittance and high electrical conductivity as compared with other materials, ..." (on the fifth to seventh lines of page 81)

(D) It can be understood from the description of each items of Evidence A above that the electron carrier concentration of the conductive oxides is greater than  $10^{18}$  cm<sup>-3</sup>; the conductivity may occur in the conductive oxide film in such a manner that the composition is slightly reductively deviated from the stoichiometric composition, and thereby intrinsic defects such as oxygen vacancies form a donor level; and thus when the carrier concentration is reduced to  $10^{18}$  cm<sup>-3</sup> or less by increasing the intra-film oxygen content, the state of degeneracy is resolved, and then, the conductive oxide film can be used for the semiconductor active layer; and the above technical knowledge was known before the priority date of the subject patent.

B <Regarding InGaO<sub>3</sub>(ZnO)<sub>m</sub>>

(A) Evidence A No. 7 describes the following matters.

(A7-a) "Amorphous transparent conductive oxide  $InGaO_3(ZnO)_m~(m{\leq}4)$ : a Zn 4s conductor" (Title)

#### (A7-b) "Summary

With the purpose of creating ZnO-based amorphous transparent conductors, various amorphous films  $InGaO_3(ZnO)_m$  (m≤4) were prepared using a pulsed-laser deposition method. ... It was revealed that the conduction band tail had a large dispersion and the Fermi level was located at the conduction band edge. ... The present system is the first amorphous oxide semiconductor in which Zn 4s orbitals form the extended conduction band." (on the tenth line of page 1 to the second line of page 2 of the translation)

(A7-c) "Thin film specimens were fabricated by pulsed laser deposition method (PLD method.) A circular plate of  $InGaO_3(ZnO)_m$  having a stoichiometric composition and sintered to a high density using a conventional ceramic process and by subsequent polishing using a diamond polishing machine using  $In_2O_3$ ,  $Ga_2O_3$  and ZnO powders was prepared as the target. (on the second line to the fifth line of page 5 of the translation)

(A7-d) "Table 1 lists electric transport parameters of the amorphous  $InGaO_3(ZnO)_m$  film at room temperature. Although doping was not intentionally performed, a conductivity of 170 to 400 Scm<sup>-1</sup> was obtained with a mobility of 12 to 20 cm<sup>2</sup>V<sup>-1</sup>s<sup>-1</sup> and a carrier density of 10<sup>19</sup> to 10<sup>20</sup> cm<sup>-3</sup>." (on the first line to the fifth line of page 9 of the translation)

(B) Evidence A No. 6 describes the following matters.

(A6-b) (reproduced) "In addition, the composition is slightly reductively deviated from the stoichiometric composition, and thereby intrinsic defects such as oxygen vacancies form a donor level. Thus, the conduction electron density (carrier concentration) reaches approximately  $10^{18}$  to  $10^{19}$  cm<sup>-3</sup>. In the band structure of these conductive oxides, the valence band is mainly composed of the 2p orbital of oxygen atom and the conduction band is composed of the s orbital of metal atom (see 4-2-2). When the carrier density is increased to more than  $10^{18}$  cm<sup>-3</sup>, the Fermi level reaches the conduction band and enters into a state called degeneracy." (on the second line to the seventh line of page 80)

(A6-e) Tables 4-5 of page 149 have a title "The crystal structure and the electrical-optical properties of transparent conductive metal oxides", which list the crystal structure and the substance name of the transparent conductive metal oxide such as: "CdIn<sub>2</sub>O<sub>4</sub>, MgIn<sub>2</sub>O<sub>4</sub> (bulk), MgIn<sub>2</sub>O<sub>4</sub>, MgIn<sub>2</sub>O<sub>4</sub>:H, MgIn<sub>2</sub>O<sub>4</sub>:Li, ZnGa<sub>2</sub>O<sub>4</sub> (bulk), CdGa<sub>2</sub>O<sub>4</sub> (bulk), Zn<sub>2</sub>SnO<sub>4</sub>" as the substance name whose crystal structure is "spinel," "InGaMgO<sub>4</sub> (bulk), InGaZnO<sub>4</sub> (bulk), InGaZnO<sub>4</sub>, In<sub>2</sub>O<sub>3</sub>(ZnO)<sub>3</sub> (bulk), In<sub>2</sub>O<sub>3</sub>(ZnO)<sub>5</sub>" as the substance name whose crystal structure is "YbFe<sub>2</sub>O<sub>4</sub>," "Ga<sub>2</sub>O<sub>3</sub> (single crystal), GaInO<sub>3</sub>:Sn" as the substance name whose crystal structure is " $\beta$ -Ga<sub>2</sub>O<sub>3</sub>," "AgSbO<sub>3</sub>,  $Cd_{2(1-x)}Y_{2x}Sb_2O_7$ " as the substance name whose crystal structure is "pyrochlore," "Cd<sub>2</sub>GeO<sub>4</sub>, Cd<sub>2</sub>GeO<sub>4</sub>:In" as the substance name whose crystal structure is "olivine," "AgInO<sub>2</sub>" as the substance name whose crystal structure is "delafossite," "Cd<sub>2</sub>SnO<sub>4</sub>" as the substance name whose crystal structure is "Sr<sub>2</sub>PbO<sub>4</sub>," "CdSnO<sub>3</sub>" as the substance name whose crystal structure is "ilmenite," "In<sub>2</sub>TeO<sub>6</sub>" as the substance name whose crystal structure is "Na2SiF6," "ZnSnO3" as the substance name whose crystal structure is "perovskite," and " $Zn_2In_2O_5$ ,  $Zn_{0.66}In_2O_{3.66}$ ,  $Zn_{1.2}In_{1.9}Sn_{0.1}O_{4.25}$ " as the substance name whose crystal structure is "others," and the carrier densities of InGaZnO<sub>4</sub> (bulk) and InGaZnO<sub>4</sub> are  $5.2 \times 10^{19}$  cm<sup>-3</sup> and  $1.2 \times 10^{20}$  cm<sup>-3</sup> respectively.

(C) Evidence A No. 4 describes the following matters.

(A4-a) "Article having transparent conductive oxide thin film and fabricating method therefor" ([Title of the Invention])

(A4-b) "A first aspect of the article of the present invention comprising a film containing an amorphous oxide expressed by a general formula  $Zn_xM_yIn_zO_{(x+3y/2+3z/2)}$  (where M is at least one element of aluminum and gallium, the ratio x/y is in the range of 0.2 to 12, and the ratio z/y is in the range of 0.4 to 1.4) in at least a part of at least one surface of the base material." ([0009])

(A4-c) "According to the manufacturing method of the present invention, for example, when a sintered body In:Ga:Zn=1:1:1 is used as a target, a thin film  $6.2x10^{-3}[\Omega cm]$  can be easily obtained. In this case, the major cause of the high conductivity is that the mobility indicates a high value of 10 or more despite the amorphous material. In addition, when a sintered body of homologous IGZO InGaO<sub>3</sub>(ZnO)<sub>m</sub> (m: an integer of 2 or more) with increased Zn component is used as the target, a thin film having a resistivity of  $4.3x10^{-3}[\Omega cm]$  can be easily obtained." ([0034])

### (A4-d) "1. Creating the target

Each powder of  $In_2O_3$ ,  $Ga_2O_3$ , and ZnO is weighted so that the ratio of contained metal is 1:1:1 respectively. The weighed powders were wet-mixed by a planetary ball mill apparatus. The wet-mixed powders were calcined at 1000°C for five hours and then crushed again by the planetary ball mill apparatus. The crushed powders were formed into a circular plate shape with a diameter of 20 mm by uniaxial pressing, followed by CIP treatment. Then, the plate was sintered at 1550°C for two hours in the air, and then a sintered body was obtained. It was confirmed by XRD that an oxide expressed by InGaZnO<sub>4</sub> was generated." ([0040])

(A4-e) "In the case of homologous  $InGaO_3(ZnO)_m$ , each powder of  $In_2O_3$ ,  $Ga_2O_3$ , and ZnO was weighted so that the ratio of contained metal is 1:1:m (m is an integer of 2 or more) respectively." ([0041])

(A4-f) "[FIG. 1] XRD results confirming that the oxide expressed by InGaZnO<sub>4</sub> was generated." ([Brief Description of Drawings])

(D) Evidence A No. 8 describes the following matters.
(A8-a) "A Novel Amorphous Transparent Conductive Film InGaO<sub>3</sub>(ZnO)<sub>m</sub>" (Title)

(A8-b) "2. Experiment A sintered body of  $InGaO_3(ZnO)_m$  (m=1 to 4) was irradiated with KrF excimer laser light in the oxygen atmosphere, and thereby a thin film was formed on a quartz glass substrate opposed thereto at room temperature.

3. Results and Discussion - - - The sample of m=1 was observed - - - and confirmed to be an amorphous film." (on the fifth to tenth lines of the text)

(E) Evidence A No. 9 describes the following matters.

(A9-a) "The amorphous InGaZnO<sub>4</sub> has been known as an n-type semiconductor, and was fabricated at room temperature by radio-frequency (RF) sputtering <sup>[17]</sup>. The electrical conductivity thereof was  $1.4 \times 10^{-1}$  Scm<sup>-1</sup> at room temperature. The carrier density is estimated as  $4.2 \times 10^{16}$  cm<sup>-3</sup> using a mobility value of 21 cm<sup>2</sup>V<sup>-1</sup>s<sup>-1[17]</sup> as previously reported. The element fabricated on a plastic sheet is flexible as shown in FIG. 3b." (on the first line to the sixth line of page 8 of the translation)

(A9-b) "a-InGaZnO<sub>4</sub> film was deposited in Ar using a disk-shaped target of a polycrystalline InGaZnO<sub>4</sub> film." (on the first line to the second line of page 12 of the translation)

(F) It is recognized from the description of each items of Evidence A above that it was suggested that "the amorphous oxide thin film" with "a crystallized composition thereof expressed by a formula  $InGaO_3(ZnO)_m$  (m is a natural number of less than 6)" was known before the priority date of the subject patent and  $InGaO_3(ZnO)_m$  (m≤4) was a degenerate semiconductor.

C <Regarding the ease of conceiving of using "the amorphous oxide thin film" with "a crystallized composition thereof expressed by a formula  $InGaO_3(ZnO)_m$  (m is a natural number of less than 6)" in Cited Invention 1>

(A) The description of the subject patent describes the following matters.

(Subject patent-a) "[0003]

In addition, recently, a <u>TFT using a transparent conductive oxide polycrystalline thin</u> <u>film using ZnO as the channel layer has been actively developed</u> (Patent Document 1). The above thin film can be formed at low temperature and is transparent to visible light. Thus, a flexible transparent TFT can be formed on a substrate such as a plastic plate or film.

# [0004]

However, the conventional ZnO cannot form a stable amorphous phase at room temperature, but most ZnO exhibit a polycrystalline phase. Thus, the electron mobility cannot be increased due to the scattering on the polycrystalline grain boundaries. Further, <u>oxygen defects can be easily introduced into ZnO, and a large number of carrier electrons occur. Thus, it is difficult to reduce the electrical conductivity. For this reason, it is also difficult to increase the on/off ratio of the transistor."</u>

## (Subject patent-b) "[0005]

In addition, Patent document 2 describes <u>an amorphous oxide expressed by</u>  $Zn_xM_yIn_zO_{(x+3y/2+3z/2)}$  (where M is at least one element of Al and Ga with the ratio x/y in the range of 0.2 to 12 and with the ratio z/y in the range of 0.4 to 1.4) as the amorphous <u>oxide</u>. However, the electron carrier concentration of the amorphous oxide film obtained herein was <u>10<sup>18</sup>/cm<sup>3</sup></u> or more, which was sufficient to be used simply for a transparent electrode, but difficult to be applied to a TFT channel layer. This is because it was found that the <u>TFT using the above amorphous oxide film as the channel</u> layer could not obtain a sufficient on/off ratio, and hence was unsuitable for the <u>normally-off type TFT</u>.

## [0006]

[Patent document 1] Japanese Unexamined Patent Application Publication No. 2003-298062

[Patent document 2] Japanese Unexamined Patent Application Publication No. 2000-044236"

(Subject patent-c) "[Problems to be Solved by the Invention]

[0007]

In view of this, <u>it is an object of the present invention to provide a film formation</u> method for an amorphous oxide thin film with a low electron carrier concentration, and further it is another object of the present invention to provide a thin film transistor using the amorphous oxide thin film as a channel layer."

# (Subject patent-d) "[0010]

As the channel layer of a thin film transistor, an amorphous oxide with an electron carrier concentration of less than  $10^{18}$ /cm<sup>3</sup> can be used, but an amorphous oxide with an electron carrier concentration of  $10^{17}$ /cm<sup>3</sup> or less is preferable and an amorphous oxide with an electron carrier concentration of  $10^{16}$ /cm<sup>3</sup> or less is more preferable. In addition, the method of the present invention can form an amorphous oxide film in which as the electron carrier concentration is increased, the electron mobility is increased. In addition, the method of the present invention can form an amorphous oxide film exhibiting degenerate conduction. It should be noted that the degenerate conduction as used herein refers to a state where the thermal activation energy in the temperature dependence of the electrical resistance is 30 meV or less."

(Subject patent-e) "[0020]

In addition, the method of the present invention can use a material in which as the electron carrier concentration is increased, the electron mobility is increased for a thin film transistor as the amorphous oxide."

# (Subject patent-f) "[0025]

It should be noted that the electron carrier concentration of the amorphous oxide according to the film formation method of the present invention does not need to satisfy

 $10^{16}$ /cm<sup>3</sup> or less in the entire range of 0°C to 40°C. For example, the carrier electron density may only need to be  $10^{16}$ /cm<sup>3</sup> or less at 25°C. In addition, when the electron carrier concentration is  $10^{16}$ /cm<sup>3</sup> or less, a normally-off TFT can be obtained in a high yield. The electron carrier concentration can be measured by Hall-effect measurement."

## (Subject patent-g) "[0030]

In the case of the transparent amorphous oxide thin film whose composition in the crystalline state is expressed by  $InGaO_3(ZnO)_m$  (where m is a value of less than 6), if the value of m is less than 6, the amorphous state is maintained stable up to a high temperature of 800°C or more, but as the value of m is increased, that is, as the ratio of ZnO to  $InGaO_3$  is increased closer to the ZnO composition, the transparent amorphous oxide thin film is easily crystallized. Therefore, as the channel layer of the amorphous TFT, the value of m is preferably less than 6. When the composition ratio of the target material (for example, polycrystal) for use in film formation by sputtering method or pulsed laser deposition method is made to satisfy m<6 above, a desired amorphous oxide can be obtained."

## (Subject patent-h) "[0031]

Note that as the amorphous oxide, Zn in the composition ratio of the InGaZn above may be replaced with  $Zn_{1-x}Mg_x$ . The substitution amount of Mg can be in the range of  $0 < x \le 1$ . As the substitution amount is increased, the electron carrier concentration is decreased. Note that when Mg is added, the electron mobility of the oxide film is reduced as compared with a film without Mg, but to a small degree. Meanwhile, further, the electron carrier concentration can be reduced as compared with a film without Mg, and hence the film with Mg added is more preferable as the TFT channel layer. The substitution amount of Mg is preferably more than 20% and less than 85% (x is 0.2 < x < 0.85), more preferably 0.5 < x < 0.85. To cause the electron carrier concentration to be  $10^{16}$ /cm<sup>3</sup> or less, x should be  $0.80 \le x < 0.85$  as shown in FIG. 4."

## (Subject patent-i) "[0037]

## (Transistor)

An amorphous oxide film with an electron carrier concentration of  $10^{16}$ /cm<sup>3</sup> or less is used for the channel layer to provide a field-effect transistor including a source terminal, a drain terminal, and a gate terminal with a gate insulating film interposed therebetween. When a voltage of approximately 5 V is applied between the source and drain terminals,

the current between the source and drain terminals when the gate voltage is not applied can be made approximately  $10^{-7}$  ampere. Assuming that electrons in the valence band are thermally excited, the theoretical lower limit of the electron carrier concentration is  $10^{5}$ /cm<sup>3</sup> or less, but the practical possibility is approximately  $10^{12}$ /cm<sup>3</sup>."

### (Subject patent-j) "[0038]

In addition, when a mixed crystal compound including at least two or more kinds of one kind of  $Al_2O_3$ ,  $Y_2O_3$ , and  $HfO_2$ , or a compound thereof as the gate insulating layer, <u>the</u> leak current between the source and gate terminals and between the drain and gate terminals can be made approximately  $10^{-7}$  ampere, and thereby a normally-off transistor can be provided.

### [0039]

As the overlapped s orbital of metal ions is increased, the electron mobility of the oxide crystal is increased. The oxide crystal of Zn, In with a large atomic number has a large electron mobility of 0.1 to 200 cm<sup>2</sup>/(V.second). Further, the oxide is an ionic bond between oxygen and metal ions and hence has no direction of chemical bond and has a random structure. Thus, even in an amorphous state with an uneven bond direction, the electron mobility can have approximately the same magnitude as compared with the electron mobility in the crystalline state. Meanwhile, when Zn, In is replaced with an element with a small atomic number, the electron mobility is reduced. Therefore, by using the above described amorphous oxide, the electron mobility can be controlled to be in a range of approximately  $0.01 \text{ cm}^2/(V.second)$  to  $20 \text{ cm}^2/(V.second)$ ."

### (Subject patent-k)"[0040]

Note that <u>in the case of a normal compound</u>, as the carrier concentration is increased, <u>the electron mobility is reduced due to scattering between carriers or the like</u>, while in contrast to this, <u>in the case of the amorphous oxide according to the film formation</u> method of the present invention, as the electron carrier concentration is increased, the <u>electron mobility is increased</u>, but the physical mechanism thereof is not clear."

## (Subject patent-l) "[0041]

When a voltage is applied to the gate terminal, electrons can be injected into the above amorphous oxide channel layer. Then, current flows between the source and drain terminals, and the ON state occurs between the two terminals. <u>The amorphous oxide film according to the film formation method of the present invention is such that as the electron carrier concentration is increased, the electron mobility is increased, and hence</u>

the current in the ON state of the transistor can be further increased. In other words, the saturation current and the on/off ratio can be further increased. When the amorphous oxide film with a large electron mobility is used as the TFT channel layer, the saturation current can be increased, and the TFT switching speed can be increased, enabling high-speed operation."

# (Subject patent-m) "[0042]

For example, when the electron mobility is approximately 0.01 cm<sup>2</sup>/(V.second), the amorphous oxide film can be used as the TFT channel layer for driving a liquid crystal display device. In addition, when the amorphous oxide film with an electron mobility of approximately 0.1 cm<sup>2</sup>/(V.second) is used, a TFT having the same or more performance as the TFT using the amorphous silicon film and driving a moving image display device can be fabricated.

# [0043]

Further, in order to provide a TFT requiring large current such as for operating an organic light emitting diode driven by current, the electron mobility is preferably more than 1 cm<sup>2</sup>/(V.second). It should be noted that <u>when an amorphous oxide exhibiting</u> degenerate conduction obtained by the film formation method of the present invention is used as the channel layer, the temperature dependence of the current in a state of large electron carrier concentration, that is, the saturation current of the transistor is reduced, and hence a TFT excellent in temperature characteristic can be provided."

# (Subject patent-n) "[0053]

The obtained thin film has an electron mobility of more than  $1 \text{ cm}^2/(\text{V.second})$  as shown in FIG. 2. However, when the oxygen partial pressure is increased to 6.5 Pa or more by the pulsed laser deposition method of the present embodiment, the surface of the deposited film becomes uneven, and is difficult to be used as the TFT channel layer. Therefore, a normally-off transistor can be fabricated using a transparent amorphous oxide thin film including In-Ga-Zn-O fabricated by the pulsed laser deposition method, whose composition is expressed by InGaO<sub>3</sub>(ZnO)<sub>m</sub> (where m is a value less than 6) in the crystalline state, in an atmosphere with an oxygen partial pressure of preferably more than 5 Pa and less than 6.5 Pa.

## [0054]

In addition, a value of more than  $1 \text{ cm}^2/\text{V}$ .second was obtained as the electron mobility of the thin film and <u>the on/off ratio was increased to more than  $10^3$ </u>. As described above, when the InGaZn oxide film is formed by the PLD method under the conditions

described in the present embodiment, the oxygen partial pressure is preferably controlled to be 5 Pa or more and less than 6.5 Pa. Note that to achieve the electron carrier concentration of  $10^{16}$ /cm<sup>3</sup>, it depends on the conditions of the oxygen partial pressure, the configuration of the film-forming apparatus, the materials for use in film formation, the compositions, and the like."

### (Subject patent-o) "[0061]

Using a polycrystalline sintered body having an  $InGaO_3(ZnO)_4$  composition as the target, the relationship between the electron carrier concentration and the electron mobility regarding the In-Zn-Ga-O system amorphous oxide film formed by different oxygen partial pressures was examined. The results are shown in FIG. 2. <u>It was shown that when the electron carrier concentration was increased from  $10^{16}/cm^3$  to  $10^{20}/cm^3$ , the electron mobility was increased (Note from the body: original writing error was corrected, the same shall apply hereinafter) from approximately 3 cm<sup>2</sup>/(V.second) to approximately 11 cm<sup>2</sup>/(V.second). Also regarding the amorphous oxide film obtained using a polycrystalline sintered body having an InGaO<sub>3</sub>(ZnO) composition as the target, similar trends were observed."</u>

## (Subject patent-p) "[0069]

More specifically, a <u>normally-off transistor with an on/off ratio of more than  $10^3$ </u> using a transparent amorphous oxide thin film composed of In-Ga-Zn-O fabricated by the sputter deposition method in an argon gas atmosphere with an oxygen partial pressure of more than  $4x10^{-2}$  Pa, preferably  $5x10^{-1}$  Pa or less, and expressed by InGaO<sub>3</sub>(ZnO)<sub>m</sub> (m is a natural number of less than 6) composition in the crystalline state <u>was fabricated</u>."

## (Subject patent-q) "[0070]

When the apparatus and materials shown in the present embodiment are used, the oxygen partial pressure for use in film formation by the sputter is, for example, in the range of  $4 \times 10^{-2}$  Pa or more and  $5 \times 10^{-1}$  Pa or less. Note that when the thin film is formed by the pulsed laser deposition method and the sputter method, the electron mobility is increased as the number of conduction electrons is increased as shown in FIG. 2."

(Subject patent-r) "[0071]

As described above, the oxygen defects can be reduced by controlling the oxygen partial pressure, and as a result, the electron carrier concentration can be reduced. In addition, unlike the polycrystalline state, in the amorphous state, there is inherently no grain boundary, and hence an amorphous thin film with high electron mobility can be obtained. It should be noted that even if a polyethylene terephthalate (PET) film with a thickness of 200 $\mu$ m is used instead of the glass substrate, the obtained InGaO<sub>3</sub>(ZnO)<sub>4</sub> amorphous oxide film exhibited similar characteristics."

#### (Subject patent-s) "[0085]

The present embodiment can provide a thin film transistor having a small electron carrier concentration, accordingly a high electrical resistance, a large electron mobility, and a large channel layer (Note from the body: original writing error was corrected.) Note that the above described amorphous oxide had excellent characteristics such that the electron mobility was increased as the electron carrier concentration was increased and degenerate conduction was exhibited. According to the present embodiment, the thin film transistor was fabricated on the glass substrate, but film formation itself can be performed at room temperature, and hence a substrate such as a plastic plate or film can be used. Note also that the amorphous oxide obtained by the present embodiment has almost no light absorption of visible light, and hence can provide a transparent, flexible TFT."

(B) Judging from the above, it is understood from the above description of the subject patent description that patent invention 1 is the invention to solve the problem such that oxygen defects can be easily introduced into ZnO in the TFT using the transparent conductive oxide polycrystalline thin film using ZnO as the channel layer, a large number of carrier electrons occur, thus it is difficult to reduce the electrical conductivity, and thus it is also difficult to increase the on/off ratio of the transistor; and the problem in the prior art such that the TFT using the amorphous oxide expressed by  $Zn_xM_yIn_zO_{(x+3y/2+3z/2)}$  (where M is at least one element of Al and Ga with the ratio x/y in the range of 0.2 to 12 and with the ratio z/y in the range of 0.4 to 1.4), whose electron carrier concentration is  $10^{18}/cm^3$  or more and which is an amorphous oxide, as the channel layer could not obtain a sufficient on/off ratio, and hence was unsuitable for the normally-off type TFT.

Further, it is recognized from the above description of the subject patent description that the following characteristics are exhibited by the amorphous oxide thin film formed by the film formation method, which is a specific film formation method of

forming a semi-insulating transparent In-Ga-Zn-O thin film having an electron mobility of  $0.1 \text{ cm}^2/(\text{V.second})$  or more at room temperature, an electron carrier concentration of  $10^{16}/\text{cm}^3$  or less at room temperature by controlling the magnitude of oxygen partial pressure so that the formed thin film has an electron carrier concentration of  $10^{16}/\text{cm}^3$  or less at room temperature, using a polycrystal of the oxide as a target, in a state where a temperature of the substrate is not intentionally increased, without intentionally adding impurity ions for enhancing electric resistance to the thin film, in an atmosphere containing an oxygen gas, when "the amorphous oxide thin film" which is "an oxide thin film with a crystallized composition thereof expressed by a formula InGaO<sub>3</sub>(ZnO)<sub>m</sub> (m is a natural number of less than 6)" according to patent invention 1 is deposited on the substrate using the film formation method specified by patent invention 1, namely, the pulsed laser deposition method or the RF sputtering method.

(i) "An amorphous oxide film with an electron carrier concentration of  $10^{16}$ /cm<sup>3</sup> or less is used for the channel layer to provide a field-effect transistor including a source terminal, a drain terminal, and a gate terminal with a gate insulating film interposed therebetween. When a voltage of approximately 5 V is applied between the source and drain terminals, the current between the source and drain terminals when the gate voltage is not applied can be made approximately  $10^{-7}$  ampere," in other words, "can provide a thin film transistor having a channel layer with a small electron carrier concentration, accordingly a high electrical resistance, and a large electron mobility," and thus is suitable for obtaining "the normally-off TFT."

(ii) "In the case of a normal compound, as the carrier concentration is increased, the electron mobility is reduced due to scattering between carriers or the like, while in contrast to this, in the case of the amorphous oxide according to the film formation method of the present invention, as the electron carrier concentration is increased, the electron mobility is increased," and thus for example, "the In-Zn-Ga-O system amorphous oxide film formed by different oxygen partial pressures using the polycrystalline sintered body having an InGaO<sub>3</sub>(ZnO)<sub>4</sub> composition as the target" exhibits electrical characteristics such that "when the electron carrier concentration is increased from  $10^{16}$ /cm<sup>3</sup> to  $10^{20}$ /cm<sup>3</sup>, the electron mobility is increased from approximately 3 cm<sup>2</sup>/(V.second) to approximately 11 cm<sup>2</sup>/(V.second)." As a result,

(iii) "When a voltage is applied to the gate terminal, electrons can be injected into the above amorphous oxide channel layer. Then, current flows between the source and

drain terminals, and the ON state occurs between the two terminals," while "the amorphous oxide film according to the film formation method of the present invention is such that as the electron carrier concentration is increased, the electron mobility is increased, and hence the current in the ON state of the transistor can be further increased," and "further has excellent characteristics such as exhibiting degenerate conduction," and hence for example, "can provide a transistor with an on/off ratio of more than  $10^{3}$ " and "when an amorphous oxide exhibiting degenerate conduction obtained by the film formation method of the present invention is used as the channel layer, the temperature dependence of the current in a state of large electron carrier concentration, that is, the saturation current of the transistor is reduced, and hence a TFT excellent in temperature characteristic can be provided."

In short, it is recognized from the description of the subject patent description that patent invention 1 exhibits the above (i)-(iii) characteristics and hence exhibits the effect of being suitable for the thin film formation method for use in the TFT channel layer.

(C) Meanwhile, Cited Invention 1 is the vapor-phase film formation method by which the percentage of the oxygen gas  $(O_2/Ar+O_2)$  at film deposition is 1% or more in the reactive sputtering using an Ar gas and an oxygen gas, and the intra-film oxygen content of the ITO (Indium Tin Oxide) film as an oxide transparent conductive film used for the conventional transparent electrode is increased, whereby the number of carriers generated by deviation from the stoichiometric composition (oxygen deficiency) of the deposited ITO film is reduced; the carrier concentration of the ITO film is controlled to  $10^{18}$  cm<sup>-3</sup> or less; and the degeneracy is resolved to reduce the conductivity, thereby to provide the ITO film (semiconductor active layer) as a semiconductor.

(D) Then, according to A (B) above, regarding the oxide conductive film, Evidence A No. 5 describes "More specifically, for example,  $In_2O_3$  doped with tin (Sn) (generally referred to as ITO (Indium Tin Oxide), SnO<sub>2</sub> doped with antimony (Sb) or fluorine (F), ZnO doped with In, ZnO doped with gallium (Ga) (generally referred to as GZO), ZnO doped with Al (generally referred to as AZO), or the like may be used as the transparent conductive film material." (excerpt (A5-b))

In addition, according to A (B) above, regarding the oxide conductive film, Evidence A No. 6 describes "As a typical electrically conductive oxide thin film having some sufficient conductivity,  $In_2O_3^{(1),2)}$ ,  $SnO_2^{(3),4)}$ ,  $ZnO^{(5),6)}$ ,  $CdO^{(7),8)}$ ,  $CdIn_2O_4^{(9)}$ ,  $Cd_2SnO_4^{10),11}$ ,  $Zn_2SnO_4$ ,  $In_2O_3$ -ZnO system<sup>12)</sup> and the like are reported." (excerpt (A6-a))

Further, according to B (B) above, Evidence A No. 6 describes the table titled "The crystal structure and the electrical-optical properties of transparent conductive metal oxides", which list the crystal structure and the substance name of the transparent conductive metal oxide such as: "CdIn<sub>2</sub>O<sub>4</sub>, MgIn<sub>2</sub>O<sub>4</sub>(bulk), MgIn<sub>2</sub>O<sub>4</sub>, MgIn<sub>2</sub>O<sub>4</sub>:H, MgIn<sub>2</sub>O<sub>4</sub>:Li, ZnGa<sub>2</sub>O<sub>4</sub>(bulk), CdGa<sub>2</sub>O<sub>4</sub>(bulk), Zn<sub>2</sub>SnO<sub>4</sub>" as the substance name whose crystal structure is "spinel," "InGaMgO<sub>4</sub>(bulk), InGaZnO<sub>4</sub>(bulk), InGaZnO<sub>4</sub>, In<sub>2</sub>O<sub>3</sub>(ZnO)<sub>3</sub>(bulk), In<sub>2</sub>O<sub>3</sub>(ZnO)<sub>5</sub>" as the substance name whose crystal structure is "YbFe<sub>2</sub>O<sub>4</sub>," "Ga<sub>2</sub>O<sub>3</sub> (single crystal), GaInO<sub>3</sub>:Sn" as the substance name whose crystal structure is " $\beta$ -Ga<sub>2</sub>O<sub>3</sub>," "AgSbO<sub>3</sub>, Cd<sub>2(1-x)</sub>Y<sub>2x</sub>Sb<sub>2</sub>O<sub>7</sub>" as the substance name whose crystal structure is "pyrochlore," "Cd<sub>2</sub>GeO<sub>4</sub>, Cd<sub>2</sub>GeO<sub>4</sub>:In" as the substance name whose crystal structure is "olivine," "AgInO<sub>2</sub>" as the substance name whose crystal structure is "delafossite," "Cd<sub>2</sub>SnO<sub>4</sub>" as the substance name whose crystal structure is "Sr<sub>2</sub>PbO<sub>4</sub>," "CdSnO<sub>3</sub>" as the substance name whose crystal structure is "ilmenite," "In<sub>2</sub>TeO<sub>6</sub>" as the substance name whose crystal structure is "Na2SiF6," "ZnSnO3" as the substance name structure crystal is "perovskite," and "Zn<sub>2</sub>In<sub>2</sub>O<sub>5</sub>, whose  $Zn_{0.66}In_2O_{3.66}$ , Zn<sub>1.2</sub>In<sub>1.9</sub>Sn<sub>0.1</sub>O<sub>4.25</sub>" as the substance name whose crystal structure is "others" respectively. (excerpt (A6-e))

Considering the above, as shown in Evidence A No. 5 and Evidence A No. 6, it can be said that a large number of materials were known as the oxide conductive film before the priority date of the subject patent.

(E) However, from any items of Evidence A, it is not possible to recognize that before the priority date of the subject patent, there was known a method of quantitatively predicting the electrical characteristics such as the magnitude of "the electron mobility at room temperature," "the electron carrier concentration at room temperature," and "the electron carrier concentration" of the thin film used as the semiconductor layer of the thin film transistor affecting the magnitude of "the electron mobility," from the composition of the materials forming the thin film, the crystal structure thereof, and the method of forming the thin film, and it is not possible to recognize that such predicting method was technical common knowledge.

(F) Judging from the above, it is recognized that Cited Invention 1 describes the technical idea that the intra-film oxygen content of the transparent conductive oxide film is increased, whereby the number of carriers generated by deviation from the

stoichiometric composition (oxygen deficiency) is reduced, and the carrier concentration is controlled to  $10^{18}$  cm<sup>-3</sup> or less, and the degeneracy is resolved to reduce the conductivity, thereby to provide a semiconductor; additionally as examined in A above, the conductivity may occur in the conductive oxide film in such a manner that the composition is slightly reductively deviated from the stoichiometric composition, and the carrier concentration is increased, whereby intrinsic defects such as oxygen vacancies form a donor level, and thus when the carrier concentration is reduced to 10<sup>18</sup>.cm<sup>-3</sup> or less by increasing the intra-film oxygen content, the state of degeneracy is resolved, and then, the conductive oxide film can be used for the semiconductor active layer, and this knowledge was known before the priority date of the patent; and further as examined in B above, the "amorphous oxide thin film" with "a crystallized composition thereof expressed by a formula InGaO<sub>3</sub>(ZnO)<sub>m</sub> (m is a natural number of less than 6)" was known before the priority date of the patent, and InGaO<sub>3</sub>(ZnO)<sub>m</sub>  $(m \le 4)$  is a degenerate semiconductor. Although it is recognized that the idea, knowledge, and other findings above were suggested, as examined in (E) above, it cannot be recognized that before the priority date of the patent, there was known a method of quantitatively predicting the electrical properties such as the magnitude of "the electron mobility at room temperature," "the electron carrier concentration at room temperature," and "the electron carrier concentration" of the thin film used as the semiconductor layer of the thin film transistor affecting the magnitude of "the electron mobility," from the composition of the materials forming the thin film, the crystal structure thereof, and the method of forming the thin film. Therefore, as described in (D) above, it is found that when a large number of materials are known as conductive oxide films, as a material for implementing the technical idea that the intra-film oxygen content of the conductive oxide film is increased, whereby the number of carriers generated by deviation from the stoichiometric composition (oxygen deficiency) is reduced, and the carrier concentration is controlled to 10<sup>18</sup>.cm<sup>-3</sup> or less, and the degeneracy is resolved to reduce the conductivity, thereby to provide a semiconductor, a person skilled in the art cannot find motivation to particularly select the "amorphous oxide thin film" which is "an oxide thin film with a crystallized composition thereof expressed by a formula  $InGaO_3(ZnO)_m$  (m is a natural number of less than 6)" from the large number of materials instead of the "ITO" film of Cited Invention 1.

