

DESCRIPTION

TITLE OF INVENTION: GLASS FOR SUBSTRATE, AND GLASS SUBSTRATE

TECHNICAL FIELD

5 The present invention relates to an information recording medium such as a magnetic disk (hard disk), a glass substrate to be used for such an information recording medium, and glass to be used for such a substrate.

BACKGROUND ART

10 In recent years, along with an increase in the recording capacity of a hard disk drive, densification for a high recording density has been in progress at a high pace. However, along with the densification for a high recording density, microfabrication of magnetic particles is likely to impair thermal stability, thus leading to a problem of cross talk or a decrease in the S/N ratio of a playback signal. Under the circumstance, 15 attention has been drawn to a thermal assist magnetic recording technique as a combined technique of optics and magnetism. This is a technique wherein a magnetic recording layer is irradiated with a laser beam or near field light to lower the coercive force locally at the heated portion, and in such a state, an external magnetic field is applied for recording, and the recorded magnetization is retrieved by e.g. GMR 20 element, whereby recording can be made on a high coercive force medium, and it becomes possible to microfabricate magnetic particles while maintaining the thermal stability. However, in order to form a high coercive force medium in the form of a multi-layered film, it is required to sufficiently heat the substrate, and a highly heat resistant substrate is desired.

25 Further, also for a perpendicular magnetic recording system, a magnetic recording layer different from a conventional one has been proposed in order to meet the requirement for densification for a high recording density, but for the formation of such a magnetic recording layer, the substrate is required to be heated at a high temperature, in many cases.

30 Whereas, a silicon substrate has been proposed as a substrate which is useful for the above mentioned thermal assist magnetic recording technique (Patent Document 1).

A silicon substrate is usually weak in strength as compared with a glass substrate. Accordingly, also in the production of a magnetic disk to form a magnetic recording layer by heating the substrate at a high temperature, it is preferred to use a glass substrate.

5 As a substrate for an information recording medium, particularly as a substrate for a magnetic disk, a glass substrate is widely used. For example, lithium-containing aluminosilicate glass having a high Young's modulus or one having chemical tempering treatment applied thereto (Patent Document 2), or crystallized glass having a crystal phase precipitated by heat-treating glass having a specific composition (Patent
10 Document 3) is used.

PRIOR ART DOCUMENTS

PATENT DOCUMENTS

Patent Document 1: JP-A-2009-199633

15 Patent Document 2: JP-A-2001-180969

Patent Document 3: JP-A-2000-119042

DISCLOSURE OF INVENTION

TECHNICAL PROBLEM

20 Substrate glass for chemical tempering treatment has its heat resistance adjusted to be low so that chemical tempering treatment can efficiently be applied thereto, and accordingly, it is likely to collapse by the heat at the time of forming the above-mentioned high coercive force medium in the form of a multi-layered film. Further, if a chemically tempered glass substrate is subjected to the above heating, the
25 ion exchange-treated layer is likely to undergo diffusion by such heating, whereby the strength may deteriorate. Further, if it is attempted to use a crystallized glass substrate, the substrate surface is likely to get warped by the above heating due to the difference in the thermal expansion coefficient between the crystal phase and the bulk body.

30 If the rotational speed of a recording medium is increased, deflection is likely to form in the recording medium, and the resonance becomes large, whereby the surface of the recording medium is likely to collide with a magnetic head, thus leading to an

error in reading or a danger of crushing of a magnetic head. Therefore, with a current recording medium, it is not possible to reduce the distance (flying height) between a magnetic head and a recording medium more than a certain level, which tends to be a factor to hinder an increase of a recording density of a magnetic recording layer.

- 5 Such a problem of the deflection and resonance of a recording medium can be solved by using a substrate material having a high elastic modulus.

In a case where glass is used as a substrate for a magnetic disk, many processing treatments are required including circular processing, coring, inner and outer circumference processing, etc. During such processing treatments, many scratches which can be starting points for fracture are likely to be formed at e.g. glass edges, and slight scratch marks formed not only in the production steps but also during mounting on a spindle or during other handlings, are likely to cause fracture of a substrate. This problem becomes more serious especially along with an increase in rotational speed of a magnetic disk. This problem may be solved by using glass for a substrate which is less susceptible to cracking.

It is an object of the present invention to provide scratch resistant glass for a substrate which has a high specific modulus and a high glass transition point, which is suitable to comprehensively meet such requirements.

