CLAIMS

1. Glass for a magnetic recording medium substrate, which comprises:

essential components in the form of SiO_2, Li_2O, Na_2O, and one or more alkaline earth metal oxides selected from the group consisting of MgO, CaO, SrO, and BaO;

wherein a molar ratio of a content of CaO to a combined content of MgO, CaO, SrO, and BaO (CaO/(MgO + CaO + SrO + BaO)) is equal to or less than 0.20; and which has a glass transition temperature of equal to or higher than 650°C.

2. The glass for a magnetic recording medium substrate according to claim 1, which comprises, denoted as molar percentages,

55 to 78 percent of SiO_2,

greater than 0 percent and equal to or less than 5 percent of Li_2O,

2 to 15 percent of Na_2O, and

10 to 25 percent of a combined content of MgO, CaO, SrO, and BaO.

3. The glass for a magnetic recording medium substrate according to claim 2, which comprises 0 to 12 mole percent of Al_2O_3.

4. The glass for a magnetic recording medium substrate according to any of claims 1 to 3, wherein a molar ratio, CaO/Na_2O, of a content of CaO relative to a content of Na_2O is equal to or less than 1.5.

5. The glass for a magnetic recording medium substrate according to any of claims 1 to 4, which comprises one or more selected from the group consisting of ZrO_2, TiO_2, Y_2O_3, La_2O_3, Gd_2O_3, Nb_2O_5, Ta_2O_5, and HfO_2.

6. The glass for a magnetic recording medium substrate according to any of claims 1 to 5, wherein a combined content of ZrO_2, TiO_2, Y_2O_3, La_2O_3, Gd_2O_3, Nb_2O_5, Ta_2O_5, and HfO_2 ranges from 0 to 10 mole percent.

7. The glass for a magnetic recording medium substrate according to claim 5 or 6, wherein a combined content of SiO_2, ZrO_2, TiO_2, Y_2O_3, La_2O_3, Gd_2O_3, Yb_2O_3, Nb_2O_5, Ta_2O_5, and HfO_2 is equal to or greater than 66 mole percent.

8. The glass for a magnetic recording medium substrate according to any of claims 1 to 7, which comprises 0 to 6 mole percent of ZrO_2.

9. The glass for a magnetic recording medium substrate according to any of claims 1 to 8, wherein a combined content of SiO_2 and ZrO_2 is equal to or greater than 66 mole percent.

10. The glass for a magnetic recording medium substrate according to any of claims 1 to 9, which has an average coefficient of linear expansion at 100 to 300°C of equal to or greater than 50 x 10^{-7}/°C, a Young's modulus of equal to or greater than 75 GPa, and a specific modulus of elasticity of equal to or greater than 25 MNm/kg.

11. A glass substrate for a magnetic recording medium, which is comprised of chemically strengthened glass that has been prepared by chemically strengthening the glass for a magnetic recording medium substrate according to any of claims 1 to 10.

12. The glass substrate for a magnetic recording medium according to claim 11, which is chemically strengthened glass in which a tensile stress distribution is convex in shape such that the convex shape does not contain indentations indenting to a compressive stress side in a stress profile in a virtual cross section perpendicular to two main surfaces as obtained by the Babinet method.

13. The glass substrate for a magnetic recording medium according to claim 11 or 12, which is chemically strengthened glass in which an average value Tav of a tensile stress obtained by the Babinet method and a maximum value Tmax of the tensile stress satisfy the following equation (1):

$$Tav/Tmax \geq 0.5.$$

14. A glass substrate for a magnetic recording medium, which is comprised of chemically strengthened glass having a glass transition temperature of equal to or higher than 650°C in which a tensile stress distribution is convex in shape such that the convex shape does not contain indentations indenting to a compressive stress side in a stress profile in a virtual cross section perpendicular to two main surfaces as obtained by the Babinet method.