Accordingly, it cannot be recognized that it was easy to use the "amorphous oxide thin film" which is "an oxide thin film with a crystallized composition thereof expressed by a formula  $InGaO_3(ZnO)_m$  (m is a natural number of less than 6)" as a material instead of the "ITO" film of Cited Invention 1.

On pages 16 to 17 of the oral proceedings statement brief, the demandant argues that there was a strong motivation for commonality of operation and function; but the material having commonality of operation and function such as a material with an energy band gap of 3eV or more is not limited to only "the amorphous oxide thin film" with "a crystallized composition thereof expressed by a formula  $InGaO_3(ZnO)_m$  (m is a natural number of less than 6)" of the large number of materials described in (D) above, and hence in light of the commonality of operation and function such as a material with an energy band gap of 3eV or more, it cannot be recognized that there is a motivation to select the "amorphous oxide thin film," which is "an oxide thin film with a crystallized composition thereof expressed by a formula  $InGaO_3(ZnO)_m$  (m is a natural number of less than 6)" of the large number of materials described in (D) above, and hence in light of the commonality of operation and function such as a material with an energy band gap of 3eV or more, it cannot be recognized that there is a motivation to select the "amorphous oxide thin film," which is "an oxide thin film with a crystallized composition thereof expressed by a formula  $InGaO_3(ZnO)_m$  (m is a natural number of less than 6)" from the large number of materials as a material instead of the "ITO" film of Cited Invention 1.

In addition, on page 17 of the oral proceedings statement brief, the demandant argues that a person skilled in the art who knows the demand for material with a low content of  $In_2O_3$  described in Evidence A No. 4 has a strong motivation to use "In-Ga-Zn-O" disclosed in Evidence A No. 4, but assuming that a high material cost of  $In_2O_3$  and resource depletion are expected, as the material instead of the "ITO" film of Cited Invention 1, it should be noted that there is a strong motivation to select not "the amorphous oxide thin film," which is "an oxide thin film with a crystallized composition thereof expressed by a formula  $InGaO_3(ZnO)_m$  (m is a natural number of less than 6)" including  $In_2O_3$ , but a material without  $In_2O_3$  from the materials described in (D) above, and hence it cannot be recognized that there is a motivation to select "the amorphous oxide thin film," which is "an oxide thin film with a crystallized composition thereof expressed by a formula  $InGaO_3(ZnO)_m$  (m is a natural number of less than 6)" including  $In_2O_3$ , but a material without  $In_2O_3$  from the materials described in (D) above, and hence it cannot be recognized that there is a motivation to select "the amorphous oxide thin film," which is "an oxide thin film with a crystallized composition thereof expressed by a formula  $InGaO_3(ZnO)_m$  (m is a natural number of less than 6)" including  $In_2O_3$  from the large number of materials as a material instead of the "ITO" film of Cited Invention 1.

(G) Furthermore, in order to state that a person skilled in the art could easily use "the amorphous oxide thin film" with "a crystallized composition thereof expressed by a formula  $InGaO_3(ZnO)_m$  (m is a natural number of less than 6)" instead of the ITO film in Cited Invention 1, it can be said that it is required that there is a motivation to conceive the replacement; there is no obstructing factor; and the means of implementing the technical idea that "the intra-film oxygen content is increased, whereby the number of carriers generated by deviation from the stoichiometric composition (oxygen

deficiency) of the deposited ITO film is reduced, the carrier concentration of the ITO film is controlled to  $10^{18}$ .cm<sup>-3</sup> or less, and the degeneracy is resolved to reduce the conductivity, thereby to provide the ITO film (semiconductor active layer) as a semiconductor" in the Cited Invention 1 by "the amorphous oxide thin film" with "a crystallized composition thereof expressed by a formula InGaO<sub>3</sub>(ZnO)<sub>m</sub> (m is a natural number of less than 6)" was clear for a person skilled in the art before the priority date of the patent; and further the effect exerted by the replacement falls within the range predicted by the person skilled in the art.

(H) When examined in light of the above, when a person skilled in the art adopts "the transparent conductive oxide film" to be replaced with the ITO film based on the technical idea that "the intra-film oxygen content is increased, whereby the number of carriers generated by deviation from the stoichiometric composition (oxygen deficiency) of the deposited ITO film is reduced, the carrier concentration of the ITO film is controlled to 10<sup>18</sup>.cm<sup>-3</sup> or less, and the degeneracy is resolved to reduce the conductivity, thereby to provide the ITO film (semiconductor active layer) as a semiconductor" in the Cited Invention 1, it can be said that it is natural to consider whether or not the material is easy to increase the intra-film oxygen content, thereby to reduce the number of carriers generated by deviation from the stoichiometric composition (oxygen deficiency) of the deposited film, and to control the carrier concentration of the film to  $10^{18}$  cm<sup>-3</sup> or less, while "the oxide thin film with a crystallized composition thereof expressed by a formula InGaO<sub>3</sub>(ZnO)<sub>m</sub> (m is a natural number of less than 6)" is such that the number of elements constituting the material is as many as four types, and hence it can be said that it is more difficult to use this material as compared with the other materials with a smaller number of material types than the four types as the number of types of elements constituting the material in terms of ease of control of film formation for preventing the film composition from being deviated from the stoichiometric composition.

More specifically, when "the oxide thin film with a crystallized composition thereof expressed by a formula  $InGaO_3(ZnO)_m$  (m is a natural number of less than 6)" is selected, four types of elements should be controlled to reduce deviation from the stoichiometric composition, it is expected to involve more difficulty as compared with two types or three types of elements constituting the material such as the ITO ( $In_2O_3$  doped with tin (Sn)) of the Cited Invention 1 in terms of control of film formation for preventing the film composition from being deviated from the stoichiometric composition.

In view of the above, as described in (D) above, when a large number of materials were known as the conductive oxide film, in terms of control of film formation for preventing the film composition from being deviated from the stoichiometric composition under the condition where there are four types of elements constituting the material as the material instead of the "ITO" film of Cited Invention 1 having three types of elements constituting the material, it can be said that there is an obstructing factor for deliberately selecting "the oxide thin film with a crystallized composition thereof expressed by a formula  $InGaO_3(ZnO)_m$  (m is a natural number of less than 6)" where it is expected to involve more difficulty as compared with the three types of elements constituting the material.

In addition, it can be said that the state called "amorphous" also involves more difficulty as compared with other crystalline states such as a single crystal in terms of reducing the amount of intrinsic defects such as oxygen vacancies, and hence it can be said that there is also an obstructing factor for selecting the state called "amorphous" in Cited Invention 1.

Judging from the above, also in terms of these viewpoints, it cannot be recognized that a person skilled in the art could easily conceive of selecting "an amorphous oxide thin film," which is "an oxide thin film with a crystallized composition thereof expressed by a formula  $InGaO_3(ZnO)_m$  (m is a natural number of less than 6)" as the material instead of the "ITO" film of Cited Invention 1.

Further, although the material with "a crystallized composition thereof expressed by a formula  $InGaO_3(ZnO)_m$  (m is a natural number of less than 6)" was publicly known before the priority date of the patent, in light of the description summarized in (D) above, it stops short of being recognized that the material was a common material as exemplified as "More specifically, for example, as the transparent conductive film material" or a typical material as exemplified as "typical electrically conductive oxide thin film," and hence it cannot be said that when the ITO of Cited Invention 1 is replaced, a person skilled in the art would first consider this material.

(I) Furthermore, from the consideration in A above, although it is understood as a common technical idea that the carrier concentration of "the amorphous oxide thin film" with "a crystallized composition thereof expressed by a formula  $InGaO_3(ZnO)_m$  (m is a natural number of less than 6)" is reduced by increasing the percentage of the oxygen gas at film deposition, it cannot be said that there was known a specific film formation method for reducing the carrier concentration of "the amorphous oxide thin film" with "a crystallized composition thereof expressed by a formula  $InGaO_3(ZnO)_m$  (m is a natural number of less than 6)" is reduced by increasing the percentage of the oxygen gas at film deposition, it cannot be said that there was known a specific film formation method for reducing the carrier concentration of "the amorphous oxide thin film" with "a crystallized composition thereof expressed by a formula  $InGaO_3(ZnO)_m$  (m is a

natural number of less than 6)" up to  $10^{18}$ .cm<sup>-3</sup> or less. Therefore, it cannot be said that there was known a method of implementing the technical idea of Cited Invention 1 using "the amorphous oxide thin film" with "a crystallized composition thereof expressed by a formula InGaO<sub>3</sub>(ZnO)<sub>m</sub> (m is a natural number of less than 6)," and hence it cannot be recognized that a person skilled in the art could easily replace the ITO film with "the amorphous oxide thin film" with "a crystallized composition thereof expressed by a formula InGaO<sub>3</sub>(ZnO)<sub>m</sub> (m is a natural number of less than 6)."

It should be noted that when it is understood along the argument of the demandant as in the above excerpt (A9-a) of Evidence A No. 9 "The amorphous InGaZnO<sub>4</sub> was known as an n-type semiconductor, and was fabricated at room temperature by radio-frequency (RF) sputtering<sup>[17]</sup>. The electrical conductivity thereof was  $1.4 \times 10^{-1}$  Scm<sup>-1</sup> at room temperature. The carrier density was estimated as  $4.2 \times 10^{16}$  cm<sup>-3</sup> using a value of 21 cm<sup>2</sup>V<sup>-1</sup>s<sup>-1[17]</sup> as the previously reported mobility" that this description indicated that there was known a film formation method of using "the amorphous oxide thin film" with "a crystallized composition thereof expressed by a formula InGaO<sub>3</sub>(ZnO)<sub>m</sub> (m is a natural number of less than 6)" to obtain a carrier density of  $4.2 \times 10^{16}$  cm<sup>-3</sup>, in light of the description "a-InGaZnO<sub>4</sub> film was formed in Ar using a disk-shaped target of a polycrystalline InGaZnO<sub>4</sub> film." in the above excerpt (A9-b) of Evidence A No. 9, the film already satisfied the condition where the film was formed by a film formation method without oxygen gas, and the film was formed by the film formation method without oxygen gas such that the carrier concentration of the film was  $10^{18}$ .cm<sup>-3</sup> or less required by Cited Invention 1.

Judging from the above, it cannot be recognized that it is necessary to apply the film formation method described in Evidence A No. 9 to Cited Invention 1 and further to add an oxygen gas.

Therefore, there is no motivation to combine the film formation method described in Evidence A No. 9 with Cited Invention 1, and hence it cannot be recognized that based on the Cited Invention 1 and the invention described in Evidence A No. 9, it would be easy to implement a method where the percentage of the oxygen gas at film deposition is increased, and the intra-film oxygen content of a transparent conductive oxide film used for the conventional transparent electrode is increased, whereby the number of carriers generated by deviation from the stoichiometric composition (oxygen deficiency) of the deposited film is reduced, the carrier concentration of the film is controlled to  $10^{18}$ .cm<sup>-3</sup> or less, and the degeneracy is resolved to reduce the conductivity, thereby to provide the film (semiconductor active layer) as a semiconductor.
(J) Further, patent invention 1 has the properties that the electron carrier concentration at room temperature is  $10^{16}$ /cm<sup>3</sup> or less and the electron mobility at room temperature is 0.1 cm<sup>2</sup>/(V.second) or more, as the matters specifying the invention, while Cited Invention 1 is such that the carrier concentration is controlled to  $10^{18}$ .cm<sup>-3</sup> or less, and the degeneracy is resolved to reduce the conductivity, thereby to provide the semiconductor active layer as a semiconductor. Therefore, it can be said that the carrier concentration of  $10^{18}$ .cm<sup>-3</sup> or less is enough to solve the problem of the invention as long as the degeneracy is resolved to reduce the conductivity, thereby to provide the semiconductor active layer as a semiconductor. Thus, it cannot be found that there is a motivation to use the carrier concentration of  $10^{16}$ .cm<sup>-3</sup> or less which is two digits less than the carrier concentration of  $10^{18}$ .cm<sup>-3</sup> or less as the matters specifying the Cited Invention 1.

Furthermore, it cannot be recognized from the description of the respective items of Evidence A that there was known a method of quantitatively predicting the electrical properties such as the magnitude of "the electron mobility at room temperature," "the electron carrier concentration at room temperature," and "the electron carrier concentration" of the thin film used as the semiconductor layer of the thin film transistor affecting the magnitude of "the electron mobility," from the composition of the materials forming the thin film, the crystal structure thereof, and the method of forming the thin film, and it cannot be recognized that such predicting method was technical common knowledge as examined in (E) above. Therefore, it cannot be recognized that before the priority date of the patent, a person skilled in the art could easily achieve an electron mobility of  $0.1 \text{ cm}^2/(\text{V.second})$  or more at room temperature under the condition where "the amorphous oxide thin film" with "a crystallized composition thereof expressed by a formula InGaO<sub>3</sub>(ZnO)<sub>m</sub> (m is a natural number of less than 6)" has an electron carrier concentration of  $10^{16}/\text{cm}^3$  or less at room temperature.

In addition, as described in (D) above, while a large number of conductive oxide films were known, it cannot be recognized that in the large number of oxide amorphous thin films, the properties that the electron mobility at room temperature was  $0.1 \text{ cm}^2/(\text{V.second})$  or more and the electron carrier concentration at room temperature was  $10^{16}/\text{cm}^3$  or less were the properties to the extent that they were provided in common.

Therefore, it cannot be said that a person skilled in the art could easily achieve an electron mobility of  $0.1 \text{ cm}^2/(\text{V.second})$  or more at room temperature and an electron

carrier concentration of  $10^{16}$ /cm<sup>3</sup> or less at room temperature described in Cited Invention 1.

(K) It should be noted that Evidence A No. 10 and Evidence A No. 11 describe the following matters.

(A-10a) "Thin-Film Transistor Fabricated in <u>Single-Crystalline</u> Transparent Oxide Semiconductor" (Title of the document)

(A-10b) "We report the fabrication of a transparent field-effect transistor using a <u>single</u> <u>crystal transparent oxide semiconductor  $InGaO_3(ZnO)_5$ </u> for an electronic channel and an amorphous hafnium oxide for a gate insulating film." (on the fourth to sixth lines of page 1 of the translation)

(A-10c) "InGaO<sub>3</sub>(ZnO)<sub>5</sub> has a property layered superlattice structure (FIG. 1A), namely, - - -, and <u>it is believed that excellent electronic properties are brought by the structure</u>. - - Further, <u>the In<sub>2</sub>O<sub>3</sub> layer functions as a blocking barrier to prevent oxygen from</u> <u>diffusing outside</u>, whereby formation of oxygen deficiencies may be suppressed. - - -<u>Therefore, it is easier to keep the material in the stoichiometric ratio and to reduce the</u> <u>carrier concentration up to the intrinsic level in a single crystal</u>." (on the 21st line of page 2 to the ninth line of page 3 of the translation)

(A-10d) "In FIG. 2, - - - of the <u>single crystal InGaO<sub>3</sub>(ZnO)<sub>5</sub></u> thin film fabricated - - - . <u>The value of the electron mobility (obtained as the field-effect mobility) - - -, and hence</u> the carrier concentration is estimated to be approximately  $10^{13}$  cm<sup>-3</sup>." (on the tenth to eleventh lines of page 4 of the translation)

(A-10e) "It is understood that this TFET operates as the enhancement type." (on the 15th to 16th lines of page 5 of the translation)

(A-11a) "<u>Natural superlattice homologous single crystal thin film</u>, method for preparation, and device using said <u>single crystal thin film</u>" (Title of Invention)

(A-11b) "Background Art

A structure where ultra-thin crystal layers of different substances are regularly superimposed into several layers is collectively called a "superlattice."" (on the ninth to eleventh lines of page 1 of the description)

(A-11c) "In addition, <u>if no homogeneous superlattice can be formed, it means that a</u> chemical composition of the homologous phase is deviated from the stoichiometric ratio. When the chemical composition is deviated, oxygen defects are generated during the homologous phase, which generates a conduction carrier. In general, it is extremely difficult to control the concentration of a conduction carrier generated due to oxygen defects. In general, in order to fabricate an electronic device such as a normally-off type field-effect transistor, it is necessary to reduce its concentration to the intrinsic level or less (<10<sup>14</sup> cm<sup>-3</sup>)." (on the third to eighth lines of page 8 of the description)

Then, in light of the description "InGaO<sub>3</sub>(ZnO)<sub>5</sub> has a property layered superlattice structure (FIG. 1A), namely, - - -, and it is believed that excellent electronic properties are brought by the structure. -- Further, the  $In_2O_3$  layer functions as a blocking barrier to prevent oxygen from diffusing outside, whereby formation of oxygen deficiencies may be suppressed. - - - Therefore, it is easier to keep the material in the stoichiometric ratio and to reduce the carrier concentration up to the intrinsic level in a single crystal." of the above excerpt (A-10c), and "In addition, if no homogeneous superlattice can be formed, it means that a chemical composition of the homologous phase is deviated from the stoichiometric ratio. When the chemical composition is deviated, oxygen defects are generated during the homologous phase, which generates a conduction carrier. In general, it is extremely difficult to control the concentration of a conduction carrier generated due to oxygen defects." of the above excerpt (A-11c), it can be said that the transparent oxide semiconductor  $InGaO_3(ZnO)_5$ of "a single crystal" has a property layered superlattice structure, the In<sub>2</sub>O<sub>3</sub> layer functions as a blocking barrier to prevent oxygen from diffusing outside, whereby formation of oxygen deficiencies may be suppressed, and hence it is easier to keep the material in the stoichiometric ratio and to reduce the carrier concentration up to the intrinsic level in a single crystal, but no homogeneous superlattice can be formed, for example, in "amorphous," a chemical composition of the homologous phase is deviated from the stoichiometric ratio, resulting in that oxygen defects are generated during the homologous phase, which generates a conduction carrier. Therefore, it can be understood that it is extremely difficult to control the concentration of a conduction carrier generated due to oxygen defects.

In other words, it can be understood from the description of Evidence A No. 10 and Evidence A No. 11 that it is extremely difficult to reduce the carrier concentration of "the amorphous oxide thin film" with "a crystallized composition thereof expressed by a formula  $InGaO_3(ZnO)_m$  (m is a natural number of less than 6)" without homogeneous superlattice in the thin film, up to  $10^{16}$ .cm<sup>-3</sup> or less, but from the description of Evidence A No. 10 and Evidence A No. 11, it is not possible to read a specific film formation method of reducing carrier concentration of "the amorphous oxide thin film" with "a crystallized composition thereof expressed by a formula InGaO<sub>3</sub>(ZnO)<sub>m</sub> (m is a natural number of less than 6)" up to  $10^{16}$ .cm<sup>-3</sup> or less.

Judging from the above, including the description of Evidence A No. 10 and Evidence A No. 11, it cannot be recognized that a person skilled in the art could easily conceive that in order to obtain a normally-off type field-effect transistor, the electron carrier concentration at room temperature of "the amorphous oxide thin film" with "a crystallized composition thereof expressed by a formula  $InGaO_3(ZnO)_m$  (m is a natural number of less than 6)" is reduced up to  $10^{16}$  cm<sup>-3</sup> or less.

(L) Then, as examined in (B) above, there were problems in the prior art such that it is difficult to increase the on/off ratio of the transistor, and the like. In view of these problems, patent invention 1 adopted a film formation method for forming a semi-insulating thin film with an electron carrier concentration of  $10^{16}/\text{cm}^3$  or less at room temperature and an electron mobility of  $0.1 \text{ cm}^2/(\text{V.second})$  or more at room temperature using the composition and crystal structure of a specific thin film and the film formation conditions specified by patent invention 1. Then, the field-effect transistor using the thin film for the channel layer had excellent properties as follows. (i) When a voltage of approximately 5 V was applied between the source and drain terminals, the current between the source and drain terminals when the gate voltage was not applied could be made approximately  $10^{-7}$  ampere; (ii) as the electron carrier concentration was increased, the electron mobility was increased; and (iii) further a transistor with an on/off ratio of more than  $10^3$  was fabricated, and furthermore, had excellent properties exhibiting degenerate conduction. Therefore, it can be said that patent invention 1 achieved the effects suitable for the TFT channel layer such that the temperature dependence of the current in a state of large electron carrier concentration, that is, the saturation current of the transistor was reduced, a TFT excellent in temperature property could be provided, and the like. In contrast to this, Evidence A No. 1 does not disclose a specific value of the current between the source and drain terminals when the gate voltage is not applied or a relationship between the electron carrier concentration and the electron mobility. In addition, it cannot be recognized that the other items of Evidence A include a description of predicting these effects. Therefore, when the above configuration of the different feature 1-1 is adopted in Cited Invention 1, it cannot be said that a person skilled in the art could predict that the above configuration exerted the aforementioned effects.

(M) Based on the above reason, when the above different feature 1-1 is examined, it cannot be recognized that a person skilled in the art could easily arrive at the configuration of patent invention 1 from Cited Invention 1, and hence it cannot be recognized that a person skilled in the art could easily invent the patent invention 1 from Cited Invention 1 and the inventions described in the respective items of Evidence A above.

(N) In the written demand for trial, the demandant argues that "When the technical common knowledge about the transparent oxide thin film and the like before the priority date as described above is taken into consideration, it can be recognized that a person skilled in the art could easily conceive of adopting "the In-Ga-Zn-O thin film" known as the transparent oxide thin film which is a degenerate semiconductor as well as the ITO film for Cited Invention 1 before the priority date of the patent.

In addition, the demandant argues that it can be recognized that a person skilled in the art could easily conceive of adopting "the amorphous oxide thin film" with "a crystallized composition thereof expressed by a formula  $InGaO_3(ZnO)_m$  (m is a natural number of less than 6)" which is "an In-Ga-Zn-O thin film" for Cited Invention 1 before the priority date of the patent."

However, as examined in "(3) Judgment of the different feature" above, it cannot be assumed that the electrical properties such as the magnitude of "the electron mobility at room temperature," "the electron carrier concentration at room temperature," and "the electron carrier concentration" of the thin film used as the semiconductor layer of the thin film transistor affecting the magnitude of "the electron mobility" could be quantitatively predicted from the composition of the materials forming the thin film, the crystal structure thereof, and the method of forming the thin film before the priority date of the patent. In addition, a person skilled in the art cannot find motivation to particularly select the "amorphous oxide thin film," which is "an oxide thin film with a crystallized composition thereof expressed by a formula  $InGaO_3(ZnO)_m$  (m is a natural

number of less than 6)" from a large number of materials known as a conductive oxide film. Further, it cannot be said that there was known a specific film formation method for reducing the carrier concentration of "the amorphous oxide thin film" with "a crystallized composition thereof expressed by a formula  $InGaO_3(ZnO)_m$  (m is a natural number of less than 6)" up to an electron mobility of  $0.1 \text{ cm}^2/(\text{V.second})$  or more at room temperature and an electron carrier concentration of  $10^{16}$ .cm<sup>-3</sup> or less at room temperature by controlling the magnitude of oxygen partial pressure.

Furthermore, the field-effect transistor using the thin film formed by patent invention 1 for the channel layer had excellent properties as follows. (i) When a voltage of approximately 5 V was applied between the source and drain terminals, the current between the source and drain terminals when the gate voltage was not applied could be made approximately  $10^{-7}$  ampere; (ii) as the electron carrier concentration was increased, the electron mobility was increased; and (iii) further a transistor with an on/off ratio of more than  $10^3$  was fabricated, and furthermore, had excellent properties exhibiting degenerate conduction. Therefore, it can be said that patent invention 1 achieved the exceptional effects suitable for the TFT channel layer such that the temperature dependence of the current in a state of large electron carrier concentration, that is, the saturation current of the transistor was reduced, a TFT excellent in temperature property could be provided, and the like.

Therefore, the demandant argues that "it should be recognized that a person skilled in the art could easily conceive of adopting "the amorphous oxide thin film" with "a crystallized composition thereof expressed by a formula  $InGaO_3(ZnO)_m$  (m is a natural number of less than 6)" which is "an In-Ga-Zn-O thin film" for Cited Invention 1 before the priority date of the patent", but the argument of the demandant cannot be accepted.

# (4) Summary

It cannot be recognized that a person skilled in the art could easily invent the patent invention 1 based on the invention described in Evidence A No. 1, Evidence A No. 4, Evidence A No. 5, Evidence A No. 6, Evidence A No. 7, Evidence A No. 8, Evidence A No. 9, Evidence A No. 10, and Evidence A No. 11.

### 4 Patent invention 2

Patent invention 2 is as recognized in "No. 2 The Invention", and is reproduced as follows. [Claim 2] A vapor-phase film formation method for an amorphous oxide thin film, wherein a pulsed laser deposition method or an RF sputtering method is applied to an oxide thin film with a crystallized composition thereof expressed by a formula  $InGaO_3(Zn_{1-x}Mg_xO)_m$  (m is a natural number of less than 6,  $0.80 \le x < 0.85$ ), when depositing the thin film on a substrate using a polycrystal of the oxide as a target in an atmosphere containing an oxygen gas without intentionally adding impurity ions for enhancing electric resistance to the thin film in a state where a temperature of the substrate is not intentionally increased, a semi-insulating transparent In-Ga-Zn-Mg-O thin film having an electron mobility of  $0.1 \text{ cm}^2/(\text{V.second})$  or more at room temperature and an electron carrier concentration of  $10^{16}/\text{cm}^3$  or less at room temperature is formed by controlling the magnitude of oxygen partial pressure so that the formed thin film has an electron carrier concentration of  $10^{16}/\text{cm}^3$  or less at room temperature.

5 Matters described in the respective items of Evidence A

Evidence A No. 1, Evidence A No. 4, Evidence A No. 5, Evidence A No. 6, Evidence A No. 7, Evidence A No. 8, Evidence A No. 9, Evidence A No. 10, and Evidence A No. 11 describe matters summarized in "2 Matters described in Evidence A No. 1 in No. 5 Regarding the reason for invalidation 1" and "3 Judgment by the body in No. 5 Regarding the reason for invalidation 1."

In addition, Evidence A No. 12 describes the following matters.

(A-12a) "[Claim 1] A <u>conductive oxide</u> expressed by the general formula  $M(1)_xM(2)_yIn_zO_{(x+3y/2+3z/2)-d}$  (where M(1) is <u>at least one</u> element of <u>magnesium and zinc</u>, M(2) is at least one element of aluminum and <u>gallium</u>, the ratio (x:y) is in the range of 0.2 to 1.8:1, the ratio (z:y) is in the range of 0.4 to 1.4:1, and oxygen deficiency amount d is in the range of  $3x10^{-5}$  to  $1x10^{-1}$  times (x+3y/2+3z/2))" ([Scope of claims])

(A-12b) "[Claim 13] A method of forming an oxide film on a transparent substrate by a method sputtering using an oxide expressed by the formula general  $M(1)_x M(2)_y In_z O_{(x+3y/2+3z/2)}$  (where M(1) is at least one element of magnesium and zinc, M(2) is at least one element of aluminum and gallium, the ratio (x:y) is in the range of 0.1 to 2.2:1, and the ratio (z:y) is in the range of 0.4 to 1.8:1) as a target, wherein the method is a method of fabricating an electrode having a conductive layer, the layer being a layer made of a conductive oxide described in claim 1, wherein a heating temperature of the substrate is in the range of 100 to 900°C and a pressure at film formation is in the range of  $5 \times 10^{-4}$  to 1 Torr, and the (00n) plane (note that n is a positive integer) of the conductive oxide is substantially oriented in parallel with the surface of the transparent substrate." ([Scope of claims])

# (A-12c) "[Field of Industrial Application]

The present invention relates to a conductive oxide having an excellent electrical conductivity, an electrode using the conductive oxide, and a method of fabricating the same. The conductive oxide of the present invention has not only an excellent electrical conductivity but also an excellent transparency in the entire visible region, and hence is particularly useful as an electrode for a display, a solar cell, and the like requiring optical transparency." ([0001])

(A-12c) "Namely, in the prior art, there was not known a material whose absorption edge is located at a shorter wavelength than 450 nm and which has an electric conductivity equal to or greater than that of the ITO. In view of this, it is <u>an object of the present invention</u> to provide a novel material which has a larger thickness than that of the ITO film, but does not cause coloring, since the material <u>has absorption edge located at a shorter wavelength than 450 nm</u> and which <u>has an electric conductivity equal to or greater than that of the ITO</u>. Further, it is another object of the present invention to provide an electrode useful for a liquid crystal display, an EL display, a solar cell, and the like using the novel material." ([0008])

(A-12d) "The conductive oxide according to a first aspect of the present invention

In the general formula  $M(1)_x M(2)_y In_z O_{(x+3y/2+3z/2)-d}$ , M(1) is at least one element of magnesium and zinc. In other words, M(1) may be a single one of magnesium and zinc, or M(1) may be a mixture of magnesium and zinc. When magnesium coexists with zinc, the ratio between magnesium and zinc is not particularly limited. It should be noted that as the ratio of magnesium is increased, the absorption edge is shifted to shorter wavelength, and the transparency tends to increase. As the ratio of zinc is increased, the conductivity tends to increase." ([0013])

(A-12e) " $\underline{M(2)}$  may be a <u>single one</u> of aluminum and <u>gallium</u>, or M(2) may be a mixture of aluminum and gallium. When aluminum coexists with gallium, the ratio between aluminum and gallium is not particularly limited. It should be noted that as the ratio of aluminum is increased, the crystallization temperature tends to increase. As the ratio of gallium is increased, the crystallization temperature tends to decrease." ([0014])

(A-12f) "The conductive oxide of the present invention expressed by the general formula  $M(1)M(2)InO_4$  may also be expressed by the general formula  $Mg_aZn_{1-a}A1_bGa_{1-b}InO_4$ , wherein a is in the range of 0 to 1 and b is in the range of 0 to 1. The specific examples of the conductive oxide of the present invention expressed by  $Mg_aZn_{1-a}A1_bGa_{1-b}InO_4$  include  $MgA1InO_4$ ,  $ZnA11nO_4$ ,  $MgGaInO_4$ ,  $ZnGaInO_4$ ,  $Mg_aZn_{1-a}A11nO_4$ ,  $Mg_aZn_{1-a}GaInO_4$ ,  $MgA1_bGa_{1-b}InO_4$ , and  $ZnA1_bGa_{1-b}InO_4$ . a and b in the formula may be appropriately determined by the composition by considering the optical properties and conductivity required for the conductive oxide." ([0028])

(A-12g) "The oxide of the present invention expressed by the general formula  $\underline{M(1)_x M(2)_y In_z O_{(x+3y/2+3z/2)}}$  basically has an octahedral structure of  $InO_6$ . FIG. 1 illustrates the atom model of the octahedral structure of  $InO_6$  (an open circle represents the In atom, a black circle represents the oxygen atom.) FIG. 1 is a view seen from a direction perpendicular to the (00n) plane, and FIG. 1B is a view seen from a direction parallel to the (00n) plane. FIG. 2 is a view schematically illustrating an octahedron of  $InO_6$ , the (00n) plane of the octahedron, and further the relationship with the substrate. In the electrode of the present invention, it is preferable in terms of high conductivity that the (00n) plane (note that n is a positive integer) of the conductive oxide is substantially oriented in parallel with the surface of the transparent substrate. In this respect, as schematically illustrated in FIG. 3, for the unoriented film, the electronic path is zigzag, while for the oriented film, the electronic path is linear and the conductivity is increased." ([0048])

# (A-12h) "Examples 2-22 to 2-30

The calcined powder was prepared by the same method as in example 2-1 so that the ratio of metal elements contained in the calcined powder was a value in Table 8. The resultant calcined powder was press-formed into a disk shape with a diameter of 25 mm by uniaxial pressing (100 kg/cm<sup>2</sup>). Then, the disk-shaped powder was sintered in the air at 1300°C to 1700°C for two hours, whereby a sintered body with a relative density of 90% or more was obtained. The surface of the sintered body was polished and was fixed with adhesive on the packing plate, which was used as a sputtering target. This sputtering target was fixed to a Model BC1457 sputtering apparatus fabricated by Nippon Shinku Co., Ltd. <u>A gas with Ar/O<sub>2</sub> ratio of 45/5 was introduced into the apparatus and an RF power of 180 W was applied for 40 minutes, whereby an amorphous thin film with a thickness of 800 Å was fabricated on a quartz glass</u>

<u>substrate heated to 500°C</u>. <u>This film was heated in the air at 400°C to 800°C</u>. <u>The</u> product was subjected to structural analysis using the apparatus used in example 2-1, and then it was confirmed that a crystal with  $YbFe_2O_4$ -type structure was formed.

<u>Then, a thin film sample crystallized for injecting electrons was treated at 400°C to 800°C in the hydrogen stream, whereby the conductive oxide of the present invention was obtained</u>. The electric conductivity and the absorption edge wavelength of these conductive oxides were measured by the same method as example 2-1. It should be noted that the absorption edge wavelength was measured by the light transmission method, and a wavelength with a transmittance of 50% was used as the absorption edge wavelength. Table 8 lists the electric conductivity and the absorption edge wavelength obtained. It is understood from the results in Table 8 that they were excellent as the electrode of the conductive oxide of the present invention." ([0100] to [0101])

6 Judgment by the body regarding patent invention 2

(1) Comparison

Cited Invention 1 is as examined in "3 Judgment by the body regarding patent invention 1" above, and is reproduced as follows.