20 SOLUTION TO PROBLEM

The present invention provides glass for a substrate, which comprises, as represented by mol% based on the following oxides, from 66 to 77% of SiO_2 , from 7 to 17% of Al_2O_3 , from 0 to 7% of B_2O_3 , from 0 to 9% of Li_2O , from 0 to 8% of Na_2O , from 0 to 3% of K_2O , from 0 to 13% of MgO , from 0 to 6% of CaO , from 0 to 5% of TiO_2 and from 0 to 5% of ZrO_2 , wherein the total of contents of SiO_2 , Al_2O_3 and B_2O_3 i.e. $\text{SiO}_2 + \text{Al}_2\text{O}_3 + \text{B}_2\text{O}_3$ is from 81 to 92%, the total of contents of Li_2O , Na_2O and K_2O i.e. $\text{Li}_2\text{O} + \text{Na}_2\text{O} + \text{K}_2\text{O}$ is from 3 to 9%, the total of contents of MgO and CaO i.e. $\text{MgO} + \text{CaO}$ is from 4 to 13%, the total of contents of Na_2O , K_2O and CaO i.e. $\text{Na}_2\text{O} + \text{K}_2\text{O} + \text{CaO}$ is from 0 to 10%, and the total of contents of TiO_2 and ZrO_2 i.e. $\text{TiO}_2 + \text{ZrO}_2$ is from 0 to 5% (hereinafter referred to as the glass of the present invention). Here, for example "from 0 to 7% of B_2O_3 " means that B_2O_3 is not essential but may be contained up to 7%.

Further, the present invention provides the above glass for a substrate, wherein

the ratio of the B_2O_3 content to the Al_2O_3 content i.e. B_2O_3/Al_2O_3 is at most 0.6.

Further, the present invention provides the above glass for a substrate, wherein the ratio of Na_2O+K_2O+CaO to $SiO_2+Al_2O_3+B_2O_3$ i.e.

$(Na_2O+K_2O+CaO)/(SiO_2+Al_2O_3+B_2O_3)$ is at most 0.125.

5 Further, the present invention provides the above glass for a substrate, wherein SiO_2 is at most 74%, Al_2O_3 is at least 8%, Li_2O is less than 2%, MgO is at most 11%, TiO_2 is at most 3%, ZrO_2 is at most 3%, $Li_2O+Na_2O+K_2O$ is at least 3.5%, $MgO+CaO$ is from 5 to 12.5%, TiO_2+ZrO_2 is at most 3.5%, and $(MgO+CaO)/(SiO_2+Al_2O_3+B_2O_3)$ is at most 0.15.

10 Further, the present invention provides the above glass for a substrate, which contains Li_2O or Na_2O .

Further, the present invention provides the above glass for a substrate, wherein B_2O_3 is at most 3%, Li_2O is at least 2%, Na_2O is at most 4%, and $Li_2O+Na_2O+K_2O$ is at least 3.5%.

15 Further, the present invention provides the above glass for a substrate, wherein $(MgO+CaO)/(SiO_2+Al_2O_3+B_2O_3)$ is from 0.04 to 0.16.

Further, the present invention provides the above glass for a substrate, wherein the total of contents of the above 10 components is at least 98%.

20 Further, the present invention provides a glass substrate made of the above glass for a substrate.

Further, the present invention provides the above glass substrate, which is used as a substrate for an information recording medium.

Further, the present invention provides the above glass substrate, wherein the substrate for an information recording medium is a substrate for a magnetic disk.

25 Further, the present invention provides a chemically tempered glass substrate obtained by chemically tempering a glass plate made of the above glass for a substrate.

Further, the present invention provides the above chemically tempered glass substrate, which is used as a substrate for an information recording medium.

30 Further, the present invention provides the above chemically tempered glass substrate, wherein the substrate for an information recording medium is a substrate for a magnetic disk.

Further, the present invention provides a magnetic disk having a magnetic recording layer formed on the above glass substrate or on the above chemically tempered glass substrate.

5 ADVANTAGEOUS EFFECTS OF INVENTION

It is possible to obtain glass for a substrate having a high glass transition point, which may be used for e.g. an information recording medium. It is thereby possible to increase the heat treatment temperature to be carried out after forming a magnetic film on a substrate and to obtain an information recording medium having a high recording
10 density.

Further, it is possible to obtain glass for a substrate having a high specific modulus, which may be used for e.g. an information recording medium. It is thereby possible to prevent warpage or deflection during rotational driving and to obtain an information recording medium having a high recording density.

15 Further, it is possible to obtain scratch resistant glass for a substrate, which may be used for e.g. an information recording medium. It is thereby possible to prevent scratching in production steps, during mounting on a spindle or during other handlings, or to prevent cracking of a substrate.

Further, at the time of mounting a substrate, a spindle made of metal is fixed by a
20 member made of metal, and therefore, if the difference in thermal expansion coefficient is large between the substrate and such metal spindle or metal member, a stress may be formed at the time of a temperature change, whereby cracking of the substrate may occur. Usually, the thermal expansion coefficient of glass is small as compared with the thermal expansion coefficient of metal, and at the time of using glass as a
25 substrate, it is preferred to use glass for a substrate, which has a thermal expansion coefficient as large as possible thereby to increase matching of the thermal expansion with a metal spindle and other metal drive members.

