CLAIMS:

1. A halftone phase shift photomask blank comprising a transparent substrate and a halftone phase shift film thereon providing a phase shift of 150° to 200° and a transmittance of 9% to 40% with respect to light of wavelength up to 200 nm, wherein

said halftone phase shift film consists of a transition metal, silicon, oxygen and nitrogen, has an average transition metal content of at least 3 at%, and is composed of a plurality of layers including at least one stress relaxation layer consisting of the transition metal, silicon, oxygen and nitrogen and at least one phase shift adjusting layer consisting of the transition metal, silicon, oxygen and nitrogen,

said stress relaxation layer has an oxygen content of at least 3 at% which is the lowest,

said phase shift adjusting layer has an oxygen content of at least 5 at% which is at least 2 at% higher than the oxygen content of the stress relaxation layer.

2. The photomask blank of claim 1 wherein said halftone phase shift film is formed contiguous to the transparent substrate.

3. The photomask blank of claim 2 wherein a layer disposed closest to the transparent substrate is the stress relaxation layer.

4. The photomask blank of any one of claims 1 to 3 wherein said halftone phase shift film consists of at least three layers, and each of the phase shift adjusting layers is disposed contiguous to any stress relaxation layer.

5. The photomask blank of any one of claims 1 to 4 wherein the transition metal content is in a range of 5 at% to 10 at%.

6. The photomask blank of any one of claims 1 to 5 wherein the transition metal is molybdenum.

7. The photomask blank of any one of claims 1 to 6 wherein the halftone phase shift film has a transmittance of 9% to 12%.

8. The photomask blank of any one of claims 1 to 6 wherein the halftone phase shift film has a transmittance of 15% to 30%.

9. The photomask blank of any one of claims 1 to 8 which is processed into a halftone phase shift photomask, the photomask being suited for use in photolithography for forming a pattern with a half pitch of up to 50 nm on a processable substrate, and in the patternwise exposure step for transferring the pattern to a photoresist film formed on the processable substrate using exposure light of wavelength up to 200 nm.

10. A method for preparing a halftone phase shift photomask blank comprising a transparent substrate and a halftone phase shift film thereon providing a phase shift of 150° to 200° and a transmittance of 9% to 40% with respect to light of wavelength up to 200 nm,

said method comprising the step of forming a halftone phase shift film on the transparent substrate, said halftone phase shift film consisting of a transition metal, silicon, oxygen and nitrogen, having an average transition metal content of at least 3 at%, and being composed of a plurality of layers including at least one stress relaxation layer consisting of the transition metal, silicon, oxygen and nitrogen and at least one phase shift adjusting layer consisting of the transition metal, silicon, oxygen and nitrogen, said stress relaxation layer having an oxygen content of at least 3 at% which is the lowest, said phase shift adjusting layer having an oxygen content of at least 5 at% which is at least 2 at% higher than the oxygen content of the stress relaxation layer.

11. The method of claim 10 wherein the halftone phase shift film has a transmittance of 9% to 12%, and the method further

includes the step of irradiating pulse of infrared-containing light to the halftone phase shift film on the substrate.

12. The method of claim 11, further comprising the step of heat treating the halftone phase shift film on the substrate by holding at 250 to 600°C for at least 2 hours prior to the step of pulse irradiation of infrared-containing light.

13. The method of claim 10 wherein the halftone phase shift film has a transmittance of 15% to 30%, and the method further includes the step of heat treating the halftone phase shift film on the substrate by holding at 250 to 600°C for at least 2 hours, but not the step of pulse irradiation of infrared-containing light.

14. A halftone phase shift photomask comprising a transparent substrate and a halftone phase shift film thereon providing a phase shift of 150° to 200° and a transmittance of 9% to 40% with respect to light of wavelength up to 200 nm, wherein

said halftone phase shift film consists of a transition metal, silicon, oxygen and nitrogen, has an average transition metal content of at least 3 at%, and is composed of a plurality of layers including at least one stress relaxation layer consisting of the transition metal, silicon, oxygen and nitrogen and at least one phase shift adjusting layer consisting of the transition metal, silicon, oxygen and nitrogen, the stress relaxation layer has an oxygen content of at least 3 at% which is the lowest, the phase shift adjusting layer has an oxygen content of at least 5 at% which is at least 2 at% higher than the oxygen content of the stress relaxation layer.

