[DOCUMENT] CLAIMS

[Claim 1]

A mask blank comprising a phase shift film on a transparent substrate,

wherein the phase shift film has a structure where a first layer, a second layer, and a third layer are stacked in this order from a side of the transparent substrate,

wherein the first layer is provided in contact with a surface of the transparent substrate,

wherein refractive indexes n_1 and n_2 of the first layer and the second layer, respectively, at a wavelength of an exposure light of an ArF excimer laser satisfy a relation of $n_1<n_2$,

wherein extinction coefficients k_1, k_2, and k_3 of the first layer, the second layer, and the third layer, respectively, at a wavelength of the exposure light satisfy a relation of $k_1<k_2<k_3$, and

wherein film thicknesses d_1 and d_2 of the first layer and the second layer, respectively, satisfy a relation of $d_1<d_2$.

[Claim 2]

The mask blank according to claim 1, wherein the extinction coefficient k_3 of the third layer at a wavelength of the exposure light is 1.0 or more.

[Claim 3]

A mask blank comprising a phase shift film on a transparent substrate,

wherein the phase shift film has a structure where a first layer, a second layer, and a third layer are stacked in this order from a side of the transparent substrate,

wherein the first layer is provided in contact with a surface of the transparent substrate,

wherein refractive indexes n_1, n_2, and n_3 of the first layer, the second layer, and the third layer, respectively, at a wavelength of an exposure light of an ArF excimer laser satisfy a relation of $n_3<n_1<n_2$,

wherein extinction coefficients k_1 and k_2 of the first layer and the second layer, respectively, at a wavelength of the exposure light satisfy a relation of $k_1<k_2$, and

wherein film thicknesses d_1 and d_2 of the first layer and the second layer, respectively, satisfy a relation of $d_1<d_2$.

[Claim 4]

The mask blank according to claim 3, wherein the refractive index n_3 of the third layer at a wavelength of an exposure light of an ArF excimer laser_is less than 1.8.

[Claim 5]

The mask blank according to any one of claims 3 to 4, wherein an extinction coefficient k_3 of the third layer at a wavelength of the exposure light satisfies a relation of $k_3<k_1<k_2$.

[Claim 6]

The mask blank according to claim 5, wherein the refractive index n_3 of the third layer is 1.7 or less, and the extinction coefficient k_3 of the third layer is 0.02 or less.

[Claim 7]

The mask blank according to claim 5 or 6, wherein the third layer is formed from a material comprising silicon and oxygen, or a material comprising silicon, oxygen, and one or more elements selected from a metalloid element and a non-metallic element.

[Claim 8]

The mask blank according to any one of claims 1 to 7, wherein the refractive index n_1 of the first layer is 1.8 or more and the extinction coefficient k_1 of the first layer is 0.15 or less.

[Claim 9]

The mask blank according to any one of claims 1 to 8, wherein a refractive index n_2 of the second layer is 2.2 or more and an extinction coefficient k_2 of the second layer

is 0.2 or more.

[Claim 10]

The mask blank according to any of claims 1 to 9,

wherein a refractive index n_S of the transparent substrate at a wavelength of the exposure light satisfies a relation of $n_S<n_1<n_2$, and

wherein an extinction coefficient k_S of the transparent substrate at a wavelength of the exposure light satisfies a relation of $k_S<k_1<k_2$.

[Claim 11]

The mask blank according to claim 10, wherein the refractive index n_S of the transparent substrate is 1.6 or less and the extinction coefficient k_S of the transparent substrate is 0.01 or less.

[Claim 12]

The mask blank according to any of claims 1 to 11, wherein the phase shift film has a function to transmit the exposure light at a transmittance of 15% or more, and a function to generate 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 the air for a same distance as a thickness of the phase shift film.

[Claim 13]

The mask blank according to any of claims 1 to 12,

wherein the first layer is formed from a material comprising silicon, nitrogen, and oxygen, or a material comprising silicon, nitrogen, oxygen, and one or more elements selected from a metalloid element and a non-metallic element, and

wherein the second layer is formed from a material comprising silicon and nitrogen, or a material comprising silicon, nitrogen, and one or more elements selected from a metalloid element and a non-metallic element.

[Claim 14]

The mask blank according to claim 13, wherein a

nitrogen content of the second layer is more than a nitrogen content of the first layer.

[Claim 15]

The mask blank according to any one of claims 1 to 14, wherein a film thickness d_3 of the third layer satisfies a relation of $d_3<d_1<d_2$.

[Claim 16]

The mask blank according to any of claims 1 to 15, wherein the third layer is formed from a material comprising silicon and nitrogen, or a material comprising silicon, nitrogen, and one or more elements selected from a metalloid element and a non-metallic element.

[Claim 17]

The mask blank according to any of claims 1 to 16,

wherein the phase shift film comprises a fourth layer on the third layer,

wherein a refractive index n_4 of the fourth layer at a wavelength of the exposure light satisfies a relation of $n_4<n_1<n_2$, and

wherein an extinction coefficient k_4 of the fourth layer at a wavelength of the exposure light satisfies a relation of $k_4<k_1<k_2$.

[Claim 18]

The mask blank according to claim 17, wherein the refractive index n_4 of the fourth layer is 1.7 or less and the extinction coefficient k_4 of the fourth layer is 0.02 or less.

[Claim 19]

The mask blank according to claim 17 or 18, wherein the fourth layer is formed from a material comprising silicon and oxygen, or a material comprising silicon, oxygen, and one or more elements selected from a metalloid element and a non-metallic element.

[Claim 20]

A phase shift mask provided with a transfer pattern on the phase shift film of the mask blank according to any

of claims 1 to 19.

[Claim 21]

A method of manufacturing a semiconductor device comprising the step of using the phase shift mask according to claim 20 and subjecting a resist film on a semiconductor substrate to exposure transfer of a transfer pattern.