A second resist pattern 521 is formed from the second resist film 52 (FIG. 12C). With the second resist pattern 521 made etching mask, chlorine base dry etching is carried out to pattern the light shielding film pattern 71 to form an outer frame pattern 711 of light shielding film (FIG. 12D). Finally the second resist pattern 521 is removed, yielding a photomask 91 (FIG. 12E). When the photomask having the outer frame pattern 711 of light shielding film is prepared in this way, the second resist film 52 is formed in the recess of the photomask pattern as well, indicating a possibility that after removal of the second resist film 52, resist residues are left in the recess of the photomask pattern. This can cause defects to the photomask.

Embodiments of the invention seek to provide a photomask blank from which a photomask having both a fine photomask pattern and an outer frame pattern with a high degree of light shielding can be prepared via efficient steps at a high accuracy and with a minimized possibility of defect generation.

The inventors have found that a photomask blank is constructed as comprising a transparent substrate, a second film formed on the substrate optionally via a first film, a third film formed contiguous to the second film, and a fourth film formed contiguous to the third film, wherein the first and third films are formed of materials which are resistant to chlorine base dry etching and removable by fluorine base dry etching, the second and fourth films are formed of materials which are resistant to fluorine base dry etching and removable by chlorine base dry etching, the second and fourth films are constructed such that an etching clear time of the fourth film on chlorine base dry etching under one set of conditions is longer than an etching clear time of the second film on chlorine base dry etching under the one set of conditions. When a photomask is prepared from the photomask blank, formation of a photomask pattern and formation of an outer frame pattern may be made separate in the pattern forming step of the photomask preparing method, that is, after the outer frame pattern is formed, the photomask pattern may be formed via simple steps. Thus a photomask meeting both a photomask pattern of fine size and an outer frame pattern with a high degree of light shielding can be prepared via efficient steps at a high accuracy and with a minimized possibility of defect generation.

According to a first aspect of the present invention, there is provided a photomask blank comprising a transparent substrate, a second film formed on the substrate optionally via a first film, a third film being a hard mask film formed contiguous to the second film,

and a fourth film formed contiguous to the third film, wherein the first and third films are formed of materials which are resistant to chlorine base dry etching and removable by fluorine base dry etching, the second and fourth films are formed of materials which are resistant to fluorine base dry etching and removable by chlorine base dry etching, the second and fourth films are constructed such that an etching clear time of the fourth film on chlorine base dry etching under one condition is longer than an etching clear time of the second film on chlorine base dry etching under said one condition, wherein the third film is thinner than the second film, and the thickness of the third film is up to 1/3 of the thickness of the second film.

According to a second aspect of the present invention, there is provided a photomask blank comprising a transparent substrate, a second film formed on the substrate optionally via a first film, a third film being a hard mask film formed contiguous to the second film, and a fourth film formed contiguous to the third film, wherein the first and third films are formed of materials which are resistant to chlorine base dry etching and removable by fluorine base dry etching, the second and fourth films are formed of materials which are resistant to fluorine base dry etching and removable by chlorine base dry etching, the second and fourth films are constructed such that an etching clear time of the fourth film on chlorine base dry etching under one condition is longer than an etching clear time of the second film on chlorine base dry etching under said one condition, wherein the third film is thinner than the fourth film, and the difference in thickness between the fourth film and the third film is at least 50 nm, or the thickness of the third film is up to 1/6 of the thickness of the fourth film.

Embodiments of the invention provide a photomask blank comprising a transparent substrate, a second film formed on the substrate optionally via a first film, a third film serving as a hard mask film formed contiguous to the second film, and a fourth film formed contiguous to

the third film. The first and third films are formed of materials which are resistant to chlorine base dry etching and removable by fluorine base dry etching. The second and fourth films are formed of materials which are resistant to fluorine base dry etching and removable by chlorine base dry etching. The second and fourth films are constructed such that an etching clear time of the fourth film on chlorine base dry etching under one set of conditions is longer than an etching clear time of the second film on chlorine base dry etching under said one set of conditions.

In a preferred embodiment, a ratio of the etching clear time of the fourth film to the etching clear time of the second film is up to 5.

In a preferred embodiment, the first film is formed on the substrate and the second film is formed contiguous to the first film. Typically, the first film is a phase shift film.

In a preferred embodiment, the first film is absent and the second film is formed contiguous to the substrate.

In a preferred embodiment, the first and third films or the third film is formed of silicon-containing materials; the second and fourth films are formed of silicon-free, chromium-containing materials.

