pattern is deformed. It is then difficult to transfer the resist pattern accurately to the light-shielding film.

The attempt to endow the photoresist or organic film with high resolution and high patterning accuracy as well as etch resistance encounters a technical barrier. The photoresist film must be reduced in thickness for the goal of high resolution whereas thinning of the photoresist film must be limited for the purpose of ensuring etch resistance during etching of the light-shielding film. As a result, there is a tradeoff relationship between high resolution/patterning accuracy and etch resistance. To mitigate the load to the photoresist to enable film thickness reduction for eventually forming a photomask pattern of higher accuracy, the construction (including thickness and composition) of a light-shielding film to be patterned must be ameliorated.

As to light-shielding film materials, a number of studies have been made. For example, Patent Document 4 discloses a metal film as the light-shielding film for ArF excimer laser lithography. Specifically, tantalum is used as the light-shielding film and tantalum oxide used as the antireflective film. To mitigate the load applied to the photoresist during etching of these two layers, the layers are etched with a fluorine-base gas plasma which causes relatively few damages to the photoresist. Despite a choice of such etching conditions, when two layers, light-shielding film and antireflective film are etched using only the photoresist as etch mask, the mitigation of the load to the photoresist is limited. It is difficult to fully meet the requirement to form a fine size photomask pattern at a high accuracy.

As discussed above, the prior art photomask blank structure is difficult to fully meet the requirement to form a fine size photomask pattern on the light-shielding film at a high accuracy. The problem becomes more serious with the photolithography using exposure light of shorter wavelength and requiring higher resolution, typically light with a wavelength of up to 200 nm (ArF excimer laser of 193 nm, F_2 laser of 157 nm).

index of resistance A, which is the product of resistivity and thickness when the resistance layer is a single layer, or the sum of the products of resistivity and thickness of sublayers when the resistance layer is a multilayer structure, meets the equation (1):

$$1.5\times10^{5} \geq A\times\alpha + \rho_c/d_c \qquad (1)$$

wherein α is a constant (expressed in cm^{-2}), ρ_c is the resistivity (expressed in $\Omega\cdot cm$) of the conductive layer, and d_c is the thickness (expressed in cm) of the conductive layer.

In a preferred embodiment, the conductive layer has a sheet resistance of not more than 1×10^{4} $\Omega/\square$.

In a preferred embodiment, the photomask blank further comprises a phase shift film between the substrate and the conductive layer, the phase shift film being formed of a silicon-containing material or a silicon and molybdenum-containing material.

In a preferred embodiment, the photomask blank further comprises a light-shielding film between the substrate and the conductive layer, the light-shielding film being formed of a silicon-containing material or a silicon and molybdenum-containing material.

Most often, the conductive layer is formed of a chromium-containing material.

Typically, the photomask blank is processed into a photomask by contacting a grounding terminal with the conductive layer, forcing the grounding terminal to press the conductive layer to such an extent as to establish electric conduction between the grounding terminal and the conductive layer, and performing EB writing in the grounded state.

The invention provides a method for preparing a photomask from a photomask blank, comprising the steps of furnishing the photomask blank defined above, forming a photoresist film on the resistance layer, contacting a grounding terminal with the resistance layer, forcing the grounding terminal to press the resistance layer

to such an extent as to establish electric conduction between the grounding terminal and the conductive layer, and performing EB writing on the photoresist film in the grounded state. The photomask thus obtained is suitable for pattern transfer using exposure light of wavelength up to 200 nm.