According to the present invention, it is possible to obtain glass for a substrate having a large average linear expansion coefficient, which may be used for e.g. an
30 information recording medium. It is thereby possible that the thermal expansion matching with other metal drive members becomes high, and the stress formed at the time of a temperature change becomes small, whereby e.g. cracking of the substrate

will be less likely to occur.

DESCRIPTION OF EMBODIMENTS

Now, the glass of the present invention will be described with reference to a case
 5 where it is used as a substrate for a magnetic disk, but it should be understood that the present invention is by no means limited thereto.

The glass of the present invention preferably has a specific modulus E/d of at least 32 MNm/kg. If E/d is less than 32 MNm/kg, warpage or deflection is likely to occur during rotational driving, whereby it tends to be difficult to obtain an information
 10 recoding medium having a high recording density. Typically, E/d is at most 40 MNm/kg. Here, E is a Young's modulus (unit: GPa), and d is a density (unit: g/cm^3).

The glass of the present invention preferably has a glass transition point T_g of at least 690°C. If it is less than 690°C, the substrate tends to be deformed by a heat, and it becomes difficult to sufficiently increase the thermal treatment temperature for
 15 forming a magnetic layer, whereby it tends to be difficult to increase the coercive force of the magnetic layer. It is more preferably at least 700°C.

The average linear expansion coefficient α of the glass of the present invention at from -50 to 70°C is typically from $20 \times 10^{-7}/^\circ\text{C}$ to $45 \times 10^{-7}/^\circ\text{C}$. For example, in a case where it is desired to reduce the difference in the thermal expansion coefficient from
 20 another member such as a metal drive thereby to prevent cracking of the substrate due to formation of a stress at the time of a temperature change, α is preferably at least $32 \times 10^{-7}/^\circ\text{C}$, more preferably at least $34 \times 10^{-7}/^\circ\text{C}$.

The cracking probability P of the glass of the present invention is preferably less than 80%. If it is 80% or higher, scratching is likely to occur in production steps, or
 25 during mounting on a spindle or during other handlings, whereby cracking of the substrate is likely to occur. It is more preferably at most 70%.

Now, the composition of the glass of the present invention will be described, as represented by mol%.

SiO_2 is a component to form the skeleton of the glass and is essential. If it is
 30 less than 66%, the acid resistance will decrease, d will increase, the glass tends to be susceptible to scratching, T_g will decrease, or the liquid phase temperature will increase, whereby the glass becomes unstable. It is preferably at least 67%, more

preferably at least 68%. If it exceeds 77%, the temperature T_2 at which the viscosity becomes 10^2 dPa·s and the temperature T_4 at which the viscosity becomes 10^4 dPa·s will increase, whereby melting and forming of the glass tend to be difficult, E or E/d will decrease, or α becomes small. It is preferably at most 74%, more preferably at most 72%, particularly preferably at most 70%.

Al_2O_3 has an effect to increase the weather resistance and is essential. If it is less than 7%, such an effect will be small, or E or E/d or T_g will decrease. It is preferably at least 8%, more preferably at least 10%. If it exceeds 17%, the above-mentioned T_2 and T_4 will increase, whereby melting and forming of the glass tend to be difficult, the acid resistance will decrease, α becomes small, or the liquid phase temperature tends to be too high. It is preferably at most 16%, more preferably at most 15%, further preferably at most 14%.

B_2O_3 is not essential but may be contained up to 7%, since it has an effect to make the glass scratch-resistant or to improve the melting property of the glass. If it exceeds 7%, E or E/d or T_g will decrease, or it becomes very volatile in coexistence with an alkali metal oxide component. It is preferably at most 6.5%. In a case where it is desired to increase T_g or to suppress the volatility, B_2O_3 is preferably at most 4%, more preferably at most 2%, and more preferably, B_2O_3 is not contained.

If the total of contents of SiO_2 , Al_2O_3 and B_2O_3 i.e. $SiO_2 + Al_2O_3 + B_2O_3$ is less than 81%, the glass tends to be susceptible to scratching. If it exceeds 92%, the above T_2 and T_4 will increase, or melting or molding of the glass tends to be difficult. It is preferably at most 90%, more preferably at most 88%. In a case where it is desired to increase the melting property or moldability of the glass, the above total is preferably at most 86%.

The ratio of the B_2O_3 content to the Al_2O_3 content i.e. B_2O_3/Al_2O_3 is preferably at most 0.6. If it exceeds 0.6, E or E/d may decrease. It is more preferably at most 0.5, further preferably at most 0.4, particularly preferably at most 0.3, most preferably at most 0.2.

Li_2O is not essential but may be contained up to 9%, since it increases E, E/d or α , or to improve the melting property of the glass. If it exceeds 9%, the acid resistance or weather resistance will decrease, T_g will be low, or the glass tends to be susceptible to scratching. It is preferably at most 7%. In a case where it is desired

to increase E or E/d, Li_2O is preferably at most 3%, more preferably less than 2%, further preferably at most 1%, and particularly preferably, Li_2O is not contained.