In a preferred embodiment, the second film is a light shielding film; and the second film has a thickness of 15 to 100 nm.

In a preferred embodiment, the third film has a thickness of 1 to 20 nm.

In a preferred embodiment, the third film is thinner than the second film; and the third film is thinner than the fourth film.

In a preferred embodiment, the fourth film has a thickness of 30 to 120 nm.

ADVANTAGEOUS EFFECTS OF INVENTION

Advantages are obtained when the photomask blank of the invention is processed into a photomask. In the pattern forming step of the photomask preparing method, after an outer frame pattern is formed, a photomask pattern can be formed via simple steps. The previous formation of the outer frame pattern minimizes a possibility of defect generation due to resist residues.

CLAIMS:

1. A photomask blank comprising a transparent substrate, a second film formed on the substrate optionally via a first film, a third film being a hard mask film formed contiguous to the second film, and a fourth film formed contiguous to the third film, wherein

the first and third films are formed of materials which are resistant to chlorine base dry etching and removable by fluorine base dry etching,

the second and fourth films are formed of materials which are resistant to fluorine base dry etching and removable by chlorine base dry etching,

the second and fourth films are constructed such that an etching clear time of the fourth film on chlorine base dry etching under one condition is longer than an etching clear time of the second film on chlorine base dry etching under said one condition, wherein

the third film is thinner than the second film, and the thickness of the third film is up to 1/3 of the thickness of the second film.

2. The photomask blank of claim 1, wherein a ratio of the etching clear time of the fourth film to the etching clear time of the second film is up to 5.

3. The photomask blank of claim 1 or 2, wherein the first film is formed on the substrate and the second film is formed contiguous to the first film.

4. The photomask blank of claim 3, wherein the first film is a phase shift film.

5. The photomask blank of claim 1 or 2, wherein the first film is absent and the second film is formed contiguous to the substrate.

6. The photomask blank of any one of claims 1 to 5, wherein the first and third films or the third film is formed of silicon-containing materials.

7. The photomask blank of any one of claims 1 to 6, wherein the second and fourth films are formed of silicon-free, chromium-containing materials.

8. The photomask blank of any one of claims 1 to 7, wherein the second film is a light shielding film.

9. The photomask blank of claim 8, wherein the second film has a thickness of 15 to 100 nm.

10. The photomask blank of any one of claims 1 to 9, wherein the third film has a thickness of 1 to 20 nm.

11. The photomask blank of any one of claims 1 to 10, wherein the fourth film has a thickness of 30 to 120 nm.

12. The photomask blank of any one of claims 1 to 11, wherein the difference in thickness between the second film and the third film is at least 30 nm.

13. A photomask blank comprising a transparent substrate, a second film formed on the substrate optionally via a first film, a third film being a hard mask film formed contiguous to the second film, and a fourth film formed contiguous to the third film, wherein

the first and third films are formed of materials which are resistant to chlorine base dry etching and removable by fluorine base dry etching,

the second and fourth films are formed of materials which are resistant to fluorine base dry etching and removable by chlorine base dry etching,

the second and fourth films are constructed such that an etching clear time of the fourth film on chlorine base dry etching under one condition is longer than an etching clear time of the second film on chlorine base dry etching under said one condition, wherein

the third film is thinner than the fourth film, and

the difference in thickness between the fourth film and the third film is at least 50 nm, or the thickness of the third film is up to 1⁄6 of the thickness of the fourth film.

14. The photomask blank of claim 13, wherein a ratio of the etching clear time of the fourth film to the etching clear time of the second film is up to 5.

15. The photomask blank of claim 13 or 14, wherein the first film is formed on the substrate and the second film is formed contiguous to the first film.

16. The photomask blank of claim 15, wherein the first film is a phase shift film.

17. The photomask blank of claim 13 or 14, wherein the first film is absent and the second film is formed contiguous to the substrate.

18. The photomask blank of any one of claims 13 to 17, wherein the first and third films or the third film is formed of silicon-containing materials.

19. The photomask blank any one of claims 13 to 18, wherein the second and fourth films are formed of silicon-free, chromium-containing materials.

20. The photomask blank of any one of claims 13 to 19, wherein the second film is a light shielding film.

21. The photomask blank of claim 20, wherein the second film has a thickness of 15 to 100 nm.

22. The photomask blank of any one of claims 13 to 21, wherein the third film has a thickness of 1 to 20 nm.