In another aspect, the invention provides a method for preparing a photomask suitable for pattern transfer using exposure light of wavelength up to 200 nm from a photomask blank, the photomask blank comprising a transparent substrate, a resistance layer disposed at the outermost level on a side remote from the substrate and having a resistivity of at least 0.1 Ω·cm, and a conductive layer disposed contiguous to the surface of the resistance layer adjacent to the substrate and having a resistivity of less than 0.1 Ω·cm, the resistance layer being a single layer or a multilayer structure consisting of at least two sublayers, said method comprising the step of furnishing the photomask blank wherein the single layer or each sublayer has a resistivity (expressed in Ω·cm) and a thickness (expressed in cm), with the proviso that when a resistivity value is not more than 7.5×10^5 Ω·cm, the resistivity is equal to that resistivity value, and when a resistivity value is more than 7.5×10^5 Ω·cm, the resistivity is equal to 7.5×10^5 Ω·cm, and an index of resistance A, which is the product of resistivity and thickness when the resistance layer is a single layer, or the sum of the products of resistivity and thickness of sublayers when the resistance layer is a multilayer structure, meets the equation (1):

$$1.5\times10^5 \geq A\times\alpha + \rho_c/d_c \qquad (1)$$

wherein α is a constant (expressed in cm^{-2}), ρ_c is the resistivity of the conductive layer (expressed in Ω·cm), and d_c is the thickness of the conductive layer (expressed in cm), said method further comprising the steps of forming a photoresist film on the resistance layer, contacting a

grounding terminal with the resistance layer, forcing the grounding terminal to press the resistance layer to such an extent as to establish electric conduction between the grounding terminal and the conductive layer, and performing EB writing on the photoresist film in the grounded state.

ADVANTAGEOUS EFFECTS OF INVENTION

Although a photomask blank includes a multilayer film of reduced thickness, the blank may be processed into a photomask having necessary optical properties. Even when a mask pattern is written on the photomask blank using an EB lithography system, which is designed such that a ground is established as point contact, the photomask (blank) ensures to establish a ground at a necessary, fully low resistance value and prevents the resist film from being electrically charged during EB writing, thus enabling pattern transfer at a high accuracy of writing position.

BRIEF DESCRIPTION OF ACCOMPANYING DRAWINGS

FIG. 1 is a cross-sectional view of a photomask blank in one embodiment of the invention.

FIG. 2 is a cross-sectional view of a photomask blank in another embodiment of the invention.

FIG. 3 is a cross-sectional view of a photomask blank in a further embodiment of the invention.

FIGS. 4(A) and 4(B) illustrate a main path of current flow upon measurement of electric properties with probes in contact with the surface of a resistance layer, FIG. 4(A) being a plan view with two probes in contact with the resistance layer surface and FIG. 4(B) being a cross-sectional view taken along a line connecting the centers of two probes.

FIG. 5 is a diagram of an equivalent circuit showing current flow below the surface of the photomask blank.

DESCRIPTION OF PREFERRED EMBODIMENTS

The photomask blank of the invention is to be processed into a photomask suitable for pattern transfer using exposure

3. The photomask blank of claim 1, further comprising a phase shift film between the substrate and the conductive layer, the phase shift film being formed of a silicon-containing material or a silicon and molybdenum-containing material.

4. The photomask blank of claim 1, further comprising a light-shielding film between the substrate and the conductive layer, the light-shielding film being formed of a silicon-containing material or a silicon and molybdenum-containing material.

5. The photomask blank of claim 1 wherein the conductive layer is formed of a chromium-containing material.

6. The photomask blank of claim 1 wherein the photomask blank is processed into a photomask by contacting a grounding terminal with the resistance layer, forcing the grounding terminal to press the resistance layer to such an extent as to establish electric conduction between the grounding terminal and the conductive layer, and performing EB writing in the grounded state.

7. A method for preparing a photomask suitable for pattern transfer using exposure light of wavelength up to 200 nm from a photomask blank, the photomask blank comprising a transparent substrate, a resistance layer disposed at the outermost level on a side remote from the substrate and having a resistivity of at least 0.1 Ω·cm, and a conductive layer disposed contiguous to the surface of the resistance layer adjacent to the substrate and having a resistivity of less than 0.1 Ω·cm, the resistance layer being a single layer or a multilayer structure consisting of at least two sublayers,

said method comprising the step of furnishing the photomask blank wherein the single layer or each sublayer has