a recess, the first plasma generated from a first process gas; (c) supplying a second plasma to the substrate, the second plasma generated from a second process gas comprising tungsten; and (d) etching the recess with a third plasma generated from a third process gas.

[0004a] In one aspect, there is provided an etching method, comprising (a) providing a substrate, the substrate including a silicon-containing film and a mask on the silicon-containing film, and the silicon-containing film including silicon oxide films and silicon nitride films alternately stacked on one another; (b) etching the silicon-containing film with a first plasma to form a recess, the first plasma generated from a first process gas comprising a $C_xH_yF_z$ gas and an oxygen-containing gas, where x and z are integers greater than or equal to 1, and y is an integer greater than or equal to 0; (c) forming a tungsten-containing layer on a side wall of the recess by supplying a second plasma to the substrate, the second plasma generated from a second process gas comprising a tungsten hexafluoride gas; and (d) etching the recess with a third plasma generated from a third process gas comprising a $C_xH_yF_z$ gas and an oxygen-containing gas, where x and z are integers greater than or equal to 1, and y is an integer greater than or equal to 0.

[0004b] In yet another aspect, there is provided a plasma processing apparatus, comprising a chamber; a substrate support to support a substrate in the chamber, the substrate including a silicon-containing film and a mask on the silicon-containing film; a gas supply to supply a first process gas, a second process gas, and a third process gas into the chamber, the second process gas comprising tungsten; a plasma generator configured to generate, in the chamber, a first plasma from the first process gas, a second plasma from the second process gas, and a third plasma from the third process gas; and a controller configured to control the gas supply and the plasma generator to etch the silicon-containing film with the first plasma to form a recess; supply the second plasma to

the substrate after forming the recess; and etch the recess with the third plasma after supplying the second plasma to the substrate.

BRIEF DESCRIPTION OF DRAWINGS

[0005] FIG. 1 is a schematic diagram of a plasma processing system according to an exemplary embodiment.

FIG. 2 is a schematic diagram of a plasma processing apparatus according to an exemplary embodiment.

FIG. 3 is a flowchart of an etching method according to an exemplary embodiment.

FIG. 4 is a cross-sectional view of an exemplary substrate to be processed with the method shown in FIG. 3.

FIG. 5 is a cross-sectional view showing a processing of the substrate in an etching method according to an exemplary embodiment.

FIG. 6 is a cross-sectional view showing a processing of the substrate in the etching method according to the exemplary embodiment.

FIG. 7 is a cross-sectional view showing a processing of the substrate in the etching method according to the exemplary embodiment.

FIG. 8 is a plan view showing a processing of the substrate in the etching method according to the exemplary embodiment.

FIG. 9 is a cross-sectional view taken along line IX-IX in FIG. 8.

FIG. 10 is a cross-sectional view of the recess formed by etching, showing an example mechanism that causes more edge roughness.