Na_2O is not essential but may be contained up to 8%, since it has an effect to increase α or to improve the melting property of the glass. If it exceeds 8%, the acid resistance or weather resistance will decrease, T_g will be low, or the glass tends to be susceptible to scratching. It is preferably at most 7.5%. Further, when Na_2O is contained, its content is preferably at least 1%. In a case where it is desired to increase α , Na_2O is preferably at least 3%, more preferably at least 4%, further preferably at least 5%, particularly preferably at least 6%.

K_2O is not essential but may be contained up to 3%, since it has an effect to increase α or to improve the melting property of the glass. If it exceeds 3%, the acid resistance or weather resistance will decrease, T_g tends to be low, or the glass tends to be susceptible to scratching. It is preferably at most 2%, more preferably at most 1%, and further preferably, K_2O is not contained.

If the total R_2O of contents of Li_2O , Na_2O and K_2O is less than 3%, α becomes small, or the melting property of the glass decreases. It is preferably at least 3.5%, more preferably at least 4%, further preferably at least 4.5%, particularly preferably at least 5%. If R_2O exceeds 9%, the acid resistance or weather resistance will decrease, T_g tends to be low, or the glass tends to be susceptible to scratching. It is preferably at most 8.5%, more preferably at most 8%, further preferably at most 7.5%.

MgO is not essential but may be contained up to 13%, since it will increase E, E/d or α , or will improve the melting property of the glass. If it exceeds 13%, T_g tends to be low, the glass tends to be susceptible to scratching, or the liquid phase temperature tends to be too high. It is preferably at most 12%, more preferably at most 11%, further preferably at most 10.5%, particularly preferably at most 10%. When MgO is contained, its content is preferably at least 4%. In a case where it is desired to increase E or E/d, MgO is preferably at least 5%, more preferably at least 6%, further preferably at least 7%, particularly preferably at least 8%.

CaO is not essential but may be contained up to 6% since it increases α or improves the melting property of the glass. If it exceeds 6%, T_g tends to be low, the glass tends to be susceptible to scratching, or the liquid phase temperature tends to be too high. It is preferably at most 5%, more preferably at most 3%, further preferably

at most 2%, particularly preferably at most 1%.

If the total of contents of MgO and CaO i.e. $\text{MgO} + \text{CaO}$ is less than 4%, α becomes small, or the melting property of the glass will decrease. It is preferably at least 5%, more preferably at least 6%, further preferably at least 7%, particularly preferably at least 8%, most preferably at least 9%. If the above total exceeds 13%, the acid resistance or weather resistance will decrease, T_g tends to be low, or the glass tends to be susceptible to scratching. It is preferably at most 12.5, more preferably at most 12%, particularly preferably at most 11.5%, most preferably at most 11%.

The ratio of $\text{MgO} + \text{CaO}$ to $\text{SiO}_2 + \text{Al}_2\text{O}_3 + \text{B}_2\text{O}_3$ i.e. $(\text{MgO} + \text{CaO}) / (\text{SiO}_2 + \text{Al}_2\text{O}_3 + \text{B}_2\text{O}_3)$ is preferably at most 0.16. If it exceeds 0.16, the acid resistance or weather resistance will decrease, T_g becomes low, or the glass tends to be susceptible to scratching. It is more preferably at most 0.15, further preferably at most 0.14.

If the total of contents of Na_2O , K_2O and CaO i.e. $\text{Na}_2\text{O} + \text{K}_2\text{O} + \text{CaO}$ exceeds 10%, the acid resistance or weather resistance will decrease, T_g tends to be low, or the glass tends to be susceptible to scratching. It is preferably at most 9%. For example, in a case where it is desired to increase α , $\text{Na}_2\text{O} + \text{K}_2\text{O} + \text{CaO}$ is preferably at least 2%, more preferably at least 5%, further preferably at least 7%, particularly preferably at least 8%.

The ratio of $\text{Na}_2\text{O} + \text{K}_2\text{O} + \text{CaO}$ to $\text{SiO}_2 + \text{Al}_2\text{O}_3 + \text{B}_2\text{O}_3$ i.e. $(\text{Na}_2\text{O} + \text{K}_2\text{O} + \text{CaO}) / (\text{SiO}_2 + \text{Al}_2\text{O}_3 + \text{B}_2\text{O}_3)$ is preferably at least 0.125. If it exceeds 0.125, the acid resistance or weather resistance will decrease, T_g tends to be low, or the glass tends to be susceptible to scratching. It is more preferably at most 0.124, further preferably at most 0.123, particularly preferably at most 0.122, most preferably at most 0.121.