"A vapor-phase film formation method for a semiconductor layer of a thin film transistor, wherein the thin film transistor comprises a gate electrode, a gate insulating film, a source electrode, a drain electrode, and a semiconductor layer; and the semiconductor layer has a carrier concentration of  $10^{18}$ .cm<sup>-3</sup> or less, and the semiconductor layer is a translucent film, wherein

the percentage of the oxygen gas  $(O_2/Ar+O_2)$  at film deposition is 1% or more in the reactive sputtering using an Ar gas and an oxygen gas, and the intra-film oxygen content of the ITO (Indium Tin Oxide) film as a transparent conductive oxide film used for the conventional transparent electrode is increased, whereby the number of carriers generated by deviation from the stoichiometric composition (oxygen deficiency) of the deposited ITO film is reduced; the carrier concentration of the ITO film is controlled to  $10^{18}$ .cm<sup>-3</sup> or less; and the degeneracy is resolved to reduce the conductivity, thereby to provide the ITO film (semiconductor active layer) as a semiconductor."

A The patent invention 2 is compared with the Cited Invention 1.

B "The ITO (Indium Tin Oxide) film" in the Cited Invention 1 and "the oxide thin film with a crystallized composition thereof expressed by a formula  $InGaO_3(Zn_{1-x}Mg_xO)_m$ 

(m is a natural number of less than 6,  $0.80 \le x < 0.85$ )" in the patent invention 2 are common in that both films are "oxide thin films."

C In addition, "the ITO film (semiconductor active layer) as a semiconductor" in the Cited Invention 1 and "the transparent In-Ga-Zn-Mg-O thin film" in the patent invention 2 are common in that both films are "transparent oxide thin films."

D Therefore, the film formation method wherein "the percentage of the oxygen gas  $(O_2/Ar+O_2)$  at film deposition is 1% or more in the reactive sputtering using an Ar gas and an oxygen gas, and the intra-film oxygen content of the ITO (Indium Tin Oxide) film as a transparent conductive oxide film used for the conventional transparent electrode is increased, whereby the number of carriers generated by deviation from the stoichiometric composition (oxygen deficiency) of the deposited ITO film is reduced; the carrier concentration of the ITO film is controlled to  $10^{18}$  cm<sup>-3</sup> or less; and the degeneracy is resolved to reduce the conductivity, thereby to provide the ITO film (semiconductor active layer) as a semiconductor" in the Cited Invention 1 and the method wherein "when depositing the thin film on a substrate using a polycrystal of the oxide as a target in an atmosphere containing an oxygen gas without intentionally adding impurity ions for enhancing electric resistance to the thin film in a state where a temperature of the substrate is not intentionally increased, a semi-insulating transparent In-Ga-Zn-Mg-O thin film having an electron mobility of 0.1 cm<sup>2</sup>/(V.second) or more at room temperature and an electron carrier concentration of 10<sup>16</sup>/cm<sup>3</sup> or less at room temperature is formed by controlling the magnitude of oxygen partial pressure so that the formed thin film has an electron carrier concentration of  $10^{16}/\text{cm}^3$  or less at room temperature" in the patent invention 2 are common in that both methods are such that "when depositing the thin film on a substrate in an atmosphere containing an oxygen gas, the magnitude of oxygen partial pressure is controlled to reduce the electron carrier concentration of the formed thin film, thereby to form a transparent oxide thin film."

E Considering the above, the corresponding features and the different features between the patent invention 2 and the Cited Invention 1 are as follows.

<Corresponding feature>

A vapor-phase film formation method for an oxide thin film, wherein

when depositing the thin film on a substrate in an atmosphere containing an oxygen gas, the magnitude of oxygen partial pressure is controlled to reduce the

electron carrier concentration of the formed thin film, thereby to form a transparent oxide thin film.

<The different feature>

- Different feature 1-2: The transparent oxide thin film to be formed differs in that in the case of the patent invention 2, the transparent oxide thin film is ""an oxide thin film with a crystallized composition thereof expressed by a formula InGaO<sub>3</sub>(Zn<sub>1-x</sub>Mg<sub>x</sub>O)<sub>m</sub> (m is a natural number of less than 6,  $0.80 \le x < 0.85$ )" formed by "a pulsed laser deposition method or an RF sputtering method" "using a polycrystal of the oxide as a target, in a state where a temperature of the substrate is not intentionally increased, without intentionally adding impurity ions for enhancing electric resistance to the thin film" and is "an amorphous oxide thin film," which is "semi-insulating transparent In-Ga-Zn-Mg-O thin film," wherein "the electron carrier concentration of the formed thin film at room temperature is  $10^{16}$ /cm<sup>3</sup> or less," and "the electron mobility at room temperature is 0.1 cm<sup>2</sup>/(V.second) or more,"" while in the case of Cited Invention 1, the transparent oxide thin film is ""an ITO film which is a transparent electrode," wherein "the carrier concentration is controlled to  $10^{18}$ .cm<sup>-3</sup> or less.""

- (2) Judgment of the different feature
- Regarding the different feature 1-2
- A <Regarding the substitution of a transparent oxide thin film>

As examined in "Different feature 1-1" above, it cannot be recognized that a person skilled in the art could easily arrive at the configuration of patent invention 1 from Cited Invention 1, that is, to conceive of using "an oxide thin film with a crystallized composition thereof expressed by a formula  $InGaO_3(ZnO)_m$  (m is a natural number of less than 6)" as the material instead of the "ITO" film of Cited Invention 1.

More specifically, the transparent In-Ga-Zn-Mg-O amorphous oxide thin film was publicly known, the ratio between Zn and Mg could be appropriately determined, and further in light of the description in Evidence A No. 12, it was known before the priority date of the patent that as the ratio of Zn was increased, the conductivity was increased, and hence considering the optical properties and the conductivity required for the conductive oxide, there could be room to construe that a person skilled in the art could easily conceive that in the transparent In-Ga-Zn-O amorphous oxide thin film such as InGaO<sub>3</sub>(ZnO)<sub>m</sub>, Zn was replaced with Zn+Mg and the ratio between Zn and Mg

was adjusted. In spite of the above, it cannot be recognized that a person skilled in the art could easily arrive at the configuration of patent invention 1 from Cited Invention 1, that is, to conceive of using "an oxide thin film with a crystallized composition thereof expressed by a formula  $InGaO_3(ZnO)_m$  (m is a natural number of less than 6)" as the material instead of the "ITO" film of Cited Invention 1. Therefore, it cannot be recognized that a person skilled in the art could conceive of using "an oxide thin film with a crystallized composition thereof expressed by a formula  $InGaO_3(ZnO)_m$  (m is a natural number of less than 6)" as the natural number of less than 6)" as the material instead of the "ITO" film of Cited Invention 1. Therefore, it cannot be recognized that a person skilled in the art could conceive of using "an oxide thin film with a crystallized composition thereof expressed by a formula  $InGaO_3(ZnO)_m$  (m is a natural number of less than 6)" as the material instead of the "ITO" film of Cited Invention 1, and further it cannot be recognized that a person skilled in the art could easily conceive of replacing "an oxide thin film with a crystallized composition thereof expressed by a formula  $InGaO_3(ZnO)_m$  (m is a natural number of less than 6)" with "an oxide thin film" with "a crystallized composition thereof expressed by a formula  $InGaO_3(ZnO)_m$  (m is a natural number of less than 6)" with "an oxide thin film" with "a crystallized composition thereof expressed by a formula  $InGaO_3(ZnO)_m$  (m is a natural number of less than 6,  $0.80 \le x < 0.85$ ).

Furthermore, a person skilled in the art cannot find motivation to cause the percentage of Mg<sub>x</sub> to Zn<sub>1-x</sub> to be particularly  $0.80 \le x < 0.85$  from the description "When magnesium coexists with zinc, the ratio between magnesium and zinc is not particularly limited. It should be noted that as the ratio of magnesium is increased, the absorption edge is shifted to shorter wavelength, and the transparency tends to increase. As the ratio of zinc is increased, the conductivity tends to increase." in the excerpt (A-12d) of Evidence A No. 12 above. In addition, it is recognized that patent invention 2 would exert such an exceptional effect exceeding the scope of the prediction made by a person skilled in the art by causing the percentage of  $Mg_x$  to  $Zn_{1-x}$  to be particularly  $0.80 \le x < 0.85$  as "Note that when Mg is added, the electron mobility of the oxide film is reduced as compared with a film without Mg, but to a small degree. Meanwhile, further, the electron carrier concentration can be reduced as compared with a film without Mg, and hence the film with Mg added is more preferable as the TFT channel layer. --- To cause the electron carrier concentration to be  $10^{16}$ /cm<sup>3</sup> or less, x should be 0.80≤x<0.85 as shown in FIG. 4." described in the excerpt (Subject patent-h) of the patent description above.

Therefore, it cannot be construed from the description on Evidence A No. 1, Evidence A No. 4, Evidence A No. 5, Evidence A No. 6, Evidence A No. 7, Evidence A No. 8, Evidence A No. 9, Evidence A No. 10, Evidence A No. 11, and Evidence A No. 12, that a person skilled in the art could easily conceive that "the oxide thin film such as ITO" was replaced with "the amorphous oxide thin film" which is "an In-Ga-Zn-Mg-O thin film" with "a crystallized composition thereof expressed by a formula

InGaO<sub>3</sub>(Zn<sub>1-x</sub>Mg<sub>x</sub>O)<sub>m</sub> (m is a natural number of less than 6,  $0.80 \le x < 0.85$ )" in Cited Invention 1.

### (3) Summary

It cannot be recognized that a person skilled in the art could easily invent the patent invention 2 based on the invention described in Evidence A No. 1, Evidence A No. 4, Evidence A No. 5, Evidence A No. 6, Evidence A No. 7, Evidence A No. 8, Evidence A No. 9, Evidence A No. 10, Evidence A No. 11, and Evidence A No. 12.

#### 7 Patent inventions 3 to 5

The patent inventions 3 to 5 are as previously recognized in "No. 2 The Invention," and are reproduced as follows.

### [Claim 3]

The vapor-phase film formation method for an amorphous oxide thin film according to claim 1 or 2, wherein a glass substrate, a plastic substrate, or a plastic film is used as the substrate.

# [Claim 4]

The vapor-phase film formation method for an amorphous oxide thin film according to claim 1, wherein the pulsed laser deposition method is used to form the film in a vacuum atmosphere with an oxygen partial pressure of more than 5 Pa. [Claim 5]

The vapor-phase film formation method for an amorphous oxide thin film according to claim 1, wherein the RF sputtering method is used to form the film in a mixed atmosphere of an oxygen gas and an argon gas with an oxygen partial pressure of more than  $4x10^{-2}$  Pa."

8 Judgment by the body regarding the patent inventions 3 to 5

The patent inventions 3 to 5 cite the patent invention 1 or cite the patent invention 1 or the patent invention 2 to further limit the materials of the substrate or the oxygen partial pressure and the like in the patent invention 1 or in the patent invention 1 or the patent invention 2.

Meanwhile, Evidence A No. 1, Evidence A No. 4, Evidence A No. 5, Evidence A No. 6, Evidence A No. 7, Evidence A No. 8, Evidence A No. 9, Evidence A No. 10, Evidence A No. 11, and Evidence A No. 12 describe the matters summarized above.

In addition, Evidence A No. 1 describes the use of a transparent insulating substrate such as glass ([0013]); Evidence A No. 9 describes "an amorphous oxide p-n heterojunction diode composed of p-ZnO-Rh<sub>2</sub>O<sub>3</sub> and n-InGaZnO<sub>4</sub> was fabricated on a glass substrate or a plastic substrate at room temperature by a sputtering technique." (on the twelfth to fifteenth lines of page 1 of the translation); and Evidence A No. 3 describes a method of fabricating an oxide thin film with an oxygen partial pressure of 0.2 mbar by the pulsed laser deposition method (on the sixth to eighth lines and the 20th to 26th lines of page 10.)

However, as examined above, it cannot be recognized that a person skilled in the art could easily invent the patent invention 1 or the patent invention 2, and hence it cannot be recognized that a person skilled in the art could easily invent the patent inventions 3 to 5 which further limit the patent invention 1, or the patent invention 1 or the patent invention 2.

Therefore, it cannot be recognized that a person skilled in the art could easily invent the patent inventions 3 to 5 based on the invention described in Evidence A No. 1, Evidence A No. 3, Evidence A No. 4, Evidence A No. 5, Evidence A No. 6, Evidence A No. 7, Evidence A No. 8, Evidence A No. 9, Evidence A No. 10, Evidence A No. 11, and Evidence A No. 12.

9 Summary of the reason for invalidation 1

As described above, it cannot be said that a person skilled in the art could easily invent the patent inventions 1 to 5.

Therefore, the reason for invalidation 1 against the patent inventions 1 to 5 is groundless.

No. 6 Regarding the reason for invalidation 2

1 Patent invention 1

The patent invention 1 is as recognized in "No. 2 The Invention."

2 Matters described in Evidence A No. 2

Evidence A No. 2 describes the following matters regarding "Semiconductor device and display device using the same" (Title of the Invention) together with FIGS. 1 to 7.

(A-2a) "Technical Field

The present invention relates to a semiconductor device using group-II oxide as a semiconductor layer and a display device using the same, and particularly to a method of improving performance suitable for the semiconductor device using zinc oxide as the semiconductor layer." (on the third to sixth lines of page 1 of the description)

(A-2b) "Japanese Unexamined Patent Application Publication No. 2000-150900 (publication date: May 30, 2000; hereinafter referred to as patent document 2) describes improving an aperture ratio of the liquid crystal display device by causing the transistor to be transparent using a <u>transparent semiconductor such as zinc oxide</u> for the channel layer of the transistor and using transparent insulating oxide for the gate insulating layer." (on the first to fifth lines of page 2 of the description)

(A-2c) "It is an object of the present invention to provide a semiconductor device, whose semiconductor layer contains group-II oxide, and whose performance is improved by a general purpose technique, and a display device using the same." (on the sixth to eighth lines of page 5 of the description)

(A-2d) "The semiconductor device of the present invention is characterized by being a semiconductor device, whose semiconductor layer contains group-II oxide, wherein amorphous aluminum oxide ( $Al_2O_3$ ) is laminated on at least one surface of the semiconductor layer.

According to the above configuration, <u>in order to improve the performance of</u> the semiconductor device, wherein a semiconductor layer thereof contains group-II oxide such as zinc oxide, the prior art used a technique for improving a crystallinity of a laminated film and controlling the crystallinity, interfacial control associated therewith, and further <u>doping impurities</u>; while the present invention laminates amorphous <u>aluminum oxide on at least one surface of the semiconductor layer</u>. Such a structure makes it possible to obtain the same level of performance as that of a semiconductor <u>device obtained by fabricating all laminated films by crystalline laminated films</u> which cannot be fabricated by laminated films other than amorphous aluminum oxide films. It is considered that <u>this is because the defect level at an interface therebetween is</u> reduced by laminating the amorphous aluminum oxide on the group-II oxide semiconductor layer. The defect level refers to an electronic defect in a semiconductor layer so as to block carrier movement." (on the seventh to 23rd lines of page 5 of the translation) (A-2e) "This makes it possible to provide a semiconductor device including a semiconductor layer made of group-II oxide, wherein <u>improvement of crystallinity is</u> <u>not so strong demand as before for a semiconductor layer of zinc oxide, it is easy to</u> form a film, and it is possible to easily cope with an increase in size of a substrate." (on the 24th line of page 5 to the third line of page 6 of the description)

(A-2f) "In the semiconductor device of the present invention, the group-II oxide is preferably zinc oxide. Examples of the group-II oxide that can be used for the semiconductor layer include zinc oxide (ZnO), magnesium zinc oxide ( $Mg_xZn_{1-x}O$ ), cadmium zinc oxide ( $Cd_xZn_{1-x}$ ), cadmium oxide (CdO), and the like, of which zinc oxide is particularly suitable and is particularly expected to improve the properties." (on the tenth to 15th line of page 6 of the description)

(A-2g) "The channel layer 5 is a semiconductor layer made of group-II oxide including zinc oxide (ZnO), magnesium zinc oxide ( $Mg_xZn_{1-x}O$ ), cadmium zinc oxide ( $Cd_xZn_{1-x}O$ ), cadmium oxide (CdO), and the like, or a mixture thereof, wherein zinc oxide is particularly suitable. The film thickness of the channel layer 5 is generally set to be within a range of 100 nm or more and 200 nm or less, but is not particularly limited.

The channel layer 5 may be crystalline to improve the mobility or may be <u>amorphous</u> considering the scattering due to crystal grain boundaries." (on the 19th line of page 8 to the first line of page 9 of the description)

(A-2h) "Zinc oxide has the property of easily taking on a crystallinity and orientation by itself, and hence, for example, when the <u>sputtering method</u> is used, there may be used a method of adjusting the film formation rate lower than that of the case where the channel layer 5 does not have crystallinity or orientation." (on the fourth to seventh lines of page 9 of the description)

(A-2i) "Table 1 specifically lists the effects of improving the properties by FET1 having a structure of FIG. 1 from the experimental results by the present inventors. Examples of important properties representing the performance of FET include a Vg-Id property which is a current change property between the source and the drain with respect to the gate voltage. Examples of the indicator characterizing this Vg-Id property include threshold voltage, mobility, on/off ratio, and hysteresis, which are listed in Table 1.

The experimental conditions were as follows. The threshold voltage, mobility, on/off ratio, and hysteresis were obtained by measuring the Vg-Id properties using the semiconductor parameter analyzer (fabricated by Agilent Co., Ltd., model 4155C.)

It should be noted that  $\underline{zinc}$  oxide was used as the channel layer 5 in all of these samples.

More specifically, the following experiment used an FET including a substrate 2 with a thickness of 0.7 mm made from alkali-free glass, a gate layer 3 with a thickness of 150 nm made from tantalum (Ta), a gate insulating layer 4 with a thickness of 200 nm made from the following material, <u>a channel layer 5 with a thickness of 100 nm made from crystalline zinc oxide</u>, and a source layer 6 and a drain layer 7 each having a thickness of 100 nm made from aluminum (Al), all of which were laminated in this order to form the FET as illustrated in FIG. 1.

The sample of the prior art was prepared by causing each laminated film to have a crystallinity; the sample of the present invention was prepared by laminating crystalline zinc oxide as the channel layer 5 on the gate insulating layer 4 of amorphous aluminum oxide (resistivity  $5 \times 10^{13} \Omega$ .cm) as described above; and the sample for comparison was prepared by laminating crystalline zinc oxide on the gate insulating layer 4 of amorphous silicon nitride (resistivity  $1 \times 10^{16} \Omega$ .cm) instead of amorphous aluminum oxide of the present invention. In addition, the sample of the prior art used calcium zirconate (resistivity  $3 \times 10^{14} \Omega$ .cm) as the gate insulating layer 4." (on the seventh line of page 10 to the eighth line of page 11 of the description)

(A-2j) Table 1 indicates that the threshold voltage is  $0.0\pm3.0$  V, the on/off ratio is  $10^7$ , the mobility is 3.0 to 4.0 cm<sup>2</sup>/V.s, and the hysteresis is within 3.0 V in the invention described in Evidence A No. 2.

(A-2k) "The channel layer 25 may be composed of zinc oxide and the like in the same way as the channel layers 5 and 15, and may be crystalline or <u>amorphous</u>." (on the twelfth to thirteenth lines of page 14 of the description)

(A-21) "Then, <u>zinc oxide (ZnO)</u> was deposited on the gate insulating layer 4 as the channel layer 5 by <u>the PLD method</u>. <u>The deposition conditions were as follows</u>. <u>Specifically, the KrF excimer laser was used with a laser power density of 1.0 J/cm<sup>2</sup>, a laser pulse repetition frequency of 10 Hz, a deposition atmosphere of oxygen, and a deposition pressure of 200 m Torr ( $\approx 26.7$  Pa), and a zinc oxide sintered body was used</u>

as the target with a film thickness of approximately 5 to 100 nm." (on the 16th to 22nd lines of page 20 of the description)

# (A-2m) "Claims

1. A semiconductor device, whose semiconductor layer contains group-II oxide, wherein amorphous aluminum oxide is laminated on at least one surface of the semiconductor layer.

2. The semiconductor device according to claim 1, wherein the group-II oxide is zinc oxide." (on the first to seventh lines of page 24 of the description)

3 Judgment by the body regarding patent invention 1

(1) Cited Invention 2

When the excerpts (A-2a) to (A-2m) above are summarized, it is recognized that Evidence A No. 2 describes the following invention (hereinafter referred to as "Cited Invention 2".)

"In a semiconductor device, whose semiconductor layer contains group-II oxide, wherein amorphous aluminum oxide is laminated on at least one surface of the semiconductor layer, in a film formation method of forming an oxide semiconductor layer by the PLD method using zinc oxide (ZnO) which is the semiconductor layer, wherein

when depositing the semiconductor layer on the substrate using a zinc oxide sintered body as a target in an atmosphere containing oxygen,

a Zn-O transparent oxide semiconductor layer is formed by setting a deposition pressure thereof to 26.7 Pa."

(2) Comparison

A The patent invention 1 is compared with the Cited Invention 2.

B The "transparent oxide semiconductor layer" of the Cited Invention 2 corresponds to the "transparent" "oxide thin film" of the patent invention 1.

C The "PLD method" of the Cited Invention 2 corresponds to the "pulsed laser deposition method" of the patent invention 1, which is "a vapor-phase film formation method."

D Regarding oxide, the "ZnO" oxide semiconductor layer of the Cited Invention 2 and "the "transparent In-Ga-Zn-O thin film" and the "oxide thin film" with a crystallized composition thereof expressed by a formula  $InGaO_3(ZnO)_m$  (m is a natural number of less than 6)" of the patent invention 1 are common in that both films are "oxide thin films containing Zn and O."

E The configuration including the expressions "in an atmosphere containing oxygen" and "by setting a deposition pressure thereof to 26.7 Pa" of the Cited Invention 2 corresponds to the configuration including the expression "in an atmosphere containing an oxygen gas" of the patent invention 1.

In addition, the Cited Invention 2 is such that "when the semiconductor layer is deposited on the substrate using a zinc oxide sintered body as a target in an atmosphere containing oxygen, a deposition pressure thereof is set to 26.7 Pa" and when the thin film is deposited on the substrate in an atmosphere containing an oxygen gas, impurity ions for enhancing electric resistance are not intentionally added to the thin film.

Therefore, the patent invention 1 and the Cited Invention 2 are matched in that "the thin film is deposited on the substrate without intentionally adding impurity ions for enhancing electric resistance to the thin film in an atmosphere containing an oxygen gas."

F Considering the above, the patent invention 1 and the Cited Invention 2 have the following corresponding features and different features.

# <Corresponding feature>

"A vapor-phase film formation method, using a pulsed laser deposition method for an oxide thin film containing Zn and O, wherein a thin film is deposited on the substrate using a sintered body of the oxide as a target without intentionally adding impurity ions for enhancing electric resistance to the thin film in an atmosphere containing an oxygen gas, thereby to form a transparent oxide thin film."

#### <Different features>

Different feature 2-1: The difference is that the "oxide thin film containing Zn and O" is a thin film with "a crystallized composition thereof expressed by a formula  $InGaO_3(ZnO)_m$  (m is a natural number of less than 6)" in the patent invention 1,

while it is a layer of "ZnO" in the Cited Invention 2.

• Different feature 2-2: The difference is that the thin film deposited on the substrate is an "amorphous oxide thin film" and a "semi-insulating" thin film "with an electron mobility of 0.1 cm<sup>2</sup>/(V.second) or more at room temperature and an electron carrier concentration of  $10^{16}$ /cm<sup>3</sup> or less" in the patent invention 1, while

the "Zn-O transparent oxide semiconductor layer" is formed "by setting a deposition pressure thereof to 26.7 Pa when the semiconductor layer is deposited on the substrate using a zinc oxide sintered body as a target in an atmosphere containing oxygen" in the Cited Invention 2, but it is not clear whether or not the "Zn-O transparent oxide semiconductor layer" is amorphous, and the electron mobility and the electron carrier concentration thereof are unknown.

• Different feature 2-3: The patent invention 1 has a configuration such that "when the thin film is deposited on the substrate "using a polycrystal of the oxide as a target in a state where a temperature of the substrate is not intentionally increased," the magnitude of oxygen partial pressure is controlled so that the formed thin film has an electron carrier concentration of  $10^{16}$ /cm<sup>3</sup> or less at room temperature" while

the Cited Invention 2 does not specify the above configuration.

(3) Judgment of the different features

• Regarding the different feature 2-1

A Evidence A No. 9 describes the following matters.

(A9-c) "The <u>amorphous semiconductor</u> has a particular advantage of enabling <u>low-temperature thin-film deposition</u> on a <u>large-area substrate</u>, and hence is very suitable for application to a <u>large-area electronic device</u> such as a solar battery and a flat panel display." (on the fifth to eighth lines of page 1 of the translation)

(A9-d) "This finding subsequently led to the development of an ultraviolet light-emitting diode (UV-LED)<sup>[7]</sup>, all of which are composed of <u>transparent</u> "oxide," a <u>transparent</u> transistor<sup>[8]</sup>, a <u>transparent</u> homo diode<sup>[9]</sup>, and a transparent circuit by light irradiation<sup>[10]</sup>. (on the third to sixth lines of page 2 of the translation)

(Reproduced) (A9-a) "The amorphous  $InGaZnO_4$  was known as an n-type semiconductor, and was <u>fabricated at room temperature by radio-frequency (RF)</u> <u>sputtering<sup>[17]</sup></u>. The electrical conductivity thereof was  $1.4 \times 10^{-1} \text{Scm}^{-1}$  at room temperature. The carrier density was estimated as  $4.2 \times 10^{16} \text{ cm}^{-3}$  using a mobility value

of  $21 \text{ cm}^2 \text{V}^{-1} \text{s}^{-1[17]}$  as previously reported. The element fabricated on a plastic sheet is flexible as shown in FIG. 3b." (on the first line to the sixth line of page 8 of the translation)

(Reproduced) (A9-b) "a-InGaZnO<sub>4</sub> film was <u>deposited in Ar</u> using a disk-shaped target of a polycrystalline InGaZnO<sub>4</sub> film." (on the first to second lines of page 12 of the translation)

(A9-e) "As a series of <u>n-type amorphous oxide semiconductors</u>, a-In<sub>2</sub>O<sub>3</sub><sup>[13]</sup>, a-AgSbO<sub>3</sub><sup>[14]</sup>, a-2CdO-GeO<sub>2</sub><sup>[15]</sup>, a-CdO-PbO<sub>x</sub><sup>[16]</sup>, <u>a-InGaO<sub>3</sub>(ZnO)<sub>m</sub> (m≤4)</u><sup>[17]</sup>, a-ZnO-SnO<sub>2</sub><sup>[18]</sup>, and the like have been found to date. These semiconductors are characterized by having unique electron transporting properties, that is, absence of Hall voltage sign double anomaly commonly found in existing amorphous semiconductors <sup>[19]</sup>, and having as high a mobility as a crystalline material (electron Hall mobility greater than 10 cm<sup>2</sup>V<sup>-1</sup>s<sup>-1</sup>)<sup>[20]</sup>." (on the 20th to 27th lines of page 2 of the translation)

B More specifically, Evidence A No. 9 describes that  $InGaO_3(ZnO)_m$  is used as a transparent oxide thin film which is "amorphous"; the amorphous semiconductor "enables low-temperature thin-film deposition on a large-area substrate"; the "carrier density" of the amorphous InGaZnO<sub>4</sub> "deposited in Ar using a disk-shaped target of a polycrystalline InGaZnO<sub>4</sub> film" "fabricated at room temperature by radio-frequency (RF) sputtering" "was estimated as  $4.2 \times 10^{16}$ /cm<sup>3</sup> using a value of  $21 \text{ cm}^2 \text{V}^{-1} \text{s}^{-1} \text{ [}^{17]}$  as the previously reported mobility"; and "as a series of n-type amorphous oxide semiconductors,  $a-In_2O_3^{[13]}$ ,  $a-AgSbO_3^{[14]}$ ,  $a-2CdO-GeO_2^{[15]}$ ,  $a-CdO-PbO_x^{[16]}$ ,  $a-InGaO_3(ZnO)_m (m \le 4)^{[17]}$ ,  $a-ZnO-SnO_2^{[18]}$ , and the like have been found to date."

C Judging from the above, it could be said that the semiconductor layer of the Cited Invention 2 and the amorphous InGaZnO<sub>4</sub> which is an n-type amorphous oxide semiconductor described in Evidence A No. 9 are matched in that both are transparent oxide thin films, which are semiconductors; and from the excerpt (A-2d) above "improvement of crystallinity is not strong demand, it is easy to form a film, and it is possible to easily cope with an increase in size of a substrate," the semiconductor layer of the Cited Invention 2 and the amorphous InGaZnO<sub>4</sub> which is an n-type amorphous oxide semiconductor described in Evidence A No. 9 are common in that "improvement of crystallinity is not strong demand, it is easy to form a film, and it is possible to easily cope with an increase in Evidence A No. 9 are common in that "improvement of crystallinity is not strong demand, it is easy to form a film, and it is possible to easily cope with an increase in size of a substrate."

D In addition to the above, it can be said that the oxide which is "In-Ga-Zn-O" with "a crystallized composition thereof expressed by a formula  $InGaO_3(ZnO)_m$  (m is a natural number of less than 6)" is well known as is described in any of the excerpt (7b) of Evidence A No. 7 above, the excerpts (A4-c), (A4-e), and (A4-f) of Evidence A No. 4 above, the excerpt (A6-e) of Evidence A No. 6 above, the excerpt (A8-a) of Evidence A No. 8 above, and following Evidence A No. 13

"This compound is useful as an optical functional material, a semiconductor material, a catalyst material, and the like. Examples of application of this compound may include an element for a phosphor, a semiconductor, and the like.

This compound can be fabricated by the following method.

This compound can be fabricated in such a manner that metal indium or indium oxide or a compound decomposed into indium oxide by heating, and metal gallium or gallium oxide or a compound decomposed into gallium oxide by heating, and metal zinc or zinc oxide or a compound decomposed into zinc oxide by heating are mixed with an atomic ratio of In:Ga:Zn = 1:1:2; and then the mixture is heated at 600°C or more in the air, in an oxidizing atmosphere or in a reducing atmosphere where In and Ga are not reduced from the trivalent state and Zn is not reduced by the divalent state.

Any commercially available material can be used as the <u>starting material for</u> <u>use in the present invention</u> as is, but in order to rapidly proceed the chemical reaction, the material with a <u>small particle size is good</u>, particularly a material with a particle size of <u>10  $\mu$ m or less is preferable</u>.

In addition, when used as the optical functional material or the semiconductor material, the material with less impurities, namely, with high purity is preferable.

These materials are mixed as is or sufficiently mixed together with alcohol or acetone.

The materials are mixed with an atomic ratio of In:Ga:Zn = 1:1:2. Without this mixture ratio, a single phase compound of interest cannot be obtained.

The mixture is heated at  $600^{\circ}$ C or more in the air, in an oxidizing atmosphere or in a reducing atmosphere where In and Ga are not reduced from the trivalent state and Zn is not reduced by the divalent state. The heating time is several hours or more. The temperature rising rate during heating is not limited. After heating, the air may be rapidly cooled to 0°C or the material may be rapidly pulled out into the air.

<u>It was found that</u> the <u>powder</u> of the obtained  $InGaZnMgO_4$  compound is colorless and has a crystal structure by X-ray diffraction method. The crystal structure

is a layered structure formed by laminating  $InO_{1.5}$  layer,  $(GaZn)O_{2.5}$  layer, and ZnO layer.

# Examples

An indium oxide powder with a purity of 99.99% or more, a gallium oxide powder with a purity 99.9% or more, and a special grade zinc oxide powder were weighted at a molar ratio of 1:1:2, and these powders were mixed for approximately 30 minutes by adding ethanol in a mortar, resulting in that a fine powder mixture having an average particle diameter of several  $\mu$ m was obtained. The mixture was sealed in a platinum tube, placed in a furnace set to 1300°C, and heated for 3 days. Then, the sample was removed from the furnace and rapidly cooled to room temperature.

The obtained sample was single phase  $\underline{InGaZn_2O_5}$ . The surface interval (d<sub>o</sub>) and relative reflection intensity of each reflection were measured by powder X-ray diffraction method. The results were listed in Table 2. The lattice constants as the hexagonal system were as follows.

$$a = 3.292 \pm 0.001$$
 (Å)

$$c = 22.52 \pm 0.01$$
 (Å)

The surface interval  $[d_c (Å)]$  calculated from the above lattice constants and each reflection (hkl) of Table 2 were matched very well to the actual measured surface interval  $[d_o (Å)]$ ." (on the first line in left column of page 3 to 19th line in upper left column of page 4)

E However, in order to state that a person skilled in the art could easily conceive of using  $InGaZnO_4$  which is an amorphous oxide semiconductor described in Evidence A No. 9 instead of "zinc oxide (ZnO) which is a semiconductor layer" "wherein the semiconductor layer contains group-II oxide" in Cited Invention 2, it can be said that in addition to understanding the technical significance of the matter specifying the invention, namely, "zinc oxide (ZnO) which is a semiconductor layer" "wherein the semiconductor layer contains group-II oxide" in Cited Invention 2, it is required that the substitution is not intended to detract from the technical significance of Cited Invention 2.

F Then, the technical significance of the matter specifying the invention, namely, "zinc oxide (ZnO) which is a semiconductor layer" "wherein the semiconductor layer contains group-II oxide" in Cited Invention 2 will be examined as follows.

G The following matters can be understood from the excerpts (A-2a) to (A-2m) of Evidence A No. 2 above.

(i) There was known a transistor using a transparent semiconductor such as zinc oxide for the channel layer of the transistor not later than May 30, 2000.

(ii) In order to improve the performance of the semiconductor device, wherein a semiconductor layer thereof contains group-II oxide such as zinc oxide, the prior art used a technique for improving a crystallinity of a laminated film and controlling the crystallinity, interfacial control associated therewith, and further doping impurities.

