

CLAIMS

1. An etching method for etching an object to be processed by using a substrate processing apparatus
5 including a process chamber including a first electrode and a second electrode disposed opposite to the first electrode to receive the object to be processed thereon, the method comprising a step of:
removing at least one of a first polymer and a
10 second polymer by etching the object to be processed on which a pattern of the first polymer and the second polymer is formed by phase separation of a block copolymer containing the first polymer and the second polymer without using a mask at a temperature lower than or equal
15 to 10 degrees C by using plasma of a process gas that can selectively etch the at least one of the first polymer and the second polymer.
2. The etching method as claimed in claim 1,
20 wherein the first polymer is polystyrene,
wherein the second polymer is
poly(methylmethacrylate), and
wherein the process gas contains oxygen gas and
argon gas.
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3. The etching method as claimed in claim 2,
wherein the object to be processed includes at
least a neutral film and the block copolymer sequentially
stacked on a substrate, and
30 wherein the step of removing the at least one of the first polymer and the second polymer is a step of removing poly(methylmethacrylate) and the neutral film under poly(methylmethacrylate).

4. The etching method as claimed in claim 2,
wherein the process gas contains carbon monoxide
or carbon dioxide.

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5. The etching method as claimed in claim 1,
wherein the step of removing the at least one of
the first polymer and the second polymer includes a step
of etching the object to be processed at a temperature
10 lower than or equal to -10 degrees C.

6. The etching method as claimed in claim 1,
wherein the substrate processing apparatus
includes a first high frequency power source configured to
15 supply first high frequency power for plasma generation to
the at least one of the first electrode and the second
electrode and a second high frequency power source
configured to supply second high frequency power for bias,
and

20 wherein an output of the first high frequency
power is in a range of 100 W to 300 W, and an output of
the second high frequency power is in a range of 0 W to
100 W.

25 7. The etching method as claimed in claim 6,
wherein the second high frequency power is
intermittently supplied in the step of removing the at
least one of the first polymer and the second polymer.

30 8. The etching method as claimed in claim 1,
further comprising a step of:
performing a film quality improvement process
before or after the step of removing the at least one of

the first polymer and the second polymer.

9. The etching method as claimed in claim 8,
wherein the step of performing the film quality
5 improvement process includes a step of performing a plasma
process on the polymer by plasma of a hydrogen-containing
gas or irradiating the polymer with ultraviolet light.

10. The etching method as claimed in claim 9,
10 wherein the hydrogen-containing gas is a mixed gas of
hydrogen and argon, or a mixed gas of hydrogen, nitrogen
and methane.

11. The etching method as claimed in claim 1,
15 wherein a total flow rate of the process gas in the step
of removing the at least one of the first polymer and the
second polymer is lower than or equal to 1000 sccm.

12. The etching method as claimed in claim 2,
20 wherein a partial pressure of oxygen gas in the step of
removing the at least one of the first polymer and the
second polymer is lower than or equal to 1.1 mTorr.

13. The method as claimed in claim 1, wherein a
25 value of residence time expressed as $P \cdot V / S$ is in a range
of 2 seconds to 13 seconds when an effective chamber
volume obtained by multiplying an area of the object to be
processed by a distance between the first electrode and
the second electrode is expressed as V (L), a pressure in
30 the process chamber is expressed as P (mTorr), and a flow
rate of the process gas is expressed as S (sccm).