TiO_2 is not essential but may be contained up to 5%, since it has an effect to increase E or E/d while maintaining the weather resistance, to increase T_g , or to improve the melting property of the glass. If it exceeds 5%, d will increase, α becomes small, the glass tends to be susceptible to scratching, or a phase separation is likely to occur. It is more preferably at most 3%, further preferably at most 2%, particularly preferably at most 1%, and more preferably TiO_2 is not contained.

ZrO_2 is not essential but may be contained up to 5%, since it has an effect to

increase E or E/d while maintaining the weather resistance, to increase T_g, or to improve the melting property of the glass. If it exceeds 5%, d becomes large, α becomes small, the glass tends to be susceptible to scratching, and the liquid phase temperature is likely to be too high. It is more preferably at most 3%, further preferably at most 2%, particularly preferably at most 1%, and most preferably, ZrO₂ is not contained.

The total of contents of TiO₂ and ZrO₂ is 5% at the maximum and is typically at most 3.5%. If it exceeds 5%, d will increase, α becomes small, or the glass tends to be more susceptible to scratching. It is more preferably at most 3%, further preferably at most 2%, particularly preferably at most 1%, and most preferably, neither TiO₂ nor ZrO₂ may be contained.

The glass of the present invention consists essentially of the above components, but it may contain other components within a range not to impair the purpose of the present invention i.e. in a total within a range of less than 3%, preferably less than 2%, typically less than 1%.

SrO or BaO may increase d or may make the glass susceptible to scratching but may sometimes have an effect to increase α while maintaining the weather resistance or to improve the melting property of the glass. Their content in such a case is preferably at most 2% in total. The total is more preferably at most 1.5%, further preferably at most 1%, and typically SrO and BaO are not contained.

Further, clarifying agents such as SO₃, Cl, As₂O₃, Sb₂O₃, SnO₂, etc. may be contained up to 2% in total. Further, coloring agents such as Fe₂O₃, Co₃O₄, NiO, etc. may be contained up to 2% in total.

A glass substrate for an information recording medium made of the glass of the present invention is usually a circular glass plate.

The glass substrate for a magnetic disk is widely used for e.g. a 2.5 inch substrate (outer diameter of the glass substrate: 65 mm) to be used for e.g. a notebook personal computer, or for a 1.8 inch substrate (outer diameter of the glass substrate: 48 mm) to be used for e.g. a portable MP3 player, and its market is expanding every year. On the other hand, its supply at a low price is desired. Glass to be used for such a glass substrate is preferably one suitable for mass production.

Mass production of plate glass is widely carried out by a continuous-forming

method such as a float process, a fusion method or a downdraw method, and as mentioned above, the glass of the present invention is glass which can be formed by a float process, and thus, it is suitable for mass production.

The process for producing the glass and the glass substrate of the present invention is not particularly limited, and various processes may be used. For example, materials for the respective components commonly used are blended to have a desired composition, and such a mixture is heated and melted in a glass melting furnace. Then, the glass is homogenized by e.g. bubbling, stirring or addition of a clarifying agent, followed by forming into a plate glass having a predetermined thickness by a well-known method such as a float process, a press method, a fusion method or a downdraw method, and then, after annealing, processing such as grinding or polishing is carried out as the case requires, to obtain a glass plate having a prescribed size and shape. As the forming method, a float process suitable for mass production is particularly preferred. Otherwise, a continuous forming method other than the float process, i.e. a fusion method or a downdraw method is also suitable.

EXAMPLES

Materials of the respective components were blended to obtain compositions as shown by mol% in the rows for from SiO_2 to ZrO_2 in Examples 1 to 8 in Table 1 and in Examples 28 and 29 in Table 3 and melted at a temperature of from 1,550 to 1,600°C for from 3 to 5 hours using a platinum crucible to prepare glass. In the melting, a platinum stirrer was inserted in the molten glass, and the glass was stirred for 2 hours and homogenized. Then, the molten glass was cast to form a plate and annealed to room temperature at a cooling rate of 1°C/min, and then, processed into a glass plate having a desired thickness. In the Tables, Si+Al+B represents the total (unit: mol%) of contents of SiO_2 , Al_2O_3 and B_2O_3 , B/Al represents the ratio of the B_2O_3 content to the Al_2O_3 content, R_2O represents the total (unit: mol%) of contents of Li_2O , Na_2O and K_2O , Mg+Ca represents the total (unit: mol%) of contents of MgO and CaO , MgCa/SiAlB represents $(\text{MgO}+\text{CaO})/(\text{SiO}_2+\text{Al}_2\text{O}_3+\text{B}_2\text{O}_3)$, Na+K+Ca represents the total (unit: mol%) of contents of Na_2O , K_2O and CaO , NaKCa/SiAlB represents $(\text{Na}_2\text{O}+\text{K}_2\text{O}+\text{CaO})/(\text{SiO}_2+\text{Al}_2\text{O}_3+\text{B}_2\text{O}_3)$, and Ti+Zr represents the total (unit: mol%) of contents of TiO_2 and ZrO_2 .

