[0178] In the development operation, the pattern may be developed on the semiconductor wafer by processing the semiconductor wafer that has undergone the exposure operation with a developer. When the applied resist layer is a positive resist, the portion of the resist layer on which the exposure light is incident may be dissolved by the developer. When the applied resist layer is a negative resist, a portion of the resist layer on which the exposure light is not incident may be dissolved by the developer. The resist layer is formed into a resist pattern by a process using the developer. A pattern may be formed on the semiconductor wafer using the resist pattern as a mask.

[0179] A description of the photomask overlaps the above-described content and thus will be omitted.

[0180] Hereinafter, specific examples will be described in more detail.

[0181] Manufacturing examples: Formation of light-blocking layer

[0182] Example 1: A light transmissive substrate made of quartz with 6 inches horizontally, 6 inches vertically, a thickness of 0.25 inches, and a flatness of less than 500 nm was disposed in a chamber of a DC sputtering device. A sputtering target having a composition shown in the following Table 1 was disposed in the chamber so that a T/S distance was 255 mm and an angle between the substrate and the target was 25 degrees. A magnet was installed on a rear surface of the sputtering target.

[0183] Thereafter, an atmospheric gas, in which 19 vol% Ar, 11 vol% N_2, 36 vol% CO_2, and 34 vol% He were mixed, was introduced into the chamber, and a first light-blocking layer was formed by performing a sputtering process for 250 seconds by applying power of 1.85 kW to the sputtering target and a magnet rotation speed of 113 rpm.

[0184] After the formation of the first light-blocking layer was completed, an atmosphere gas, in which 57 vol% Ar and 43 vol% N_2 were mixed, was introduced onto the first light-blocking layer in the chamber, and a second light-blocking layer was formed by performing a sputtering process for 25 seconds by applying power of 1.85 kW to the sputtering target and a magnet rotation speed of 113 rpm.

[0185] A sample on which the formation of the second light-blocking layer was completed was disposed in a thermal processing chamber. Thereafter, thermal processing was performed for 15 minutes by applying an ambient temperature of 250 °C.

[0186] A cooling plate, to which a cooling temperature ranging from 10 °C to 40 °C was applied, was installed on the substrate of a blank mask that had undergone the thermal processing process, and then cooling processing was performed. A distance between the substrate of the blank mask and the cooling plate was set to 0.1 mm. The cooling processing was performed for 5 to 20 minutes.

[0187] Example 2: A sample of a blank mask was manufactured under the same conditions, as in Example 1, except that a sputtering target was disposed as a target having a composition

CLAIMS

WHAT IS CLAIMED IS:

1. A method of manufacturing a blank mask, comprising:

providing a light transmissive substrate; and

disposing a light-blocking layer on the light transmissive substrate, the light-blocking layer comprising a transition metal and either one or both of oxygen and nitrogen, wherein the transition metal comprises Cr and Fe,

wherein disposing the light-blocking layer comprises

applying a sputtering target comprising 0.0001 to 0.035 parts by weight of Fe based on a total of 100 parts by weight of the transition metal, and

controlling an average value of grain sizes of a surface of the light-blocking layer to be in the range from 14 nm to 24 nm.

2. The method of claim 1, wherein disposing the light-blocking layer on the light transmissive substrate comprises controlling a number of grains on the surface of the light-blocking layer to be 20 or more and 55 or less per 0.01 μm^2.

3. The method of claim 1, wherein disposing the light-blocking layer comprises

disposing a first light-blocking layer on the light transmissive substrate and a second light-blocking layer on the first light-blocking layer, and

controlling an etching speed of the second light-blocking layer when etched with argon gas to be 0.3 Å/s or more and 0.5 Å/s or less.

4. The method of claim 1, wherein

disposing the light-blocking layer comprises disposing a first light-blocking layer on the light transmissive substrate and a second light-blocking layer on the first light-blocking layer, and

controlling an etching speed of the first light-blocking layer when etched with argon gas to be 0.56 Å/s or more.

5. The method of claim 1, further comprising controlling an etching speed of the light-blocking layer when etched with a chlorine-based gas to be 1.5 Å/s or more.

6. The method of claim 1, wherein the transition metal further includes any one or more among Ta, Ti, and Hf.

7. The method of claim 1, wherein

disposing the light-blocking layer comprises disposing a first light-blocking layer on the light transmissive substrate and a second light-blocking layer on the first light-blocking layer,

wherein the second light-blocking layer includes 40 at% or more and 70 at% or less transition metal.

8. A method of manufacturing a photomask comprising:

providing a light transmissive substrate; and

disposing a light-blocking pattern layer on the light transmissive substrate, the light-blocking pattern layer comprising a transition metal and either one or both of oxygen and nitrogen, wherein the transition metal comprises Cr and Fe,

wherein disposing the light-blocking layer comprises

applying a sputtering target comprising 0.0001 to 0.035 parts by weight of Fe based on a total of 100 parts by weight of the transition metal, and

controlling an average value of grain sizes of a surface of the light-blocking pattern layer to be in the range from 14 nm to 24 nm.

9. A method of manufacturing a semiconductor device, comprising:

preparing a light source, a photomask, and a semiconductor wafer, onto which a resist film has been applied;

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

developing a pattern on the semiconductor wafer,

wherein preparing the photomask comprises

providing a light transmissive substrate, and

disposing a light-blocking pattern layer on the light transmissive substrate,

wherein the light-blocking pattern layer includes a transition metal and either one or both of oxygen and nitrogen, wherein the transition metal comprises Cr and Fe, wherein disposing the light-blocking layer comprises

applying a sputtering target comprising 0.0001 to 0.035 parts by weight of Fe based on a total of 100 parts by weight of the transition metal, and

controlling an average value of grain sizes of a surface of the light-blocking pattern layer to be in the range from 14 nm to 24 nm.

10. The method of claim 9, wherein disposing the light-blocking layer comprises disposing a plurality of light-blocking layers,

wherein disposing the plurality of light-blocking layers comprises controlling an etching speed of a topmost light-blocking layer of the plurality of light-blocking layers etched with argon gas to be 0.3 Å/s or more and 0.5 Å/s or less.

11. The method of claim 9, wherein disposing the light-blocking layer comprises disposing a plurality of light-blocking layers,

wherein disposing the plurality of light-blocking layers comprises controlling an etching speed of an intermediate light-blocking layer of the plurality of light-blocking layers etched with argon gas to be 0.56 Å/s or more.