15. A glass substrate for a magnetic recording medium, which is comprised of chemically strengthened glass having a glass transition temperature of equal to or higher than 650°C in which an average value Tav of a tensile stress obtained by the Babinet method and a maximum value Tmax of the tensile stress satisfy the following equation (1):

Tav/Tmax $\geq$0.5.

16. The glass substrate for a magnetic recording medium according to any of claims 11 to 15, wherein the chemically strengthened glass is glass that has been chemically strengthened by immersion into a mixed salt melt of sodium salt and potassium salt.

17. The glass substrate for a magnetic recording medium according to claim 16, which is glass that has been chemically strengthened by immersing glass which comprises equal to or greater than 0.1 mole percent of Li_2O into the mixed salt melt.

18. The glass substrate for a magnetic recording medium according to any of claims 11 to 17, which has a fracture toughness value K_{1c} of equal to or greater than 0.8 $MPa \cdot m^{1/2}$.

19. The glass substrate for a magnetic recording medium according to any of claims 11 to 18, wherein an arithmetic average surface roughness (Ra) over an area of 1 μm x 1 μm on a main surface measured by an atomic force microscope at a resolution of 512 x 256 pixels is equal to or lower than 0.15 nm.

20. The glass substrate for a magnetic recording medium according to any of claims 11 to 19, which has a plate thickness of equal to or lower than 0.5 mm.

21. The glass substrate for a magnetic recording medium according to any of claims 11 to 20, which is a glass substrate for a magnetic recording medium, the magnetic recording medium being employed in a magnetic recording apparatus wherein a rotational speed is equal to or higher than 5000 rpm.

22. The glass substrate for a magnetic recording medium according to any of claims 11 to 21, which is a glass substrate for a magnetic recording medium, the magnetic recording medium being employed in a magnetic recording apparatus equipped with a DFH (Dynamic Flying Height) head.

23. The glass substrate for a magnetic recording medium according to any of claims 11 to 21, which is employed in a magnetic recording medium for energy-assisted magnetic recording.

24. A glass substrate blank for a magnetic recording medium, which comprises:

essential components in the form of SiO_2, Li_2O, Na_2O, and one or more alkaline earth metal oxides selected from the group consisting of MgO, CaO, SrO, and BaO;

wherein a molar ratio of a content of CaO to a combined content of MgO, CaO, SrO, and BaO (CaO/(MgO + CaO + SrO + BaO)) is equal to or less than 0.20; and which has a glass transition temperature of equal to or higher than 650°C.

25. The glass substrate blank for a magnetic recording medium according to claim 24, which is disk-shaped.

26. A method of manufacturing a glass substrate blank for a magnetic recording medium, which comprises:

blending glass starting materials to provide glass comprising essential components in the form of SiO_2, Li_2O, Na_2O, and one or more alkaline earth metal oxides selected from the group consisting of MgO, CaO, SrO, and BaO; wherein a molar ratio of a content of CaO to a combined content of MgO, CaO, SrO, and BaO (CaO/(MgO + CaO + SrO + BaO)) is equal to or less than 0.20; and which has a glass transition temperature of equal to or higher than 650°C;

melting the blended glass starting materials to provide a glass melt; and

press molding the glass melt that has been provided to prepare a substrate blank comprised of the glass.

27. The method of manufacturing a glass substrate blank for a magnetic recording medium according to claim 26, which comprises press molding the glass melt into a disk shape.

28. The method of manufacturing a glass substrate blank for a magnetic recording medium according to claim 26 or 27, which comprises press molding the glass melt in the air.

29. A method of manufacturing a glass substrate for a magnetic recording medium, which comprises processing the glass substrate blank for a magnetic recording medium according to claim 24 or 25.

30. A method of manufacturing a glass substrate for a magnetic recording medium, which comprises:

preparing a glass substrate blank for a magnetic recording medium by the method according to any of claims 26 to 28; and

processing the substrate blank.