With respect to each glass plate thus obtained, the density d (unit: g/cm^3), the above-mentioned average linear expansion coefficient α (unit: $\times 10^{-7}/^\circ\text{C}$), the Young's modulus E (unit: GPa), the specific modulus E/d (unit: MNm/kg), the glass transition point T_g (unit: $^\circ\text{C}$) and the cracking probability P (unit: %) were measured by the following methods. The results are shown in the Tables.

d : Measured by an Archimedes method using from 20 to 50 g of glass free from bubbles.

α : By means of a differential thermal dilatometer and using quartz glass as a reference sample, the rate of elongation of glass when it was heated at a rate of 5°C/min from room temperature to a temperature at which the glass was softened and elongation was no longer observed, i.e. to an yield point, was measured, and from the obtained thermal expansion curve, an average linear expansion coefficient within a range of -50 to 70°C was calculated.

E : With respect to a glass plate having a thickness of from 5 to 10 mm and a size of 3 cm square, the measurement was carried out by an ultrasonic pulse method.

T_g : By means of a differential thermal dilatometer and using quartz glass as a reference sample, the rate of elongation of glass when it was heated at a rate of 5°C/min from room temperature to its yield point, and the temperature corresponding to the critical point in the obtained thermal expansion curve was taken as the glass transition point.

P : Both surfaces of a glass plate having a thickness of from 1 to 2 mm and a size of $4\text{ cm} \times 4\text{ cm}$, were mirror-polished with colloidal silica, to obtain a sample, and by using such a sample, the cracking probability was measured. In an atmosphere of the dew point -28°C to -27°C , by adjusting the load of a Vickers hardness tester to be $2\text{ kgf} = 19.6\text{ N}$, 15 points Vickers indenters were driven in, whereupon the number of cracks formed at four corners of indentations was measured. The number of such cracks was divided by the possible number of cracks being 60 to obtain the cracking probability (unit: %). Here, the precision in measurement of P is about $\pm 10\%$.

Examples 1 to 27 in Tables 1 to 3 are working Examples of the present invention, and Examples 28 and 29 are Comparative Examples. From these results, it is evident that glasses in Examples have high specific modulus as compared with the glass in Example 28 and have high cracking resistance as compared with the glass in Example

29, while having high glass transition points.

TABLE 1

Ex.	1	2	3	4	5	6	7	8	9	10
SiO ₂	67.0	68.5	68.5	68.5	66.0	66.0	68.5	68.5	74.0	66.0
Al ₂ O ₃	12.0	13.0	15.0	15.0	11.2	14.2	13.0	15.0	13.0	17.0
B ₂ O ₃	4.0	0	2.0	2.0	6.1	6.1	0	0	0	5.0
Li ₂ O	0	0	4.0	3.3	3.3	4.2	6.2	0	0	0
Na ₂ O	5.0	7.2	5.2	1.2	1.2	1.2	1.0	1.0	6.0	6.0
K ₂ O	0	0	0	0	0	0	0	0	0	0
MgO	6.5	9.9	7.9	7.9	5.1	5.1	7.7	7.7	5.0	6.0
CaO	5.0	1.0	1.0	1.0	4.6	1.6	5.2	1.2	2.0	0
TiO ₂	0	0	0	0	0	0	0	0	0	0
ZrO ₂	0.5	0.5	0.5	0.5	2.5	2.5	0.5	0.5	0	0
Si+Al+B	83.0	81.5	85.5	85.5	83.3	86.3	81.5	83.5	87.0	88.0
B/Al	0.33	0	0.13	0.13	0.54	0.43	0	0	0	0.29
R ₂ O	5.0	7.2	5.2	5.2	4.5	4.5	5.2	7.2	6.0	6.0
Mg+Ca	11.5	10.9	8.9	8.9	9.7	6.7	12.9	8.9	7.0	6.0
MgCa/SiAlB	0.14	0.13	0.10	0.10	0.12	0.08	0.16	0.11	0.08	0.07
Na+K+Ca	10.0	8.2	6.2	2.2	5.8	2.8	6.2	2.2	8.0	6.0
NaKCa/SiAlB	0.120	0.100	0.072	0.025	0.070	0.032	0.075	0.026	0.092	0.068
Ti+Zr	0.5	0.5	0.5	0.5	2.5	2.5	0.5	0.5	0	0
d	2.43	2.47	2.45	2.45	2.47	2.46	2.48	2.46	2.41	2.40
α	34.3	42.0	32.7	22.8	28.5	23.6	27.7	24.2	35.5	33.0
Tg	742	747	741	743	694	711	752	756	740	724
E	78.3	82.0	83.4	88.4	82.8	85.0	89.6	90.9	81.3	79.9
E/d	32.2	33.2	34.0	36.1	33.6	34.5	36.1	37.0	33.7	33.3
P	67	53	47	33	53	47	65	40	6	56