(iii) Cited Invention 2 provides a structure where amorphous aluminum oxide is laminated on at least one surface of the semiconductor layer, which makes it possible to obtain the same level of performance as that of a semiconductor device obtained by fabricating all laminated films by crystalline laminated films which cannot be fabricated by laminated films other than amorphous aluminum oxide films.

(iv) It is considered that <u>this is because the defect level at an interface therebetween is</u> <u>reduced by laminating the amorphous aluminum oxide on the group-II oxide</u> <u>semiconductor layer</u>. The defect level refers to an electronic defect in a semiconductor layer so as to block carrier movement.

H Judging from the above, it can be understood that the technical significance of "zinc oxide (ZnO) which is a semiconductor layer" "wherein the semiconductor layer contains group-II oxide" in Cited Invention 2 is to obtain a semiconductor device having the same level of performance as that of a semiconductor device obtained by fabricating all laminated films by crystalline laminated films by <u>laminating</u> the <u>semiconductor layer of</u> group-II oxide such as zinc oxide (ZnO) and <u>amorphous aluminum oxide</u>, thereby to reduce the defect level, namely, an electronic defect at an interface therebetween so as to block carrier movement in the semiconductor layer.

I Meanwhile, it can be said that it is a well-known matter for a person skilled in the art in the technical field of the semiconductor device that electrical properties of a semiconductor device may differ depending on the difference in the group of the element contained in a material constituting the semiconductor device. J For example, in InGaZnO<sub>4</sub> described in Evidence A No. 9, "In" and "Ga" are an element belonging to group-III. Judging from the above, it can be recognized that when InGaZnO<sub>4</sub> which is an amorphous oxide semiconductor is used instead of "zinc oxide (ZnO) which is the semiconductor layer" wherein "the semiconductor layer contains group-II oxide" in Cited Invention 2, a person skilled in the art would expect that "In" and "Ga" which are group-III elements contained in the InGaZnO<sub>4</sub> would affect the state of the defect level at the interface formed between the InGaZnO<sub>4</sub> and amorphous aluminum oxide.

Furthermore, it can be said that the total number of elements of "In" and "Ga" belonging to the group-III in InGaZnO<sub>4</sub> is 200% of the number of elements of "Zn" belonging to the group-II, and hence a person skilled in the art would expect that "In" and "Ga" belonging to the group-III would affect the defect level at an interface formed therebetween by laminating the InGaZnO<sub>4</sub> and amorphous aluminum oxide to a considerably large extent.

Considering the above, it cannot be recognized that it is self-evident that in Cited Invention 2 having the technical significance in obtaining a semiconductor device having the same level of performance as that of a semiconductor device obtained by fabricating all laminated films by crystalline laminated films by laminating the semiconductor layer of group-II oxide such as zinc oxide (ZnO) and amorphous aluminum oxide, thereby to reduce the defect level, namely, an electronic defect at an interface therebetween so as to block carrier movement in the semiconductor layer, the modification of the group-III element to InGaZnO<sub>4</sub> containing 200% of the group-II elements instead of group-II oxide such as the zinc oxide (ZnO) would result in reduction of the defect level, namely, an electronic defect at an interface therebetween so as to block carrier movement in a semiconductor layer by laminating InGaZnO<sub>4</sub> and amorphous aluminum oxide. Therefore, it can be said that the modification would hinder the solution of the problem of reducing the defect level of Cited Invention 2. It can be said that there is an obstructing factor that a person skilled in the art would conceive of using InGaZnO<sub>4</sub> of Evidence A No. 9 instead of the semiconductor layer of group-II oxide such as zinc oxide (ZnO) in Cited Invention 2.

K Furthermore, "zinc (Zn)" which is an element constituting "zinc oxide (ZnO)" is a relatively inexpensive material, while both "In" and "Ga" which are elements constituting  $InGaZnO_4$  are materials known as rare metal, which can be said to be an expensive material as compared to "zinc (Zn)."

Judging from the above, it can be said that the use of  $InGaZnO_4$  described in Evidence A No. 9 containing a large amount of expensive "In" and "Ga" instead of inexpensive "zinc oxide (ZnO)" of Cited Invention 2 requires a motivation enough to overcome the price difference, and it cannot be recognized that the common feature examined in C above is a motivation enough to overcome the price difference and arrive at the substitution.

L Based on the above reason, when the above different feature 2-1 is examined, it cannot be recognized that a person skilled in the art could easily arrive at the configuration of patent invention 1 from Cited Invention 2.

• Regarding different features 2-2

The excerpt (A-10d) of Evidence A No. 10 above describes that "In FIG. 2, - - of the single crystal InGaO<sub>3</sub>(ZnO)<sub>5</sub> thin film fabricated - - - . <u>The value of the electron</u> mobility (obtained as the field-effect mobility) - - -, and hence the carrier concentration is estimated to be approximately  $10^{13}$  cm<sup>-3</sup>." The excerpt (A-10e) above describes that "It is understood that this TFET operates as the enhancement type." In addition, the enhancement type is a normally-off type.

In addition, Evidence A No. 11 describes that "In general, in order to fabricate an electronic device such as a normally-off type field-effect transistor, it is necessary to reduce its concentration to the intrinsic level or less ( $<10^{14} \text{ cm}^{-3}$ )." (on the sixth to eighth lines of page 8 of the description)

Judging from the above, it could be said that it was well known that the electron carrier concentration was reduced to approximately  $10^{14}$  cm<sup>-3</sup> or  $10^{13}$  cm<sup>-3</sup> in order to fabricate a normally-off type transistor.

However, the carrier concentration "estimated to be  $10^{13}$  cm<sup>-3</sup>" of Evidence A No. 10 was a value estimated for <u>single crystal</u> InGaO<sub>3</sub>(ZnO)<sub>5</sub> thin film, and hence it cannot be recognized that a person skilled in the art could easily apply the carrier concentration "estimated to be  $10^{13}$  cm<sup>-3</sup>" of Evidence A No. 10 to the <u>amorphous</u> oxide thin film with a crystallized composition thereof expressed by a formula InGaO<sub>3</sub>(ZnO)<sub>m</sub> (m is a natural number of less than 6).

Further, the excerpt (A9-a) of Evidence A No. 9 above describes that an amorphous  $InGaZnO_4$  film whose electron carrier concentration is  $4.2x10^{16}$  cm<sup>-3</sup> calculated using 21 cm<sup>2</sup>V<sup>-1</sup>s<sup>-1</sup> as the value of the mobility was fabricated, but as is clear from the excerpt (A9-b) of Evidence A No. 9 above, the a-InGaZnO<sub>4</sub> film deposited in Evidence A No. 9 was obtained by forming an amorphous InGaZnO<sub>4</sub> film whose

electron carrier concentration is  $4.2 \times 10^{16}$  cm<sup>-3</sup> in Ar. Therefore, it cannot be recognized that it could be easy to apply the invention of adjusting the oxygen concentration described in the excerpt (A-1e) and the excerpt (A-1h) of Evidence A No. 1 above and the excerpt (A-5a) and the excerpt (A-5c) of Evidence A No. 5 above, to the invention described in Evidence A No. 9.

In other words, even if a person skilled in the art came across the description of Evidence A No. 1, Evidence A No. 5, Evidence A No. 9, Evidence A No. 10, and Evidence A No. 11, it cannot be recognized that the person skilled in the art could easily reduce the electron carrier concentration to approximately  $10^{16}$  cm<sup>-3</sup> or less by controlling the oxygen partial pressure for the purpose of fabricating a normally-off type transistor when the semiconductor layer of Cited Invention 2 is applied to the transistor.

Further, it is obvious that when the electron carrier concentration of the semiconductor layer of Cited Invention 2 is reduced to  $10^{16}$  cm<sup>-3</sup> or less, the value of the electron mobility is changed, but none of Evidence A No. 1, Evidence A No. 5, Evidence A No. 9, Evidence A No. 10, and Evidence A No. 11 describes that the property of "an electron mobility of  $0.1 \text{ cm}^2/(\text{V.second})$  or more at room temperature" in the amorphous oxide thin film and the property of "an electron carrier concentration of  $10^{16}/\text{cm}^3$  or less" were achieved at the same time. Therefore, it cannot be recognized that a person skilled in the art could easily achieve the property of "an electron mobility of  $0.1 \text{ cm}^2/(\text{V.second})$  or more at noblic mobility of  $0.1 \text{ cm}^2/(\text{V.second})$  or more at room temperature concentration of  $10^{16}/\text{cm}^3$  or less" were achieved at the same time. Therefore, it cannot be recognized that a person skilled in the art could easily achieve the property of "an electron mobility of  $0.1 \text{ cm}^2/(\text{V.second})$  or more at noblic the property of "an electron mobility of  $0.1 \text{ cm}^2/(\text{V.second})$  or more at noblic the property of "an electron mobility of  $0.1 \text{ cm}^2/(\text{V.second})$  or more at noblic the property of "an electron mobility of  $0.1 \text{ cm}^2/(\text{V.second})$  or more at noblic the property of "an electron mobility of  $0.1 \text{ cm}^2/(\text{V.second})$  or more at noblic the property of "an electron mobility of  $0.1 \text{ cm}^2/(\text{V.second})$  or more at noblic the property of "an electron mobility of  $0.1 \text{ cm}^2/(\text{V.second})$  or more at noblic the property of "an electron mobility of  $0.1 \text{ cm}^2/(\text{V.second})$  or more at noblic the property of "an electron mobility of  $0.1 \text{ cm}^2/(\text{V.second})$  or more at noblic the property of "an electron carrier concentration of  $10^{16}/\text{cm}^3$  or less" at the same time.

Based on the above reason, when the above different feature 2-2 is examined, it cannot be recognized that a person skilled in the art could easily arrive at the configuration of patent invention 1 from Cited Invention 2.

#### • Regarding the effect

A According to excerpts (A-2i) and (A-2j) above, Cited Invention 2 achieved electrical properties such as a threshold voltage of  $0.0 \pm 3.0$  V, an on/off ratio of  $10^7$ , and a mobility of 3.0 to 4.0 cm<sup>2</sup>/V.s by using zinc oxide as the channel layer 5, but it cannot be recognized that a person skilled in the art could predict that the properties more excellent than the electrical properties of Cited Invention 2 described in Evidence A No. 2 could be obtained by using InGaZnO<sub>4</sub> described in Evidence A No. 9 instead of using zinc oxide as the channel layer 5 in Cited Invention 2. Therefore, it cannot be recognized that a person skilled in the art could easily conceive of using InGaZnO<sub>4</sub> described in Evidence A No. 9 instead of using ZnO<sub>4</sub> described in Evidence A No. 9 instead of using InGaZnO<sub>4</sub> described in Evidence A No. 9 instead of using InGaZnO<sub>4</sub> described in Evidence A No. 9 instead of using InGaZnO<sub>4</sub> described in Evidence A No. 9 instead of using InGaZnO<sub>4</sub> described in Evidence A No. 9 instead of using InGaZnO<sub>4</sub> described in Evidence A No. 9 instead of using InGaZnO<sub>4</sub> described in Evidence A No. 9 instead of using ZnO<sub>4</sub> described in Evidence A No. 9 instead of using ZnO<sub>4</sub> described in Evidence A No. 9 instead of using ZnO<sub>4</sub> described in Evidence A No. 9 instead of using ZnO<sub>4</sub> described in Evidence A No. 9 instead of using ZnO<sub>4</sub> described in Evidence A No. 9 instead of using ZnO<sub>4</sub> described in Evidence A No. 9 instead of using ZnO<sub>4</sub> described in Evidence A No. 9 instead of using ZnO<sub>4</sub> described in Evidence A No. 9 instead of using ZnO<sub>4</sub> described as the channel layer 5 in Cited Invention 2.

B Further, as examined in "No. 5 Regarding the reason for invalidation 1, 1 patent invention 1, (3) Judgment of the different feature, - Regarding the different feature 1-1, C (B)," patent invention 1 exerts an effect that "The amorphous oxide film according to the film formation method of the present invention is such that as the electron carrier concentration is increased, the electron mobility is increased, and hence the current in the ON state of the transistor can be further increased," etc., but such an effect could not be predicted from the Cited Invention 2 and the respective items of Evidence A.

### (4) Summary

Based on the above reason, when the above different feature 2-1 and the above different feature 2-2 are examined, it cannot be recognized that a person skilled in the art could easily arrive at the configuration of patent invention 1 from Cited Invention 2, and hence there is no need to examine the other different features and it cannot be recognized that a person skilled in the art could easily invent the patent invention 1 from Cited Invention 1 from Cited Invention 2 and the inventions described in the respective items of Evidence A above.

In short, it cannot be recognized that a person skilled in the art could easily invent the patent invention 1 based on the invention described in Evidence A No. 1, Evidence A No. 2, Evidence A No. 4, Evidence A No. 5, Evidence A No. 6, Evidence A No. 7, Evidence A No. 8, Evidence A No. 9, Evidence A No. 10, Evidence A No. 11, and Evidence A No. 13.

### 4 Patent invention 2

The patent invention 2 is as previously recognized in "No. 2 The Invention."

# 5 Matters described in the respective items of Evidence A

Evidence A No. 1, Evidence A No. 2, Evidence A No. 4, Evidence A No. 5, Evidence A No. 6, Evidence A No. 7, Evidence A No. 8, Evidence A No. 9, Evidence A No. 10, Evidence A No. 11, Evidence A No. 12, and Evidence A No. 13 describe the previously summarized matters.

# 6 Judgment by the body regarding patent invention 2

#### (1) Comparison

Cited Invention 2 is as examined in "3 Judgment by the body regarding patent invention 1" above, and is reproduced as follows.

"In a semiconductor device, whose semiconductor layer contains group-II oxide, wherein amorphous aluminum oxide is laminated on at least one surface of the semiconductor layer, in a film formation method of forming an oxide semiconductor layer by the PLD method using zinc oxide (ZnO) which is the semiconductor layer, wherein

when depositing the semiconductor layer on the substrate using a zinc oxide sintered body as a target in an atmosphere containing oxygen,

a Zn-O transparent oxide semiconductor layer is formed by setting a deposition pressure thereof to 26.7 Pa."

A The patent invention 2 is compared with the Cited Invention 2.

B The "transparent oxide semiconductor layer" of Cited Invention 2 corresponds to the ""transparent" "oxide thin film"" of patent invention 2.

C The "PLD method" of the Cited Invention 2 corresponds to the "pulsed laser deposition method" of the patent invention 2, which is "a vapor-phase film formation method."

D Regarding oxide, the "ZnO" oxide semiconductor layer of the Cited Invention 2 and "the "transparent In-Ga-Zn-Mg-O thin film" and the "oxide thin film" with a "crystallized composition thereof expressed by a formula  $InGaO_3(Zn_{1-x}Mg_xO)_m$  (m is a natural number of less than 6,  $0.80 \le x < 0.85$ )"" of the patent invention 2 are common in that both films are "oxide thin films containing Zn and O."

E The configuration including the expressions "in an atmosphere containing oxygen" and "by setting a deposition pressure thereof to 26.7 Pa" of the Cited Invention 2 corresponds to the configuration including the expression "in an atmosphere containing an oxygen gas" of the patent invention 2.

In addition, the Cited Invention 2 is such that "when the semiconductor layer is deposited on the substrate using a zinc oxide sintered body as a target in an atmosphere containing oxygen, a deposition pressure thereof is set to 26.7 Pa" but when the thin film is deposited on the substrate in an atmosphere containing an oxygen gas, impurity ions for enhancing electric resistance are not intentionally added to the thin film.

Therefore, the patent invention 2 and the Cited Invention 2 are matched in that "the thin film is deposited on the substrate without intentionally adding impurity ions for enhancing electric resistance to the thin film in an atmosphere containing an oxygen gas."

F Considering the above, the patent invention 2 and the Cited Invention 2 have the following corresponding features and different features.

## <Corresponding feature>

"A vapor-phase film formation method using a pulsed laser deposition method for an oxide thin film containing Zn and O, wherein

a thin film is deposited on a substrate using a sintered body of the oxide as a target without intentionally adding impurity ions for enhancing electric resistance to the thin film in an atmosphere containing an oxygen gas, thereby to form a transparent oxide thin film."

<The different features>

Different feature 2-4: The difference is that the "oxide thin film containing Zn and O" is a thin film with "a crystallized composition thereof expressed by a formula  $InGaO_3(Zn_{1-x}Mg_xO)_m$  (m is a natural number of less than 6,  $0.80 \le x < 0.85$ )" in the patent invention 2, while

it is an oxide of "ZnO" in the Cited Invention 2.

• Different feature 2-5: The difference is that the thin film deposited on the substrate is an "amorphous oxide thin film" and a "semi-insulating" thin film "with an electron mobility of 0.1 cm<sup>2</sup>/(V.second) or more at room temperature and an electron carrier concentration of  $10^{16}$ /cm<sup>3</sup> or less" in the patent invention 2, while

it is not clear whether or not the thin film is amorphous, and the electron mobility and the electron carrier concentration thereof are unknown in Cited Invention 2.

• Different feature 2-6: The patent invention 2 has a configuration for film formation such that "when the thin film is deposited on the substrate "using a polycrystal of the oxide as a target in a state where a temperature of the substrate is not intentionally increased," the magnitude of oxygen partial pressure is controlled so that the formed thin film has an electron carrier concentration of  $10^{16}/\text{cm}^3$  or less at room temperature" while

the Cited Invention 2 does not specify the configuration.

- (2) Judgment of the different features
- Regarding the different feature 2-4

#### A <Regarding substitution of oxides>

There have been known the oxides containing elements such as In, Ga, Zn, Mg, and O as described in Evidence A No. 12, other than the oxides containing elements such as Zn and O as described in Evidence A No. 2 and the oxides containing elements such as In, Ga, Zn, and O as described in Evidence A No. 4, Evidence A No. 6, Evidence A No. 7, Evidence A No. 8, Evidence A No. 9, and Evidence A No. 13. Further, Evidence A No. 12 also describes that the ratio between Zn and Mg could be appropriately determined; and as the ratio of Zn was increased, the conductivity was increased.

However, in view of the description of Evidence A No. 12 known before the priority date of the patent, considering the optical properties and the conductivity required for the conductive oxides, there could be room to construe that a person skilled in the art could easily conceive that in the transparent In-Ga-Zn-O amorphous oxide thin film such as  $InGaO_3(ZnO)_m$ , Zn was replaced with Zn+Mg and the ratio between Zn and Mg was adjusted. In spite of the above, as examined in "Regarding the different feature 2-1" above, it cannot be recognized that a person skilled in the art could easily conceive of using "an oxide thin film with a crystallized composition thereof expressed by a formula  $InGaO_3(ZnO)_m$  (m is a natural number of less than 6)" instead of "ZnO" in Cited Invention 2. Therefore, for the same reason as examined in "Regarding the different feature 2-1" above, it cannot be recognized that a person skilled in the art could conceive of using "an oxide thin film with a crystallized composition thereof expressed by a formula  $InGaO_3(ZnO)_m$  (m is a natural number of less than 6)" instead of "ZnO" in Cited Invention 2. Therefore, for the same reason as examined in "Regarding the different feature 2-1" above, it cannot be recognized that a person skilled in the art could conceive of using "an oxide thin film with a crystallized composition thereof expressed by a formula  $InGaO_3(ZnO)_m$  (m is a natural number of less than 6)" instead of "ZnO" in Cited Invention 2, and to further proceed to replace Zn with Zn+Mg, and adjust the ratio between Zn and Mg.

Furthermore, a person skilled in the art cannot find motivation to cause the percentage of Mg<sub>x</sub> to Zn<sub>1-x</sub> to be particularly  $0.80 \le x < 0.85$  from the excerpt (A-12d) of Evidence A No. 12 above stating that "When magnesium coexists with zinc, the ratio between magnesium and zinc is not particularly limited. It should be noted that as the ratio of magnesium is increased, the absorption edge is shifted to shorter wavelength, and the transparency tends to increase. As the ratio of zinc is increased, the conductivity tends to increase." In addition, it is recognized that patent invention 2 would exert such an exceptional effect exceeding the scope of the prediction made by a

person skilled in the art by causing the percentage of Mg<sub>x</sub> to Zn<sub>1-x</sub> to be particularly  $0.80 \le x < 0.85$  as "Note that when Mg is added, the electron mobility of the oxide film is reduced as compared with a film without Mg, but to a small degree. Meanwhile, further, the electron carrier concentration can be reduced as compared with a film without Mg, and hence the film with Mg added is more preferable as the TFT channel layer. --- To cause the electron carrier concentration to be  $10^{16}$ /cm<sup>3</sup> or less, x should be  $0.80 \le x < 0.85$  as shown in FIG. 4." described in the excerpt (Subject patent-h) of the patent description above.

Based on the above reason, when the above different feature 2-4 is examined, it cannot be recognized that a person skilled in the art could easily arrive at the configuration of patent invention 2 from Cited Invention 2.

## • Regarding the different feature 2-5

For the same reason as "Regarding the different feature 2-2" above, when the above different feature 2-5 is examined, it cannot be recognized that a person skilled in the art could easily arrive at the configuration of patent invention 2 from Cited Invention 2.

## (3) Summary

Based on the above reason, when the above different feature 2-4 and the above different feature 2-5 are examined, it cannot be recognized that a person skilled in the art could easily arrive at the configuration of patent invention 2 from Cited Invention 2, and hence there is no need to examine the other different features and it cannot be recognized that a person skilled in the art could easily invent the patent invention 2 from Cited Invention 2 and the inventions described in the respective items of Evidence A above.

In short, it cannot be recognized that a person skilled in the art could easily invent the patent invention 2 based on the inventions described in Evidence A No. 1, Evidence A No. 2, Evidence A No. 4, Evidence A No. 5, Evidence A No. 6, Evidence A No. 7, Evidence A No. 8, Evidence A No. 9, Evidence A No. 10, Evidence A No. 11, Evidence A No. 12, and Evidence A No. 13.

## 7 Patent inventions 3 to 5

The patent inventions 3 to 5 are as previously recognized in "No. 2 The Invention."

8 Judgment by the body regarding the patent inventions 3 to 5

The patent inventions 3 to 5 cite the patent invention 1 or cite the patent invention 1 or the patent invention 2 to further limit the materials of the substrate or the oxygen partial pressure and the like in the patent invention 1 or in the patent invention 1 or the patent invention 2.

Meanwhile, Evidence A No. 1, Evidence A No. 2, Evidence A No. 4, Evidence A No. 5, Evidence A No. 6, Evidence A No. 7, Evidence A No. 8, Evidence A No. 9, Evidence A No. 10, Evidence A No. 11, Evidence A No. 12, and Evidence A No. 13 describe the matters summarized above.

However, as examined above, it cannot be recognized that a person skilled in the art could easily invent the patent invention 1 or the patent invention 2, and hence it cannot be recognized that a person skilled in the art could easily invent the patent inventions 3 to 5 which further limit the patent invention 1, or the patent invention 1 or the patent invention 2.

Therefore, it cannot be recognized that a person skilled in the art could easily invent the patent inventions 3 to 5 based on the inventions described in Evidence A No. 1, Evidence A No. 2, Evidence A No. 4, Evidence A No. 5, Evidence A No. 6, Evidence A No. 7, Evidence A No. 8, Evidence A No. 9, Evidence A No. 10, Evidence A No. 11, Evidence A No. 12, and Evidence A No. 13.

9 Summary of the reason for invalidation 2

As described above, it cannot be said that a person skilled in the art could easily invent the patent inventions 1 to 5.

Therefore, the reason for invalidation 2 against the patent inventions 1 to 5 is groundless.

No. 7 Regarding the reason for invalidation 3

1 Patent invention 1

The patent invention 1 is as recognized in "No. 2 The Invention."

2 Matters described in Evidence A No. 3

Evidence A No. 3 describes the following matters regarding "Semiconductor device" (Title of the Invention) together with FIGS. 1 to 14.

(A-3a) "[Scope of claims]

1. <u>A semiconductor device comprising a transparent switching element which comprises</u> two connection electrodes of a transparent material; and an interposed transparent channel region of a semiconductor material with a transparent gate electrode of a conductive material being separated from the channel region by a transparent insulating layer, characterized in that the semiconductor material comprises a degenerate semiconductor material containing a basic material with a band gap of 2.5 eV or more between a conduction band and a valence band of electrons and a charge carrier mobility of 10 cm<sup>2</sup>/Vs or more, the material containing dopant atoms forming a fixed impurity energy level in the valence band or the conduction band of the basic material or adjacent thereto.

2. The semiconductor device according to claim 1, wherein the basic material comprises a covalent oxide of a non-transition metal.

3. The semiconductor device according to claim 1, wherein the basic material comprises a covalent oxide selected from the group consisting of Sn, Zn, and In.

4. The semiconductor device according to any one of claims 1 to 3, wherein the connection electrodes, the gate electrode, and the channel region comprise the same basic material containing dopant atoms of the same type; and the semiconductor material contains a smaller amount of dopant atoms than the dose amount of the conductive material.

5. The semiconductor device according to claim 4, wherein the conductive material contains 0.5% or more dopant atoms; and the semiconductor material contains 0.3% or less dopant atoms.

6. The semiconductor device according to claim 5, wherein the basic material contains  $SnO_2$  (Note from the body: original writing error was corrected); and the dopant atoms contain Sb." (on the first to 21st lines of page 2)

(A-3b) "Technical Field of the Invention

The present invention relates to a semiconductor device including a transparent switching element having two connection electrodes of a transparent material and an interposed transparent channel region of a semiconductor material including a transparent gate electrode of a conductive material separated from the channel region by a transparent insulating layer." (on the third to seventh lines of page 4)

## (A-3c) "Background of the Invention

Japanese Patent Application No. 60-198861 discloses a semiconductor device of the kind described above, wherein the transparent connection electrodes and the gate electrode are composed of tin-doped indium oxide, and the insulating layer is composed of silicon oxide.  $WO_3$  is used as the transparent semiconductor material of the channel region.

The known semiconductor device is a so-called "electrochromic device" (ECD). An electrolyte is present above a connection of such a device. Therefore,  $H^+$  ions diffuse from this electrolyte into the WO<sub>3</sub>. Then, the WO<sub>3</sub> can absorb visible light. In other words, the switching element can be regarded as a color. The diffusion of  $H^+$  ions proceeds comparatively slowly. The switching element has some memory effect due to the slow diffusion of the  $H^+$  ions. In other words, the switching element maintains a predetermined state for a certain period of time. The known semiconductor device is transparent to a very limited degree only, i.e. only when there are no  $H^+$  ions in the WO<sub>3</sub>. The conductivity of the WO<sub>3</sub>, which is an insulator in itself, is determined by a reduction in the amount of oxygen in the WO<sub>3</sub> ("oxygen depleted WO<sub>3</sub>").

It is found that the known semiconductor device described above has a practical disadvantage in that the state is switched comparatively slowly because switching of the switching element is also partly determined by the solid state diffusion of the  $H^+$  ions. It is also found that the absorption of visible light increases strongly in the known semiconductor material because a comparatively small amount of oxygen has already been removed, resulting in that the material is no longer transparent when a certain desired conductivity is reached in the semiconductor material. This means that the known switching element cannot be used as a switching element which is transparent under all circumstances.

It is an object of the present invention to provide a semiconductor device adapted to counteract the above mentioned problems." (on the 10th line of page 4 to the fifth line of page 5)

#### (A-3d) "Summary of the invention

In order to achieve this object, the present invention provides a semiconductor device comprising a transparent switching element which comprises two connection
electrodes of a transparent material; and an interposed transparent channel region of a semiconductor material with a transparent gate electrode of a conductive material being separated from the channel region by a transparent insulating layer, characterized in that the semiconductor material comprises a degenerate semiconductor material containing a basic material with a band gap of 2.5 eV or more between a conduction band and a valence band of electrons and a charge carrier mobility of 10 cm<sup>2</sup>/Vs or more, the material containing dopant atoms forming a fixed impurity energy level in the valence band or the conduction band of the basic material or adjacent thereto.

<u>Therefore, the basic material is selected to have a band gap of 2.5 eV or more</u> and a mobility of 10 cm<sup>2</sup>/Vs or more, and then the conductivity is determined by appropriately selecting the nature and concentration of dopant atoms. A sufficient conductivity can be obtained by selecting a concentration of dopant atoms in the range of 0.001% to 0.3%. The impurity energy levels are adjacent to the valence band or the conduction band if the levels are at a distance of approximately 0.1 eV or less from the band gap. Electrons may be readily converted to the valence band or the conduction band from the impurity energy levels at room temperature.

Visible light has insufficient energy for making electron-hole pairs in a semiconductor material having a band gap approximately 2.5 eV or more, so that this visible light is not absorbed by the semiconductor material. The degenerate semiconductor material according to the present invention is transparent because visible light cannot be absorbed due to the large band gap, while at the same time no absorption of visible light takes place through the impurity energy levels. In addition, the switching element including the semiconductor material according to the present invention operates at comparatively high speeds because of the high mobility of charge carriers.

Preferably, the basic material includes a covalent oxide of a non-transition metal. Oxides of such metals and compounds of oxides of such metals such as Ga, Sn, Zn, Sb, Pb, Ge, and In have a mobility 10 cm<sup>2</sup>/Vs or more and a band gap 2.5 eV or more (for example, see J. Phys. Chem. Ref. Data, Vol. 2, No. 1, 1973, p.163 ff.). The more ionic oxides of non-transition metals are not suitable as basic materials because a strong interaction acts between charge carriers and ions in the crystal lattice.

Preferably, the basic material includes covalent oxides selected from the group consisting of Sn, Zn, and In. These covalent oxides have a comparatively high mobility of  $30 \text{ cm}^2/\text{Vs}$  or more even when dopant atoms are added. The dopant atoms decay to the covalent oxides to be used. Therefore, dopant atoms such as Sb, F, and Cl

may be used when  $SnO_3$  is a covalent oxide; Sn dopant atoms may be used when  $In_2O_3$  is a covalent oxide; and Ga dopant atoms may be used when ZnO is a covalent oxide.

In a preferred embodiment, the connection electrodes, the gate electrode, and the channel region comprise the same basic material containing dopant atoms of the same type, while the semiconductor material contains a smaller amount of dopant atoms than the dose amount of the conductive material. Such a semiconductor device can be fabricated comparatively easily because the same material is used, differing only in the amount of dopant atoms. Preferably, the conductive material contains 0.3% or less dopant atoms. Advantageously, the basic material comprises  $SnO_2$  and the dopant atoms comprise Sb." (on the sixth line of page 5 to the 23rd line of page 6)

(A-3e) "FIGS. 1 and 2 illustrate a transparent semiconductor device comprising a switching element 1 which comprises two connection electrodes 2 and 3 of a transparent material and an interposed transparent channel region 4 of a semiconductor material. In the present embodiment, the connection electrodes and the channel region are made from the same semiconductor material. The resistance of the connection electrodes 2 and 3 is comparatively low only due to the width thereof. The channel region 4 includes a transparent conductive gate electrode 5 which is separated from the channel region 4 by a transparent insulating layer 6. According to the present invention, the semiconductor material of the channel region 4 comprises a degenerate semiconductor material having a basic material and dopant atoms. FIG. 3 illustrates the energy levels 13 of electrons of the degenerate semiconductor. The basic material has a band gap 10 of 2.5 eV or more between the conduction band 11 and the valence band 12 of electrons, and the mobility of charge carriers of the basic material is  $10 \text{ cm}^2/\text{Vs}$ . The basic material contains dopant atoms which form a fixed impurity energy level 13 in the valence band 12 or the conduction band 11 or adjacent thereto so that the basic material can be applied thereto. The impurity energy levels 13 are located adjacent to the valence band 12 or the conduction band 11 at a distance 14 of approximately 0.1 eV or less from the edge of the conduction band or the valence band. The impurity energy levels 13 are present within the entire valence band 12 or the conduction band 11. The conductivity can be determined by appropriately selecting the dopant atoms. A dopant atom concentration in the range of 0.001% to 0.3% can provide a sufficiently high conductivity. Electrons can be easily exchanged with the valence band 12 or the conduction band 11 from the impurity energy level 13 at room temperature.

The semiconductor device in FIGS. 1 and 2 can be fabricated as follows. A 50 nm thick conductive SrRuO<sub>3</sub> layer 5 is epitaxially deposited on an insulating monocrystalline SrTiO<sub>3</sub> substrate 7. Although SrRuO<sub>3</sub> is not transparent in itself, a very thin layer of SrRuO<sub>3</sub> of approximately 60 nm or less is transparent. A 0.7 µm thick molybdenum layer is deposited on this SrRuO<sub>3</sub> layer 5. The molybdenum layer is patterned in a known manner by photoresist and Ar-assisted reactive ion etching (RIE) using  $CF_4/O_2$ . Then, the patterned molybdenum is used as a mask for patterning the SrRuO<sub>3</sub> layer by RIE using CHF<sub>3</sub> to form the gate electrode 5. Then, the remaining molybdenum is removed in a so-called redox etching treatment with potassium hexacyanoferrate. Then, the transparent insulating layer 6 and the semiconductor material 4 are provided on the gate electrode 5 and on the surface of the substrate 7. In the present embodiment, a 0.2  $\mu$ m thick insulating layer 6 of BaZrO<sub>2</sub> is provided by pulsed laser deposition at a temperature of 650°C and an oxygen pressure of 0.2 mbar. Then, a 0.1  $\mu$ m thick layer 4 of In<sub>2</sub>O<sub>3</sub> doped with 0.03% Sn is deposited in a known manner on the insulating layer 6 and on the surface of the substrate 7 by pulsed laser deposition at an oxygen pressure of 0.2 mbar and at a temperature of 505°C. The layers 4 and 6 are patterned again using photoresist and a molybdenum layer in the same manner as the conductive layer for the gate electrode 5. Etching is applied for a limited period of time only so as not to damage the gate electrode 5. The channel region 4 and the connection electrodes 2 are formed in this manner.