31. The method of manufacturing a glass substrate for a magnetic recording medium according to claim 29 or 30, which comprises conducting chemical strengthening by immersing the glass in a salt melt comprising a sodium salt and a potassium salt.

32. The method of manufacturing a glass substrate for a magnetic recording medium according to claim 31, which comprises conducting chemical strengthening by immersing the glass comprising equal to or more than 0.1 mol percent of Li_2O in the salt melt.

33. The method of manufacturing a glass substrate for a magnetic recording medium according to claim 31 or 32, which comprises conducting the chemical strengthening so as to achieve chemically-strengthened glass in which an average value Tav of a tensile stress obtained by the Babinet method and a maximum value Tmax of the tensile stress satisfy the following equation (1):

$$Tav/Tmax \geq 0.5.$$

34. The method of manufacturing a glass substrate for a magnetic recording medium according to claim 31 or 32, which comprises conducting the chemical strengthening so as to achieve chemically-strengthened glass in which a tensile stress distribution is convex in shape such that the convex shape does not comprise indentations indenting to a compressive stress side in a stress profile in a virtual cross section perpendicular to two main surfaces as obtained by the Babinet method.

35. A magnetic recording medium, which comprises a magnetic recording layer on the glass substrate for a magnetic recording medium according to any of claims 11 to 21.

36. The magnetic recording medium according to claim 35, wherein the magnetic recording layer is a magnetic recording layer comprising as a main component an alloy of Pt with Fe and/or Co, and the magnetic recording medium is a magnetic recording medium for energy-assisted magnetic recording.

37. A method of manufacturing magnetic recording medium, which comprises forming a magnetic recording layer by conducting an annealing process after forming a film of a magnetic material comprising as a main component an alloy of Pt with Fe and/or Co, on a main surface of the glass substrate for a magnetic recording medium according to any of claims 11 to 23.

38. A magnetic recording apparatus of energy-assisted magnetic recording system, which comprises:

a heat-assisted magnetic recording head having a heat source to heat at least a main surface of a magnetic recording medium, a recording element member, and a reproduction element member; and

the magnetic recording medium according to claim 35 or 36.

39. The magnetic recording apparatus according to claim 38, wherein a rotational speed is equal to or higher than 5000 rpm.

40. The magnetic recording apparatus according to claim 38 or 39, which is equipped with a DFH (Dynamic Flying Height) head.

CLAIMS

1. Glass for a magnetic recording medium substrate, which comprises: essential components in the form of SiO_2, Li_2O, Na_2O, and one or more alkaline earth metal oxides selected from the group consisting of MgO, CaO, SrO, and BaO; wherein a molar ratio of a content of CaO to a combined content of MgO, CaO, SrO, and BaO (CaO/(MgO + CaO + SrO + BaO)) is equal to or less than 0.20; and which has a glass transition temperature of equal to or higher than 650° C.

2. The glass for a magnetic recording medium substrate according to claim 1, which comprises, denoted as molar percentages,

55 to 78 percent of SiO_2,

greater than 0 percent and equal to or less than 5 percent of Li_2O,

2 to 15 percent of Na_2O, and

10 to 25 percent of a combined content of MgO, CaO, SrO, and BaO.

3. The glass for a magnetic recording medium substrate according to claim 2, which comprises 0 to 12 mole percent of Al_2O_3.

4. The glass for a magnetic recording medium substrate according to claim 1, wherein a molar ratio, CaO/Na_2O, of a content of CaO relative to a content of Na_2O is equal to or less than 1.5.

5. The glass for a magnetic recording medium substrate according to claim 1, which comprises one or more selected from the group consisting of ZrO_2, TiO_2, Y_2O_3, La_2O_3, Gd_2O_3, Nb_2O_5, Ta_2O_5, and HfO_2.

