CLAIMS

1. A mask blank, comprising:

a transparent substrate having a main surface; and

a thin film for forming a transfer pattern on the main surface of the transparent substrate;

wherein the thin film is made of a material containing a transition metal and silicon and further containing at least one of oxygen and nitrogen,

wherein the thin film has as a surface layer an oxide layer having an oxygen content higher than an oxygen content of the thin film of a region excluding the surface layer,

wherein the thin film is formed so that a thickness of an outer peripheral portion is greater than a thickness of a central portion on a side of the main surface,

wherein a content of oxygen or nitrogen in the thin film of the region excluding the surface layer is higher on the outer peripheral portion than on the central portion, and

wherein the oxide layer is formed so that a thickness of the outer peripheral portion is greater than a thickness of the central portion on the side of the main surface.

2. The mask blank according to claim 1, wherein the thin film is a semitransmissive film having a transmittance of 1% or more for exposure light.

3. The mask blank according to claim 1, wherein the thin film is a halftone phase shift film having a transmittance of 1% or more for exposure light and adapted to produce a predetermined phase difference between exposure light transmitted through the thin film and exposure light transmitted in air for a distance equal to a thickness of the thin film.

4. The mask blank according to claim 2 or 3, wherein the thin film is

formed so that an in-plane distribution of the transmittance is in a range of 0.6%.

5. The mask blank according to claim 3, wherein the thin film is formed so that an in-plane distribution of the phase difference is in a range of 4 degrees.

6. A method of manufacturing the mask blank according to any one of claims 1 to 5, comprising:

a thin film forming step of forming, on the main surface of the transparent substrate, the thin film by sputtering using a target containing the transition metal and the silicon in a sputtering gas containing at least one of the oxygen and the nitrogen; and

an optical heat treatment step of carrying out, in a gas containing the oxygen, an optical heat treatment for the thin film formed in the thin film forming step to form the oxide layer as the surface layer of the thin film,

wherein the optical heat treatment step controls a cumulative irradiation dose of light irradiated onto the thin film so as to be higher at the outer peripheral portion than at the central portion on the side of the main surface.

7. The method according to claim 6, wherein the thin film forming step rotates the substrate about a rotation axis passing through a center of the main surface and disposes a sputtering surface of the sputtering target at a position facing the main surface of the substrate and having a predetermined angle with respect to the main surface so that the rotation axis of the substrate and a straight line passing through a center of the sputtering surface and parallel to the rotation axis of the substrate are offset from each other, thereby forming the thin film by the sputtering.

8. The method according to claim 6 or 7, wherein the optical heat treatment step carries out the optical heat treatment for the thin film using a light irradiator in which a plurality of cylindrical lamps are disposed in a lattice pattern.

9. The method according to claim 8, wherein the cylindrical lamp is a halogen heater.

10. A transfer mask, comprising:

the transfer pattern formed in the thin film of the mask blank according to any one of claims 1 to 5.

11. A method of manufacturing a transfer mask, comprising:

a pattern forming step of forming the transfer pattern in the thin film of the mask blank manufactured by the method according to any one of claims 6 to 9.

CLAIMS

1. A mask blank, comprising:

a transparent substrate having a main surface; and

a thin film for forming a transfer pattern on the main surface of the transparent substrate;

wherein the thin film has as a surface layer an oxide layer,

wherein the thin film is formed so that a thickness of an outer peripheral portion is greater than a thickness of a central portion on a side of the main surface,

wherein a content of nitrogen in the thin film of the region excluding the surface layer is higher at the outer peripheral portion than at the central portion, and

wherein the oxide layer is formed so that a thickness of the outer peripheral portion is greater than a thickness of the central portion on the side of the main surface.

2. The mask blank according to claim 1, wherein the thin film is a semitransmissive film having a transmittance of 1% or more for exposure light.

3. The mask blank according to claim 1, wherein the thin film is a halftone phase shift film having a transmittance of 1% or more for exposure light and adapted to produce a predetermined phase difference between exposure light transmitted through the thin film and exposure light transmitted in air for a distance equal to a thickness of the thin film.

4. The mask blank according to claim 2 or 3, wherein the thin film is formed so that an in-plane distribution of the transmittance is in a range of 0.6%.

5. The mask blank according to claim 3, wherein the thin film is formed so that an in-plane distribution of the phase difference is in a range of 4 degrees.

6. A method of manufacturing the mask blank according to any one of claims 1 to 5, comprising:

a thin film forming step of forming, on the main surface of the transparent substrate, the thin film by sputtering using a target containing the transition metal and the silicon in a sputtering gas containing at least the nitrogen; and

an optical heat treatment step of carrying out, in a gas containing the oxygen, an optical heat treatment for the thin film formed in the thin film forming step to form the oxide layer as the surface layer of the thin film,

wherein the optical heat treatment step controls a cumulative irradiation dose

of light irradiated onto the thin film so as to be higher at the outer peripheral portion than at the central portion on the side of the main surface.

7. The method according to claim 6, wherein the thin film forming step rotates the substrate about a rotation axis passing through a center of the main surface and disposes a sputtering surface of the sputtering target at a position facing the main surface of the substrate and having a predetermined angle with respect to the main surface so that the rotation axis of the substrate and a straight line passing through a center of the sputtering surface and parallel to the rotation axis of the substrate are offset from each other, thereby forming the thin film by the sputtering.

8. The method according to claim 6 or 7, wherein the optical heat treatment step carries out the optical heat treatment for the thin film using a light irradiator in which a plurality of cylindrical lamps are disposed in a lattice pattern.

9. The method according to claim 8, wherein the cylindrical lamp is a halogen heater.

10. A transfer mask, comprising:

the transfer pattern formed in the thin film of the mask blank according to any one of claims 1 to 5.

11. A method of manufacturing a transfer mask, comprising:

a pattern forming step of forming the transfer pattern in the thin film of the mask blank manufactured by the method according to claim 6 to 9.