At a voltage of -4 V or less of the gate electrode 5 relative to the connection electrode 2, the channel region of the switching element fabricated according to the first embodiment is fully depleted of charge carriers. Therefore, a resistance of 200 k $\Omega$  or more is obtained between the connection electrodes 2 and 3. At a voltage of zero V or more of the gate electrode 5, the switching element is conducting and the resistance between the connection electrodes 2 and 3 is approximately 10 k $\Omega$ . The switching element according to the first embodiment may be varied in many ways. Thus, the electrical properties of the switching element can be changed, for example, by changing the geometry such as the size of the channel region or the thickness of the insulating It is also possible to use other covalent oxides of a non-transition metal layer. containing dopant atoms for the semiconductor material of the channel region 4. Oxides of these metals and a mixture thereof have a mobility  $10 \text{ cm}^2/\text{Vs}$  or more and a band gap of 2.5 eV or more. For example, Ga2O3, Bi2O3, SnO2, ZnO, Sb2O3, PbO, GeO<sub>2</sub>, or In<sub>2</sub>O<sub>3</sub>, and a mixture of these oxides, or a compound composed of oxides such as  $GaInO_3$ ,  $ZnGa_2O_4$  and  $CdGa_2O_4$  can be used. The covalent oxides can be obtained by laser deposition, deposition after decomposition from the gas phase (CVD), or vapor

deposition. Dopant atoms can be introduced into the basic material by the vapor deposition source or the gases to be used. A concentration of dopant atoms in the range of 0.001% to 0.3% can lead to a sufficiently high conductivity for use as a semiconductor material of a switching element.

<u>Preferably, the semiconductor material comprises a covalent oxide of a metal</u> <u>selected from the group consisting of Sn, Zn, and In</u>. These covalent oxides have a mobility of 30 cm<sup>2</sup>/Vs or more even when dopant atoms are added. Therefore, the dopant atoms decay to the covalent oxides to be used. Thus, dopant atoms such as Sb, F and Cl may be used when SnO<sub>2</sub> is a covalent oxide; a dopant atom such as Sn may be used when  $In_2O_3$  is a covalent oxide; <u>and a dopant atom such as Ga when ZnO is a</u> <u>covalent oxide</u>. Especially Sb-doped SnO<sub>2</sub> also known as ATO or Sn-doped  $In_2O_3$  also known as ITO is highly suitable materials." (on the fifth line of page 9 to the 11th line of page 11)

(A-3f) "FIG. 4 illustrates a second embodiment of the switching element 1 according to the present invention. A transparent conductive material is provided on a glass substrate 7, which is a 0.2 µm thick SnO<sub>2</sub> layer doped with 1.5% Sb deposited in a known manner by pulsed laser deposition at an O<sub>2</sub> pressure of 0.2 mbar and a temperature of 505°C in the present embodiment. A 0.7 µm thick molybdenum layer is deposited on the transparent conductive material by vapor deposition. This molybdenum layer is patterned in a known manner by photoresist and RIE using  $CF_4/O_2$ . Then, the patterned molybdenum layer is used as a mask to pattern the SnO<sub>2</sub> layer doped by RIE using  $CFH_3$  thereby to form the gate electrode 5. Then, the molybdenum layer is removed by redox etching treatment with potassium Then, a 0.25 µm thick transparent insulating layer 6 of a hexacyanoferrate. ferroelectric material is provided on the gate electrode 5 and on the surface of the substrate 7. Examples of the ferroelectric materials which may be used include lithium niobate (LiNbO<sub>3</sub>), lithium tantalate (LiTaO<sub>3</sub>) and lead-zirconium titanate (PbZr<sub>x</sub>Ti<sub>1-x</sub>O<sub>3</sub>). The present embodiment uses lead-zirconium titanate PbZr<sub>0.2</sub>Ti<sub>0.8</sub>O<sub>3</sub> because this material can be provided comparatively easily without considering compatibility with other materials to be used. In addition, this material has a comparatively high polarization (approximately 60  $\mu$ C/cm<sup>2</sup>) and a low electric switching field (approximately 50 kV/cm). The lead-zirconium titanate can be obtained in a known manner by pulsed laser deposition at an oxygen pressure of 0.2 mbar and a temperature of 587°C.

Then, a 0.1  $\mu$ m thick layer 4 of SnO<sub>2</sub> doped with 0.03% Sb is provided in a known manner on the ferroelectric layer 6 and on the surface of the substrate 7 by pulsed laser deposition at an O<sub>2</sub> pressure of 0.2 mbar and a temperature of 505°C. The layers 4 and 6 are patterned again using photoresist and a molybdenum layer in the same manner as the conductive layer for the gate electrode 5. Etching is applied for a limited period of time only so as not to damage the gate electrode 5. Then, the molybdenum layer is removed again. The channel region 4 is thus formed. Then, a 0.5  $\mu$ m thick conductive layer of SnO<sub>2</sub> doped with 1.5% Sb is formed on the surface. This layer is patterned by photoresist and a molybdenum layer to form conductive connection electrodes 2 and 3 in the same manner as the conductive layer for the gate electrode.

In the present embodiment, the connection electrodes 2 and 3, the gate electrode 5, and the channel region 4 comprise the same basic material containing the dopant atoms of the same type, the semiconductor material of the connection electrodes 2 and 3, and the semiconductor material of the channel region 4 containing a smaller amount of dopant atoms than the conductive material of the gate electrode 5. Such a semiconductor device can be fabricated in a comparatively simple manner because these materials require only a single type of fabrication process." (on the 12th line of page 11 to the 16th line of page 12)

(A-3g) "In a fifth embodiment, a transistor is fabricated according to the second embodiment, but the channel region uses a different layer 4, that is, a 10 nm thick layer of  $SnO_2$  layer doped with 0.1% Sb (Note from the body: original writing error was corrected). The transistor is covered with a capping layer of 10 nm thick BaZrO<sub>3</sub>." (on the second to fifth lines of page 16)

(A-3h) "The present invention is not limited to the embodiments described above. Specifically, predetermined covalent oxides of non-transition metals have been selected as the transparent semiconductor and the conductive materials according to the above embodiments, but the semiconductor devices of the present invention may very well be fabricated using other covalent oxides of non-transition metals. The resistance between the connection electrodes and the on/off ratio, that is, the difference in resistance between the connection electrodes with or without switching of the switching element, may be adapted to specific requirements, for example, by adapting the type of the semiconductor, the insulating material, or the ferroelectric material, or the channel geometry such as the width, length, and thickness of the channel region. Thus, an

optimal material and an optimal geometry may be selected for each application in terms of the channel resistance, the on/off ratio, and the switching of the ferroelectric material. The switching voltage of the switching element can also be varied by selecting another ferroelectric material or by changing the thickness of the ferroelectric material layer. Furthermore, the materials of the semiconductor device need not be transparent except for an imaging or display element. The switching elements need be transparent only when the switching element 1 is overlapped with the imaging and display element 30. Therefore, it is very preferable that a metal layer according to the third and fourth embodiments, such as a molybdenum or aluminum layer for promoting conduction is provided in portions of the bus lines 22 and 25 as well as the connection electrode 2 and the gate electrode 5.

The predetermined techniques such as the laser deposition, CVD, and photolithography have been proposed as the methods of depositing and patterning the materials, but this does not mean that the present invention can be provided only by such techniques. It will be obvious that other techniques such as epitaxial growing (MBE) and masking materials by a printing technique may very well be used." (on the 19th line of page 16 to the 12th line of page 17)

# 3 Judgment by the body of the patent invention 1

#### (1) Cited Invention 3

When the excerpts (A-3a) to (A-3h) above are summarized, it is recognized that Evidence A No. 3 describes the following invention (hereinafter referred to as "Cited Invention 3".)

"A film formation method for the semiconductor material of the semiconductor device comprising a transparent switching element which comprises two connection electrodes of a transparent material; and an interposed transparent channel region of a semiconductor material with a transparent gate electrode of a conductive material being separated from the channel region by a transparent insulating layer, the film formation method for the semiconductor device, wherein the semiconductor material comprises a degenerate semiconductor material containing a basic material with a band gap of 2.5 eV or more between a conduction band and a valence band of electrons and a charge carrier mobility of  $10 \text{ cm}^2/\text{Vs}$  or more, the material containing dopant atoms forming a fixed impurity energy level in the valence band or the conduction band of the basic material or adjacent thereto,

the film formation method comprising: epitaxially depositing a conductive SrRuO<sub>3</sub> layer 5 on an insulating monocrystalline SrTiO<sub>3</sub> substrate 7; patterning the SrRuO<sub>3</sub> layer 5 to form a gate electrode 5; providing BaZrO<sub>2</sub> as a transparent insulating layer 6 on the gate electrode 5 and the surface of the substrate 7; and depositing a 0.1  $\mu$ m thick layer 4 of In<sub>2</sub>O<sub>3</sub> doped with 0.03% Sn as the semiconductor material on the transparent insulating layer 6 and the surface of the substrate 7 in a known manner by pulsed laser deposition at an oxygen pressure of 0.2 mbar and at a temperature of 505°C,

the film formation method capable of using other covalent oxides of a non-transition metal containing dopant atoms for  $In_2O_3$  doped with 0.03% Sn as the semiconductor material with a mobility of 10 cm<sup>2</sup>/Vs or more and a band gap of 2.5 eV or more, such as Ga<sub>2</sub>O<sub>3</sub>, Bi<sub>2</sub>O<sub>3</sub>, SnO<sub>2</sub>, ZnO, Sb<sub>2</sub>O<sub>3</sub>, PbO, GeO<sub>2</sub> or In<sub>2</sub>O<sub>3</sub>, and a mixture of these oxides, or a compound composed of oxides such as GaInO<sub>3</sub>, ZnGa<sub>2</sub>O<sub>4</sub>, or CdGa<sub>2</sub>O<sub>4</sub>."

#### (2) Comparison

A The "film formation method" of Cited Invention 3 corresponds to the "vapor-phase film formation method" of the patent invention 1 in terms of the use of the "pulsed laser deposition."

B The "layer 4" of Cited Invention 3 corresponds to the "oxide thin film" and the ""transparent" "thin film"" of the patent invention 1 in terms of the use of the "compound composed of oxides" and the " $0.1 \mu m$ " thin film.

C The configuration of Cited Invention 3 "depositing in a known manner on the insulating transparent layer 6 and on the surface of the substrate 7 by pulsed laser deposition at an oxygen pressure of 0.2 mbar and at a temperature of  $505^{\circ}$ C" and the configuration of the patent invention 1 "forming a semi-insulating transparent In-Ga-Zn-O thin film having an electron mobility of 0.1 cm<sup>2</sup>/(V.second) or more at room temperature and an electron carrier concentration of  $10^{16}$ /cm<sup>3</sup> or less at room temperature by controlling the magnitude of oxygen partial pressure so that the formed thin film has an electron carrier concentration of  $10^{16}$ /cm<sup>3</sup> or less at room temperature, when depositing the thin film on a substrate using a polycrystal of the oxide as a target in an atmosphere containing an oxygen gas without intentionally adding impurity ions for enhancing electric resistance to the thin film in a state where a temperature of the

substrate is not intentionally increased" are common in that both "deposit the thin film on the substrate in an atmosphere containing an oxygen gas."

D Regarding the electron mobility, the "mobility" of Cited Invention 3 corresponds to the "electron mobility" of the patent invention 1; and the " $10 \text{ cm}^2/\text{Vs}$  or more" of Cited Invention 3 satisfies the " $0.1 \text{ cm}^2/(\text{V.second})$  or more" of the patent invention 1.

E Then, when the comparisons A to D above are summarized, the corresponding features and the different features between the patent invention 1 and Cited Invention 3 are as follows.

### <Corresponding feature>

The vapor-phase film formation method using the pulsed laser deposition method for the oxide thin film.

The vapor-phase film formation method for forming an oxide thin film, namely, a transparent oxide thin film, wherein when depositing the thin film on a substrate in an atmosphere containing an oxygen gas, the formed thin film has an electron mobility of  $0.1 \text{ cm}^2/(\text{V.second})$  or more.

#### <Different features>

• Different feature 3-1: The oxide to be formed differs in that in the case of patent invention 1, the oxide is an "amorphous oxide thin film" which is "In-Ga-Zn-O" with "a crystallized composition thereof expressed by a formula  $InGaO_3(ZnO)_m$  (m is a natural number of less than 6)," while in the case of Cited Invention 3, the oxide "comprising a degenerate semiconductor material containing a basic material with a band gap of 2.5 eV or more between a conduction band and a valence band of electrons and a charge carrier mobility of 10 cm<sup>2</sup>/Vs or more, the material containing dopant atoms forming a fixed impurity energy level in the valence band or the conduction band of the basic material or adjacent thereto"; "capable of using other covalent oxides of a non-transition metal containing dopant atoms for  $In_2O_3$  doped with 0.03% Sn as the semiconductor material with a mobility of 10 cm<sup>2</sup>/Vs or more and a band gap of 2.5 eV or more, such as Ga<sub>2</sub>O<sub>3</sub>, Bi<sub>2</sub>O<sub>3</sub>, SnO<sub>2</sub>, ZnO, Sb<sub>2</sub>O<sub>3</sub>, PbO, GeO<sub>2</sub>, or  $In_2O_3$ , and a mixture of these oxides, or a compound composed of the oxides such as GaInO<sub>3</sub>, ZnGa<sub>2</sub>O<sub>4</sub>, and CdGa<sub>2</sub>O<sub>4</sub>"; and without specifying "amorphous."

• Different feature 3-2: The patent invention 1 has a configuration of depositing the thin film "using a polycrystal of the oxide as a target" "without intentionally adding impurity ions for enhancing electric resistance to the thin film" while the Cited Invention 3 does not specify the configuration.

• Different feature 3-3: The patent invention 1 deposits the thin film "in a state where a temperature of the substrate is not intentionally increased" while Cited Invention 3 deposits the thin film "at a temperature of 505°C."

• Different feature 3-4: The patent invention 1 has a configuration of forming "a semi-insulating transparent thin film having an electron mobility of  $0.1 \text{ cm}^2/(\text{V.second})$  or more at room temperature and an electron carrier concentration of  $10^{16}/\text{cm}^3$  or less at room temperature by controlling the magnitude of oxygen partial pressure so that the formed thin film has an electron carrier concentration of  $10^{16}/\text{cm}^3$  or less at room temperature," while the Cited Invention 3 does not specify the configuration.

More specifically, in the case of the patent invention 1, when the thin film is deposited on the substrate, the magnitude of oxygen partial pressure is controlled so that the thin film can be formed to have an electron carrier concentration of  $10^{16}$ /cm<sup>3</sup> or less at room temperature; and as a result of this control, a semi-insulating transparent oxide thin film with an electron mobility of  $0.1 \text{ cm}^2$ /(V.second) or more at room temperature and an electron carrier concentration of  $10^{16}$ /cm<sup>3</sup> or less is obtained, while in the case of Cited Invention 3, a degenerate semiconductor material containing a basic material with a charge carrier mobility of  $10 \text{ cm}^2$ /Vs or more is resultantly obtained, but it is not clear that the oxygen pressure of 0.2 mbar is the oxygen partial pressure controlled for the purpose of obtaining the formed thin film to have a predetermined electron carrier concentration.

E It should be noted that in the written demand for trial, the demandant argues that it should be recognized that Evidence A No. 3 describes the invention of "the film formation method of forming the layer 4 using a transparent semiconductor with a mobility of  $10 \text{ cm}^2/\text{Vs}$  or more in such a manner that the oxygen pressure is 0.2 mbar when the layer 4 is formed on the substrate in a state where the temperature is 505°C, using a transparent semiconductor such as Ga<sub>2</sub>O<sub>3</sub>, Bi<sub>2</sub>O<sub>3</sub>, SnO<sub>2</sub>, ZnO, Sb<sub>2</sub>O<sub>3</sub>, PbO, GeO<sub>2</sub>, and In<sub>2</sub>O<sub>3</sub>, or a mixture of these oxides, or a compound composed of the oxides such as GaInO<sub>3</sub>, ZnGa<sub>2</sub>O<sub>4</sub>, and CdGa<sub>2</sub>O<sub>4</sub> as the layer 4 in the film formation method using the

pulsed laser deposition for the layer 4 with a thickness of 10 nm or 0.1  $\mu$ m" but the argument of the demandant cannot be accepted for the following reasons.

F Meanwhile, the invention is defined as "the highly advanced creation of technical ideas utilizing the laws of nature." (Article 2(1) of the Patent Act) The demandant describes the matters specifying the invention of Cited Invention 3 "using Ga<sub>2</sub>O<sub>3</sub>, Bi<sub>2</sub>O<sub>3</sub>, SnO<sub>2</sub>, ZnO, Sb<sub>2</sub>O<sub>3</sub>, PbO, GeO<sub>2</sub>, and In<sub>2</sub>O<sub>3</sub>, and a mixture of these oxides, or a compound composed of the oxides such as GaInO<sub>3</sub>, ZnGa<sub>2</sub>O<sub>4</sub>, and CdGa<sub>2</sub>O<sub>4</sub>." The excerpt (A-3e) of Evidence A No. 3 above includes the following description.

"It is also possible to <u>use other covalent oxides of a non-transition metal</u> containing dopant atoms for the semiconductor material of the channel region 4. Oxides of these metals and a mixture thereof have a mobility 10 cm<sup>2</sup>/Vs or more and a band gap of 2.5 eV or more. For example, Ga<sub>2</sub>O<sub>3</sub>, Bi<sub>2</sub>O<sub>3</sub>, SnO<sub>2</sub>, ZnO, Sb<sub>2</sub>O<sub>3</sub>, PbO, GeO<sub>2</sub>, or In<sub>2</sub>O<sub>3</sub>, and a mixture of these oxides, or a compound composed of oxides such as GaInO<sub>3</sub>, ZnGa<sub>2</sub>O<sub>4</sub>, and CdGa<sub>2</sub>O<sub>4</sub> <u>can be used</u>. The covalent oxides can be obtained by laser deposition, deposition after decomposition from the gas phase (CVD), or vapor deposition. Dopant atoms can be introduced into the basic material by the vapor deposition source or the gases to be used. A concentration of dopant atoms in the range of 0.001% to 0.3% can lead to a sufficiently high conductivity for use as a semiconductor material of a switching element.

Preferably, the semiconductor material comprises a covalent oxide of a metal selected from the group consisting of Sn, Zn, and In. These covalent oxides have a mobility of 30 cm<sup>2</sup>/Vs or more even when dopant atoms are added. Therefore, the dopant atoms decay to the covalent oxides to be used. Thus, dopant atoms such as Sb, F and Cl may be used when  $SnO_2$  is a covalent oxide; a dopant atom such as Sn may be used when  $In_2O_3$  is a covalent oxide; and a dopant atom such as Ga when ZnO is a covalent oxide. Especially Sb-doped  $SnO_2$  also known as ATO or Sn-doped  $In_2O_3$  also known as ITO is highly suitable materials."

Then, according to the above description, only the invention relating to a semiconductor device containing dopant atoms is described, but there is no description of the invention on the assumption that dopant atoms are not added. Therefore, the demandant' argument cannot be accepted that Evidence A No. 3 describes the technical idea of the invention on the assumption that dopant atoms are not added.

Furthermore, from the description of the above excerpt (A-3e) "A concentration of dopant atoms in the range of 0.001% to 0.3% can lead to a sufficiently high conductivity for use as a semiconductor material of a switching element", it can be

understood that the addition of dopant atoms is required for the semiconductor material of Cited Invention 3 to obtain a sufficiently high conductivity for use in a "switching element." Therefore, also from this point of view, the demandant' argument on the assumption that dopant atoms are not added cannot be recognized.

On the 11th to 26th lines of page 25 of the oral proceedings statement brief dated February 9, 2015, the demandant argues that "Meanwhile, it is clear that with reference to [0046] of the patent description, - - - (each 4N reagent) - - -. Judging from the above, up to "0.01%" impurity is resultantly contained in the patent invention 1. - - - Therefore, even though a dopant atom is contained in Cited Invention 3, the dopant atom does not constitute a different feature because Evidence A No. 3 describes that when used as the semiconductor, the amount of dopant atom is more than one digit less than that in the patent invention 1."

However, the recognition of Cited Invention 3 should be made based on the matters described in Evidence A No. 3 regardless of the matters described in the patent description and determined as the technical idea. Therefore, it cannot be recognized as appropriate that only a portion of the matters specifying the invention described in Evidence A No. 3 is extracted separately from the technical idea disclosed in Evidence A No. 3 and is recognized as Cited Invention 3. Accordingly, the argument of the demandant cannot be accepted.

Furthermore, the "impurities" that cannot be removed for reasons of fabrication though preferably as small as possible and a specific amount of "dopant atoms" to be added to achieve the intended purpose differ in technical significance. The understanding of the Cited Invention 3 along the argument of the demandant treating both equally is contrary to the technical common knowledge of a person skilled in the art. Accordingly, also from this point of view, the argument of the demandant cannot be accepted.

G Further, the demandant argues in the written demand for trial that the patent invention 1 matches Cited Invention 3 in terms of "A vapor-phase film formation method using a pulsed laser deposition method for an oxide thin film containing a compound composed of Ga<sub>2</sub>O<sub>3</sub>, ZnO, and In<sub>2</sub>O<sub>3</sub>, wherein a semi-insulating transparent oxide thin film is formed so that the formed thin film may have an electron mobility of 0.1 cm<sup>2</sup>/(V.second) or more by controlling the magnitude of oxygen partial pressure when

the thin film is deposited on the substrate in an atmosphere containing an oxygen gas", but the argument of the demandant cannot be accepted for the following reasons.

H More specifically, Evidence A No. 3 describes "uses  $Ga_2O_3$ ,  $Bi_2O_3$ ,  $SnO_2$ , ZnO,  $Sb_2O_3$ , PbO,  $GeO_2$ , or  $In_2O_3$ , and a mixture of these oxides, or a compound composed of oxides such as  $GaInO_3$ ,  $ZnGa_2O_4$ , and  $CdGa_2O_4$  ", but the "compound composed of " $Ga_2O_3$ , ZnO, and  $In_2O_3$ " is not specified as a compound having that particular combination.

It is true that " $Ga_2O_3$ ," "ZnO," and " $In_2O_3$ " are found in the oxides enumerated as " $Ga_2O_3$ ,  $Bi_2O_3$ ,  $SnO_2$ , ZnO,  $Sb_2O_3$ , PbO,  $GeO_2$ , and  $In_2O_3$ " in the described matters, but the described matters exemplify only the compounds " $GaInO_3$ ," "ZnGa<sub>2</sub>O<sub>4</sub>", and "CdGa<sub>2</sub>O<sub>4</sub>" as the compounds composed of two oxides.

In other words, only the specific three oxides, namely, " $Ga_2O_3$ ", "ZnO", and " $In_2O_3$ " are selected from the description "uses  $Ga_2O_3$ ,  $Bi_2O_3$ ,  $SnO_2$ , ZnO,  $Sb_2O_3$ , PbO,  $GeO_2$  or  $In_2O_3$ , and a mixture of these oxides, or a compound composed of oxides such as  $GaInO_3$ ,  $ZnGa_2O_4$ , and  $CdGa_2O_4$ " thereby to form a compound, which means selecting only one compound from among a large number of conceivable combinations, and the selection itself may constitute creation of technical idea, namely, so-called "selection invention".

Therefore, it is true that the "compound composed of  $Ga_2O_3$ , ZnO, and  $In_2O_3$ " is contained in " $Ga_2O_3$ ,  $Bi_2O_3$ ,  $SnO_2$ , ZnO,  $Sb_2O_3$ , PbO,  $GeO_2$ , or  $In_2O_3$ , and a mixture of these oxides, or a compound composed of oxides such as  $GaInO_3$ ,  $ZnGa_2O_4$ , and  $CdGa_2O_4$ " in terms of combination, but it cannot be recognized from the description " $Ga_2O_3$ ,  $Bi_2O_3$ ,  $SnO_2$ , ZnO,  $Sb_2O_3$ , PbO,  $GeO_2$ , or  $In_2O_3$ , and a mixture of these oxides, or a compound composed of  $Sa_2O_3$ , and a mixture of these oxides, or a compound composed of oxides such as  $GaInO_3$ ,  $ZnGa_2O_4$ , and  $CdGa_2O_4$ " that Evidence A No. 3 discloses the "compound composed of  $Ga_2O_3$ , ZnO, and  $In_2O_3$ ".

Accordingly, it cannot be recognized that the patent invention 1 matches Cited Invention 3 in terms of "A vapor-phase film formation method using a pulsed laser deposition method for an oxide thin film containing a compound composed of Ga<sub>2</sub>O<sub>3</sub>, ZnO, and In<sub>2</sub>O<sub>3</sub>, wherein a semi-insulating transparent oxide thin film is formed so that the formed thin film may have an electron mobility of 0.1 cm<sup>2</sup>/(V.second) or more by controlling the magnitude of oxygen partial pressure when the thin film is deposited on the substrate in an atmosphere containing an oxygen gas."

I As described above, the recognition of the corresponding features in the reason for invalidation 3 and the recognition of the different features on the assumption of the corresponding features argued by the demandant cannot be accepted.

#### (3) Judgment of the different features

As examined above, the recognition of the corresponding features in the reason for invalidation 3 and the recognition of the different features argued by the demandant cannot be accepted. Therefore, the reason for invalidation 3 based on the recognition of the corresponding features and the recognition of the different features argued by the demandant lacks the assumption of the argument and hence cannot be accepted. However, if a person skilled in the art could easily arrive at the Cited Invention 3 based on the inventions described in Evidence A No. 1, Evidence A No. 4 to Evidence A No. 11, and Evidence A No. 13 shown as the evidence for the different features 3-1 to 3-5 in the reason for invalidation 3, there is a reasonable ground that the demandant should not be granted a patent for the invention 1 in accordance with the provisions of Article 29(2) of the Patent Act, and hence this point will be examined for the present.

• Regarding the different feature 3-1

A From the description of Evidence A No. 3, a person skilled in the art cannot find motivation to particularly select the material called "an amorphous oxide thin film" which is "In-Ga-Zn-O" with "a crystallized composition thereof expressed by a formula  $InGaO_3(ZnO)_m$  (m is a natural number of less than 6)" from a large number of materials contained in the range of a group of "a mixture of these oxides" or "a compound composed of the oxides" specified by "Ga<sub>2</sub>O<sub>3</sub>, Bi<sub>2</sub>O<sub>3</sub>, SnO<sub>2</sub>, ZnO, Sb<sub>2</sub>O<sub>3</sub>, PbO, GeO<sub>2</sub>, or In<sub>2</sub>O<sub>3</sub>, and a mixture of these oxides, or a compound composed of oxides such as GaInO<sub>3</sub>, ZnGa<sub>2</sub>O<sub>4</sub>, and CdGa<sub>2</sub>O<sub>4</sub>" of Cited Invention 3. Accordingly, as different feature 3-1 is examined, it cannot be recognized that a person skilled in the art could easily conceive of adopting the configuration of patent invention 1 from Cited Invention 3.

B The above excerpt (A-3d) of Cited Invention 3 includes the following description.

### "Summary of the invention

In order to achieve this object, the present invention provides a semiconductor device comprising a transparent switching element which comprises two connection electrodes of a transparent material; and an interposed transparent channel region of a semiconductor material with a transparent gate electrode of a conductive material being separated from the channel region by a transparent insulating layer, characterized in that the semiconductor material comprises a degenerate semiconductor material containing a basic material with a band gap of 2.5 eV or more between a conduction band and a

valence band of electrons and a charge carrier mobility of  $10 \text{ cm}^2/\text{Vs}$  or more, the material containing dopant atoms forming a fixed impurity energy level in the valence band or the conduction band of the basic material or adjacent thereto.

<u>Therefore, the basic material is selected to have a band gap of 2.5 eV or more</u> and a mobility of 10 cm<sup>2</sup>/Vs or more, and then the conductivity is determined by appropriately selecting the nature and concentration of dopant atoms. A sufficient conductivity can be obtained by selecting a concentration of dopant atoms in the range of 0.001% to 0.3%. The impurity energy levels are adjacent to the valence band or the conduction band if the levels are at a distance of approximately 0.1 eV or less from the band gap. Electrons may be readily converted to the valence band or the conduction band from the impurity energy levels at room temperature.

<u>Visible light has insufficient energy for making electron-hole pairs in a</u> <u>semiconductor material having a band gap approximately 2.5 eV or more, so that this</u> <u>visible light is not absorbed by the semiconductor material. The degenerate</u> <u>semiconductor material according to the present invention is transparent</u> because visible light cannot be absorbed due to the large band gap, while at the same time no absorption of visible light takes place through the impurity energy levels. <u>In addition, the</u> <u>switching element including the semiconductor material according to the invention</u> <u>operates at comparatively high speeds because of the high mobility of charge carriers</u>.

Preferably, the basic material includes a covalent oxide of a non-transition metal. Oxides of such metals and compounds of oxides such as Ga, Sn, Zn, Sb, Pb, Ge, and In have a mobility 10 cm<sup>2</sup>/Vs or more and a band gap 2.5 eV or more (for example, see J. Phys. Chem. Ref. Data, Vol. 2, No. 1, 1973, p.163 ff.). The more ionic oxides of non-transition metals are not suitable as basic materials because a strong interaction acts between charge carriers and ions in the crystal lattice."

C From the above description, it can be understood that the composition of the oxide to be formed in Cited Invention 3 "comprises a degenerate semiconductor material containing a basic material with a band gap of 2.5 eV or more between a conduction band and a valence band of electrons and a charge carrier mobility of  $10 \text{ cm}^2/\text{Vs}$  or more, the material containing dopant atoms forming a fixed impurity energy level in the valence band or the conduction band of the basic material or adjacent thereto," and the description "capable of using other covalent oxides of a non-transition metal containing dopant atoms for In<sub>2</sub>O<sub>3</sub> doped with 0.03% Sn as the semiconductor material with a mobility of  $10 \text{ cm}^2/\text{Vs}$  or more and a band gap of 2.5 eV or more, such as Ga<sub>2</sub>O<sub>3</sub>, Bi<sub>2</sub>O<sub>3</sub>, SnO<sub>2</sub>, ZnO, Sb<sub>2</sub>O<sub>3</sub>, PbO, GeO<sub>2</sub>, or In<sub>2</sub>O<sub>3</sub>, and a mixture of these oxides, or a compound

composed of oxides such as  $GaInO_3$ ,  $ZnGa_2O_4$ , or  $CdGa_2O_4$ ." has a technical significance such that the semiconductor material for use in Cited Invention 3 has a band gap of 2.5 eV or more; visible light has insufficient energy for making electron-hole pairs so that this visible light is not absorbed by the semiconductor material; the degenerate semiconductor material is transparent; in addition, the switching element for use in Cited Invention 3 including the semiconductor material whose mobility is selected to be  $10 \text{ cm}^2/\text{Vs}$  or more operates at comparatively high speeds because of the high mobility of charge carriers; and the dopant atoms for use in Cited Invention 3 can provide a sufficient conductivity by selecting a concentration of dopant atoms in the range of 0.001% to 0.3%.

D However, from the above description, it cannot be said that it is clear that the material called "an amorphous oxide thin film" which is "In-Ga-Zn-O" with "a crystallized composition thereof expressed by a formula  $InGaO_3(ZnO)_m$  (m is a natural number of less than 6)" is particularly excellent among the materials specified as "Ga<sub>2</sub>O<sub>3</sub>, Bi<sub>2</sub>O<sub>3</sub>, SnO<sub>2</sub>, ZnO, Sb<sub>2</sub>O<sub>3</sub>, PbO, GeO<sub>2</sub>, or In<sub>2</sub>O<sub>3</sub>, and a mixture of these oxides, or a compound composed of oxides such as GaInO<sub>3</sub>, ZnGa<sub>2</sub>O<sub>4</sub>, or CdGa<sub>2</sub>O<sub>4</sub>" in that "visible light has insufficient energy for making electron-hole pairs so that this visible light is not absorbed by the semiconductor material; the degenerate semiconductor material whose mobility is selected to be 10 cm<sup>2</sup>/Vs or more operates at comparatively high speeds because of the high mobility of charge carriers;" and "the dopant atoms can provide a sufficient conductivity by selecting a concentration of dopant atoms in the range of 0.001% to 0.3%."

E Considering the above, it cannot be said that a person skilled in the art could easily select "an amorphous oxide thin film" which is "In-Ga-Zn-O" with "a crystallized composition thereof expressed by a formula  $InGaO_3(ZnO)_m$  (m is a natural number of less than 6)" as the material of "Ga<sub>2</sub>O<sub>3</sub>, Bi<sub>2</sub>O<sub>3</sub>, SnO<sub>2</sub>, ZnO, Sb<sub>2</sub>O<sub>3</sub>, PbO, GeO<sub>2</sub>, or In<sub>2</sub>O<sub>3</sub>, and a mixture of these oxides, or a compound composed of oxides such as GaInO<sub>3</sub>, ZnGa<sub>2</sub>O<sub>4</sub>, or CdGa<sub>2</sub>O<sub>4</sub>" instead of "non-transition metal containing dopant atoms for In<sub>2</sub>O<sub>3</sub> doped with 0.03% Sn as the semiconductor material" in Cited Invention 3.

F Furthermore, as examined in "No. 5 Regarding the reason for invalidation 1, 3 Judgment by the body, (3) Judgment of the different features" above, it can be recognized from the above description of the patent description that the following

properties are exhibited by the amorphous oxide thin film formed by the film formation method, which is a specific film formation method of forming a semi-insulating transparent In-Ga-Zn-O thin film having an electron mobility of  $0.1 \text{ cm}^2/(\text{V.second})$  or more at room temperature, an electron carrier concentration of  $10^{16}/\text{cm}^3$  or less at room temperature by controlling the magnitude of oxygen partial pressure so that the formed thin film has an electron carrier concentration of  $10^{16}/\text{cm}^3$  or less at room temperature, using a polycrystal of the oxide as a target, in a state where a temperature of the substrate is not intentionally increased, without intentionally adding impurity ions for enhancing electric resistance to the thin film, in an atmosphere containing an oxygen gas, when "the amorphous oxide thin film" which is "an oxide thin film with a crystallized composition thereof expressed by a formula InGaO<sub>3</sub>(ZnO)<sub>m</sub> (m is a natural number of less than 6)" according to patent invention 1 is deposited on the substrate using the film formation method specified by patent invention 1, namely, the pulsed laser deposition method or the RF sputtering method.

(i) "An amorphous oxide film with an electron carrier concentration of  $10^{16}$ /cm<sup>3</sup> or less is used for the channel layer to provide a field-effect transistor including a source terminal, a drain terminal, and a gate terminal with a gate insulating film interposed therebetween. When a voltage of approximately 5 V is applied between the source and drain terminals, the current between the source and drain terminals when the gate voltage was not applied could be made approximately  $10^{-7}$  ampere." In other words, can "provide a thin film transistor having a channel layer with a small electron carrier concentration, accordingly a high electrical resistance, and a large electron mobility," and thus is suitable for obtaining "the normally-off TFT."

