CLAIMS

1. A reflective mask blank comprising:

a substrate;

a multilayer reflective film provided on the substrate; and

an absorber film provided on the multilayer reflective film,

wherein the absorber film includes at least one high absorption coefficient element selected from a group consisting of cobalt (Co) and nickel (Ni) and an element that increases a dry etching rate in at least a part of the absorber film,

the absorber film includes a lower surface region including a surface on a side of the substrate and an upper surface region including a surface on a side opposite to the substrate,

a concentration (atomic %) of the high absorption coefficient element in the upper surface region is higher than a concentration (atomic %) of the high absorption coefficient element in the lower surface region,

a material of the upper surface region consists of a material comprising the high absorption coefficient element or a material comprising the high absorption coefficient element and the element that increases a dry etching rate, and

the absorber film is formed by a sputtering method with a target comprising the high absorption coefficient element.

2. The reflective mask blank according to claim 1, wherein a concentration (atomic %) of the element that increases the dry etching rate in the lower surface region is higher than a concentration (atomic %) of the element that increases the dry etching rate in the upper surface region.

3. The reflective mask blank according to claim 1 or 2, wherein the element that increases the dry etching rate is at least one element selected from a group consisting of tantalum (Ta), tungsten (W), and tin (Sn).

4. The reflective mask blank according to any one of claims 1 to 3, wherein the upper surface region consists of a material comprising Co alone, Ni alone, $CoTa_3$, CoTa, Co_3Ta, $NiTa_3$, or NiTa.

5. The reflective mask blank according to any one of claims 1 to 4, wherein the absorber film is a layered film including a lower layer including the lower surface region and an upper layer including the upper surface region, and when a concentration (atomic %) of the high absorption coefficient element that is included in a material of the lower layer is $C1_{lower}$ and a concentration (atomic %) of the high absorption coefficient element that is included in a material of the upper layer is

$C1_{upper}$, the following formula holds:

$$C1_{upper} > C1_{lower} \geq 0 \cdots \text{(Formula 1)}$$

6. The reflective mask blank according to claim 5, wherein when a concentration (atomic %) of the element that is included in the material of the lower layer and increases the dry etching rate is $C2_{lower}$, and a concentration (atomic %) of the element that is included in the material of the upper layer and increases the dry etching rate, is $C2_{upper}$, the following formula holds:

$$C2_{lower} > C2_{upper} \geq 0 \cdots \text{(Formula 2)}$$

7. The reflective mask blank according to claim 5 or 6, wherein the material of the upper layer includes cobalt (Co) and tantalum (Ta), and the material of the lower layer includes tantalum (Ta).

8. The reflective mask blank according to claim 5 or 6, wherein the material of the upper layer includes nickel (Ni) and tantalum (Ta), and the material of the lower layer includes tantalum (Ta).

9. The reflective mask blank according to any one of claims 5 to 8, wherein the upper layer includes a material that is etchable by a dry etching gas including a first chlorine-based gas, and the lower layer includes a material that is etchable by a dry etching gas including a second chlorine-based gas different from the first chlorine-based gas.

10. The reflective mask blank according to any one of claims 1 to 9, wherein a protective film is provided between the multilayer reflective film and the absorber film.

11. The reflective mask blank according to claim 10, wherein an etching stopper film is provided between the protective film and the absorber film, and the etching stopper film includes a material including chromium (Cr) or a material including silicon (Si).

12. The reflective mask blank according to any one of claims 1 to 11, wherein an etching mask film is provided on the absorber film, and the etching mask film includes a material including chromium (Cr) or a material including silicon (Si).

13. A reflective mask having an absorber pattern that is the absorber film with patterned in the reflective mask blank according to any one of claims 1 to 12 is patterned.

14. A method of manufacturing a reflective mask, the method comprising:

forming an absorber pattern by patterning the absorber film of the reflective mask blank according to any one of claims 1 to 12 by dry etching using a chlorine-based gas.

15. A method of manufacturing a reflective mask, the method comprising: forming an absorber pattern by patterning the absorber film of the reflective mask blank according to any one of claims 1 to 12 by dry etching using a first chlorine-based gas and a second chlorine-based gas different from the first chlorine-based gas.

16. A method of manufacturing a semiconductor device, the method comprising: a step of setting the reflective mask according to claim 13 in an exposure apparatus having an exposure light source that emits EUV light and transferring a transfer pattern to a resist film formed on a transfer-receiving substrate.