

ETCHING METHOD, PLASMA PROCESSING APPARATUS, AND SUBSTRATE PROCESSING SYSTEM

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is based on and claims priority from Japanese Patent Application Nos. 2019-167063 and 2020-121613, filed on September 13, 2019 and July 15, 2020, respectively, with the Japan Patent Office, the disclosures of which are incorporated by reference in their entireties.

TECHNICAL FIELD

[0002] The present disclosure relates to an etching method, a plasma processing apparatus, and a substrate processing system.

BACKGROUND

[0003] Japanese Laid-Open Patent Publication No. 2015-012178 discloses a plasma etching of an organic film. The plasma etching of Japanese Laid-Open Patent Publication No. 2015-012178 uses a mixed gas containing oxygen gas, carbonyl sulfate gas, and chlorine gas. The organic film is etched in the manner that sulfur and silicon chloride adhere to the side wall surface of the organic film. Accordingly, a recess formed by the etching of the organic film is suppressed from being laterally expanded. That is, a bowing is suppressed so that the shape of the recess is improved.

SUMMARY

[0004] An aspect of the present disclosure provides an etching method. The etching method includes (a) performing a plasma etching on an organic film. A mask is provided on the organic film. A recess is formed in the organic film by the plasma etching. The etching method further includes (b) forming an organic protective film on a side wall surface of the organic film that defines the recess. The etching method further includes (c) performing an additional plasma etching on the organic film after (b) is performed.

[0004a] In another aspect, the present disclosure provides a plasma processing apparatus, comprising a chamber configured to accommodate a substrate including an organic film and a mask formed on the organic film; a substrate support provided inside the chamber; a gas supply configured to supply a precursor gas into the chamber, the precursor gas containing carbon and a processing gas; a radio-frequency (RF) power supply configured to generate a RF power for generating plasma from a gas in the chamber; and a controller configured to control the gas supply and the RF power supply, wherein the controller controls the gas supply to supply the processing gas into the chamber, and controls the RF power supply to supply the RF power to generate plasma from the processing gas in order to (a) perform a plasma etching on the organic film to form a recess in the organic film, the controller controls the gas supply to supply the precursor gas into the chamber in order to (b) perform a film forming process to form an organic protective film on a side wall surface of the recess in the organic film, and the controller controls the gas supply to supply the processing gas into the chamber, and controls the RF power supply to supply the RF power to generate plasma from the processing gas in order to (c) perform an additional plasma etching on the organic film.

[0004b] In yet another aspect, the present disclosure provides a substrate processing system for etching an organic film of a substrate including the organic film and a mask formed on the organic film, the substrate processing system comprising a plurality of plasma processing apparatuses; a transfer module configured to provide a depressurizable space, connected to the

plurality of plasma processing apparatuses, and transfer the substrate to the plurality of plasma processing apparatuses through the depressurizable space; and a controller configured to control the transfer module to transfer the substrate to a first plasma processing apparatus of the plurality of plasma processing apparatuses; control the first plasma processing apparatus to generate plasma from a processing gas in order to (a) perform a plasma etching on the organic film to form a recess in the organic film; control the transfer module to transfer the substrate, that has been subjected to the plasma etching of (a), to a second plasma processing apparatus of the plurality of plasma processing apparatuses; control the second plasma processing apparatus to (b) perform a film forming process to form an organic protective film on a side wall surface of the recess in the organic film; control the transfer module to transfer the substrate, that has been subjected to the film forming process of (b), to the first plasma processing apparatus; and control the first plasma processing apparatus to generate plasma from the processing gas in order to (c) perform an additional plasma etching on the organic film.

[0005] The foregoing summary is illustrative only and is not intended to be in any way limiting. In addition to the illustrative aspects, embodiments, and features described above, further aspects, embodiments, and features will become apparent by reference to the drawings and the following detailed description.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] FIG. 1 is a flowchart of an etching method according to an embodiment.

[0007] FIG. 2 is a partial enlarged cross-sectional view of an example of a substrate.

[0008] FIG. 3 is a view schematically illustrating a plasma processing apparatus according to an embodiment.

[0009] FIG. 4 is a view illustrating an example of a layout of a plurality of heaters in the plasma processing apparatus illustrated in FIG. 3.

[0010] FIG. 5A is a partial enlarged cross-sectional view of an example of the substrate in a state after step ST1 of the etching method illustrated in FIG. 1 is performed, and FIG. 5B is a partial enlarged cross-sectional view of an example of the substrate in a state after step ST2 of the etching method illustrated in FIG. 1 is performed.

[0011] FIG. 6A is a partial enlarged cross-sectional view of an example of the substrate in a state after step ST3 of the etching method illustrated in FIG. 1 is performed, and FIG. 6B is a partial enlarged cross-sectional view of an example of the substrate in a state when an etching of