Claims

WHAT IS CLAIMED IS:

1. A blank mask, comprising:

a light transmissive substrate; and

a multilayer comprising a light shielding layer and a phase shift layer disposed between the light transmissive substrate and the light shielding layer,

wherein the phase shift layer comprises an upper surface facing the light shielding layer and a side surface connected to the upper surface, such that the light shielding layer is disposed on the upper surface and the side surface of the phase shift layer,

wherein when viewed from a top surface of the multilayer, the multilayer comprises a central portion and an outer portion surrounding the central portion,

wherein the outer portion has a curved upper surface, and

wherein, among dT values according to Equation 2 measured from the multilayer, a maximum value ranges from 10 nm to 30 nm:

[Equation 2]

$dT = T1 - T2$, and

in Equation 2, T1 denotes a thickness of the multilayer measured at a first point located in the multilayer, and T2 denotes a thickness of the multilayer measured at a second point located 0.1 mm apart from the first point in a direction of one edge of the multilayer.

2. The blank mask of claim 1, wherein the light transmissive substrate includes an upper surface facing the phase shift layer; and

wherein the light shielding layer is disposed on at least a portion of the upper surface of the light transmissive substrate.

3. The blank mask of claim 2, wherein the light transmissive substrate further comprises a side surface connected to the upper surface of the light transmissive substrate;

wherein the side surface of the light transmissive substrate comprises a first surface bent to extend from the upper surface of the light transmissive substrate, and a second surface extending from the first surface in a vertical direction of the blank mask; and

wherein the light shielding layer is disposed on at least a portion of the first surface of the light transmissive substrate.

4. The blank mask of claim 1, wherein, when viewed from the top surface of the multilayer, an area A of the light transmissive substrate, an area B of the light shielding layer, and an area C of the phase shift layer satisfy the following Equation 1:

[Equation 1]

$A \geq B > C$.

5. The blank mask of claim 1, wherein the outer portion of the multilayer comprises a slope area in which a thickness of the multilayer increases from an edge of the multilayer in an inward direction of the multilayer.

6. The blank mask of claim 5, wherein the slope area is disposed at an outermost portion of the multilayer; and

wherein in a cross-sectional view of the multilayer, the slope area has a width ranging from 0.2 mm to 1.0 mm in an in-plane direction of the multilayer.

7. The blank mask of claim 1, wherein, among ddT values according to Equation 3 measured from the multilayer, a maximum value is 30 nm or less:

[Equation 3]

$ddT = |(T1 - T2) - (T2 - T3)|$, and

in Equation 3, T1 denotes a thickness of the multilayer measured at a first point located in the multilayer, T2 denotes a thickness of the multilayer measured at a second point located 0.1 mm apart from the first point in a direction of one edge of the multilayer, and T3 denotes a thickness of the multilayer measured at a third point located 0.1 mm apart from the second point in the direction of the one edge of the multilayer.

8. The blank mask of claim 1, wherein the multilayer includes a lower surface in contact with the light transmissive substrate;

wherein the phase shift layer comprises a lower surface in contact with the light transmissive substrate;

wherein in a cross-sectional view of the multilayer, the lower surface of the multilayer comprises a first edge which is one end and a second edge which is the other end opposite to the first edge, and the lower surface of the phase shift layer comprises a third edge which is one end positioned adjacent to the first edge, and a fourth edge which is the other end positioned adjacent to the second edge; and

wherein a smaller value of a distance value between the first edge and the third edge and a distance value between the second edge and the fourth edge is 0.1 nm or more.

9. A photomask made from a blank mask, the blank mask comprising:

a light transmissive substrate; and

a multilayer comprising a light shielding layer and a phase shift layer that is disposed between the light transmissive substrate and the light shielding layer,

wherein the phase shift layer comprises an upper surface facing the light shielding layer and a side surface connected to the upper surface, such that the light shielding layer is disposed on the upper surface and the side surface of the phase shift layer,

wherein when viewed from a top surface of the multilayer, the multilayer comprises a central portion and an outer portion surrounding the central portion,

wherein the outer portion has a curved upper surface, and

wherein, among dT values according to Equation 2 measured from the multilayer, a maximum value ranges from 10 nm to 30 nm:

[Equation 2]

$dT = T1 - T2$, and

in Equation 2, T1 denotes a thickness of the multilayer measured at a first point located in the multilayer, and T2 denotes a thickness of the multilayer measured at a second point located 0.1 mm apart from the first point in a direction of one edge of the multilayer.

10. A method of manufacturing a semiconductor device, the method comprising:

preparing a light source, a photomask, and a semiconductor wafer on which a resist layer is applied;

selectively transmitting and emitting a light incident from the light source through the photomask to the semiconductor wafer; and

developing a photoresist pattern formed on the semiconductor wafer,

wherein the photomask is made from the blank mask according to claim 1.