TABLE 2

Ex.	11	12	13	14	15	16	17	18	19	20
SiO ₂	70.0	74.0	70.0	71.0	72.0	69.0	69.0	71.0	71.0	66.0
Al ₂ O ₃	17.0	8.0	11.0	15.0	10.5	14.0	11.0	12.0	11.5	17.0
B ₂ O ₃	5.0	2.0	0	0	1.5	2.0	3.0	0	0	0
Li ₂ O	0	0	0	0	0	2.0	0.0	0	0	9.0
Na ₂ O	6.0	3.0	6.0	8.0	3.5	0	6.0	6.0	6.0	0
K ₂ O	1.0	1.0	1.0	1.0	0	3.0	0	0	0	0
MgO	0	7.0	11.0	5.0	6.5	10.0	7.0	7.0	7.0	8.0
CaO	0	5.0	0	0	6.0	0	1.0	1.0	1.0	0
TiO ₂	0	0	0	0	0	0	0	3.0	2.0	0
ZrO ₂	1.0	0	1.0	0	0	0	3.0	0	1.5	0
Si+Al+B	92.0	84.0	81.0	86.0	84.0	85.0	83.0	83.0	82.5	83.0
B/Al	0.29	0.25	0.00	0.00	0.14	0.14	0.27	0	0	0
R ₂ O	7.0	4.0	7.0	9.0	3.5	5.0	6.0	6.0	6.0	9.0
Mg+Ca	0	12.0	11.0	5.0	12.5	10.0	8.0	8.0	8.0	8.0
MgCa/SiAlB	0	0.14	0.14	0.06	0.15	0.12	0.10	0.10	0.10	0.10
Na+K+Ca	7.0	9.0	7.0	9.0	9.5	3.0	7.0	7.0	7.0	0
NaKCa/SiAlB	0.076	0.107	0.086	0.105	0.113	0.035	0.084	0.084	0.085	0
Ti+Zr	1.0	0	1.0	0	0	0	3.0	3.0	3.5	0
d	2.39	2.41	2.46	2.42	2.43	2.41	2.49	2.46	2.49	2.43
α	33.7	35.2	41.6	45.2	32.5	30.7	35.2	36.4	35.6	29.6
Tg	721	698	725	719	729	739	728	743	753	720
E	76.7	79.6	84.0	80.2	81.6	83.2	83.2	83.7	84.7	90.6
E/d	32.1	33.0	34.1	33.2	33.5	34.5	33.3	34.0	34.0	37.3
P	45	0	31	50	27	49	35	44	45	53

TABLE 3

Ex.	21	22	23	24	25	26	27	28	29
SiO ₂	70.0	77.0	73.0	73.0	72.0	69.0	73.0	66.0	68.5
Al ₂ O ₃	17.0	7.0	11.0	17.0	10.0	14.0	11.0	11.2	13.0
B ₂ O ₃	3.0	0	0	0	0	0	0	7.8	0
Li ₂ O	5.0	3.0	2.0	4.0	5.0	4.0	4.0	0	0
Na ₂ O	0	0	4.0	0	0	0	0	0	5.2
K ₂ O	1.0	0	0	0	0	3.0	0	0	0
MgO	4.0	13.0	10.0	0.0	8.0	10.0	7.0	5.1	7.7
CaO	0	0	0	6.0	0	0	0	4.6	5.2
SrO	0	0	0	0	0	0	0	5.2	0
BaO	0	0	0	0	0	0	0	0.1	0
TiO ₂	0	0	0	0	0	0	5.0	0	0
ZrO ₂	0	0	0	0	5.0	0	0	0	0.5
Si+Al+B	90.0	84.0	84.0	90.0	82.0	83.0	84.0	85.0	81.5
B/Al	0.18	0	0	0	0	0	0	0.70	0
R ₂ O	6.0	3.0	6.0	4.0	5.0	7.0	4.0	0	5.2
Mg+Ca	4.0	13.0	10.0	6.0	8.0	10.0	7.0	9.7	12.9
MgCa/SiAlB	0.04	0.15	0.12	0.07	0.10	0.12	0.08	0.11	0.16
Na+K+Ca	1.0	0	4.0	6.0	0	3.0	0	9.9	10.3
NaKCa/SiAlB	0.011	0	0.048	0.067	0	0.036	0	0.116	0.126
Ti+Zr	0	0	0	0	5.0	0	5.0	0	0.5
d	2.38	2.40	2.42	2.41	2.55	2.43	2.45	2.5	2.44
α	23.5	22.5	33.2	21.2	20.7	34.9	20.7	30.1	40.5
Tg	735	731	725	784	781	729	762	720	741
E	83.5	86.6	84.7	84.6	92.0	85.5	88.2	77.0	82.2
E/d	35.1	36.0	35.0	35.0	36.1	35.2	35.9	30.8	33.7
P	21	0	0	60	1	58	1	60	92

INDUSTRIAL APPLICABILITY

The present invention is applicable to an information recording medium such as a
5 magnetic disk and to the production of a glass substrate to be used for e.g. an
information recording medium.

