METHOD OF PROCESSING SUBSTRATE, METHOD OF MANUFACTURING SEMICONDUCTOR DEVICE, SUBSTRATE PROCESSING APPARATUS, AND PROGRAM

TECHNICAL FIELD

[0001] The present disclosure relates to a method of processing a substrate, a method of manufacturing a semiconductor device, a substrate processing apparatus, and a program.

BACKGROUND

[0002] In the related art, as one process of manufacturing a semiconductor device, a process of forming a semiconductor film on an insulating film provided on a surface of a substrate may be performed.

[Prior Art Documents]

[0003] Patent Documents

Patent Document 1: Japanese Patent Application Laid-open No. 2014-175320

SUMMARY

[0004] Some embodiments of the present disclosure provide a technique capable of improving the characteristics of a semiconductor device.

[0005] According to one embodiment of the present disclosure, there is provided a technique that includes (a) forming a chlorine-containing semiconductor layer on an insulating film provided on a surface of a substrate by supplying a first gas containing a semiconductor element and chlorine to the substrate; and (b) forming a semiconductor film on the chlorine-containing semiconductor layer by supplying a second gas containing a semiconductor element to the substrate, wherein a chlorine concentration in the chlorine-containing semiconductor layer formed in (a) is made 1.0×10^{20} atoms/cm^3 or more and 1.0×10^{22} atoms/cm^3 or less.

BRIEF DESCRIPTION OF DRAWINGS

[0006] FIG. 1 is a schematic configuration diagram of a vertical process furnace of a substrate

WHAT IS CLAIMED IS:

1. A method of processing a substrate, comprising:

(a) forming a chlorine-containing semiconductor layer on an insulating film provided on a surface of the substrate by supplying a first gas containing a semiconductor element and chlorine to the substrate; and

(b) forming a semiconductor film on the chlorine-containing semiconductor layer by supplying a second gas containing a semiconductor element to the substrate,

wherein a chlorine concentration in the chlorine-containing semiconductor layer formed in (a) is made 1.0×10^{20} atoms/cm^3 or more and 1.0×10^{22} atoms/cm^3 or less.

2. The method of Claim 1, wherein the chlorine concentration in the chlorine-containing semiconductor layer formed in (a) is made 3.0×10^{20} atoms/cm^3 or more and 5.0×10^{21} atoms/cm^3 or less.

3. The method of Claim 1, wherein a thickness of the chlorine-containing semiconductor layer formed in (a) is made 1 monolayer or more and 30 Å or less.

4. The method of Claim 1, wherein a thickness of the chlorine-containing semiconductor layer formed in (a) is made 2.5 Å or more and 30 Å or less.

5. The method of Claim 1, wherein a thickness of the chlorine-containing semiconductor layer formed in (a) is made 3 Å or more and 20 Å or less.

6. The method of Claim 1, wherein in (a), a cycle is performed a predetermined number of times, the cycle including non-simultaneously performing:

(a1) supplying the first gas to the substrate; and

(a2) removing the first gas remaining in a space where the substrate exists.

7. The method of Claim 1, wherein in (a), a cycle is performed a predetermined number of times, the cycle including non-simultaneously performing:

(a1) supplying the first gas to the substrate;

(a2) removing the first gas remaining in a space where the substrate exists;

(a3) supplying a third gas containing a semiconductor element and hydrogen to the substrate; and

(a4) removing the third gas remaining in the space where the substrate exists.

8. The method of Claim 6 or Claim 7, wherein a chlorine concentration at an interface between the insulating film and the semiconductor film is controlled by one or more selected from the group of a temperature of the substrate, a pressure in the space where the substrate exists, a supply flow rate of the first gas, and a supply time of the first gas in (a).

9. The method of Claim 6 or Claim 7, wherein a chlorine concentration at an interface between the insulating film and the semiconductor film is controlled by the number of times the cycle is performed in (a).

10. The method of Claim 6 or Claim 7, wherein a dangling bond density at an interface between the insulating film and the semiconductor film is controlled by one or more selected from the group of a temperature of the substrate, a pressure in the space where the substrate exists, a supply flow rate of the first gas, and a supply time of the first gas in (a).

11. The method of Claim 6 or Claim 7, wherein a dangling bond density at an interface between the insulating film and the semiconductor film is controlled by the number of times the cycle is performed in (a).

12. The method of Claim 1, wherein a thickness of the chlorine-containing semiconductor

layer is smaller than a thickness of each of the insulating film and the semiconductor film.

13. The method of Claim 1, wherein each of the insulating film and the semiconductor film is chlorine-free.

14. The method of Claim 1, wherein the semiconductor element includes at least one selected from the group of silicon and germanium.

15. The method of Claim 1, wherein the chlorine-containing semiconductor layer includes at least one selected from the group of a chlorine-containing silicon layer, a chlorine-containing germanium layer, and a chlorine-containing silicon germanium layer, and

wherein the semiconductor film includes at least one selected from the group of a silicon film, a germanium film, and a silicon germanium film.

16. The method of Claim 1, further comprising:

(c) annealing the substrate after the semiconductor film is formed on the chlorine-containing semiconductor layer.

17. The method of Claim 16, wherein in the annealing, the chlorine-containing semiconductor layer and the semiconductor film are crystallized.

18. A method of manufacturing a semiconductor device, comprising:

(a) forming a chlorine-containing semiconductor layer on an insulating film provided on a surface of a substrate by supplying a first gas containing a semiconductor element and chlorine to the substrate; and

(b) forming a semiconductor film on the chlorine-containing semiconductor layer by supplying a second gas containing a semiconductor element to the substrate,

wherein a chlorine concentration in the chlorine-containing semiconductor layer formed

in (a) is made 1.0×10^{20} atoms/cm^3 or more and 1.0×10^{22} atoms/cm^3 or less.

19. A substrate processing apparatus, comprising:

a process chamber in which a substrate is processed;

a first gas supply system configured to supply a first gas containing a semiconductor element and chlorine to the substrate in the process chamber;

a second gas supply system configured to supply a second gas containing a semiconductor element to the substrate in the process chamber; and

a controller configured to be capable of controlling the first gas supply system and the second gas supply system so as to perform, in the process chamber:

(a) forming a chlorine-containing semiconductor layer on an insulating film provided on a surface of the substrate by supplying the first gas to the substrate; and

(b) forming a semiconductor film on the chlorine-containing semiconductor layer by supplying the second gas to the substrate,

wherein a chlorine concentration in the chlorine-containing semiconductor layer formed in (a) is made 1.0×10^{20} atoms/cm^3 or more and 1.0×10^{22} atoms/cm^3 or less.

20. A program that causes, by a computer, a substrate processing apparatus to perform a process comprising:

(a) forming a chlorine-containing semiconductor layer on an insulating film provided on a surface of a substrate by supplying a first gas containing a semiconductor element and chlorine to the substrate; and

(b) forming a semiconductor film on the chlorine-containing semiconductor layer by supplying a second gas containing a semiconductor element to the substrate,

wherein a chlorine concentration in the chlorine-containing semiconductor layer formed in (a) is made 1.0×10^{20} atoms/cm^3 or more and 1.0×10^{22} atoms/cm^3 or less.