CLAIMS

[Claim 1]

A reflective mask blank for EUV lithography comprising:

a substrate;

a multilayer reflective film that reflects EUV light;

a protection film that protects the multilayer reflective film; and

an absorption film that absorbs the EUV light, in this order from bottom to top, wherein

the protection film includes:

an upper layer made of a rhodium-based material containing Rh, or containing Rh and at least one element selected from a group consisting of N, O, C, B, Ru, Nb, Mo, Ta, Ir, Pd, Zr, and Ti, the rhodium-based material containing 50 at% to 100 at% of Rh; and

a lower layer containing at least one element selected from a group consisting of Ru, Nb, Mo, Zr, Y, C, and B, and satisfying a condition (I)

$$k < -0.15n + 0.16 \quad \text{... (I)}$$

in an EUV region [in the formula, n represents a refractive index and k represents an extinction coefficient].

[Claim 2]

The reflective mask blank according to claim 1, wherein

the lower layer contains at least one element selected from a group consisting of Ru and Nb.

[Claim 3]
The reflective mask blank according to claim 1 or 2, wherein
the refractive index n of the lower layer is 0.92 or less.

[Claim 4]
The reflective mask blank according to claim 1 or 2, wherein
the lower layer contains Ru.

[Claim 5]
The reflective mask blank according to claim 1 or 2, wherein
a thickness of the upper layer is 0.5 nm or more and 3.5 nm or less, and
a thickness of the lower layer is 0.4 nm or more and 2.5 nm or less.

[Claim 6]
The reflective mask blank according to claim 1 or 2, wherein
the absorption film contains at least one element selected from Ru, Ir, Pt, Pd, Au, Ta, and Cr; and at least one non-metal element selected from O, B, and C.

[Claim 7]
The reflective mask blank according to claim 1 or 2 further comprising an etching mask film on the absorption film, wherein

the etching mask film contains at least one element selected from a group consisting of Al, Hf, Y, Cr, Nb, Ti, Mo, Ta, and Si.

[Claim 8]

A reflective mask comprising the reflective mask blank according to claim 1 or 2, wherein

a pattern is formed in the absorption film.

[Claim 9]

A method of manufacturing a reflective mask blank comprising:

on a substrate,

forming a multilayer reflective film that reflects EUV light;

forming a protection film that protects the multilayer reflective film; and

forming an absorption film that absorbs the EUV light, wherein

the forming the protection film includes

(i) forming a lower layer that contains at least one element selected from a group consisting of Ru, Nb, Mo, Zr, Y, C, and B, and satisfies a condition (I)

$$k < -0.15n + 0.16 \quad ...(I)$$

in an EUV region [in the formula n represents a refractive index and k represents an extinction coefficient]; and

(ii) forming an upper layer made of a rhodium-based material that contains Rh, or contains Rh and at least one element selected from a group

consisting of N, O, C, B, Ru, Nb, Mo, Ta, Ir, Pd, Zr, and Ti, the rhodium-based material containing 50 at% to 100 at% of Rh.

[Claim 10]

The method of manufacturing a reflective mask blank according to claim 9, wherein

film formation is continuously performed without exposure to an atmosphere from a start of the forming the lower layer of the protection film until an end of the forming the upper layer of the protection film.

[Claim 11]

The method of manufacturing a reflective mask blank according to claim 10, wherein

the film formation is continuously performed without exposure to an atmosphere from a start of forming the multilayer reflective film until an end of the forming the lower layer and the upper layer of the protection film.

[Claim 12]

The method of manufacturing a reflective mask blank according to claim 10 or 11, wherein

each of the lower layer and the upper layer of the protection film is formed using a magnetron sputtering method or an ion beam sputtering method.

[Claim 13]

The method of manufacturing a reflective mask blank according to claim11, wherein

each of the multilayer reflective film, and the lower layer and the upper layer of the protection film is formed using a magnetron sputtering method or an ion beam sputtering method.

[Claim 14]

A method of manufacturing a reflective mask, comprising:

preparing the reflective mask blank manufactured by using the method of manufacturing a reflective mask blank according to claim 9; and

forming an opening pattern in the absorption film.