CLAIMS

1. A phase shift mask blank used for producing a phase shift mask to which an exposure light with a wavelength of 200 nm or less is applied,

the phase shift mask blank comprising:

a transparent substrate; and

a phase shift film formed on the transparent substrate; wherein

the phase shift film includes: a phase difference and transmittance adjustment layer capable of adjusting each of a phase and transmittance by a predetermined amount with respect to a transmitting exposure light; and a protective layer against gas permeation formed on the phase difference and transmittance adjustment layer and preventing gas permeation into the phase difference and transmittance adjustment layer,

the phase difference and transmittance adjustment layer is located on the transparent substrate side, wherein the phase difference and transmittance adjustment layer contains silicon, a transition metal, nitrogen, oxygen, and carbon, and

the transition metal is at least one selected from molybdenum, titanium, vanadium, cobalt, nickel, zirconium, niobium, and hafnium, and

when a film thickness of the phase difference and transmittance adjustment layer is defined as d1 and a film thickness of the protective layer against gas

permeation is defined as d2, d1 is larger than d2, and d2 is 15 nm or less.

2. The phase shift mask blank according to claim 1, wherein the phase shift film has resistance to oxygen-containing chlorine-based etching (Cl/O base) and can be etched by fluorine-based etching (F base).

3. The phase shift mask blank according to claim 1 or 2, wherein the protective layer against gas permeation contains at least one selected from tantalum metal, a tantalum compound, tungsten metal, a tungsten compound, tellurium metal, and a tellurium compound.

4. The phase shift mask blank according to claim 3, wherein the tantalum compound contains tantalum and at least one selected from oxygen, nitrogen, and carbon.

5. The phase shift mask blank according to claim 3, wherein the tungsten compound contains tungsten and at least one selected from oxygen, nitrogen, and carbon.

6. The phase shift mask blank according to claim 3, wherein the tellurium compound contains tellurium and at least one selected from oxygen, nitrogen, and carbon.

7. A phase shift mask to which an exposure light with a wavelength of 200 nm or less is applied and which includes a circuit pattern,

the phase shift mask comprising:

a transparent substrate; and

a phase shift film formed on the transparent substrate; wherein

the phase shift film includes: a phase difference and transmittance adjustment layer capable of adjusting each of a phase and transmittance by a predetermined amount with respect to a transmitting exposure light; and a protective layer against gas permeation formed on the phase difference and transmittance adjustment layer and preventing gas permeation into the phase difference and transmittance adjustment layer,

the phase difference and transmittance adjustment layer is located on the transparent substrate side, wherein the phase difference and transmittance adjustment layer contains silicon, a transition metal, nitrogen, oxygen, and carbon, and

the transition metal is at least one selected from molybdenum, titanium, vanadium, cobalt, nickel, zirconium, niobium, and hafnium, and

when a film thickness of the phase difference and transmittance adjustment layer is defined as d1 and a film thickness of the protective layer against gas permeation is defined as d2, d1 is larger than d2, and d2 is 15 nm or less.

8. The phase shift mask according to claim 7, wherein the phase shift film has resistance to oxygen-containing chlorine-based etching (Cl/O base) and can be etched by fluorine-based etching (F base).

9. The phase shift mask according to claim 7 or 8, wherein the protective layer against gas permeation contains at least one selected from tantalum metal, a tantalum compound, tungsten metal, a tungsten compound, tellurium metal, and a tellurium compound.

10. The phase shift mask according to claim 9, wherein the tantalum compound contains tantalum and at least one selected from oxygen, nitrogen, and carbon.

11. The phase shift mask according to claim 9, wherein the tungsten compound contains tungsten and at least one selected from oxygen, nitrogen, and carbon.

12. The phase shift mask according to claim 9, wherein the tellurium compound contains tellurium and at least one selected from oxygen, nitrogen, and carbon.

13. A method for manufacturing a phase shift mask using the phase shift mask blank according to any one of claims 1 to 6,

the method comprising:

forming a light shielding film on the phase shift film;

forming a resist pattern on the light shielding film formed on the phase shift film;

after forming the resist pattern, forming a pattern on the light shielding film by the oxygen-containing chlorine-based etching (Cl/O base);

after forming the pattern on the light shielding film, forming a pattern on the phase shift film by the fluorine-based etching (F base);

after forming the pattern on the phase shift film, removing the resist pattern; and

after removing the resist pattern, removing the light shielding film by the oxygen-containing chlorine-based etching (Cl/O base) from the phase shift film.