Patent Document 2 below discloses a method for manufacturing a pellicle film. A pellicle film with a thickness of 10 nanometers or more and 100 nanometers or less is formed on a substrate. The surface of the substrate opposite to the surface on which the pellicle film was formed is etched, and a part of the substrate is removed, so that the pellicle film is exposed. As materials of the pellicle film, SiC and so on are listed. A silicon substrate is mentioned as the substrate.

[0008]

Patent Document 3 below discloses the following technology. The entire surface of a Si substrate is carbonized. Subsequently, a SiC film having a thickness of about 1 micrometer is formed on the entire surface of the Si substrate by using the LPCVD method. A SiC film on one of surfaces of the Si substrate is removed in an arbitrary area. The Si substrate exposed in the window section of the SiC film is dissolved and removed. A structure in which the SiC film is self-supported in the window section of the SiC film is manufactured.

Prior Art Document

Document(s) related to patents

[0009]

[Prior Art Document 1] International Publication No. 2014/188710 pamphlet

[Prior Art Document 2] Japanese Patent Laid-Open No. 2017-83791

[Prior Art Document 3] Japanese Patent Laid-Open No. (HEI) 9-310170

Problems to be solved by the invention

[0010]

There is a demand for pellicle films consisting of SiC to have a large area to cover a large area photo mask, and to thin films to achieve high transmittance. However, when trying to increase an area of a SiC film or thin the film (for example, when trying to make it 100 nanometers or less in thickness), the mechanical strength of the SiC film will be low. Hence, phenomena in which a SiC film contains cracks, or a SiC film peels off from the Si substrate may occur. The production yield ratio was significantly lower.

[0011]

The present invention has been made to solve the above problems. The object of the present invention is to provide a pellicle and a method for manufacturing a pellicle which can improve the production yield ratio.

SUMMARY

Ways to solve the problems

[0012]

According to one aspect of the present disclosure, a pellicle comprises: a supporting member with a ring-like and planar shape and containing Si, and a pellicle film formed on one principal surface of the supporting member, wherein the pellicle film includes a SiC film having a thickness of 10 nanometers or more and 100 nanometers or less, and the SiC film includes a first SiC film formed on the one principal surface of the supporting

member and having a first average carbon concentration, and a second SiC film formed on one principal surface of the first SiC film and having a second average carbon concentration different from the first average carbon concentration.

[0013]

Preferably, according to an example, a SiC film is not formed on another principal surface of the supporting member.

[0014]

Preferably, according to an example, a Si oxide film is not formed on a principal surface opposite to a side

on which the supporting member is formed on the SiC film.

[0015]

Preferably, according to an example, the pellicle film further includes a radiation film formed on one principal surface of the second SiC film, and the radiation film has a higher radiation factor than radiation factors of the first and second SiC film.

[0016]

Preferably, according to an example, the radiation film contains Ru.

[0017]

Preferably, according to an example, a thickness of the first SiC film is greater than 0 and less than or equal to 10 nanometers and the first average carbon concentration is lower than the second average carbon concentration.

[0018]

Preferably, according to an example, a transmittance rate of the pellicle film for light having wavelength of 13.5 nanometers is 70% or more.

[0019]

Preferably, according to an example, the supporting member is composed of a Si substrate.

[0020]

Preferably, according to an example, the supporting member includes a Si substrate and a Si oxide film formed on one principal surface of the Si substrate.

[0021]

According to another aspect of the present disclosure, a method for manufacturing a pellicle comprises: a step to prepare a supporting member containing Si, and a step to form a pellicle film on one principal surface of the supporting member, wherein the step to form the pellicle film includes a step to form a first SiC film having a first average carbon concentration on one principal surface of the supporting member, by carbonizing Si of the one principal surface of the supporting member, and a step to form a second SiC film having a second average carbon concentration different from the first average carbon concentration on one principal surface of the first SiC film, wherein the method further comprises a step to exposes at least a part of another principal surface of the first SiC film by wet etching.

[0022]

Preferably, according to an example, the step to form the pellicle film includes a step to form a radiation film having a radiation factor higher than radiation factors of the first and second SiC films on one principal surface of the second SiC film.

[0023]

Preferably, according to an example, the step to expose at least a part of another principal surface of the first SiC film is performed after the step to form the radiation film.

[0024]

Preferably, according to an example, at least the supporting member and the first SiC film are moved relative to liquid chemical used for the wet etching, in the step to expose at least a part

of another principal surface of the first SiC film.

[0025]

Preferably, according to an example, at least the supporting member and the first SiC film are moved in a direction in a plane parallel to the another principal surface of the first SiC film, in the step to expose at least a part of another principal surface of the first SiC film.

[0026]

Preferably, according to an example, at least with the supporting member and the first SiC film rotated, liquid chemical used for the wet etching is injected onto another principal surface of the supporting member, in the step to expose at least a part of another principal surface of the first SiC film.

[0027]

Preferably, according to an example, the method further comprises a step to form a recessed part having Si as a bottom surface on a central part of another principal surface of the supporting member, wherein the first SiC film is exposed on the bottom surface of the recessed part, in the step to expose at least a part of another principal surface of the first SiC film.

[0028]

Preferably, according to an example, the central part of the another principal surface of the supporting member is removed by wet etching, with a mask layer consisting of an oxide film or a nitride film formed on the another principal surface of the supporting member as a mask, in the step to form a recessed part on the central part of the another principal surface of the supporting member.

[0029]

Preferably, according to an example, mixed acid including hydrofluoric acid and nitric acid is used as liquid chemical used for the wet etching, in the step to expose at least a part of another principal surface of the first SiC film.

[0030]

Preferably, according to an example, a Si substrate is prepared as the supporting member, in the step to prepare a supporting member.

[0031]

Preferably, according to an example, a Si substrate, a Si oxide film formed on one principal surface of the Si substrate, and a Si film formed on one principal surface of the Si oxide film are prepared in the step to prepare the supporting member, and at least a part of the Si film is carbonized, in the step to form the first SiC film.

EFFECT OF THE INVENTION

[0032]

According to the present invention, it is possible to provide a pellicle and a method for manufacturing a pellicle that can improve the production yield ratio.

BRIEF DESCRIPTION OF THE DRAWINGS

[0033]

FIG. 1 is a cross-sectional view showing the configuration of pellicle 1 in the first embodiment of the present invention.

FIG. 2 is a plan view indicating the configuration of pellicle 1, when viewed from the direction perpendicular to top surface 12a of SiC film 12, in the first embodiment of the present invention.

FIG. 3 is a cross-sectional view indicating the first step of the method for manufacturing of pellicle 1, in the first embodiment of the present invention.

FIG. 4 is a cross-sectional view indicating the second step of the method for manufacturing of pellicle 1 in the first embodiment of the present invention.

FIG. 5 is a cross-sectional view indicating the third step of the method for manufacturing of pellicle 1 in the