(ii) "In the case of a normal compound, as the carrier concentration is increased, the electron mobility is reduced due to scattering between carriers or the like, while in contrast to this, in the case of the amorphous oxide according to the film formation method of the present invention, as the electron carrier concentration is increased, the electron mobility is increased," and thus for example, "the In-Zn-Ga-O system amorphous oxide film formed by different oxygen partial pressures using the polycrystalline sintered body having an  $InGaO_3(ZnO)_4$  composition as the target" exhibits electrical properties such that "when the electron carrier concentration is increased from  $10^{16}/cm^3$  to  $10^{20}/cm^3$ , the electron mobility is increased from approximately 3 cm<sup>2</sup>/(V.second) to approximately 11 cm<sup>2</sup>/(V.second)." As a result,

(iii) "When a voltage is applied to the gate terminal, electrons can be injected into the above amorphous oxide channel layer. Then, current flows between the source and drain terminals, and the ON state occurs between the two terminals," while "the amorphous oxide film according to the film formation method of the present invention is such that as the electron carrier concentration is increased, the electron mobility is increased, and hence the current in the ON state of the transistor can be further increased," and "further has excellent properties such as exhibiting degenerate conduction," and hence for example, "can provide a transistor with an on/off ratio of more than  $10^{3}$ " and "when an amorphous oxide exhibiting degenerate conduction by the film formation method of the present invention is used as the channel layer, the temperature dependence of the current in a state of large electron carrier concentration, that is, the saturation current of the transistor is reduced, and hence a TFT excellent in temperature property can be provided."

In short, it is recognized from the description of the patent description that patent invention 1 exhibits the properties of (i) to (iii) above and hence exhibits the effect of being suitable for the thin film formation method for use in the TFT channel layer.

Judging from the above, it cannot be said that the selection of the material called "an amorphous oxide thin film" which is "In-Ga-Zn-O" with "a crystallized composition thereof expressed by a formula  $InGaO_3(ZnO)_m$  (m is a natural number of less than 6)" in the patent invention 1 has a significant effect and a person skilled in the art could appropriately select the material.

G Therefore, it cannot be said that a person skilled in the art could easily conceive the different feature 3-1 based on Cited Invention 3.

H Then, the following will examine whether or not a person skilled in the art could easily arrive at the configuration of patent invention 1 from the different feature 3-1 above of Cited Invention 3 based on other publicly known documents.

I The following matters have been known regarding the oxide "with a composition thereof expressed by a formula  $InGaO_3(ZnO)_m$ ".

(A) Matters described in Evidence A No. 7(Reproduced) (A7-b) "Summary

With the purpose of creating Zn-O-based amorphous transparent conductors, various amorphous films  $InGaO_3(ZnO)_m$  (m≤4) were prepared using a pulsed laser deposition method. - - - It was revealed that the conduction band tail had a large dispersion and the Fermi level was located at the conduction band edge. - - - The present system is the first amorphous oxide semiconductor in which Zn4s orbitals form the extended conduction band." (on the first line of page 1 to the second line of page 2 of the translation)

### (B) Matters described in Evidence A No. 4

(Reproduced) (A4-c) "According to the fabrication method of the present invention, for example, when a sintered body with In:Ga:Zn=1:1:1 is used as a target, a thin film  $6.2x10^{-3}[\Omega \text{cm}]$  can be easily obtained. In this case, the major cause of the high conductivity is that the mobility indicates a high value of 10 or more despite the amorphous material. In addition, when a sintered body of homologous IGZOInGaO<sub>3</sub>(ZnO)<sub>m</sub> (m: an integer of 2 or more) with increased Zn component is used as the target, a thin film having a resistivity of  $4.3x10^{-3}[\Omega \text{cm}]$  can be easily obtained." ([0034])

(Reproduced) (A4-e) "In the case of homologous  $GaO_3(ZnO)_m$ , each powder of  $In_2O_3$ ,  $Ga_2O_3$ , and ZnO was weighted so that the ratio of contained metal is 1:1:m (m is an integer of 2 or more) respectively." ([0041])

#### (A4-g) "2. Film formation

A film formation method using a laser ablation method will be described below as an example.

#### Example 1

Of the sintered body prepared above, the surface of the sintered body with In:Ga:Zn=1:1:1 was polished and fixed to an inconel holder by metal In. This was fixed to a laser ablation apparatus fabricated by Nippon Shinku Co., Ltd. Then, KrF excimer laser light fabricated by Lambda Physik Co., Ltd., was emitted to the rotating surface with an energy density of  $4J/cm^2$  and a pulse interval of 5 Hz to produce plume. The atmosphere in the chamber caused O<sub>2</sub> gas to flow at 15 to 25 CCM and to have a total pressure of 0.8 to 1.0 [Pa]. A quartz glass substrate with a square of 10 mm and a thickness of 0.5 mm was disposed 30 mm immediately above the target. Then, the substrate is exposed to plume for 30 minutes while being rotated so that the film has

uniform thickness, whereby a thin film with a thickness of approximately 300 nm was obtained. The composition ratio was obtained by X-ray fluorescence method. It was confirmed by XRD that the film was uniform amorphous (FIG. 1.) The absorption edge was obtained by calculating an optical constant from the transmission and reflection spectra of the sample. The electrical properties were obtained by Hall effect measurement using van der Pauw method." ([0042])

(Reproduced) (A4-f) "[FIG. 1] XRD results confirming that the oxide expressed by InGaZnO<sub>4</sub> was generated." ([Brief Description of Drawings])

(C) Matters described in Evidence A No. 6

(A6-f) "In addition, from the same view point, - - - in the case of  $InGaZnO_4$ , it can be considered - - - (FIGS. 4.55)" (on the sixth to ninth lines of page 149)

(D) Matters described in Evidence A No. 8

(Reproduced) (A8-a) "A Novel Amorphous Transparent Conductive Film  $InGaO_3(ZnO)_m$ " (Title)

# (E) Matters described in Evidence A No. 9

(Reproduced) (A9-e) "<u>As</u> a series of <u>n-type amorphous oxide semiconductors</u>, a-In<sub>2</sub>O<sub>3</sub><sup>[13]</sup>, a-AgSbO<sub>3</sub><sup>[14]</sup>, a-2CdO-GeO<sub>2</sub><sup>[15]</sup>, a-CdO-PbO<sub>x</sub><sup>[16]</sup>, <u>a-InGaO<sub>3</sub>(ZnO)<sub>m</sub> (m≤4)</u><sup>[17]</sup>, a-ZnO-SnO<sub>2</sub><sup>[18]</sup>, and the like have been found to date. These semiconductors are characterized by having unique electron transporting properties, that is, absence of Hall voltage sign double anomaly commonly found in existing amorphous semiconductors <sup>[19]</sup>, and having as high a mobility as a crystalline material (electron Hall mobility greater than 10 cm<sup>2</sup>V<sup>-1</sup>s<sup>-1</sup>)<sup>[20]</sup>." (on the 20th to 27th lines of page 2 of the translation)

#### (F) Matters described in Evidence A No. 13

(A-13a) "<u>This compound is useful as an optical functional material, a semiconductor</u> material, a catalyst material, and the like. <u>Examples of application of this compound</u> may include an element for a phosphor, a semiconductor, and the like.

This compound can be fabricated by the following method.

This compound <u>can be fabricated</u> in such a manner that metal indium or indium oxide or a compound decomposed into indium oxide by heating, and metal gallium or gallium oxide or a compound decomposed into gallium oxide by heating, and metal zinc or zinc oxide or a compound decomposed into zinc oxide by heating are <u>mixed with an</u> <u>atomic ratio of In:Ga:Zn = 1:1:2</u>; and then <u>the mixture is heated at 600°C or more</u> in the air, in an oxidizing atmosphere or in a reducing atmosphere where In and Ga are not reduced from the trivalent state and Zn is not reduced by the divalent state.

Any commercially available material can be used as the starting material for use in the present invention as is, but in order to rapidly proceed the chemical reaction, the material with a small particle size is good, particularly a material with a particle size of 10  $\mu$ m or less is preferable.

In addition, when used as the optical functional material or the semiconductor material, the material with less impurities, namely, with high purity is preferable.

These materials are mixed as is or sufficiently mixed together with alcohol or acetone.

The materials are mixed with an atomic ratio of In:Ga:Zn = 1:1:2. Without this mixture ratio, a single phase compound of interest cannot be obtained.

The mixture is heated at 600°C or more in the air, in an oxidizing atmosphere or in a reducing atmosphere where In and Ga are not reduced from the trivalent state and Zn is not reduced by the divalent state.

The heating time is several hours or more. The temperature rising rate during heating is not limited. After heating, the air may be rapidly cooled to  $0^{\circ}$ C or the material may be rapidly pulled out into the air.

<u>It was found that the powder</u> of <u>the obtained  $InGaZnMgO_4$  compound</u> is colorless and <u>has a crystal structure by X-ray diffraction method</u>. The crystal structure is a layered structure formed by laminating  $In_{1.5}$  layer, (GaZn)O<sub>2.5</sub> layer, and ZnO layer.

# **Examples**

An indium oxide powder with a purity of 99.99% or more, a gallium oxide powder with a purity of 99.9% or more, and a special grade zinc oxide powder were weighted at a molar ratio of 1:1:2, and these powders were mixed for 30 minutes by adding ethanol in a mortar, resulting in that <u>a fine powder mixture having an average</u> <u>particle diameter of several  $\mu$ m was obtained</u>. The mixture was sealed in a platinum tube, placed in a furnace set to 1300°C, and heated for 3 days. Then, the sample was removed from the furnace and rapidly cooled to room temperature.

The obtained sample was single phase  $InGaZn_2O_5$ . <u>The surface interval (d\_o)</u> and relative reflection intensity of each reflection were measured by powder X-ray <u>diffraction method</u>. <u>The results were listed in Table 2</u>. The lattice constants as the hexagonal system were as follows.

 $a = 3.292 \pm 0.001$  (Å)

 $c = 22.52 \pm 0.01$  (Å)

The surface interval  $[d_c (Å)]$  calculated from the above lattice constants and each reflection (hkl) of Table 2 were matched very well to the actual measured surface interval  $[d_o (Å)]$ ." (on the first line in left column of page 3 to 19th line in left column of page 4)

J Judging from the above, it can be recognized from the description of (A) to (F) above that an oxide with "a composition thereof expressed by a formula  $InGaO_3(ZnO)_m$ " was known before the priority date of the case.

However, from the description of the respective items of Evidence A above, a person skilled in the art cannot find motivation to particularly select the oxide with "a composition thereof expressed by a formula  $InGaO_3(ZnO)_m$ " from "for example,  $Ga_2O_3$ ,  $Bi_2O_3$ ,  $SnO_2$ , ZnO,  $Sb_2O_3$ , PbO,  $GeO_2$ , or  $In_2O_3$ , and a mixture of these oxides, or a compound composed of oxides such as  $GaInO_3$ ,  $ZnGa_2O_4$ , and  $CdGa_2O_4$ " of Cited Invention 3.

Further, it can be recognized that as examined in "4 Judgment by the body, (1) Cited Invention 3" above, Cited Invention 3 assumes that the addition of dopant atoms is the matter specifying the invention, and as examined in B to C above, there is a technical significance such that the addition of dopant atoms can provide a sufficient conductivity. Meanwhile, even though a person skilled in the art could easily select an oxide with "a composition thereof expressed by a formula  $InGaO_3(ZnO)_m$ " as the oxide of Cited Invention 3, it cannot be recognized that there was known a dopant atom that can provide a sufficient conductivity by adding an oxide with "the composition thereof expressed by a formula InGaO<sub>3</sub>(ZnO)<sub>m</sub>" thereto. Accordingly, it cannot be recognized that a person skilled in the art could easily use an oxide with "a composition thereof expressed by a formula InGaO<sub>3</sub>(ZnO)<sub>m</sub>" as the oxide of that a person skilled in the art could easily use an oxide with "a composition thereof expressed by a formula InGaO<sub>3</sub>(ZnO)<sub>m</sub>" as the oxide of Cited Invention 3, it cannot be recognized that there was known a dopant atom that can provide a sufficient conductivity by adding an oxide with "the composition thereof expressed by a formula InGaO<sub>3</sub>(ZnO)<sub>m</sub>" as the oxide of Cited Invention 3.

Furthermore, it can be understood that the patent invention 1 could provide the effect as examined in F above by using "an amorphous oxide thin film" with "a composition thereof expressed by a formula  $InGaO_3(ZnO)_m$ ", but even though the description of the respective items of Evidence A above is taken into consideration, it cannot be recognized that the effect falls within the range predicted by the person skilled in the art.

Based on the above reason, even though the description of the respective items of Evidence A above is taken into consideration, when the above different feature 3-1 is examined, it cannot be recognized that a person skilled in the art could easily arrive at the configuration of patent invention 1 from Cited Invention 3.

#### • Regarding different feature 3-4

The above excerpt (A-10d) of Evidence A No. 10 describes that "In FIG. 2, - - of the single crystal InGaO<sub>3</sub>(ZnO)<sub>5</sub> thin film fabricated - - - . <u>The value of the electron</u> mobility (obtained as the field-effect mobility) - - -, and hence the carrier concentration is estimated to be approximately  $10^{13}$  cm<sup>-3</sup>." The above excerpt (A-10e) describes that "It is understood that this TFET operates as the enhancement type." The enhancement type is a normally-off type.

In addition, Evidence A No. 11 describes that "In general, in order to fabricate an electronic device such as a normally-off type field-effect transistor, it is necessary to reduce its concentration to the intrinsic level or less ( $<10^{14}$  cm<sup>-3</sup>)." (on the sixth to eighth lines of page 8 of the description)

Judging from the above, it could be said that it was well known that the electron carrier concentration was reduced to approximately  $10^{14}$  cm<sup>-3</sup> or  $10^{13}$  cm<sup>-3</sup> in order to fabricate a normally-off type transistor.

However, the carrier concentration "estimated to be  $10^{13}$  cm<sup>-3</sup>" of Evidence A No. 10 was a value estimated for <u>single crystal</u> InGaO<sub>3</sub>(ZnO)<sub>5</sub> thin film, and hence it cannot be recognized that a person skilled in the art could easily apply the carrier concentration "estimated to be  $10^{13}$  cm<sup>-3</sup>" of Evidence A No. 10 to the <u>amorphous</u> oxide thin film with a crystallized composition thereof expressed by a formula InGaO<sub>3</sub>(ZnO)<sub>m</sub> (m is a natural number of less than 6).

Further, the excerpt (A9-a) of Evidence A No. 9 above describes that an amorphous InGaZnO<sub>4</sub> film whose electron carrier concentration is  $4.2 \times 10^{16}$  cm<sup>-3</sup> calculated using 21 cm<sup>2</sup>V<sup>-1</sup>s<sup>-1</sup> as the value of the mobility was fabricated, but as is clear from the excerpt (A9-b) of Evidence A No. 9 above, the a-InGaZnO<sub>4</sub> film formed in Evidence A No. 9 was obtained by forming an amorphous InGaZnO<sub>4</sub> film whose electron carrier concentration is  $4.2 \times 10^{16}$  cm<sup>-3</sup> in Ar. Therefore, it cannot be recognized that it could be easy to apply the invention of adjusting the oxygen concentration described in the excerpt (A-1e) and the excerpt (A-1h) of Evidence A No. 1 above and the excerpt (A-5a) and the excerpt (A-5c) of Evidence A No. 5 above, to the invention described in Evidence A No. 9.

In short, even if a person skilled in the art came across the description of Evidence A No. 1, Evidence A No. 5, Evidence A No. 9, Evidence A No. 10, and Evidence A No. 11, it cannot be recognized that the person skilled in the art could easily reduce the electron carrier concentration to approximately  $10^{16}$  cm<sup>-3</sup> or less by controlling the oxygen partial pressure for the purpose of fabricating a normally-off type

transistor when the semiconductor material of Cited Invention 3 is applied to the transistor.

Further, it is clear that when the electron carrier concentration of the semiconductor layer of Cited Invention 3 is reduced to  $10^{16}$  cm<sup>-3</sup> or less, the value of the electron mobility is changed, but none of Evidence A No. 1, Evidence A No. 5, Evidence A No. 9, Evidence A No. 10, and Evidence A No. 11 describes that the property of "an electron mobility of  $0.1 \text{ cm}^2/(\text{V.second})$  or more at room temperature" in the amorphous oxide thin film and the property of "an electron carrier concentration of  $10^{16}/\text{cm}^3$  or less" were achieved at the same time. Therefore, it cannot be recognized that a person skilled in the art could easily achieve the property of "an electron mobility of  $0.1 \text{ cm}^2/(\text{V.second})$  or more at no electron carrier concentration of  $10^{16}/\text{cm}^3$  or less" were achieved at the same time. Therefore, it cannot be recognized that a person skilled in the art could easily achieve the property of "an electron mobility of  $0.1 \text{ cm}^2/(\text{V.second})$  or more at no temperature" and the property of "an electron carrier concentration of  $10^{16}/\text{cm}^3$  or less" at the same time.

Based on the above reason, when the above different feature 3-4 is examined, it cannot be recognized that a person skilled in the art could easily arrive at the configuration of patent invention 1 from Cited Invention 3.

### (4) Summary

Based on the above reason, when the above different feature 3-1 and the above different feature 3-4 are examined, it cannot be recognized that a person skilled in the art could easily arrive at the configuration of patent invention 1 from Cited Invention 3, and hence there is no need to examine the other different features and it cannot be recognized that a person skilled in the art could easily invent the patent invention 1 from Cited Invention 1 from Cited Invention 3 and the inventions described in the respective items of Evidence A above.

In short, it cannot be recognized that a person skilled in the art could easily invent the patent invention 1 based on the invention described in Evidence A No. 1, Evidence A No. 3, Evidence A No. 4, Evidence A No. 5, Evidence A No. 6, Evidence A No. 7, Evidence A No. 8, Evidence A No. 9, Evidence A No. 10, Evidence A No. 11, and Evidence A No. 13.

4 Regarding the prosecution history of other applications

The demandant shows the prosecution history of Japanese Patent Application No. 2007-502848 as Evidence A No. 14 to Evidence A No. 22, and argues to the effect that the judgment on the above application described in Evidence A No. 14 to Evidence A No. 22 should be equally applicable to the patent invention 1 and the like. However, the Japanese Patent Application No. 2007-502848 and the patent invention are different

applications distinct from each other in terms of invention, and hence the body has no reason to be bound by the judgment in the prosecution history of the Japanese Patent Application No. 2007-502848. Also in actual judgments, the trial decision of the Japanese Patent Application No. 2007-502848 is based on "cannot find a description of exerting an exceptional effect" (on the last line of page 10, the fifth to the sixth line of page 11, and the 10th line of page 13 of the trial decision). The demandant argues that the judgment on the above applications described in Evidence A No. 14 to Evidence A No. 22 should be equally applicable to the patent invention 1 and the like, but as examined in D above, it can be recognized that the patent invention 1 exerts an exceptional effect, and hence the argument of the demandant cannot be accepted.

#### 5 Patent invention 2

The patent invention 2 is as recognized in "No. 2 The Invention."

### 6 Matters described in the respective items of Evidence A

Evidence A No. 1, Evidence A No. 3, Evidence A No. 4, Evidence A No. 5, Evidence A No. 6, Evidence A No. 7, Evidence A No. 8, Evidence A No. 9, Evidence A No. 10, Evidence A No. 11, Evidence A No. 12, and Evidence A No. 13 describe the matters summarized above.

#### 7 Judgment by the body regarding patent invention 2

# (1) Comparison

Cited Invention 3 is as examined in "3 Judgment by the body regarding patent invention 1" above, and is reproduced as follows.

"A film formation method for forming the semiconductor material of the semiconductor device comprising a transparent switching element which comprises two connection electrodes of a transparent material; and an interposed transparent channel region of a semiconductor material with a transparent gate electrode of a conductive material being separated from the channel region by a transparent insulating layer,

the film formation method for forming the semiconductor material of the semiconductor device, wherein the semiconductor material comprises a degenerate semiconductor material containing a basic material with a band gap of 2.5 eV or more between a conduction band and a valence band of electrons and a charge carrier mobility of  $10 \text{ cm}^2/\text{Vs}$  or more, the material containing dopant atoms forming a fixed

impurity energy level in the valence band or the conduction band of the basic material or adjacent thereto,

the film formation method comprising: epitaxially depositing a conductive SrRuO<sub>3</sub> layer 5 on an insulating monocrystalline SrTiO<sub>3</sub> substrate 7; patterning the SrRuO<sub>3</sub> layer 5 to form a gate electrode 5; providing BaZrO<sub>2</sub> as a transparent insulating layer 6 on the gate electrode 5 and the surface of the substrate 7; and depositing a 0.1  $\mu$ m thick layer 4 of In<sub>2</sub>O<sub>3</sub> doped with 0.03% Sn as the semiconductor material on the transparent insulating layer 6 and the surface of the substrate 7 in a known manner by pulsed laser deposition at an oxygen pressure of 0.2 mbar and at a temperature of 505°C,

the film formation method capable of using other covalent oxides of a non-transition metal containing dopant atoms for  $In_2O_3$  doped with 0.03% Sn as the semiconductor material with a mobility of 10 cm<sup>2</sup>/Vs or more and a band gap of 2.5 eV or more, such as Ga<sub>2</sub>O<sub>3</sub>, Bi<sub>2</sub>O<sub>3</sub>, SnO<sub>2</sub>, ZnO, Sb<sub>2</sub>O<sub>3</sub>, PbO, GeO<sub>2</sub>, and In<sub>2</sub>O<sub>3</sub>, and a mixture of these oxides, or a compound composed of oxides such as GaInO<sub>3</sub>, ZnGa<sub>2</sub>O<sub>4</sub>, or CdGa<sub>2</sub>O<sub>4</sub>."

A The patent invention 2 is compared with the Cited Invention 3.

B The "film formation method" of the Cited Invention 3 corresponds to the "vapor-phase film formation method" of the patent invention 2 in terms of using the "pulsed laser deposition."

C The "layer 4" of the Cited Invention 3 corresponds to the "oxide thin film" and the ""transparent" "thin film"" of the patent invention 2 in that it uses a "compound composed of oxides" and it is a " $0.1 \mu$ m" thin film.

D The configuration of the Cited Invention 3 of "depositing on the transparent insulating layer 6 and the surface of the substrate 7 in a known manner by pulsed laser deposition at an oxygen pressure of 0.2 mbar and at a temperature of  $505^{\circ}$ C" and the configuration of the patent invention 2 "wherein when depositing the thin film on a substrate using a polycrystal of the oxide as a target in an atmosphere containing an oxygen gas without intentionally adding impurity ions for enhancing electric resistance to the thin film in a state where a temperature of the substrate is not intentionally increased, a semi-insulating transparent In-Ga-Zn-Mg-O thin film having an electron mobility of 0.1 cm<sup>2</sup>/(V.second) or more at room temperature and an electron carrier

concentration of  $10^{16}$ /cm<sup>3</sup> or less at room temperature is formed by controlling the magnitude of the oxygen partial pressure so that the formed thin film has an electron carrier concentration of  $10^{16}$ /cm<sup>3</sup> or less at room temperature." are common in that "the thin film is deposited on the substrate in an atmosphere containing an oxygen gas."

E Regarding the electron mobility, the "mobility" of the Cited Invention 3 corresponds to the "electron mobility" of the patent invention 2; and the " $10 \text{ cm}^2/\text{Vs}$  or more" of the Cited Invention 3 satisfies " $0.1 \text{ cm}^2/(\text{V.second})$  or more" of the patent invention 2.

F Considering the above, the corresponding features and the different features between the patent invention 2 and Cited Invention 3 are as follows.

# <Corresponding feature>

The vapor-phase film formation method using the pulsed laser deposition method for the oxide thin film.

The vapor-phase film formation method for forming an oxide thin film, namely, a transparent oxide thin film, wherein when depositing the thin film on a substrate in an atmosphere containing an oxygen gas, the formed thin film has an electron mobility of  $0.1 \text{ cm}^2/(\text{V.second})$  or more.

# <Different features>

• Different feature 3-5: The oxide to be formed differs in that in the case of patent invention 2, the oxide is "In-Ga-Zn-O" which is an "amorphous oxide thin film" with "a crystallized composition thereof expressed by a formula InGaO<sub>3</sub>(Zn<sub>1-x</sub>Mg<sub>x</sub>O)<sub>m</sub> (m is a natural number of less than 6,  $0.80 \le x < 0.85$ )," while in the case of the Cited Invention 3, the oxide "comprising a degenerate semiconductor material containing a basic material with a band gap of 2.5 eV or more between a conduction band and a valence band of electrons and a charge carrier mobility of 10 cm<sup>2</sup>/Vs or more, the material containing dopant atoms forming a fixed impurity energy level in the valence band or the conduction band of the basic material or adjacent thereto"; "capable of using other covalent oxides of a non-transition metal containing dopant atoms for In<sub>2</sub>O<sub>3</sub> doped with 0.03% Sn as the semiconductor material with a mobility of 10 cm<sup>2</sup>/Vs or more and a band gap of 2.5 eV or more, such as Ga<sub>2</sub>O<sub>3</sub>, SnO<sub>2</sub>, ZnO, Sb<sub>2</sub>O<sub>3</sub>, PbO, GeO<sub>2</sub>, and In<sub>2</sub>O<sub>3</sub>, and a mixture of these oxides, or a compound composed of the oxides such as GaInO<sub>3</sub>, ZnGa<sub>2</sub>O<sub>4</sub>, and CdGa<sub>2</sub>O<sub>4</sub>"; and without specifying "an amorphous oxide thin film."

• Different feature 3-6: The patent invention 2 has a configuration of depositing the thin film "using a polycrystal of the oxide as a target" "without intentionally adding impurity ions for enhancing electric resistance to the thin film" while the Cited Invention 3 does not specify the configuration.

• Different feature 3-7: The patent invention 2 deposits the thin film "in a state where a temperature of the substrate is not intentionally increased" while Cited Invention 3 deposits the thin film "at a temperature of 505°C."

• Different feature 3-8: The patent invention 2 has a configuration of forming "a semi-insulating" transparent thin film "having an electron mobility of 0.1  $\text{cm}^2/(\text{V.second})$  or more at room temperature and an electron carrier concentration of  $10^{16}/\text{cm}^3$  or less at room temperature by controlling the magnitude of the oxygen partial pressure so that the formed thin film has an electron carrier concentration of  $10^{16}/\text{cm}^3$  or less at room temperature," while the Cited Invention 3 does not specify the configuration.

More specifically, in the case of the patent invention 2, when the thin film is deposited on the substrate, the magnitude of the oxygen partial pressure is controlled so that the thin film can be formed to have an electron carrier concentration of  $10^{16}$ /cm<sup>3</sup> or less at room temperature; and as a result of this control, a semi-insulating transparent oxide thin film with an electron mobility of 0.1 cm<sup>2</sup>/(V.second) or more at room temperature and an electron carrier concentration of  $10^{16}$ /cm<sup>3</sup> or less is obtained, while in the case of the Cited Invention 3, a degenerate semiconductor material containing a basic material with a charge carrier mobility of  $10 \text{ cm}^2/\text{Vs}$  or more is resultantly obtained, but it is not clear that the oxygen pressure of 0.2 mbar is the oxygen partial pressure controlled for the purpose of obtaining the formed thin film to have a predetermined electron carrier concentration at room temperature.

- (2) Judgment of the different features
- Regarding the different feature 3-5
- A <Regarding substitution of oxides>

There have been known the oxides containing elements such as In, Ga, Zn, Mg, and O as described in Evidence A No. 12, other than the oxides described in Evidence A No. 3 and the oxides containing elements such as In, Ga, Zn, and O as described in Evidence A No. 4, Evidence A No. 6, Evidence A No. 7, Evidence A No. 8, Evidence A

No. 9, and Evidence A No. 13. Further, Evidence A No. 12 also describes that the ratio between Zn and Mg could be appropriately determined; and as the ratio of Zn was increased, the conductivity was increased.

Then, in view of the description of Evidence A No. 12 that was known before the priority date of the patent, considering the optical properties and the conductivity required for the conductive oxide, it can be said that there could be room to construe that a person ordinarily skilled in the art would have easily conceived that in the transparent In-Ga-Zn-O amorphous oxide thin film such as  $InGaO_3(ZnO)_m$ , Zn was replaced with Zn+Mg and the ratio between Zn and Mg was adjusted.

However, as examined in "the different feature 3-1" above, it cannot be recognized that a person ordinarily skilled in the art would have easily arrived at the configuration of the patent invention 1 from the Cited Invention 3, that is, a person ordinarily skilled in the art would have easily conceived of using "an amorphous oxide thin film" which is "an oxide thin film with a crystallized composition thereof expressed by a formula InGaO<sub>3</sub>(ZnO)<sub>m</sub> (m is a natural number of less than 6)" instead of "using other covalent oxides of a non-transition metal containing dopant atoms as the semiconductor material with a mobility of  $10 \text{ cm}^2/\text{Vs}$  or more and a band gap of 2.5 eV or more, such as Ga<sub>2</sub>O<sub>3</sub>, Bi<sub>2</sub>O<sub>3</sub>, SnO<sub>2</sub>, ZnO, Sb<sub>2</sub>O<sub>3</sub>, PbO, GeO<sub>2</sub>, and In<sub>2</sub>O<sub>3</sub>, and a mixture of these oxides, or a compound composed of the oxides such as GaInO<sub>3</sub>, ZnGa<sub>2</sub>O<sub>4</sub>, and CdGa<sub>2</sub>O<sub>4</sub>". It might be possible that a person ordinarily skilled in the art would have easily conceived that in the transparent In-Ga-Zn-O amorphous oxide thin film such as InGaO<sub>3</sub>(ZnO)<sub>m</sub>, Zn was replaced with Zn+Mg and the ratio between Zn and Mg was adjusted. In spite of the above, for the same reason as examined in "Regarding the different feature 3-1" above, it cannot be recognized that a person ordinarily skilled in the art would have easily conceived of using "an oxide thin film with a crystallized composition thereof expressed by a formula InGaO<sub>3</sub>(Zn<sub>1-x</sub>Mg<sub>x</sub>O)<sub>m</sub> (m is a natural number of less than 6,  $0.80 \le x < 0.85$ )" instead of "using other covalent oxides of a non-transition metal containing dopant atoms as the semiconductor material with a mobility of 10 cm<sup>2</sup>/Vs or more and a band gap of 2.5 eV or more, such as  $Ga_2O_3$ , Bi<sub>2</sub>O<sub>3</sub>, SnO<sub>2</sub>, ZnO, Sb<sub>2</sub>O<sub>3</sub>, PbO, GeO<sub>2</sub>, and In<sub>2</sub>O<sub>3</sub>, and a mixture of these oxides, or a compound composed of oxides such as GaInO<sub>3</sub>, ZnGa<sub>2</sub>O<sub>4</sub>, and CdGa<sub>2</sub>O<sub>4</sub>" described above in the Cited Invention 3.

Furthermore, a person ordinarily skilled in the art would not have been able to find motivation to cause the percentage of  $Mg_x$  to  $Zn_{1-x}$  to be particularly  $0.80 \le x < 0.85$  from the description "When magnesium coexists with zinc, the ratio between magnesium and zinc is not particularly limited. It should be noted that as the ratio of

magnesium is increased, the absorption edge is shifted to shorter wavelength, and the transparency tends to increase. As the ratio of zinc is increased, the conductivity tends to increase." in the excerpt (A-12d) of Evidence A No. 12 above. In addition, it is recognized that patent invention 2 would exert such an exceptional effect exceeding the scope of the prediction made by a person ordinarily skilled in the art by causing the percentage of Mg<sub>x</sub> to Zn<sub>1-x</sub> to be particularly  $0.80 \le x < 0.85$  as "Note that when Mg is added, the electron mobility of the oxide film is reduced as compared with a film without Mg, but to a small degree. Meanwhile, further, the electron carrier concentration can be reduced as compared with a film without Mg added is more preferable as the TFT channel layer. - - To cause the electron carrier concentration to be  $10^{16}$ /cm<sup>3</sup> or less, x should be  $0.80 \le x < 0.85$  as shown in FIG. 4." described in the excerpt (Patent-h) of the patent description above.

Based on the above reason, when the above different feature 3-5 is examined, it cannot be recognized that a person ordinarily skilled in the art would have easily arrived at the configuration of patent invention 2 from the Cited Invention 3.

#### • Regarding the different feature 3-8

For the same reason as "Regarding the different feature 3-4" above, when the above different feature 3-8 is examined, it cannot be recognized that a person ordinarily skilled in the art would have easily arrived at the configuration of patent invention 2 from the Cited Invention 3.

#### (3) Summary

Based on the above reason, when the above different feature 3-5 and the above different feature 3-8 are examined, it cannot be recognized that a person ordinarily skilled in the art would have easily arrived at the configuration of patent invention 2 from the Cited Invention 3, and hence there is no need to examine the other different features and it cannot be recognized that a person ordinarily skilled in the art would have easily made the patent invention 2 from the Cited Invention 3 and the inventions described in the respective items of Evidence A above.

In short, it cannot be recognized that a person ordinarily skilled in the art would have easily made the patent invention 2 based on the inventions described in Evidence A No. 1, Evidence A No. 3, Evidence A No. 4, Evidence A No. 5, Evidence A No. 6, Evidence A No. 7, Evidence A No. 8, Evidence A No. 9, Evidence A No. 10, Evidence A No. 11, Evidence A No. 12, and Evidence A No. 13.

8 Patent inventions 3 to 5

The patent inventions 3 to 5 are as recognized in "No. 2 The Invention."

9 Judgment by the body regarding the patent inventions 3 to 5

The patent inventions 3 to 5 cite the patent invention 1 or cite the patent invention 1 or the patent invention 2 to further limit the materials of the substrate or the oxygen partial pressure and the like in the patent invention 1 or in the patent invention 1 or the patent invention 2.

Meanwhile, Evidence A No. 1, Evidence A No. 3, Evidence A No. 4, Evidence A No. 5, Evidence A No. 6, Evidence A No. 7, Evidence A No. 8, Evidence A No. 9, Evidence A No. 10, Evidence A No. 11, Evidence A No. 12, and Evidence A No. 13 describe the matters summarized above.