6. The glass for a magnetic recording medium substrate according to claim 5, wherein a combined content of SiO_2, ZrO_2, TiO_2, Y_2O_3, La_2O_3, Gd_2O_3, Yb_2O_3, Nb_2O_5, Ta_2O_5, and HfO_2 is equal to or greater than 66 mole percent.

7. The glass for a magnetic recording medium substrate according to claim 1, wherein a combined content of ZrO_2, TiO_2, Y_2O_3, La_2O_3, $_2$, Nb_2O5, Ta_2O5, and HfO_2 ranges from 0 to 10 mole percent.

8. The glass for a magnetic recording medium substrate according to claim 1, which comprises 0 to 6 mole percent of ZrO_2.

9. The glass for a magnetic recording medium substrate according to claim 1, wherein a combined content of SiO_2 and ZrO_2 is equal to or greater than 66 mole percent.

10. The glass for a magnetic recording medium substrate according to claim 1, which has an average coefficient of linear expansion at 100 to 300 °C. of equal to or greater than 50 x 10^{-7}/ C, a Young's modulus of equal to or greater than 75 GPa, and a specific modulus of elasticity of equal to or greater than 25 MNm/kg.

11. A glass substrate for a magnetic recording medium, comprising:

a glass having essential components in the form of SiO_2, Li_2O, Na_2O, and

one or more alkaline earth metal oxides selected from the group consisting of MgO, CaO, SrO, and BaO;

wherein a molar ratio of a content of CaO to a combined content of MgO, CaO, SrO, and BaO (CaO/(MgO+CaO+SrO+BaO)) is equal to or less than 0.20;

wherein the glass has a transition temperature of equal to or higher than 650° C; and

wherein the glass has a compressive stress layer proximate a surface of the substrate and formed by chemical strengthening.

12. The glass substrate for a magnetic recording medium according to claim 11, which comprises chemically strengthened glass in which a tensile stress distribution is convex in shape such that the convex shape does not contain indentations indenting to a compressive stress side in a stress profile in a virtual cross section perpendicular to two main surfaces as obtained by a Babinet method.

13. The glass substrate for a magnetic recording medium according to claim 11, which comprises chemically strengthened glass in which an average value Tav of a tensile stress obtained by a Babinet method and a maximum value Tmax of the tensile stress satisfy the following equation (1):

$Tav/Tmax \geq 0.5$.

14. The glass substrate for a magnetic recording medium according to claim 11, wherein the chemically strengthened glass comprises glass that has been chemically strengthened by immersion into a mixed salt melt of sodium salt and potassium salt.

15. The glass substrate for a magnetic recording medium according to claim 14, which comprises glass that has been chemically strengthened by immersing glass which comprises equal to or greater than 0.1 mole percent of Li_2O into the mixed salt melt.

16. The glass substrate for a magnetic recording medium according to claim 11, which has a fracture toughness value K1c of equal to or greater than 0.8 $MPam^{1/2}$.

17. The glass substrate for a magnetic recording medium according to claim 11, wherein an arithmetic average surface roughness (Ra) over an area of 1 μm x 1 μm on a main surface measured by an atomic force microscope at a resolution of 512 x 256 pixels is equal to or lower than 0.15 nm.

18. The glass substrate for a magnetic recording medium according to claim 11, which has a plate thickness of equal to or lower than 0.5 mm.

19. A glass substrate for a magnetic recording medium, which comprises:

a chemically strengthened glass,

wherein said glass is characterized by (1) a glass transition temperature of equal to or higher than 650° C, and (2) a tensile stress distribution that is convex in shape such that the convex shape does not contain indentations indenting to a compressive stress side in a stress

profile in a virtual cross section perpendicular to two main surfaces as obtained by a Babinet method.

20. A glass substrate for a magnetic recording medium, which comprises:

a chemically strengthened glass,

wherein said glass is characterized by (1) a glass transition temperature of equal to or higher than 650° C, and (2) an average value Tav of a tensile stress obtained by a Babinet method and a maximum value Tmax of the tensile stress that satisfy the following equation (1):

$Tav/Tmax \geq 0.5$.

