CLAIMS

1. A mask blank comprising a transparent substrate and a phase shift film formed thereon,

wherein the phase shift film has a structure in which a lower layer, an intermediate layer, and an upper layer are formed in this order from the transparent substrate;

wherein the lower layer is formed of a material consisting of silicon and nitrogen or a material consisting of silicon, nitrogen, and one or more elements selected from metalloid elements and non-metal elements;

wherein the intermediate layer is formed of a material consisting of silicon, nitrogen, and oxygen or a material consisting of silicon, nitrogen, oxygen, and one or more elements selected from metalloid elements and non-metal elements;

wherein the upper layer is formed of a material consisting of silicon and oxygen or a material consisting of silicon, oxygen, and one or more elements selected from metalloid elements and non-metal elements,

wherein the lower layer is greater in nitrogen content than the intermediate layer and the upper layer;

wherein the upper layer is greater in oxygen content than the intermediate layer and the lower layer;

wherein a ratio of film thickness of the intermediate layer is 0.15 or more with respect to an overall film thickness of the phase shift film;

wherein a ratio of film thickness of the upper layer is 0.10 or less with respect to the overall film thickness of the phase shift film; and

wherein an etching rate for dry etching by a fluorine-based gas of the intermediate layer is slower than an etching rate for dry etching by a fluorine-based gas of the lower layer and faster than an etching rate dry etching by a fluorine-based gas of the upper layer.

2. The mask blank according to claim 1, wherein a ratio of film thickness of the lower layer is 0.80 or less with respect to the overall film thickness of the phase shift film, such that a total of the ratio of film thickness of the lower layer with respect to the overall film thickness of the phase shift film,

the ratio of film thickness of the intermediate layer with respect to the overall film thickness of the phase shift film, and the ratio of film thickness of the upper layer with respect to the overall film thickness of the phase shift film does not exceed 1.0.

3. The mask blank according to claim 1 or 2, wherein the intermediate layer is greater in nitrogen content than the upper layer and greater in oxygen content than the lower layer.

4. The mask blank according to any one of claims 1 to 3, wherein the intermediate layer has a nitrogen content of 30 atomic% or more and an oxygen content of 10 atomic% or more.

5. The mask blank according to any one of claims 1 to 4, wherein the lower layer has a nitrogen content of 50 atomic% or more.

6. The mask blank according to any one of claims 1 to 5, wherein the upper layer has an oxygen content of 50 atomic% or more.

7. The mask blank according to any one of claims 1 to 6, wherein the lower layer is greater in film thickness than the intermediate layer and the upper layer and the intermediate layer is greater in film thickness than the upper layer.

8. The mask blank according to any one of claims 1 to 7, wherein the phase shift film has a function of allowing exposure light of an ArF excimer laser to be transmitted therethrough at a transmittance of 2% or more and a function of causing a phase difference of 150 degrees or more and 200 degrees or less between the exposure light transmitted through the phase shift film and the exposure light transmitted through air for a same distance as a thickness of the phase shift film.

9. The mask blank according to any one of claims 1 to 8, comprising a light shielding film formed on the phase shift film.

10. The mask blank according to any one of claims 1 to 9, wherein the upper layer has an oxygen content of 66 atomic% or less.

11. The mask blank according to any one of claims 1 to 10, wherein the upper layer has a nitrogen content of 10 atomic% or less.

12. The mask blank according to any one of claims 1 to 11, wherein a total content of silicon and oxygen in the upper layer is 95 atomic% or more.

13. A phase shift mask comprising a transparent substrate and a phase shift film formed thereon and having a transparent pattern,

wherein the phase shift film has a structure in which a lower layer, an intermediate layer, and an upper layer are formed in this order from the transparent substrate;

wherein the lower layer is formed of a material consisting of silicon and nitrogen or a material consisting of silicon, nitrogen, and one or more elements selected from metalloid elements and non-metal elements;

wherein the intermediate layer is formed of a material consisting of silicon, nitrogen, and oxygen or a material consisting of silicon, nitrogen, oxygen, and one or more elements selected from metalloid elements and non-metal elements;

wherein the upper layer is formed of a material consisting of silicon and oxygen or a material consisting of silicon, oxygen, and one or more elements selected from metalloid elements and non-metal elements,

wherein the lower layer is greater in nitrogen content than the intermediate layer and the upper layer;

wherein the upper layer is greater in oxygen content than the intermediate layer and the lower layer;

wherein a ratio of film thickness of the intermediate layer is 0.15 or more with respect to an overall film thickness of the phase shift film;

wherein a ratio of film thickness of the upper layer is 0.10 or less with respect to the overall film thickness of the phase shift film; and

wherein an etching rate for dry etching by a fluorine-based gas of the intermediate layer is slower than an etching rate for dry etching by a fluorine-based gas of the lower layer and faster than an etching rate dry etching by a fluorine-based gas of the upper layer.

14. The phase shift mask according to claim 13, wherein a ratio of film thickness of the lower layer is 0.80 or less with respect to the overall film thickness of the phase shift film, such that a total of the ratio of film thickness of the lower layer with respect to the overall film thickness of the phase shift film, the ratio of film thickness of the intermediate layer with respect to the overall

film thickness of the phase shift film, and the ratio of film thickness of the upper layer with respect to the overall film thickness of the phase shift film does not exceed 1.0.

15. The phase shift mask according to claim 13 or 14, wherein the intermediate layer is greater in nitrogen content than the upper layer and greater in oxygen content than the lower layer.

16. The phase shift mask according to any one of claims 13 to 15, wherein the intermediate layer has a nitrogen content of 30 atomic% or more and an oxygen content of 10 atomic% or more.

17. The phase shift mask according to any one of claims 13 to 16, wherein the lower layer has a nitrogen content of 50 atomic% or more.

18. The phase shift mask according to any one of claims 13 to 17, wherein the upper layer has an oxygen content of 50 atomic% or more.

19. The phase shift mask according to any one of claims 13 to 18, wherein the lower layer is greater in film thickness that the intermediate layer and the upper layer and the intermediate layer is greater in film thickness than the upper layer.

20. The phase shift mask according to any one of claims 13 to 19, wherein the phase shift film has a function of allowing exposure light of an ArF excimer laser to be transmitted therethrough at a transmittance of 2% or more and a function of causing a phase difference of 150 degrees or more and 200 degrees or less between the exposure light transmitted through the phase shift film and the exposure light transmitted through air for a same distance as a thickness of the phase shift film.

21. The phase shift mask according to any one of claims 13 to 20, further comprising a light shielding film formed on the phase shift film and having a light shielding pattern.

22. The phase shift mask according to any one of claims 13 to 21, wherein the upper layer has an oxygen content of 66 atomic% or less.

23. The phase shift mask according to any one of claims 13 to 22, wherein the upper layer has a nitrogen content of 10 atomic% or less.

24. The phase shift mask according to any one of claims 13 to 23, wherein a total content of silicon and oxygen in the upper layer is 95 atomic% or more.

25. A method for manufacturing a semiconductor device, comprising a step of carrying out exposure transfer of a transfer pattern onto a resist film on a semiconductor substrate by using the phase shift mask according to any one of claims 13 to 24.