In addition, as examined above, it cannot be recognized that a person ordinarily skilled in the art would have easily made the patent invention 1 or the patent invention 2, and hence it cannot be recognized that a person ordinarily skilled in the art would have easily made the patent inventions 3 to 5 which further limit the patent invention 1, or the patent invention 1 or the patent invention 2.

Therefore, it cannot be recognized that a person ordinarily skilled in the art would have easily made the patent inventions 3 to 5 based on the inventions described in Evidence A No. 1, Evidence A No. 3, Evidence A No. 4, Evidence A No. 5, Evidence A No. 6, Evidence A No. 7, Evidence A No. 8, Evidence A No. 9, Evidence A No. 10, Evidence A No. 11, Evidence A No. 12, and Evidence A No. 13.

10 Summary of the reason for invalidation 3

As described above, it cannot be said that a person ordinarily skilled in the art would have easily made the patent inventions 1 to 5.

Therefore, the reason for invalidation 3 against the patent inventions 1 to 5 is groundless.

No. 8 Regarding the reason for invalidation 4

1 Patent invention 1

The patent invention 1 is as recognized in "No. 2 The Invention."

2 The invention described in Evidence A No. 4

Evidence A No. 4 relates to "Article having transparent <u>conductive</u> oxide thin film and fabrication method therefor" (Title of the Invention) and describes the following matters together with FIG. 1 and Tables 1 to 4.

(A4-h) "[Claim 1] <u>An article comprising a film containing an amorphous oxide</u> expressed by a general formula  $Zn_xM_yIn_zO_{(x+3y/2+3z/2)}$  (where M is at least one element of aluminum and gallium, a ratio x/y is in a range of 0.2 to 12, and a ratio z/y is in a range of 0.4 to 1.4) in at least a part of at least one surface of a base material.

[Claim 2] An article comprising a film containing an amorphous oxide expressed by a general formula  $Zn_xM_yIn_zO_{(x+3y/2+3z/2)}$  (where M is at least one element of aluminum and gallium, a ratio x/y is in a range of 0.2 to 12,and a ratio z/y is in a range of 0.4 to 1.4) and obtained by injecting positive ions in at least a part of at least one surface of the base material.

[Claim 3] The article according to claim 2, wherein an oxygen deficiency amount d and an amount of injected positive ions are selected so that an amount of carrier electrons falls within a range of  $1 \times 10^{18}$  to  $1 \times 10^{22}$ /cm<sup>3</sup>.

[Claim 4] The article according to any one of claims 1 to 3, wherein the ratio x/(x+y+z) is 0.5 or more.

[Claim 5] The article according to any one of claims 1 to 4, wherein the base material is a polymer substrate, a polymeric flexible substrate, or a glass substrate.

[Claim 6] The article according to claim 5, wherein the base material comprises a film-like or sheet-like transparent polymer.

[Claim 7] An <u>electrode</u> comprising the article according to any one <u>of claims 1</u> to 6.

[Claim 8] The <u>electrode</u> according to claim 7, wherein a <u>conductive layer</u> thereof comprises a <u>homogeneous amorphous oxide film</u>.

[Claim 9] The electrode according to claim 7 or 8, comprising an underlying layer between the substrate and the conductive layer.

[Claim 10] The electrode according to claim 9, wherein the underlying layer is one or two or more layers selected from the group consisting of a filter layer, a TFT layer, an EL layer, a semiconductor layer, and an insulating layer.

[Claim 11] The electrode according to any one of claims 8 to 10, for use in a liquid crystal display, an EL display, or a solar battery.

[Claim 12] A method of fabricating the article according to claim 1, the method comprising forming an oxide film by a sputtering method or a laser ablation method, using an oxide expressed by a general formula  $Zn_xM_yIn_zO_{(x+3y/2+3z/2)}$  (where M is at least one element of aluminum and gallium, a ratio x/y is in a range of 0.2 to 12, and a ratio

z/y is in a range of 0.4 to 1.4) as a target, at a substrate temperature in a range of room temperature to 300°C, and at a pressure in a range of  $1 \times 10^{-2}$  [Pa] to 10[Pa].

[Claim 13] The method of fabricating the article according to claim 2, the method comprising: forming an oxide film by a sputtering method or a laser ablation method, using an oxide expressed by a general formula  $Zn_xM_yIn_zO_{(x+3y/2+3z/2)}$  (where M is at least one element of aluminum and gallium, a ratio x/y is in a range of 0.2 to 12, and a ratio z/y is in a range of 0.4 to 1.4) as a target, at a substrate temperature in a range of room temperature to 300°C, and at a pressure in a range of  $1x10^{-2}$ [Pa] to 10[Pa]; and then injecting positive ions into the oxide film.

[Claim 14] The fabrication method according to claim 12 or 13, performing heat treatment and/or reduction treatment at a temperature in a range of 10 to 300°C after film formation."([Scope of claims])

### (A4-i) "[Field of the Invention]

<u>The present invention relates to an article comprising a transparent conductive</u> <u>film containing an amorphous oxide having high conductivity and visibility, particularly</u> <u>blue light transparency, and easy to be fabricated</u>, as well as the <u>fabrication method</u> therefor. The present invention further relates to an <u>electrode comprising the article of</u> <u>the present invention</u>." ([0001])

#### (A4-j) "[Prior Art]

<u>An light transmissive liquid crystal panel display is widely used for various</u> <u>electric products as a thin-type, light-weight display device</u>. In particular, the light transmissive liquid crystal panel display is actively introduced into an Office Automation equipment such as a personal computer and a word processor. Currently, the demand for a display for use in a laptop with a size of diagonally about 10 inches and a space-saving desktop personal computer has been increasing more and more. Further, improvements have been made towards increasing the size of screen area, the number of pixels, and the degree of high definition.

<u>The light transmissive liquid crystal panel display requires a transparent</u> electrode, and ITO is mainly used as the transparent electrode material. The ITO is transparent in almost the entire range of the ultraviolet region, can reduce the electrical resistivity up to approximately  $1 \times 10^{-4}$   $\Omega$ cm, and thus has been suitable as a transparent electrode material for a liquid crystal display and the like. In recent years, an amorphous phase of ITO, that is, a so-called amorphous ITO has come to be used in response to demand for higher definition. The reason for this is that the amorphous ITO has better patterning properties than the crystalline ITO, and thus allows a fine electrode pattern to be precisely formed; and the electrical resistivity becomes greater than the crystalline ITO, but the resistance value is sufficient for a TFT-type pixel electrode as the mainstream of the liquid crystal display. In addition, <u>the plastic substrate tends to be used to reduce the weight of the display and the amorphous ITO allowing the film to be formed at room temperature is considered to be suitable. The reason for this is that a temperature of 200°C or more is required to form a crystalline ITO film.</u>

[Problems to be Solved by the Invention]  $In_2O_3$  accounts for 90% or more of the component of the amorphous ITO. Therefore, with the recent spread of liquid crystal displays, the price of  $In_2O_3$  has soared to about two times, which is a factor of increasing the material cost (Note from the body: original writing error was corrected). Note that  $In_2O_3$  is a rare metal, which is expected to be depleted when it continues to be mined for about 30 years. For the above reasons, what is becoming necessary is a material low in content of  $In_2O_3$ , low in raw material cost, and low in resource environmental load.

Accordingly, it is an <u>object of the present invention to provide a new</u> <u>transparent conductor material</u> with a high resource environmental load, capable of reducing the content of  $In_2O_3$ , easy to be fabricated at a temperature of around room temperature, with a low resistance, with the optical absorption edge in the ultraviolet region, and <u>excellent in blue light transparency</u>, and a fabrication method therefor, as <u>well as further an electrode using the same transparent conductor material</u>."([0002] to [0005])

(A4-k) "The present inventors have found that a zinc-indium based oxide, which is an oxide containing a predetermined amount of aluminum or gallium, can be easily fabricated at a temperature of around room temperature, has a low resistance, has the optical absorption edge in the ultraviolet region, and is excellent in blue light transparency. With these findings, the present inventors have completed the present invention." ([0006])

(Reproduced) (A4-b) "A first aspect of the article of the present invention comprising a film containing an amorphous oxide expressed by a general formula  $Zn_xM_yIn_zO_{(x+3y/2+3z/2)}$  (where M is at least one element of aluminum and gallium, a ratio x/y is in a range of 0.2 to 12, and a ratio z/y is in a range of 0.4 to 1.4) in at least a part of at least one surface of the base material." ([0009])

(A4-1) "A first fabrication method of the present invention is the method of fabricating the article of the first aspect of the present invention <u>comprising forming an oxide film</u> by a sputtering method or a laser ablation method, using an oxide expressed by a general formula  $Zn_xM_yIn_zO_{(x+3y/2+3z/2)}$  (where M is at least one element of aluminum and gallium, a ratio x/y is in a range of 0.2 to 12, and a ratio z/y is in a range of 0.4 to 1.4) as a target, at a substrate temperature in a range of room temperature to 300°C, and at a pressure in a range of 1x10<sup>-2</sup>[Pa] to 10[Pa]." ([0011])

(A4-m) "The ratio (x/y) is in a range of 0.2 or more, and 12 or less. The raw material cost is increased with the ratio (x/y) less than 0.2. With the ratio (x/y) greater than 12, the Zn component becomes too large and becomes chemically unstable in the air. The ratio (x/y) is preferably in a range of 1 to 10, and more preferably in a range of 4 to 10. The ratio (z/y) is in a range of 0.4 or more, and 1.4 or less. With the ratio (z/y) less than 0.4,  $In_2O_3$  becomes insufficient, and the electrical conductivity is decreased. With the ratio (z/y) greater than 1.4, the Ga<sub>2</sub>O<sub>3</sub> component becomes insufficient, and the transparency in the blue light region is decreased. The ratio (z/y) is preferably in a range of 0.6 or more and 1.4 or less, and more preferably in a range of 0.8 or more and 1.2 or less." ([0014])

(A4-n) "Further, in the article of the present invention, the ratio x/(x+y+z) is preferably in a range of 0.5 or more in terms of reducing the raw material cost and the environmental load. The ratio x/(x+y+z) is preferably in a range of 0.6 to 0.9. Further, in the film of the article of the present invention, the substantially all amount of the oxide is preferably noncrystalline in terms of the transmittance and the conductivity, but may contain a crystalline oxide to an extent not to impair the transmittance and the conductivity." ([0015])

(A4-o) "The conductivity of the oxide of the present invention becomes good when the amount of carrier electron in the conduction band is in a predetermined range. The amount of such carrier electron is in a range of  $1 \times 10^{18}$ /cm<sup>3</sup> to  $1 \times 10^{22}$ /cm<sup>3</sup>. Note that the amount of carrier electron is preferably in a range of  $1 \times 10^{19}$ /cm<sup>3</sup> to  $5 \times 10^{21}$ /cm<sup>3</sup>. It should be noted that the amount of carrier electron can be measured by the electric conductivity measuring device using the van der Pauw method." ([0016])

(A4-p) "The first fabrication method of the present invention uses an oxide expressed by a general formula  $Zn_xM_yIn_zO_{(x+3y/2+3z/2)}$  (where M is at least one element of aluminum and gallium, a ratio x/y is in a range of 0.2 to 12, and a ratio z/y is in a range of 0.4 to 1.4.) as a target."([0027])

(A4-q) "The composition of the thin film to be formed has a small deviation from the target and at most 5%, and hence <u>the composition of the target can be regarded as the same as the desired thin film composition</u>." ([0028])

(A4-r) "Examples of the target may include a mixed sintered body containing a zinc oxide, for example, in a range of x/y>1, or a <u>homologous sintered body containing a</u> <u>zinc oxide by an integer multiple</u>."([0029])

(A4-s) "In the fabrication method of the present invention, an oxide film is formed at a substrate temperature in a range of room temperature to  $300^{\circ}$ C in an oxygen atmosphere or in an oxygen radical atmosphere at a pressure in a range of  $1 \times 10^{-2}$ [Pa] to 10[Pa] by a sputtering method or a laser ablation method. The sputtering method or the laser ablation method also allows an amorphous oxide film to be formed at a substrate temperature in a range of room temperature to  $300^{\circ}$ C at a pressure (oxygen partial pressure) in a range of  $1 \times 10^{-2}$ [Pa] to 10[Pa]. The substrate temperature is preferably in a range of 0 to  $150^{\circ}$ C, and the pressure is preferably in a range of 0.01[Pa] to 1[Pa]." ([0030])

(Reproduced) (A4-c) "According to the fabrication method of the present invention, for example, when a sintered body with In:Ga:Zn=1:1:1 is used as a target, a thin film  $6.2x10^{-3}[\Omega \text{cm}]$  can be easily obtained. In this case, the major cause of the high conductivity is that the mobility indicates a high value of 10 or more despite the amorphous material. In addition, when a sintered body of homologous IGZO InGaO<sub>3</sub>(ZnO)<sub>m</sub> (m: an integer of 2 or more) with increased Zn component is used as the target, a thin film having a resistivity of  $4.3x10^{-3}[\Omega \text{cm}]$  can be easily obtained." ([0034])

(A4-t) "[Advantageous Effects of Invention] The article of the present invention has a low content of  $In_2O_3$ , a low material cost, a small environmental load, and a visible light transmittance of 85% or more, an absorbing short wave length of 385 nm, and hence can reduce resistance on a black and white screen and a color screen by increasing the film thickness. In addition, the material constituting the film has as high as a crystallization temperature of 400°C or more, and hence has an advantage of maintaining a stable amorphous nature in a normal use temperature range and having no variation in resistivity. The material is a stable oxide and hence has excellent environmental resistance and can be used as a transparent electrode for a solar battery to be used in the field." ([0036])

# (Reproduced) (A4-d) "1. Creating the target

Each powder of  $In_2O_3$ ,  $Ga_2O_3$ , and ZnO was weighted so that the ratio of contained metal was 1:1:1 respectively. The weighed powders were wet-mixed by a planetary ball mill apparatus. The wet-mixed powders were calcined at 1000°C for five hours and then crushed again by the planetary ball mill apparatus. The crushed powders were formed into a circular plate shape with a diameter of 20 mm by uniaxial pressing, followed by CIP treatment. Then, the plate was sintered at 1550°C for two hours in the air, and then a sintered body was obtained. It was confirmed by XRD that an oxide expressed by InGaZnO<sub>4</sub> was generated." ([0040])

(Reproduced) (A4-e) "In the case of homologous  $InGaO_3(ZnO)_m$ , each powder of  $In_2O_3$ ,  $Ga_2O_3$ , and ZnO was weighted so that the ratio of contained metal is 1:1:m (m is an integer of 2 or more) respectively." ([0041])

#### (Reproduced) (A4-g) "2. Film formation

A film formation method using a laser ablation method will be described below as an example.

### Example 1

Of the sintered body prepared above, the surface of the sintered body with In:Ga:Zn=1:1:1 was polished and fixed to an inconel holder by metal In. This was fixed to a laser ablation apparatus fabricated by Nippon Shinku Co., Ltd. Then, KrF excimer laser light fabricated by Lambda Physik Co., Ltd., was emitted to the rotating surface with an energy density of  $4J/cm^2$  and a pulse interval of 5 Hz to produce plume. The atmosphere in the chamber caused O<sub>2</sub> gas to flow at 15 to 25 CCM and to have a total pressure of 0.8 to 1.0 [Pa]. A quartz glass substrate with a square of 10 mm and a thickness of 0.5 mm was disposed 30 mm immediately above the target. Then, the substrate is exposed to plume for 30 minutes while being rotated so that the film has uniform thickness, whereby a thin film with a thickness of approximately 300 nm was obtained. The composition ratio was obtained by X-ray fluorescence method. It was confirmed by XRD that the film was uniform amorphous (FIG. 1.) The absorption edge was obtained by calculating an optical constant from the transmission and
reflection spectra of the sample. The electrical properties were obtained by Hall effect measurement using van der Pauw method." ([0042])

(A4-u) Table 1 in [0043] shows the following matters:

at a flow rate of 15 CCM (total pressure of 0.6 Pa), composition ratio (In/Ga): 0.87, composition ratio (Zn/Ga): 0.85, resistivity:  $6.5 \times 10^{-3}$   $\Omega$ .cm, carrier density:  $8.3 \times 10^{19}$ /cm<sup>3</sup>, mobility: 11.6 cm<sup>2</sup>/Vs, absorption edge: 403 nm;

at a flow rate of 20 CCM (total pressure of 0.8 Pa), composition ratio (In/Ga): 0.94, composition ratio (Zn/Ga): 0.84, resistivity:  $6.2 \times 10^{-3} \Omega$ .cm, carrier density:  $8.5 \times 10^{19}$ /cm<sup>3</sup>, mobility: 11.9 cm<sup>2</sup>/Vs, absorption edge: 383 nm;

and at a flow rate of 25 CCM (total pressure of 1.0 Pa), composition ratio (In/Ga): 0.88, composition ratio (Zn/Ga): 0.88, resistivity:  $8.8 \times 10^{-3}$   $\Omega$ .cm, carrier density:  $4.8 \times 10^{19}$ /cm<sup>3</sup>, mobility: 14.9 cm<sup>2</sup>/Vs, absorption edge: 382 nm.

3 Judgment by the body regarding the patent invention 1

(1) Cited Invention 4

When the excerpts (A4-a) to (A4-u) above are summarized, it is recognized that Evidence A No. 4 describes the following invention (hereinafter referred to as "Cited Invention 4".)

"A method of fabricating an article comprising a film containing an amorphous oxide expressed by a general formula  $Zn_xM_yIn_zO_{(x+3y/2+3z/2)}$  (where M is at least one element of aluminum and gallium, a ratio x/y is in a range of 0.2 to 12, and a ratio z/y is in a range of 0.4 to 1.4) at least a part of at least one surface of the base material;

the method of fabricating an article comprising a transparent conductive film containing an amorphous oxide having high conductivity and visibility, particularly blue light transparency, and easy to be fabricated;

the method of forming an oxide film

using an oxide expressed by a general formula  $Zn_xM_yIn_zO_{(x+3y/2+3z/2)}$  (where M is at least one element of aluminum and gallium, a ratio x/y is in a range of 0.2 to 12, and a ratio z/y is in a range of 0.4 to 1.4) as a target,

at a substrate temperature in a range of room temperature to 300°C, and

at a pressure in a range of  $1 \times 10^{-2}$  [Pa] to 10[Pa],

by a sputtering method or a laser ablation method.

The target was fabricated in such a manner that each powder of  $In_2O_3$ ,  $Ga_2O_3$ , and ZnO was weighted so that the ratio of contained metal was 1:1:1 respectively; the

weighed powders were wet-mixed by a planetary ball mill apparatus; the wet-mixed powders were calcined at 1000°C for five hours and then crushed again by the planetary ball mill apparatus; the crushed powders were formed into a circular plate shape with a diameter of 20 mm by uniaxial pressing, followed by CIP; then, the plate was sintered at 1550°C for two hours in the air, and then a sintered body was obtained.

The surface of the sintered body with In:Ga:Zn=1:1:1 was polished and fixed to an inconel holder by metal In; this was fixed to a laser ablation apparatus fabricated by Nippon Shinku Co., Ltd; then, KrF excimer laser light fabricated by Lambda Physik Co., Ltd., was emitted to the rotating surface with an energy density of  $4J/cm^2$  and a pulse interval of 5 Hz to produce plume; the atmosphere in the chamber caused O<sub>2</sub> gas to flow at 15 to 25 CCM and to have a total pressure of 0.8 to 1.0 [Pa]; a quartz glass substrate with a square of 10 mm and a thickness of 0.5 mm was disposed 30 mm immediately above the target; then, the substrate is exposed to plume for 30 minutes while being rotated so that the film has uniform thickness, whereby the following uniform amorphous thin films with a thickness of approximately 300 nm was formed:

a thin film at a flow rate of 15 CCM (total pressure of 0.6 Pa), composition ratio (In/Ga): 0.87, composition ratio (Zn/Ga): 0.85, resistivity:  $6.5 \times 10^{-3} \Omega$ .cm, carrier density:  $8.3 \times 10^{19}$ /cm<sup>3</sup>, mobility: 11.6 cm<sup>2</sup>/Vs, absorption edge: 403 nm;

a thin film at a flow rate of 20 CCM (total pressure of 0.8 Pa), composition ratio (In/Ga): 0.94, composition ratio (Zn/Ga): 0.84, resistivity:  $6.2 \times 10^{-3} \Omega$ .cm, carrier density:  $8.5 \times 10^{19}$ /cm<sup>3</sup>, mobility: 11.9 cm<sup>2</sup>/Vs, absorption edge: 383 nm; and

a thin film at a flow rate of 25 CCM (total pressure of 1.0 Pa), composition ratio (In/Ga): 0.88, composition ratio (Zn/Ga): 0.88, resistivity:  $8.8 \times 10^{-3} \Omega$ .cm, carrier density:  $4.8 \times 10^{19}$ /cm<sup>3</sup>, mobility: 14.9 cm<sup>2</sup>/Vs, absorption edge: 382 nm."

### (2) Comparison

A The patent invention 1 is compared with the Cited Invention 4.

B The "laser ablation method" of the Cited Invention 4 corresponds to "the vapor-phase film formation method using the pulsed laser deposition method" of the patent invention 1.

C The target fabricated in such a manner that "each powder of  $In_2O_3$ ,  $Ga_2O_3$ , and ZnO was weighted so that the ratio of contained metal was 1:1:1 respectively; the weighed powders were wet-mixed by a planetary ball mill apparatus; the wet-mixed powders were calcined at 1000°C for five hours and then crushed again by the planetary ball mill

apparatus; the crushed powders were formed into a circular plate shape with a diameter of 20 mm by uniaxial pressing, followed by CIP; then, the plate was sintered at 1550°C for two hours in the air, and then a sintered body was obtained." of the Cited Invention 4 is recognized as "polycrystal" in light of technical common sense.

D "a substrate temperature in a range of room temperature to 300°C" of the Cited Invention 4 is recognized to include "a state where a temperature of the substrate is not intentionally increased" of the patent invention 1.

E Cited Invention 4 and the patent invention 1 are common in that "the thin film is deposited on the substrate in an atmosphere containing an oxygen gas without intentionally adding impurity ions for enhancing electric resistance to the thin film."

F "carrier density," "mobility," and "amorphous" of the Cited Invention 4 correspond to "electron carrier concentration at room temperature," "electron mobility at room temperature," and "amorphous" of the patent invention 1 respectively.

G Cited Invention 4 matches the patent invention 1 in terms of "an electron mobility of  $0.1 \text{ cm}^2/(\text{V.second})$  or more at room temperature."

H The method of forming ""a film containing an amorphous oxide expressed by general formula  $Zn_xM_yIn_zO_{(x+3y/2+3z/2)}$  (where M is at least one element of aluminum and gallium, a ratio x/y is in a range of 0.2 to 12, and a ratio z/y is in a range of 0.4 to 1.4), that is, a transparent conductive film containing an amorphous oxide having high conductivity and visibility, particularly blue light transparency, and easy to be fabricated"; "a thin film with composition ratio (In/Ga): 0.87, composition ratio (Zn/Ga): 0.85, resistivity:  $6.5 \times 10^{-3} \Omega$ .cm, carrier density:  $8.3 \times 10^{19}$ /cm<sup>3</sup>, mobility: 11.6 cm<sup>2</sup>/Vs, ---"; "a thin film with composition ratio (In/Ga): 0.94, composition ratio (Zn/Ga): 0.84, resistivity:  $6.2 \times 10^{-3} \Omega.$  cm, carrier density:  $8.5 \times 10^{19}$ /cm<sup>3</sup>, mobility:  $11.9 \text{ cm}^2$ /Vs, ---"; and "a thin film with composition ratio (In/Ga): 0.88, composition ratio (Zn/Ga): 0.88, resistivity:  $8.8 \times 10^{-3} \Omega$ .cm, carrier density:  $4.8 \times 10^{19}$ /cm<sup>3</sup>, mobility: 14.9 cm<sup>2</sup>/Vs, ---"" of the Cited Invention 4 and the method of forming "a semi-insulating oxide thin film with a crystallized composition thereof expressed by a formula InGaO<sub>3</sub>(ZnO)<sub>m</sub> (m is a natural number of less than 6) with an electron mobility of  $0.1 \text{ cm}^2/(\text{V.second})$  or more at room temperature, and an electron carrier concentration of 10<sup>16</sup>/cm<sup>3</sup> or less, that is a vapor-phase film formation method of forming an amorphous oxide thin film" of the

patent invention 1 are common in that both methods are a film formation method of forming "a transparent In-Ga-Zn-O thin film, that is, an amorphous oxide thin film."

I Considering the above, the corresponding features and the different features between the patent invention 1 and Cited Invention 4 are as follows.

### <Corresponding features>

A vapor-phase film formation method for an oxide thin film using a pulsed laser deposition method or an RF sputtering method,

When a thin film is deposited on the substrate using a polycrystal of the oxide as a target in a state where a temperature of the substrate is not intentionally increased without intentionally adding impurity ions for enhancing electric resistance to the thin film in an atmosphere containing an oxygen gas,

A vapor-phase film formation method for an amorphous oxide thin film for forming a transparent In-Ga-Zn-O thin film with an electron mobility of 0.1  $\text{cm}^2/(\text{V.second})$  or more at room temperature.

<Different features>

• Different feature 4-1: in the case of patent invention 1, the formed thin film is "a semi-insulating thin film with an electron carrier concentration of  $10^{16}$ /cm<sup>3</sup> or less," while in the case of the Cited Invention 4, the formed thin film is "a transparent conductive film" with "a carrier density of  $8.3 \times 10^{19}$ /cm<sup>3</sup>," "a carrier density of  $8.5 \times 10^{19}$ /cm<sup>3</sup>," and " a carrier density of  $4.8 \times 10^{19}$ /cm<sup>3</sup>."

• Different feature 4-2: patent invention 1 "controls the magnitude of the oxygen partial pressure so that the formed thin film has an electron carrier concentration of  $10^{16}$ /cm<sup>3</sup> or less at room temperature," while in the Cited Invention 4, ""at a pressure in a range of  $1 \times 10^{-2}$ [Pa] to 10[Pa]," "the atmosphere in the chamber caused O<sub>2</sub> gas to flow at 15 to 25 CCM and to have a total pressure of 0.8 to 1.0 [Pa]."" In other words, Cited Invention 4 does not clarify the technical idea of specifying a specific value of the "electron carrier concentration at room temperature of the thin film" formed "by controlling the magnitude of the oxygen partial pressure."

• Different feature 4-3: the patent invention 1 is a film formation method of forming "an oxide thin film with a crystallized composition thereof expressed by a formula  $InGaO_3(ZnO)_m$  (m is a natural number of less than 6)," while Cited Invention 4 is a

method of forming ""a film containing an amorphous oxide expressed by "a general formula  $Zn_xM_yIn_zO_{(x+3y/2+3z/2)}$  (where M is at least one element of aluminum and gallium, a ratio x/y is in a range of 0.2 to 12, and a ratio z/y is in a range of 0.4 to 1.4)," "a thin film with composition ratio (In/Ga): 0.87, composition ratio (Zn/Ga): 0.85 ---," "a thin film with composition ratio (In/Ga): 0.94, composition ratio (Zn/Ga): 0.84 ---," and "a thin film with composition ratio (In/Ga): 0.88, composition ratio (Zn/Ga): 0.88, --- ."" In other words, Cited Invention 4 does not specify that the crystallized composition is expressed by a formula InGaO<sub>3</sub>(ZnO)<sub>m</sub> (m is a natural number of less than 6), that is, the composition ratio (In/Ga) between In and Ga is "1" and the composition ratio (Zn/Ga) between Zn and Ga is one of the natural numbers "1," "2," - - "5".

#### (3) Judgment of the different feature

## • Regarding the different feature 4-1

From the description of the excerpt (A4-j) of Evidence A No. 4 above, the problem to be solved is recognized such that "a light transmissive liquid crystal panel display is widely used for various electric products as a thin-type, light-weight display device"; "the light transmissive liquid crystal panel display requires a transparent electrode, and ITO is mainly used as the transparent electrode material"; and "the ITO is transparent in almost the entire range of the ultraviolet region, can reduce the electrical resistivity up to approximately  $1 \times 10^{-4} \Omega$ cm, and thus has been suitable as a transparent electrode material for a liquid crystal display and the like"; but "In<sub>2</sub>O<sub>3</sub> accounts for 90% or more of the component of the amorphous ITO"; "therefore, with the recent spread of liquid crystal displays, the price of In<sub>2</sub>O<sub>3</sub> has soared to about two times, which is a factor of increasing the material cost (Note from the body: original writing error was corrected)"; "note that  $In_2O_3$  is a rare metal, which is expected to be depleted when it continues to be mined for about 30 years"; "for the above reasons, what is becoming necessary is a material low in content of In<sub>2</sub>O<sub>3</sub>, low in raw material cost, and low in resource environmental load". It is understood that Cited Invention 4 is intended to "provide a new transparent conductor material with a high resource environmental load, capable of reducing the content of In<sub>2</sub>O<sub>3</sub>, easy to be fabricated at a temperature of around room temperature, with a low resistance, with the optical absorption edge in the ultraviolet region, and excellent in blue light transparency, and a fabrication method therefor, as well as further an electrode using the same transparent conductor material."

In other words, it can be said that the invention of the Cited Invention 4 is based on the premise that the thin film is "a conductor" in relation to the problem to be solved by the invention.

In addition, from the description of Evidence A No. 4, a person ordinarily skilled in the art cannot find a description or a suggestion of motivation to replace the thin film with a "semi-insulating" thin film "with an electron carrier concentration of  $10^{16}$ /cm<sup>3</sup> or less."

Meanwhile, as examined in the different feature 4-1, it is clear that if the matters specifying the invention of the patent invention 1 could be used from the Cited Invention 4, that is, a "semi-insulating" thin film with "an electron carrier concentration of  $10^{16}$ /cm<sup>3</sup> or less" could be used instead of the "transparent conductive film" of the Cited Invention 4, the electrical resistivity of the thin film would be deviated from a suitable range as the transparent electrode material such as a liquid crystal display. Then, as examined in the different feature 4-1, it is recognized that the use of the matters specifying the invention of the patent invention 1 in the Cited Invention 4 would prevent the problem to be solved in the Cited Invention 4.

Therefore, as examined in the different feature 4-1, there is an obstructing factor in the Cited Invention 4, and thus it cannot be recognized that a person ordinarily skilled in the art would have easily arrived at the matters specifying the invention of the patent invention 1 from the Cited Invention 4.

It should be noted that on the 10th to 22nd lines of page 76 of the written demand for trial, the demandant of the trial argues that

"(4-1-5) Consideration on the different feature 15

<Technical common sense to the oxide thin film before the priority date of the patent>, <well-known property of the transparent oxide thin film which is a degenerate semiconductor>, and <regarding the electron carrier concentration> described in (1-1-5) above, all of which are hereby incorporated herein by reference.

<Summary of the different feature 15>

<u>Considering the description of (1-1-5) above</u>, a person ordinarily skilled in the art would have easily conceived of using a "semi-insulating" In-Ga-Zn-O thin film with "an electron carrier concentration of  $10^{16}$ /cm<sup>3</sup> or less" instead of the "conductive" In-Ga-Zn-O thin film with "an electron carrier concentration of  $10^{18}$ /cm<sup>3</sup> or more" of the Cited Invention 4.

In addition, even if the description such as the patent description is taken into consideration, the demandant cannot find a description that the patent invention 1 would exert particularly significant effects or effects beyond the predictable range."

However, <Technical common sense to the oxide thin film before the priority date of the patent>, <well-known property of the transparent oxide thin film which is a degenerate semiconductor>, and <regarding the electron carrier concentration> described in (1-1-5) above are intended to argue that the Cited Invention 1 is a film formation method of forming a thin film having electrical properties as a semiconductor with an electron carrier concentration of  $10^{18}$ /cm<sup>3</sup> or less, and in this case, it is easy to have an electron carrier concentration of  $10^{16}$ /cm<sup>3</sup> or less. In other words, they are intended to argue that it is easy to change the value of the electron carrier concentration from  $10^{18}$ /cm<sup>3</sup> or less to  $10^{16}$ /cm<sup>3</sup> or less within a framework of the electrical properties usable as the semiconductor active layer which is "a semiconductor thin film with an electron carrier concentration of  $10^{18}$ /cm<sup>3</sup> or less," but they are not intended to argue that it is easy to use a "semi-insulating" thin film with "an electron carrier concentration of  $10^{16}$ /cm<sup>3</sup> or less" instead of "a transparent conductive film" which is the different feature 4-1 between the Cited Invention 4 and the patent invention 1, that is, it is easy to replace "a conductive film" having electrical properties used as an electrode with "a semi-insulating" thin film having electrical properties used as the semiconductor active layer.

Evidence A No. 1, Evidence A No. 4, Evidence A No. 5, Evidence A No. 6, Evidence A No. 7, Evidence A No. 9, Evidence A No. 10, and Evidence A No. 11 describe matters summarized in "No. 5 reason for invalidation 1," but contrary to the argument of the demandant, "the description (1-1-5)" does not include the ease of replacing the "conductive film" with the "semi-insulating" thin film. Therefore, even if "the description (1-1-5)" is considered, it cannot be recognized that a person ordinarily skilled in the art would have been easily used a "semi-insulating" In-Ga-Zn-O thin film with "an electron carrier concentration of  $10^{16}/\text{cm}^3$  or less" instead of a "conductive" In-Ga-Zn-O thin film with "an electron carrier concentration of  $10^{18}/\text{cm}^3$ or more" of the Cited Invention 4.

# • Regarding the different feature 4-2

As examined in "Regarding the different feature 4-1" above, a person ordinarily skilled in the art would not have easily conceived of using the "semi-insulating" thin film instead of the "transparent conductive film" of the Cited Invention 4. However, in case a person ordinarily skilled in the art had easily used the "semi-insulating" thin film instead of the "transparent conductive film" of the Cited Invention 4, the different feature 4-2 will be examined as follows.