21. A glass substrate blank for a magnetic recording medium, which comprises: essential components in the form of SiO_2, Li_2O, Na_2O, and one or more alkaline earth metal oxides selected from the group consisting of MgO, CaO, SrO, and BaO; wherein a molar ratio of a content of CaO to a combined content of MgO, CaO, SrO, and BaO (CaO/(MgO+CaO+SrO+BaO)) is equal to or less than 0.20; and which has a glass transition temperature of equal to or higher than 650° C.

22. A method of manufacturing a glass substrate blank for a magnetic recording medium, which comprises: blending glass starting materials to provide glass comprising essential components in the form of SiO_2, Li_2O, Na_2O, and one or more alkaline earth metal oxides selected from the group consisting of MgO, CaO, SrO, and BaO; wherein a molar ratio of a content of CaO to a combined content of MgO, CaO, SrO, and BaO (CaO/(MgO+CaO+SrO+BaO)) is equal to or less than 0.20; and which has a glass transition temperature of equal to or higher than 650° C; melting the blended glass starting materials to provide a glass melt; and press molding the glass melt that has been provided to prepare a substrate blank comprised of the glass.

23. The method of manufacturing a glass substrate blank for a magnetic recording medium according to claim 22, which comprises press molding the glass melt in the air.

24. A method of manufacturing a glass substrate for a magnetic recording medium, which comprises:

preparing a glass substrate blank for a magnetic recording medium by the method according to claim 22; and

processing the substrate blank.

25. A method of manufacturing a glass substrate for a magnetic recording medium, comprising:

processing a glass substrate blank for a magnetic recording medium which comprises: essential components in the form of SiO_2, Li_2O, Na_2O, and one or more alkaline earth metal oxides selected from the group consisting of MgO, CaO, SrO, and BaO; wherein a molar ratio of a content of CaO to a combined content of MgO, CaO, SrO, and BaO (CaO/(MgO+CaO+SrO+BaO)) is equal to or less than 0.20; and which has a glass transition temperature of equal to or higher than 650° C.

26. A magnetic recording medium, comprising:

a glass, said glass having essential components in the form of SiO_2, Li_2O, Na_2O, and

one or more alkaline earth metal oxides selected from the group consisting of MgO, CaO, SrO, and BaO;

wherein a molar ratio of a content of CaO to a combined content of MgO, CaO, SrO, and BaO (CaO/(MgO+CaO+SrO+BaO)) is equal to or less than 0.20;

wherein the glass has a transition temperature of equal to or higher than 650° C; and

wherein the glass has a compressive stress layer proximate a surface of the substrate and formed by chemical strengthening, and

a magnetic recording layer on the glass substrate for a magnetic recording medium.

27. A magnetic recording apparatus of energy-assisted magnetic recording system, which comprises:

a heat-assisted magnetic recording head having a heat source to heat at least a main surface of a magnetic recording medium,

a recording element member, and a reproduction element member; and

a magnetic recording medium, comprising:

a glass, said glass having essential components in the form of SiO_2, Li_2O, Na_2O, and one or more alkaline earth metal oxides selected from the group consisting of MgO, CaO, SrO, and BaO;

wherein a molar ratio of a content of CaO to a combined content of MgO, CaO, SrO, and BaO (CaO/(MgO+CaO+SrO+BaO)) is equal to or less than 0.20;

wherein the glass has a transition temperature of equal to or higher than 650° C; and

wherein the glass has a compressive stress layer proximate a surface of the substrate and formed by chemical strengthening, and

a magnetic recording layer on the glass substrate for a magnetic recording medium.

28. The magnetic recording apparatus according to claim 27, wherein a rotational speed is equal to or higher than 5000 rpm.

29. The magnetic recording apparatus according to claim 27, which is equipped with a DFH (Dynamic Flying Height) head.