molybdenum (Mo), and at least one additive element selected from the group consisting of nitrogen (N), carbon (C), boron (B), silicon (Si) and hydrogen (H), and the other layer containing molybdenum (Mo) and being substantively free of other elements other than molybdenum (Mo). Further, the inventers found that the multilayer reflection film has a sufficiently lowed background level (BGL) in defect inspection with a sufficiently high reflectance with respect to exposure light.

In one aspect, the disclosure provides a reflective mask blank comprising a substrate, a multilayer reflection film formed on one main surface of the substrate and reflects exposure light, wherein

the multilayer reflection film has a periodically laminated structure portion in which low refractive index layers and high refractive index layers are alternately laminated,

at least one of the low refractive index layers constituting the multilayer reflection film has a two-layered structure consisting of a first sublayer and a second sublayer,

the first sublayer comprises molybdenum (Mo), and at least one additive element selected from the group consisting of nitrogen (N), carbon (C), boron (B), silicon (Si) and hydrogen (H), and has a thickness of more than 0.3 nm and not more than 0.6 nm,

the second sublayer comprises molybdenum (Mo) and is substantively free of other elements other than molybdenum (Mo), and

the multilayer reflection film has a crystalline diameter of not less than 2.6 nm that is calculated from the X-ray diffraction peak of Mo (110) detected in X-ray diffraction.

Preferably, in the low refractive index layer, the first sublayer is formed at the side of the substrate, and the second sublayer is formed at the side remote from the substrate.

Preferably, the high refractive index layer contains silicon (Si).

Preferably, the substrate has dimensions of 152 mm-square of the one main surface and 6.35 mm of thickness, and

an amount of change in flatness (ΔTIR) within a range of 142 mm-square at the center of the one main surface that is a difference of flatnesses before and after forming the multilayer reflection film is not more than 0.7 μm as an absolute value.

Preferably, the reflective mask blank includes a protection layer that is formed at the side remote from the substrate and in contact with the periodically laminated structure portion.

Preferably, the reflective mask blank further includes an absorber film that absorbs the exposure light on the multilayer reflection film.

In another example, the disclosure provides a reflective mask including a pattern formed by patterning the absorber film of the reflective mask blank

ADVANTAGEOUS EFFECTS OF THE INVENTION

According to the invention, a reflective mask blank that includes a multilayer reflection film having a sufficiently lowed background level in defect inspection with a high reflectance with respect to exposure light can be provided.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. 1A and 1B are cross-sectional views illustrating examples of first embodiment of a reflective mask blank of the invention. FIG. 1A is a reflective mask blank in which a multilayer reflection film consists of a periodically laminated structure portion, and FIG. 1B is a reflective mask blank in which a multilayer reflection film consists of a periodically laminated structure portion and a protection layer.

FIGS. 2A and 2B are cross-sectional views illustrating examples of second embodiment of a reflective mask blank of the invention. FIG. 2A is a reflective mask blank in which a multilayer reflection film consists of a periodically laminated structure portion, and FIG. 2B is a reflective mask blank in which a multilayer reflection film consists of a periodically laminated structure portion and a protection layer.

DESCRIPTION OF THE PREFERRED EMBODIMENT

A reflective mask blank of the invention includes a substrate, and a multilayer reflection film formed on one main surface (front side surface) of the substrate and reflects exposure light, in particular, EUV light. The reflective mask blank of the invention is suitable for a material used in manufacturing a reflective mask. The multilayer reflection film of the invention has a periodically laminated structure portion in which low refractive index layers and high refractive index layers are alternately laminated. The multilayer reflection film of the invention may further include a protection layer that is formed at the side remote from the substrate and in contact with the periodically laminated structure portion. The multilayer reflection film of the invention preferably consists of the

CLAIMS:

1. A reflective mask blank comprising a substrate, a multilayer reflection film formed on one main surface of the substrate and reflects exposure light, wherein

the multilayer reflection film has a periodically laminated structure portion in which low refractive index layers and high refractive index layers are alternately laminated,

at least one of the low refractive index layers constituting the multilayer reflection film has a two-layered structure consisting of a first sublayer and a second sublayer,

the first sublayer comprises molybdenum (Mo), and at least one additive element selected from the group consisting of nitrogen (N), carbon (C), boron (B), silicon (Si) and hydrogen (H), and has a thickness of more than 0.3 nm and not more than 0.6 nm,

the second sublayer comprises molybdenum (Mo) and is substantively free of other elements other than molybdenum (Mo), and

the multilayer reflection film has a crystalline diameter of not less than 2.6 nm that is calculated from the X-ray diffraction peak of Mo (110) detected in X-ray diffraction.

2. The reflective mask blank of claim 1 wherein in the low refractive index layer, the first sublayer is formed at the side of the substrate, and the second sublayer is formed at the side remote from the substrate.

3. The reflective mask blank of claim 1 or 2 wherein the high refractive index layer comprises silicon (Si).

4. The reflective mask blank of any one of claims 1 to 3 wherein

the substrate has dimensions of 152 mm-square of the one main surface and 6.35 mm of thickness, and

an amount of change in flatness (ΔTIR) within a range of 142 mm-square at the center of the one main surface that is a difference of flatnesses before and after forming the multilayer reflection film is not more than 0.7 μm as an absolute value.

5. The reflective mask blank of any one of claims 1 to 4 comprising a protection layer that is formed at the side remote from the substrate and in contact with the periodically laminated structure portion.

6. The reflective mask blank of any one of claims 1 to 5 further comprising an absorber film that absorbs the exposure light on the multilayer reflection film.

7. A reflective mask comprising a pattern formed by patterning the absorber film of the reflective mask blank of claim 6.