CLAIMS:

1. A halftone phase shift photomask blank comprising a transparent substrate and a halftone phase shift film thereon providing a phase shift of 150° to 200° and a transmittance of 9% to 40% with respect to light of wavelength up to 200 nm, wherein

said halftone phase shift film consists of a transition metal, silicon, oxygen and nitrogen, has an average transition metal content of at least 3 at%, and is composed of a plurality of layers including at least one stress relaxation layer consisting of the transition metal, silicon, oxygen and nitrogen and at least one phase shift adjusting layer consisting of the transition metal, silicon, oxygen and nitrogen,

said stress relaxation layer has an oxygen content of at least 3 at% which is the lowest,

said phase shift adjusting layer has an oxygen content of at least 5 at% which is at least 2 at% higher than the oxygen content of the stress relaxation layer.

2. The photomask blank of claim 1 wherein said halftone phase shift film is formed contiguous to the transparent substrate.

3. The photomask blank of claim 2 wherein a layer disposed closest to the transparent substrate is the stress relaxation layer.

4. The photomask blank of any one of claims 1 to 3 wherein said halftone phase shift film consists of at least three layers, and each of the phase shift adjusting layers is disposed contiguous to any stress relaxation layer.

5. The photomask blank of any one of claims 1 to 4 wherein the transition metal content is in a range of 5 at% to 10 at%.

6. The photomask blank of any one of claims 1 to 5 wherein the transition metal is molybdenum.

7. The photomask blank of any one of claims 1 to 6 wherein the halftone phase shift film has a transmittance of 9% to 12%.

8. The photomask blank of any one of claims 1 to 6 wherein the halftone phase shift film has a transmittance of 15% to 30%.

9. The photomask blank of any one of claims 1 to 8 which is processed into a halftone phase shift photomask, the photomask being suited for use in photolithography for forming a pattern with a half pitch of up to 50 nm on a processable substrate, and in the patternwise exposure step for transferring the pattern to a photoresist film formed on the processable substrate using exposure light of wavelength up to 200 nm.

10. A method for preparing a halftone phase shift photomask blank comprising a transparent substrate and a halftone phase shift film thereon providing a phase shift of 150° to 200° and a transmittance of 9% to 40% with respect to light of wavelength up to 200 nm,

said method comprising the step of forming a halftone phase shift film on the transparent substrate, said halftone phase shift film consisting of a transition metal, silicon, oxygen and nitrogen, having an average transition metal content of at least 3 at%, and being composed of a plurality of layers including at least one stress relaxation layer consisting of the transition metal, silicon, oxygen and nitrogen and at least one phase shift adjusting layer consisting of the transition metal, silicon, oxygen and nitrogen, said stress relaxation layer having an oxygen content of at least 3 at% which is the lowest, said phase shift adjusting layer having an oxygen content of at least 5 at% which is at least 2 at% higher than the oxygen content of the stress relaxation layer.

11. The method of claim 10 wherein the halftone phase shift film has a transmittance of 9% to 12%, and the method further includes the step of irradiating pulse of infrared-containing light to the halftone phase shift film on the substrate.

12. The method of claim 11, further comprising the step of heat treating the halftone phase shift film on the substrate by holding at 250 to 600°C for at least 2 hours prior to the step of pulse irradiation of infrared-containing light.

13. The method of claim 10 wherein the halftone phase shift film has a transmittance of 15% to 30%, and the method further includes the step of heat treating the halftone phase shift film on the substrate by holding at 250 to 600°C for at least 2 hours, but not the step of pulse irradiation of infrared-containing light.

14. A halftone phase shift photomask comprising a transparent substrate and a halftone phase shift film thereon providing a phase shift of 150° to 200° and a transmittance of 9% to 40% with respect to light of wavelength up to 200 nm, wherein

said halftone phase shift film consists of a transition metal, silicon, oxygen and nitrogen, has an average transition metal content of at least 3 at%, and is composed of a plurality of layers including at least one stress relaxation layer consisting of the transition metal, silicon, oxygen and nitrogen and at least one phase shift adjusting layer consisting of the transition metal, silicon, oxygen and nitrogen, the stress relaxation layer has an oxygen content of at least 3 at% which is the lowest, the phase shift adjusting layer has an oxygen content of at least 5 at% which is at least 2 at% higher than the oxygen content of the stress relaxation layer.