etching the processing target object. Further, when performing this etching process, it is also required that a depth of the space formed in the first region and a depth of the space formed in the second region be substantially same, a deformation degree of a planar shape of the space be small, and, especially, the deformation degree of the space at a bottom portion (deep portion) thereof be small. Here, the deformation of the space refers to a phenomenon that an actually formed space has a planar shape different from a required planar shape. For example, if the required planar shape is a circular shape, the deformation of space refers to a phenomenon that the actually formed space has a planar shape different from the circular shape.

SUMMARY

[0006] In one exemplary embodiment, an etching method of etching a first region and a second region of a processing target object is provided. The first region includes a multilayered film in which silicon oxide films and silicon nitride films are alternately stacked. The second region consisting of a single-layered silicon oxide film. The processing target object includes a mask provided with openings on the first region and the second region. The etching method includes (i) mounting the processing target object on an electrostatic chuck provided within a processing vessel of a plasma processing apparatus; (ii) generating plasma of a first processing gas containing a fluorocarbon gas and an oxygen gas within the processing vessel (hereinafter, referred to as "first plasma process") to etch the first region and the second region simultaneously; and (iii) generating plasma of a second processing gas containing a hydrogen gas, a nitrogen trifluoride gas, a hydrogen bromide gas and a carbon-containing gas within the processing vessel (hereinafter, referred to as "second plasma process") to etch the first region and the second region simultaneously. Here, a temperature of the electrostatic chuck is set to a first temperature in the generating of the plasma of the first

processing gas, and the temperature of the electrostatic chuck is set to a second temperature lower than the first temperature in the generating of the plasma of the second processing gas.

[0007] The etching by the plasma of the first processing gas is characterized in that an etching rate of the second region is higher than an etching rate of the first region. Further, in the etching by the plasma of the first processing gas, the deformation degree of the formed space at the bottom portion thereof increases. Further, in the etching by the plasma of the first processing gas, the higher the temperature of the electrostatic chuck, *i.e.*, the temperature of the processing target object becomes, the smaller the deformation degree of the openings of the mask becomes, though the etching rate of the first region decreases.

[0008] The etching by the plasma of the second processing gas is characterized in that the etching rate of the first region is higher than the etching rate of the second region, and the deformation degree of the formed spaces at the bottom portions thereof is small. Further, in the etching by the plasma of the second processing gas, the lower the temperature of the electrostatic chuck, *i.e.*, the temperature of the processing target object becomes, the higher the etching rate of the first region becomes. Further, in the etching by the plasma of the second processing gas, when the temperature of the electrostatic chuck, *i.e.*, the temperature of the processing target object is low, it is possible to suppress occurrence of a phenomenon that a portion of the space in the depth direction thereof is enlarged in a transverse direction.

[0009] Since the etching by the plasma of the first processing gas has the above-described characteristics, the space formed in the second region is deeper than the space formed in the first region upon the completion of the first plasma process. Further, the deformation degree of the spaces at the bottom portions thereof is increased. In addition, in the first plasma process, since the temperature of the electrostatic chuck is set to the first temperature which is

WE CLAIM

1. An etching method of etching a first region and a second region of a processing target object, the first region including a multilayered film in which silicon oxide films and silicon nitride films are alternately stacked, the second region consisting of a single-layered silicon oxide film, and the processing target object including a mask provided with openings on the first region and the second region, the etching method comprising:

mounting the processing target object on an electrostatic chuck provided within a processing vessel of a plasma processing apparatus;

generating plasma of a first processing gas containing a fluorocarbon gas and an oxygen gas within the processing vessel to etch the first region and the second region simultaneously; and

generating plasma of a second processing gas containing a hydrogen gas, a nitrogen trifluoride gas, a hydrogen bromide gas and a carbon-containing gas within the processing vessel to etch the first region and the second region simultaneously,

wherein a temperature of the electrostatic chuck is set to a first temperature in the generating of the plasma of the first processing gas, and

the temperature of the electrostatic chuck is set to a second temperature lower than the first temperature in the generating of the plasma of the second processing gas.

2. The etching method of Claim 1,

wherein the first temperature is in the range from 20℃ to 40℃, and the second temperature is lower than 20℃.

3. The etching method of Claim 1,

wherein the openings are holes.

4. The etching method of Claim 1, further comprising:

generating plasma of a third processing gas containing a fluorocarbon gas and an oxygen gas within the processing vessel to etch the first region and the second region simultaneously,

wherein the processing target object includes, as a base of the first region and the second region, an underlying layer made of silicon or tungsten,

the generating of the plasma of the first processing gas and the generating of the plasma of the second processing gas are performed until immediately before the underlying layer is exposed, and

the temperature of the electrostatic chuck is set to a third temperature higher than the first temperature in the generating of the plasma of the third processing gas.

5. The etching method of Claim 4,

wherein the third temperature is equal to or higher than 70℃.

6. The etching method of Claim 1,

wherein a sequence including the generating of the plasma of the first processing gas and the generating of the plasma of the second processing gas is repeated multiple times.