The excerpt (A4-o) of the Evidence A No. 4 above describes that "The conductivity of the oxide of the present invention becomes good when the amount of carrier electron in the conduction band is in a predetermined range. The amount of such carrier electron is in a range of  $1 \times 10^{18}$ /cm<sup>3</sup> to  $1 \times 10^{22}$ /cm<sup>3</sup>. Note that the amount of carrier electron is preferably in a range of  $1 \times 10^{19}$ /cm<sup>3</sup> to  $5 \times 10^{21}$ /cm<sup>3</sup>." The excerpt (A4-m) of the Evidence A No. 4 above describes that "The ratio (z/y) is in a range of 0.4 or more, and 1.4 or less. With the ratio (z/y) of less than 0.4, In<sub>2</sub>O<sub>3</sub> becomes insufficient, and the electrical conductivity is decreased." From the above description, since the electrical conductivity is adjusted by adjusting the ratio (z/y) in a range of 0.4 or more, and 1.4 or less, it can be said that it is natural that a person ordinarily skilled in the art who came across to read Evidence A No. 4 would control the conductivity of the Cited Invention 4 in such a manner that, if the amount of carrier electron should be changed to less than  $1 \times 10^{18}$ /cm<sup>3</sup>, the ratio (z/y) between "In" and "M" would be adjusted to less than 0.4 to cause In<sub>2</sub>O<sub>3</sub> to be insufficient, thereby reducing the electrical conductivity.

Thus, such a reduction in the content of  $In_2O_3$  is recognized as in line with solving the problem of the Cited Invention 4 such that "Accordingly, it is an object of the present invention to provide a new transparent conductive material with a high resource environmental load, capable of reducing the content of  $In_2O_3$ , ---" described in the excerpt (A4-j) above.

Judging from the above, in case a person ordinarily skilled in the art had easily used the "semi-insulating" thin film instead of the "transparent conductive film" of the Cited Invention 4, it would be natural that the amount of carrier electrons could be reduced by causing the ratio (z/y) between "In" and "M" to be less than 0.4 in the Cited Invention 4. Therefore, it cannot be recognized that a person ordinarily skilled in the art would have easily conceived of adopting the configuration of the different feature 4-2, that is, by controlling the magnitude of the oxygen partial pressure instead of by causing the ratio (z/y) between "In" and "M" to be less than 0.4 as described in Evidence A No. 4.

• Regarding the different feature 4-3

As examined in "Regarding the different feature 4-1" above, a person ordinarily skilled in the art would not have easily conceived of using the "semi-insulating" thin film instead of the "transparent conductive film" of the Cited Invention 4. However, in case a person ordinarily skilled in the art had easily used the "semi-insulating" thin film instead of the "transparent conductive film" of the Cited Invention 4, the different feature 4-3 will be examined as follows.

According to the Cited Invention 4, none of the composition ratio (In/Ga) and the composition ratio (Zn/Ga) is "1," and hence it cannot be recognized that it is an oxide thin film with a crystallized composition thereof expressed by a formula  $InGaO_3(ZnO)_m$  (m is a natural number of less than 6).

Furthermore, if it was easy to use the "semi-insulating" thin film instead of the "transparent conductive film" of the Cited Invention 4, as examined in "Regarding the different feature 4-2" above, it would be natural to understand that the ratio (z/y) between "In" and "M" would be less than 0.4 to cause  $In_2O_3$  to be insufficient, thereby to reduce the electrical conductivity. Thus, it is clear that if "the ratio (z/y) is less than 0.4," it is not an oxide thin film with a crystallized composition thereof expressed by a formula  $InGaO_3(ZnO)_m$  (m is a natural number of less than 6).

Therefore, as examined in different feature 4-3, it cannot be recognized that a person ordinarily skilled in the art would have easily arrived at the matters specifying the invention of the patent invention 1 from the Cited Invention 4.

In addition, in the excerpt (Subject patent-b) above, the Evidence A No. 4 is disclosed as [patent document 2] in the patent description, which states that "However, the <u>electron carrier concentration</u> of the amorphous oxide film obtained herein was  $10^{18}$ /cm<sup>3</sup> or more, which was sufficient to be used simply for a transparent electrode, but difficult to be applied to a TFT channel layer. This is because it was found that the TFT using the above amorphous oxide film as the channel layer could not obtain a sufficient on/off ratio, and hence was unsuitable for the normally-off type TFT." In light of the above description, it is understood that the Evidence A No. 4 has a problem that the TFT using the thin film formed by the Cited Invention 4 as the channel layer cannot obtain a sufficient on/off ratio. As examined in "(1) Cited Invention 1, (3) Judgment regarding the different features, - Regarding the different feature 1-1, C (B)" above, the patent invention 1 exerts an effect such as "The amorphous oxide film according to the film formation method of the present invention is such that as the electron carrier concentration is increased, the electron mobility is increased, and hence

the current in the ON state of the transistor can be further increased." The effect cannot be predicted from the description of the Cited Invention 4 and the respective items of Evidence A.

(L) Based on the above reason, when the different feature 4-1 to different feature 4-3 above are examined, it cannot be recognized that a person ordinarily skilled in the art would have easily arrived at the configuration of the patent invention 1 from the Cited Invention 4. Therefore, it cannot be recognized that a person ordinarily skilled in the art would have easily made the patent invention 1 based on the inventions described in Cited Invention 4 as well as Evidence A No. 1, Evidence A No. 4, Evidence A No. 5, Evidence A No. 6, Evidence A No. 7, Evidence A No. 9, Evidence A No. 10, and Evidence A No. 11.

#### (4) Summary

It cannot be recognized that a person ordinarily skilled in the art would have easily made the patent invention 1 based on the inventions described in Evidence A No. 1, Evidence A No. 4, Evidence A No. 5, Evidence A No. 6, Evidence A No. 7, Evidence A No. 9, Evidence A No. 10, and Evidence A No. 11.

#### 4 Patent inventions 3 to 5

The patent inventions 3 to 5 are as recognized in "No. 2 The Invention."

### 5 Judgment by the body regarding the patent inventions 3 to 5

The patent inventions 3 to 5 cite the patent invention 1 or cite the patent invention 2 against which no petition for the reason for invalidation 4 was filed, to further limit the materials of the substrate or the oxygen partial pressure and the like in the patent invention 1 or in the patent invention 2.

Meanwhile, Evidence A No. 1, Evidence A No. 3, Evidence A No. 4, Evidence A No. 5, Evidence A No. 6, Evidence A No. 7, Evidence A No. 9, Evidence A No. 10, and Evidence A No. 11 describe the matters summarized above.

In addition, as examined in "3 Judgment by the body" above, it cannot be recognized that a person ordinarily skilled in the art would have easily made the patent invention 1, and there is no petition for the reason for invalidation 4 filed against the patent invention 2. Thus, it cannot be recognized that a person ordinarily skilled in the art would have easily made the patent inventions 3 to 5 which further limit the patent invention 1, or the patent invention 1 or the patent invention 2.

6 Summary of the reason for invalidation 4

As described above, it cannot be said that a person ordinarily skilled in the art would have easily made the patent inventions 1, 3, 4, and 5.

Therefore, the reason for invalidation 4 against the patent inventions 1 as well as the patent inventions 3, 4, and 5 is groundless.

No. 9 Regarding the reason for invalidation 5

1 Patent invention 1

The patent invention 1 is as recognized in "No. 2 The Invention."

2 Specific reasons for the reason for invalidation 5 against the patent invention 1

According to the description in the written demand for trial, it is recognized that the specific reasons for the reason for invalidation 5 against the patent invention 1 are summarized as follows.

Regarding the amorphous oxide of the patent document 2 (Japanese Unexamined Patent Application Publication No. 2000-044236: hereinafter referred to as Evidence A No. 4), [Background Art] of the patent description describes that "the electron carrier concentration was  $10^{18}$ /cm<sup>3</sup> or more, which was sufficient to be used simply for a transparent electrode, but difficult to be applied to a TFT channel layer" and "it was found that the TFT was unsuitable for the normally-off type TFT." ([0005])

In view of this, the patent description describes that in order to achieve a normally-off type TFT, it is important to <u>control the oxygen partial pressure</u> when a "semi-insulating" amorphous oxide thin film with "an electron carrier concentration of  $10^{16}$ /cm<sup>3</sup> or less" of the patent invention 1 is formed, when formed by a pulsed laser deposition, and when formed by a sputtering method.

However, as shown in Table 1 below, the oxygen partial pressure in the patent description is <u>overlapped</u> with the oxygen partial pressure in the patent document 2 (Evidence A No. 4) both by the pulsed laser deposition and the sputtering method.

<u>Although the oxygen partial pressure is overlapped with each other</u>, the patent invention 1 obtains "<u>semi-insulating</u>," while the patent document 2 (Evidence A No. 4) obtains "<u>conductivity</u>."

In this light, there is an extremely serious discrepancy or inconsistency between the patent description and the patent document 2 (Evidence A No. 4) described in [Background Art] thereof. If a person ordinarily skilled in the art had come across to read both descriptions, the person ordinarily skilled in the art would have required to perform trials and errors or complicated advanced experiments beyond the reasonable extent that could be expected therefrom in order to obtain the "semi-insulating" amorphous oxide thin film with "an electron carrier concentration of  $10^{16}/\text{cm}^3$  or less" of the patent invention 1.

Therefore, the patent description is not clear and sufficient enough to enable a person ordinarily skilled in the art to carry out the invention 1.

The demandant of a trial created Table 1 in the written demand for trial. Table 1 lists a summary of the description of [0046], [0047], [0051] to [0060], [0063] to [0065], and [0067] to [0070] in the patent description as well as the description of [0011], [0030], [0027] to [0029], [0030], [0031], and [0040] in the patent document 2 (Evidence A No. 4).

In Table 1, the target starting material, the calcination temperature, and the sintering temperature and time are common among the patent invention 1 and the patent description, and the patent document 2 (Evidence A No. 4) as follows.

• Regarding PLD

According to the patent invention 1 and the patent description,

a semi-insulating amorphous oxide film was obtained under the following film formation conditions:

for the target calcination time of 2h,

at a pressure (oxygen partial pressure) Pa of 4.5 or more and 6.5 or less,

at a substrate temperature of 25°C.

According to the patent document 2 (Evidence A No. 4),

a conductive amorphous oxide film was obtained under the following film formation conditions:

for the target calcination time of 5h,

at a pressure (oxygen partial pressure) Pa of  $1 \times 10^{-2}$  to 10,

preferably 0.01 to 1,

 $7.9 \times 10^{-2}$  to 1.4 (Example)

at a substrate temperature of room temperature to 300°C.

• Regarding sputtering

According to the patent invention 1 and the patent description,

a semi-insulating amorphous oxide film was obtained under the following film formation conditions:

for the target calcination time of 2h,

at a pressure (oxygen partial pressure) Pa of  $3 \times 10^{-2}$  or more and  $5 \times 10^{-1}$  or less,

at a substrate temperature of 25°C.

According to the patent document 2 (Evidence A No. 4),

a conductive amorphous oxide film was obtained under the following film formation conditions:

for the target calcination time of 5h,

at a pressure (oxygen partial pressure) Pa of  $1 \times 10^{-2}$  to 10,

preferably 0.01 to 1,

at a substrate temperature of room temperature to 300°C.

As described above, the detailed description of the invention of the patent description does not meet the requirement stipulated in Article 36(4)(i) of the Patent Act.

Therefore, the invention according to claim 1 of the patent falls under the Article 123(1)(iv) of the Patent Act, and should be invalidated.

3 Judgment by the body regarding the patent invention 1

(1) The detailed description of the invention in the patent description includes the following description.

(Subject patent-t) "[0044]

Examples

(Example 1: fabricating an amorphous In-Ga-Zn-O thin film by a PLD method)

Film formation was performed using a PLD film formation apparatus as illustrated in FIG. 7. In FIG. 7, reference numeral 701 denotes an RP (rotary pump), reference numeral 702 denotes a TMP (turbo molecular pump), reference numeral 703 denotes a preparation room, reference numeral 704 denotes an electron gun for RHEED, reference numeral 705 denotes a substrate holding means for rotating and moving upward and downward a substrate, reference numeral 706 denotes a laser incident window, reference numeral 707 denotes a substrate, reference numeral 708 denotes a target, reference numeral 709 denotes a radical source, reference numeral 710 denotes a gas inlet port, reference numeral 711 denotes a target holding means for rotating and

moving upward and downward a target, reference numeral 712 denotes a bypass line, reference numeral 713 denotes a main line, reference numeral 714 denotes a TMP (turbo molecular pump), reference numeral 715 denotes an RP (rotary pump), reference numeral 716 denotes a titanium getter pump, and reference numeral 717 denotes a shutter. In addition, In FIG. 7, reference numeral 718 denotes an IG (ion vacuum gauge), reference numeral 719 denotes a PG (Pirani vacuum gauge), reference numeral 721 denotes a growth chamber (chamber).

[0045]

<u>An In-Ga-Zn-O based amorphous oxide semiconductor thin film was deposited</u> on a SiO<sub>2</sub> glass substrate (1737, manufactured by Corning Incorporated) by the pulsed laser deposition method using a KrF excimer laser. As the deposition preprocessing, the substrate was subjected to ultrasound degreasing cleaning using acetone, ethanol, and ultrapure water, each for five minutes, and then was dried in the air at 100°C. [0046]

As the polycrystalline target, an  $InGaO_3(ZnO)_4$  sintered body (with a diameter of 20 mm and a thickness of 5 mm) was used. This target was obtained in such a manner that  $In_2O_3$ ,  $Ga_2O_3$ , and ZnO (each 4N reagent) were wet-mixed as the starting material, and then subjected to (ethanol as solvent), calcination (1000°C for 2h), dry grinding, and sintering (1550°C for 2h). The electrical conductivity of the thus fabricated target was 90 (S/cm).

[0047]

The film formation was performed by controlling that the ultimate vacuum within the growth chamber was  $2x10^{-6}$  (Pa) and the oxygen partial pressure was 6.5 (Pa) during growth. Note that the oxygen partial pressure within the chamber 721 was 6.5 Pa and the substrate temperature was 25°C. Note also that the distance between the target 708 and the substrate 707 to be subjected film formation was 30 (mm), the power of the KrF excimer laser incident from the incident window 716 was in a range of 1.5 to  $3 \text{ (mJ/cm}^2/\text{pulse)}$ . Note also that the pulse width was 20 (nsec), the pulse rate was 10 (Hz), and the irradiation spot diameter was 1x1 (mm square). Thus, film formation was performed at a film-forming rate of 7 (nm/min).

X-ray diffraction was conducted on the obtained thin film by irradiation with X-rays at an incident angle substantially parallel to the surface of the thin film (thin film method, at an incident angle of 0.5 degrees), and clear diffraction peak was not observed. Accordingly, the fabricated In-Ga-Zn-O based thin film can be said to be <u>amorphous</u>. Furthermore, X-ray reflectance measurement was performed and pattern analysis was performed. As a result, it was found that the mean-square roughness (Rrms) of the thin film was approximately 0.5 nm, and the film thickness thereof was approximately 120 nm. As a result of X-ray fluorescence (XRF) analysis, it was found that the metal composition ratio of the thin film was In:Ga:Zn = 0.98:1.02:4; and the electrical conductivity thereof was approximately less than  $10^{-2}$ S/cm. It is estimated that the electron carrier concentration thereof was approximately  $10^{16}$ /cm<sup>3</sup> or less, and the electron mobility thereof was approximately 5 cm<sup>2</sup>/(V.second). [0049]

From the optical absorption spectrum analysis, the forbidden band energy width of the fabricated amorphous thin film was determined to be approximately 3 eV. From the above, it was found that the fabricated In-Ga-Zn-O based thin film exhibited an amorphous phase close to the composition of  $InGaO_3(ZnO)_4$  as a crystal and was a transparent and flat thin film with a small oxygen deficiency and a small electrical conductivity.

[0050]

Specific description will be made with reference to FIG. 1. The figure shows change in electron carrier concentration of the oxide film formed by changing the oxygen partial pressure when a transparent amorphous oxide thin film which is composed of In-Ga-Zn-O and whose composition assumed in the crystalline state is expressed by a formula  $InGaO_3(ZnO)_m$  (where m is a value of less than 6) was formed under the same conditions as those of this example. [0051]

Film formation was performed in an atmosphere with a high oxygen partial pressure of more than 4.5 Pa under the same conditions as those of this example. As a result, as illustrated in FIG. 1, the electron carrier concentration was able to be reduced to less than  $10^{18}$ /cm<sup>3</sup>. In this case, the temperature of the substrate was maintained at substantially room temperature in a state where the temperature was not intentionally increased. Note that in order to use a flexible plastic film as the substrate, the substrate temperature is preferably kept at a temperature of less than  $100^{\circ}$ C. [0052]

<u>A further increase in oxygen partial pressure can further reduce the electron</u> <u>carrier concentration.</u> For example, <u>as illustrated in FIG. 1, the InGaO<sub>3</sub>(ZnO)<sub>4</sub> thin</u> <u>film formed at a substrate temperature of 25°C and an oxygen partial pressure of 5 Pa</u> was able to further reduce the electron carrier concentration to  $10^{16}$ /cm<sup>3</sup>."

## (Subject patent-u) "[0063]

### (Example 3: forming an In-Zn-Ga-O based amorphous oxide film by an SP method)

The film formation by a radio-frequency SP method using argon gas as the atmosphere gas will be described. The SP method was performed using an apparatus illustrated in FIG. 8. In FIG. 8, reference numeral 807 denotes a substrate to be subjected to film formation, reference numeral 808 denotes a target, reference numeral 805 denotes a substrate holding means having a cooling mechanism, reference numeral 814 denotes a turbo molecular pump, reference numeral 815 denotes a rotary pump, reference numeral 817 denotes a shutter, reference numeral 818 denotes an ion vacuum gauge, reference numeral 819 denotes a Pirani vacuum gauge, reference numeral 819 denotes a pirani vacuum gauge, reference numeral 819 denotes a by Corning Incorporated) was prepared as the substrate 807 to be subjected to film formation. As the film formation preprocessing, the substrate was subjected to ultrasound degreasing cleaning using acetone, ethanol, and ultrapure water, each for five minutes, and then was dried in the air at 100°C.

#### [0064]

As the target material, a polycrystalline sintered body (with a diameter of 20 mm and a thickness of 5 mm) having a composition of  $InGaO_3(ZnO)_4$  was used. This sintered body was fabricated in such a manner that  $In_2O_3$ ,  $Ga_2O_3$ , and ZnO (each 4N reagent) were wet-mixed as the starting material, and then subjected to (ethanol as solvent), calcination (1000°C for 2h), dry grinding, and sintering (1550°C for 2h). The electrical conductivity of the target 808 was 90 (S/cm) and was in a semi-insulating state.

## [0065]

The ultimate vacuum within the growth chamber 821 was  $1 \times 10^{-4}$  (Pa), and the total pressure of oxygen gas and argon gas during growth was constant in a range of 4 to  $0.1 \times 10^{-1}$  (Pa). Under the above conditions, the oxygen partial pressure was changed in a range of  $10^{-3}$  to  $2 \times 10^{-1}$  (Pa) by changing the partial pressure ratio between argon gas and oxygen. Note that the substrate temperature was room temperature, and the distance between the target 808 and the substrate 807 to be subjected film formation was 30 (mm). The applied power was RF 180 W, and the film formation rate was 10 (nm/min).

# [0066]

X-ray diffraction was conducted on the obtained thin film by irradiation with X-rays at an incident angle substantially parallel to the surface of the thin film (thin film

method, at an incident angle of 0.5 degrees), and clear diffraction peak was not detected. Accordingly, it was found that the fabricated In-Zn-Ga-O based film was an amorphous film. Furthermore, X-ray reflectance measurement was performed and pattern analysis was performed. As a result, it was found that the mean-square roughness (Rrms) of the thin film was approximately 0.5 nm, and the film thickness thereof was approximately 120 nm. As a result of X-ray fluorescence (XRF) analysis, it was found that the metal composition ratio of the thin film was In:Ga:Zn = 0.98:1.02:4. [0067]

The electrical conductivity of the amorphous oxide film obtained by changing the oxygen partial pressure in the atmosphere at film formation was measured. The results are illustrated in FIG. 3. As illustrated in FIG. 3, the electrical conductivity was reduced to less than  $10^{-2}$  S/cm by forming the film in an atmosphere with a high oxygen partial pressure of more than  $4 \times 10^{-2}$  Pa. [0068]

A further increase in oxygen partial pressure further reduced the electron carrier concentration. For example, as illustrated in FIG. 3, the  $InGaO_3(ZnO)_4$  thin film formed at a substrate temperature of 25°C and an oxygen partial pressure of  $10^{-1}$  Pa further reduced the electron carrier concentration to  $10^{-10}$  S/cm. Note that the electrical resistance of the  $InGaO_3(ZnO)_4$  thin film formed at an oxygen partial pressure of more than  $10^{-1}$  Pa was too high and the electrical conductivity was not able to be measured. In this case, the electron mobility was not able to be measured, but it was estimated by an extrapolation from a value of a film with a large electron carrier concentration that the electron mobility was approximately 1 cm<sup>2</sup>/V.second."

(2) Judging from the above, the description of the excerpt (Subject patent-t) and the excerpt (Subject patent-u) above including the structure of the film formation apparatus, the preprocessing of the materials, and the film formation conditions is detailed and specific; and the guiding principle such that an increase in oxygen partial pressure can reduce the electron carrier concentration is understandable. Therefore, it can be recognized that the patent description is clear and sufficient enough to enable a person ordinarily skilled in the art to carry out the patent invention 1.

(3) The demandant of the trial argues that the oxygen partial pressure in the patent invention 1 is overlapped with the oxygen partial pressure in Evidence A No. 4; despite the above, "semi-insulating" is obtained in the patent invention 1, while "conductivity" is obtained in the patent document 2 (Evidence A No. 4); both descriptions have an

extremely serious discrepancy or inconsistency; if a person ordinarily skilled in the art had come across to read both descriptions, the person ordinarily skilled in the art would have required to perform trials and errors or complicated advanced experiments beyond the reasonable extent that can be expected therefrom in order to obtain the "semi-insulating" amorphous oxide thin film with "an electron carrier concentration of  $10^{16}/\text{cm}^3$  or less" of the patent invention 1.

However, the range of the oxygen partial pressure and the substrate temperature specified by the patent invention 1 is sufficiently smaller than the range of the oxygen partial pressure and the substrate temperature described in Evidence A No. 4. In addition, in terms of the composition of the film to be formed, Evidence A No. 4 is "an oxide expressed by a general formula  $Zn_xM_yIn_zO_{(x+3y/2+3z/2)}$  (where M is at least one element of aluminum and gallium, a ratio x/y is in a range of 0.2 to 12, and a ratio z/y is in a range of 0.4 to 1.4)," which means that the range of x, y, and z is broadly defined, while the patent invention 1 is "an oxide thin film with a crystallized composition thereof expressed by a formula InGaO<sub>3</sub>(ZnO)<sub>m</sub> (m is a natural number of less than 6)," which means that the range of values corresponding to M, x, y, and z above is more narrowly defined such that M corresponds to "gallium," x corresponds to "a natural number of less than 6," and y and z correspond to "1." In light of this, it can be understood that the patent invention 1 is an invention made by finding that a semi-insulating film could be obtained by selecting a specific narrow range of conditions from a wide range of conditions under which a conductive film was assumed to be obtained in prior art. In addition, the description of the structure of the film formation apparatus, the material composition, the preprocessing, the film formation conditions, and the like is detailed and specific; and the guiding principle such that an increase in oxygen partial pressure can reduce the electron carrier concentration is understandable. Therefore, it can be said that the patent description including the description of the excerpt (Subject patent-t) and the excerpt (Subject patent-u) above is clear and sufficient enough to enable a person ordinarily skilled in the art to carry out the patent invention 1.

As described above, it could not be said that there is an extremely serious discrepancy or inconsistency between the patent invention 1 and the patent document 2 (Evidence A No. 4), and hence the argument of the demandant of the trial that the person ordinarily skilled in the art would have required to perform trials and errors or complicated advanced experiments beyond the reasonable extent that can be expected therefrom in order to obtain the "semi-insulating" amorphous oxide thin film with "an

electron carrier concentration of  $10^{16}$ /cm<sup>3</sup> or less" of the patent invention 1 cannot be accepted.

4 Patent inventions 3 to 5

Patent inventions 3 to 5 are as recognized in "No. 2 The Invention."

5 Specific reasons for the reason for invalidation 5 against the patent inventions 3 to 5

According to the description in the written demand for trial, it is recognized that the specific reasons for the reason for invalidation 5 against the patent inventions 3 to 5 are summarized as follows.

The patent invention 3 to the patent invention 5 cite claim 1, and for the same reason as in the patent invention 1, the patent description is not clear and sufficient enough to enable a person ordinarily skilled in the art to carry out the patent invention 3 to the patent invention 5.

Furthermore, a person ordinarily skilled in the art could not carry out the patent invention 4 for the following reason including the above reason.

More specifically, <Regarding the electron carrier concentration> of (1-1-5) describes to the effect that the electron carrier concentration of the patent invention 1 cited by the patent invention 4 is " $10^{16}$ /cm<sup>3</sup> or less" which can be construed to be " $10^{16}$ /cm<sup>3</sup> order or less." If it is assumed to be " $1x10^{16}$ /cm<sup>3</sup> or less," the following discrepancy or inconsistency would occur between the patent description and the patent invention 4.

The patent description describes that "A further increase in oxygen partial pressure can further reduce the electron carrier concentration. For example, as illustrated in FIG. 1, the InGaO<sub>3</sub>(ZnO)<sub>4</sub> thin film formed at a substrate temperature of 25°C and an oxygen partial pressure of 5 Pa was able to further reduce the electron carrier concentration to  $10^{16}$ /cm<sup>3</sup>." ([0052]) If it is assumed to be "<u>1x</u>10<sup>16</sup>/cm<sup>3</sup> or less," it is clear that <u>1x</u>10<sup>16</sup>/cm<sup>3</sup> or less is not obtained at 5 Pa with reference to FIG. 1.

As described above, " $10^{16}$ /cm<sup>3</sup> or less" in the patent invention 1 cited by the patent invention 4 is assumed to be " $1x10^{16}$ /cm<sup>3</sup> or less," discrepancy or inconsistency occurs between the patent description and the patent invention 4. Therefore, the patent

description is not clear and sufficient enough to enable a person ordinarily skilled in the art to carry out the invention 4.

Thus, the detailed description of the invention of the patent description does not meet the requirements provided in Article 36(4)(i) of the Patent Act.

Accordingly, the invention according to claims 3, 4, and 5 of the patent falls under the provisions in Article 123(1)(iv) of the Patent Act and should be invalidated.

6 Judgment by the body regarding the patent inventions 3 to 5

(1) As examined in "3 Judgment by the body" above, it can be said that the patent invention 3 to the patent invention 5 cite claim 1, and the patent description is clear and sufficient enough to enable a person ordinarily skilled in the art to carry out the patent invention 1.

In addition, it can be recognized that the matters specifying the invention of the patent invention 3 to the patent invention 5 which additionally limit the patent invention 1 are a well-known configuration.

Therefore, the patent invention 3 to the patent invention 5 cite claim 1, and furthermore, it can be recognized that the matters specifying the invention of the patent invention 3 to the patent invention 5 which additionally limit the patent invention 1 are a well-known configuration, and thus for the same reason as in the patent invention 1, it cannot be said that the patent description is not clear and sufficient enough to enable a person ordinarily skilled in the art to carry out the patent invention 3 to the patent invention 5.

(2) In addition, the demandant of the trial argues to the effect that if the electron carrier concentration of " $10^{16}$ /cm<sup>3</sup> or less" is assumed to be " $1 \times 10^{16}$ /cm<sup>3</sup> or less," the patent description is not clear and sufficient enough to enable a person ordinarily skilled in the art to carry out the patent invention 4.

More specifically, the demandant of the trial argues that " $10^{16}$ /cm<sup>3</sup> or less" can be construed to indicate not " $1x10^{16}$ /cm<sup>3</sup> or less" but " $10^{16}$ /cm<sup>3</sup> order or less" because it is understood that the electron carrier concentration is not  $10^{16}$ /cm<sup>3</sup> or less but in between  $10^{16}$ /cm<sup>3</sup> and  $10^{17}$ /cm<sup>3</sup> at an oxygen partial pressure of 5 Pa with reference to FIG. 1 attached to the patent application on page 16 to 17 of the written demand for trial.

However, it is recognized as natural that, considering the significant digits in data, a person ordinarily skilled in the art who had read both the patent description and

FIG. 1 would have recognized that data represented by the rightmost circle in FIG. 1 attached to the patent application, which was located slightly right hand side from the scale indicating 6 Pa, represented the data "As illustrated in FIG. 1, --- formed at 6 Pa, --- was able to be reduced to less than  $8 \times 10^{15}$ /cm<sup>3</sup>" in [0060] of the patent description, and data represented by a circle second from the right and located slightly right hand side from the scale indicating 5 Pa and slightly upward from the scale indicating  $10^{16}$ /cm<sup>3</sup>, represented the data "when the oxygen partial pressure was 5 Pa, - - was  $10^{16}$ /cm<sup>3</sup> - - " in [0059] of the patent description.

In addition, it is recognized that " $1x10^{16}$ /cm<sup>3</sup>" is often notated as " $10^{16}$ /cm<sup>3</sup>" by omitting "1x" therefrom. Against this, the demandant of the trial argues that by deliberately construing that from the description of the patent description, data represented by a circle third from the right in FIG. 1 attached to the patent application, which was located slightly left hand side from the scale indicating 5 Pa and slightly upward from the scale indicating  $10^{17}$ /cm<sup>3</sup>, represented the data "when the oxygen partial pressure was 5 Pa, - - was  $10^{16}$ /cm<sup>3</sup> - - " in [0059] of the patent description, the data should be interpreted to indicate that the data is not " $1x10^{16}$ /cm<sup>3</sup>" and hence the notation of " $10^{16}$ /cm<sup>3</sup>" in the patent description represents " $10^{16}$ /cm<sup>3</sup> order." However, it cannot be said that such an interpretation is reasonable since the above described natural interpretation is viable.

(3) Furthermore, as argued by the demandant of the trial, if it is recognized that the notation of " $10^{16}$ /cm<sup>3</sup>" and the like in the patent description represents not " $1x10^{16}$ /cm<sup>3</sup>" but " $10^{16}$ /cm<sup>3</sup> order," "less than  $10^{18}$ /cm<sup>3</sup>" in the description "The results are illustrated in FIG. 1. The electron carrier concentration was able to be reduced to less than  $10^{18}$ /cm<sup>3</sup> by forming the film in an atmosphere at an oxygen partial pressure of more than 4.5 Pa" in [0058] of the patent description should be construed to indicate not "less than  $1x10^{18}$ /cm<sup>3</sup>" but "less than  $10^{18}$ /cm<sup>3</sup> order." However, in this case it is difficult to understand what numerical range the "less than --- order" represents.

Furthermore, if the description "the oxygen partial pressure was changed in a range of  $10^{-3}$  to  $2x10^{-1}$  (Pa)" in [0065] of the patent description is construed that "the oxygen partial pressure was changed in a range of  $10^{-3}$  order to  $2x10^{-1}$  (Pa)," it can be said to be unnatural that one of the numerical range is determined by an order and the other is determined by a specific value.

Accordingly, it can be recognized that the notation of " $10^{16}$ /cm<sup>3</sup>" and the like in the patent description should be construed that "1x" is omitted from " $1x10^{16}$ /cm<sup>3</sup>."

(4) In addition, the demandant of the trial argues to the effect that if " $10^{16}$ /cm<sup>3</sup> or less" is regarded as " $1 \times 10^{16}$ /cm<sup>3</sup> or less" in the patent invention 1 cited by the patent invention 4, discrepancy or inconsistency would occur between the patent description and the patent invention 4, and the patent description is not clear and sufficient enough to enable a person ordinarily skilled in the art to carry out the patent invention 4. However, as examined above, it is recognized as natural that, considering the significant digits in data, a person ordinarily skilled in the art who had read both the patent description and FIG. 1 would have recognized that data represented by a circle second from the right in FIG. 1 attached to the patent application, which was located slightly right hand side from the scale indicating 5 Pa, and slightly upward from the scale indicating  $10^{16}/\text{cm}^3$ , represented the data described in "when the oxygen partial pressure was 5 Pa, - - - was  $10^{16}$ /cm<sup>3</sup> - - -" [0059] of the patent description, and it is also recognized that data represents a value of approximately  $10^{16}$ /cm<sup>3</sup>. Therefore, it is recognized that the patent description discloses the description "A further increase in oxygen partial pressure can further reduce the electron carrier concentration. For example, as illustrated in FIG. 1, the InGaO<sub>3</sub>(ZnO)<sub>4</sub> thin film formed at a substrate temperature of 25°C and an oxygen partial pressure of 5 Pa was able to further reduce the electron carrier concentration to  $10^{16}$ /cm<sup>3</sup>." ([0052]) together with FIG. 1 having a disclosureconsistent with the description.

In short, there is no discrepancy or inconsistency between the patent description and the patent invention 4, and hence it cannot be said that the patent description is not clear and sufficient enough to enable a person ordinarily skilled in the art to carry out the patent invention 4.

### 7 Summary of the reason for invalidation 5

As described above, it cannot be said that the detailed description of the invention of the patent description does not meet the requirements provided in Article 36(4)(i) of the Patent Act.

Therefore, the reason for invalidation 5 against the patent inventions 1, 3, 4, and 5 is groundless.

## No. 10 Concluding Remarks

As described above, the patent regarding the invention according to claims 1 to 5 of the patent No. 4568827 does not violate the provisions of Article 29(2) of the Patent Act and hence does not falls under Article 123(1)(ii) of the Patent Act.

In addition, the patent regarding the invention according to claims 1, 3, 4, and 5 of the patent is not issued to the patent application that does not meet the requirements provided in Article 36(4)(i) of the Patent Act and hence does not fall under the provisions in Article 123(1)(iv) of the Patent Act.

Therefore, the demand for trial of the case regarding the invention according to claims 1 to 5 of the patent was groundless.

The costs in connection with the trial shall be borne by the demandant under the provisions of Article 61 of the Code of Civil Procedure which is applied mutatis mutandis in the provisions of Article 169(2) of the Patent Act.

Therefore, the trial decision shall be made as described in the conclusion.

July 28, 2015

Chief administrative judge:SUZUKI, TadaakiAdministrative judge:KATO, KoichiAdministrative judge:IIDA, Seiji