The entire disclosure of Japanese Patent Application No. 2011-166934 filed on
July 29, 2011 including specification, claims and summary is incorporated herein by
reference in its entirety.

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CLAIMS

1. Glass for a substrate, which comprises, as represented by mol% based on the following oxides, from 66 to 77% of SiO_2 , from 7 to 17% of Al_2O_3 , from 0 to 7% of B_2O_3 , from 0 to 9% of Li_2O , from 0 to 8% of Na_2O , from 0 to 3% of K_2O , from 0 to 13% of MgO ,
5 from 0 to 6% of CaO , from 0 to 5% of TiO_2 and from 0 to 5% of ZrO_2 , wherein the total of contents of SiO_2 , Al_2O_3 and B_2O_3 i.e. $\text{SiO}_2 + \text{Al}_2\text{O}_3 + \text{B}_2\text{O}_3$ is from 81 to 92%, the total of contents of Li_2O , Na_2O and K_2O i.e. $\text{Li}_2\text{O} + \text{Na}_2\text{O} + \text{K}_2\text{O}$ is from 3 to 9%, the total of contents of MgO and CaO i.e. $\text{MgO} + \text{CaO}$ is from 4 to 13%, the total of contents of Na_2O , K_2O and CaO i.e. $\text{Na}_2\text{O} + \text{K}_2\text{O} + \text{CaO}$ is from 0 to 10%, and the total of contents of TiO_2
10 and ZrO_2 i.e. $\text{TiO}_2 + \text{ZrO}_2$ is from 0 to 5%.
2. The glass for a substrate according to Claim 1, wherein the ratio of the B_2O_3 content to the Al_2O_3 content i.e. $\text{B}_2\text{O}_3 / \text{Al}_2\text{O}_3$ is at most 0.6.
3. The glass for a substrate according to Claim 1 or 2, wherein the ratio of $\text{Na}_2\text{O} + \text{K}_2\text{O} + \text{CaO}$ to $\text{SiO}_2 + \text{Al}_2\text{O}_3 + \text{B}_2\text{O}_3$ i.e. $(\text{Na}_2\text{O} + \text{K}_2\text{O} + \text{CaO}) / (\text{SiO}_2 + \text{Al}_2\text{O}_3 + \text{B}_2\text{O}_3)$ is at
15 most 0.125.
4. The glass for a substrate according to Claim 1, 2 or 3, wherein SiO_2 is at most 74%, Al_2O_3 is at least 8%, Li_2O is less than 2%, MgO is at most 11%, TiO_2 is at most 3%, ZrO_2 is at most 3%, $\text{Li}_2\text{O} + \text{Na}_2\text{O} + \text{K}_2\text{O}$ is at least 3.5%, $\text{MgO} + \text{CaO}$ is from 5 to 12.5%, $\text{TiO}_2 + \text{ZrO}_2$ is at most 3.5%, and $(\text{MgO} + \text{CaO}) / (\text{SiO}_2 + \text{Al}_2\text{O}_3 + \text{B}_2\text{O}_3)$ is at most 0.15.
- 20 5. The glass for a substrate according to Claim 1, 2, 3 or 4, which contains Li_2O or Na_2O .
6. The glass for a substrate according to Claim 1, 2, 3 or 4, wherein B_2O_3 is at most 3%, Li_2O is at least 2%, Na_2O is at most 4%, and $\text{Li}_2\text{O} + \text{Na}_2\text{O} + \text{K}_2\text{O}$ is at least 3.5%.
7. The glass for a substrate according to Claim 6, wherein
25 $(\text{MgO} + \text{CaO}) / (\text{SiO}_2 + \text{Al}_2\text{O}_3 + \text{B}_2\text{O}_3)$ is from 0.04 to 0.16.
8. The glass for a substrate according to any one of Claims 1 to 7, wherein the total of contents of the above 10 components is at least 98%.
9. A glass substrate made of the glass for a substrate as defined in any one of Claims 1 to 8.
- 30 10. The glass substrate according to Claim 9, which is used as a substrate for an information recording medium.
11. The glass substrate according to Claim 10, wherein the substrate for an

information recording medium is a substrate for a magnetic disk.

12. A chemically tempered glass substrate obtained by chemically tempering a glass plate made of the glass for a substrate as defined in any one of Claims 1 to 8.

13. The chemically tempered glass substrate according to Claim 12, which is used as
5 a substrate for an information recording medium.

14. The chemically tempered glass substrate according to Claim 13, wherein the substrate for an information recording medium is a substrate for a magnetic disk.

15. A magnetic disk having a magnetic recording layer formed on the glass substrate as defined in Claim 11 or on the chemically tempered glass substrate as defined in
10 Claim 14.