on the semiconductor substrate because interference of light caused in exposure is affected to the transfer.

Thus, a pattern to be formed on the photomask is formed more intricate than the actual circuit pattern to moderate such influence of interference of light in some cases. A pattern configuration for this purpose is exemplified by a configuration applied optical proximity correction (OPC) to the actual circuit pattern. For pattern miniaturization and accuracy enhancement, modified illumination, immersion lithography, and resolution enhancement technology (RET) are used as well as double patterning lithography.

As one of the resolution enhancement technology (RET), a phase shift method is used. The phase shift method is a contrast enhancing method by utilizing interference of light caused by a film pattern capable of inverting phase approximately 180° formed in the photomask. A halftone phase shift-type photomask is one of the photomasks employing such method. The halftone phase shift-type photomask includes a transparent substrate made of quartz or the like, which is transparent to exposure light, and a mask pattern made of a halftone phase shift film formed thereon, which can invert the phase approximately 180° and has a transmittance insufficient to contribute to pattern formation. An exemplary halftone phase shift-type photomask, ever proposed, includes a halftone phase shift film composed of molybdenum silicon oxide (MoSiO), or molybdenum silicon oxynitride (MoSiON) (JP-A H07-140635 (Patent Document 1)).

Citation List

Patent Document 1: JP-A H07-140635
Patent Document 2: JP-A 2007-33469
Patent Document 3: JP-A 2007-233179
Patent Document 4: JP-A-2007-241065

SUMMARY

In one aspect, there is provided a phase shift-type photomask blank comprising a substrate, and a phase shift film thereon, the phase shift film consisting of a single layer or multiple layers, said single layer or multiple layers comprising at least one layer composed of transition metal, silicon, nitrogen and oxygen, wherein the phase shift film has a phase shift of 150 to 250°, and a transmittance of 60 to 80%, with respect to light having a wavelength of up to 200 nm, and a thickness of up to 150 nm, and the layer composed of

transition metal, silicon, nitrogen and oxygen has a content (atomic ratio) of at least 0.001 and up to 0.03, as a ratio of the transition metal to a total content of the transition metal and silicon.

In another aspect, there is provided a phase shift-type photomask blank comprising a substrate, and a phase shift film thereon, the phase shift film consisting of a single layer or multiple layers, said single layer or multiple layers comprising at least one layer selected from the group consisting of a layer composed of transition metal, silicon, nitrogen and oxygen, and a layer composed of silicon, nitrogen and oxygen, wherein the phase shift film has a phase shift of 150 to 250°, and a transmittance of 60 to 80%, with respect to light having a wavelength of up to 200 nm, and a thickness of up to 150 nm, the layer composed of transition metal, silicon, nitrogen and oxygen has a content (atomic ratio) of up to 0.03, as a ratio of the transition metal to a total content of the transition metal and silicon, and the transition metal comprises molybdenum.

DISCLOSURE OF INVENTION

A transmittance of a phase shift film was commonly a transmittance of up to20%, typically about 6%, however, recent investigations are also directed to higher transmittance. The film having a high transmittance has also a high attenuation effect of light due to interference, making an advantageous for fine patterning in some cases. To manufacture a phase shift-type photomask blank having a high transmittance, high oxygen content is needed for increasing the transmittance. However, a higher oxygen content can increase

CLAIMS:

1. A phase shift-type photomask blank comprising a substrate, and a phase shift film thereon, the phase shift film consisting of a single layer or multiple layers, said single layer or multiple layers comprising at least one layer composed of transition metal, silicon, nitrogen and oxygen, wherein

the phase shift film has a phase shift of 150 to 250°, and a transmittance of 60 to 80%, with respect to light having a wavelength of up to 200 nm, and a thickness of up to 150 nm, and

the layer composed of transition metal, silicon, nitrogen and oxygen has a content (atomic ratio) of at least 0.001 and up to 0.03, as a ratio of the transition metal to a total content of the transition metal and silicon.

2. The phase shift-type photomask blank of claim 1, wherein the transition metal comprises molybdenum.

3. A phase shift-type photomask blank comprising a substrate, and a phase shift film thereon, the phase shift film consisting of a single layer or multiple layers, said single layer or multiple layers comprising at least one layer selected from the group consisting of a layer composed of transition metal, silicon, nitrogen and oxygen, and a layer composed of silicon, nitrogen and oxygen, wherein

the phase shift film has a phase shift of 150 to 250°, and a transmittance of 60 to 80%, with respect to light having a wavelength of up to 200 nm, and a thickness of up to 150 nm,

the layer composed of transition metal, silicon, nitrogen and oxygen has a content (atomic ratio) of up to 0.03, as a ratio of the transition metal to a total content of the transition metal and silicon, and

the transition metal comprises molybdenum.

4. The phase shift-type photomask blank of any one of claims 1 to 3, wherein each layer composing the phase shift film has a total content of nitrogen and oxygen of at least 50 at%.

5. The phase shift-type photomask blank of any one of claims 1 to 4, wherein each layer composing the phase shift film has a nitrogen content of at least 10 at%, and the nitrogen content is lower than an oxygen content in said layer.

6. The phase shift-type photomask blank of any one of claims 1 to 5, further comprising a second layer consisting of a single layer or multiple layers on the phase shift film, the second layer being composed of a chromium-containing material.

7. A phase shift-type photomask prepared by using the phase shift-type photomask blank of any one of claims 1 to 6.