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

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application is based upon and claims the benefit of priority from Japanese Patent Application No. 2020-055107, filed on March 25, 2020, the entire contents of which are incorporated herein by reference.

[0002]

TECHNICAL FIELD

[0003] The present disclosure relates to a method of manufacturing a semiconductor device, a substrate processing apparatus, and a program.

BACKGROUND

[0004] In the related art, as a process of manufacturing a semiconductor device, a process of selectively growing and forming a film on a surface of a specific base among a plurality of types of bases exposed on a surface of a substrate (hereinafter, this process is also hereinafter referred to as selective growth or selective film formation) may be often carried out.

[0005] In the selective growth, before the film is selectively grown on the surface of the specific base, a process of modifying a surface of a base on which no film is desired to be grown and suppressing a film from being grown on the modified surface may be performed.

[0006] However, in this case, when the selective growth is continuously performed for a predetermined time, selection loss may occur, which may lead to growth of a film on the modified surface. Factors that cause the selection loss may include, for example: 1. on the surface of the base, an adsorption site in a region which has not been completely modified reacts with a film-forming gas; and 2. the modified surface reacts with the film-forming gas to destroy the modified surface, such that the growth of a film cannot be suppressed.

[0007] In the case where the selection loss occurs, desired selectivity in the selective growth may

WHAT IS CLAIMED IS:

1. A method of processing a substrate, comprising:

(a) modifying a surface of a first base exposed on a surface of the substrate by supplying a modifying gas to the substrate including the first base and a second base exposed on the surface of the substrate; and

(b) selectively forming a film containing at least a first element and a second element different from the first element on a surface of the second base by supplying a precursor gas to the substrate after the surface of the first base is modified, under a condition that a film-forming reaction by thermal decomposition of the precursor gas does not substantially occur, the precursor gas containing a compound in which two or more atoms of the first element are contained in one molecule, at least one atom of the second element is interposed between two atoms of the first element, and each of the two atoms of the first element is directly bonded to one of the at least one atom of the second element

wherein in (a), a fluorine-containing gas and a silicon-containing gas are used as the modifying gas,

wherein (a) includes:

(a1) supplying the silicon-containing gas to the substrate; and

(a2) supplying the fluorine-containing gas to the substrate, and

wherein (a1) and (a2) are performed in this order.

2. The method of Claim 1, wherein the compound does not contain a bond between the atoms of the first element.

3. The method of Claim 1, wherein the compound includes a structure in which the two atoms of the first element are directly bonded to one atom of the second element, or a structure in which the two atoms of the first element are directly bonded to two atoms of the second element bonded to each other respectively.

4. The method of Claim 1, wherein in the compound, the first element is a semiconductor element or a metal element, and the second element is nitrogen, oxygen, or carbon.

5. The method of Claim 1, wherein the compound is at least one selected from the group of compounds represented by formula (1) or (2):

(1): X_3A-Y-AX_3

(2): X_3A-Z-AX_2-Z-AX_3

wherein, in the formulas (1) and (2), A is an atom of the first element represented by a silicon atom, a germanium atom, or a tetravalent metal atom; X represents a chlorine atom, a bromine atom, an iodine atom, NR_2, or OR, independently; R represents a hydrogen atom or an alkyl group containing 1 to 5 carbon atoms, independently; Y represents NH, O, CH_2, or CH_2-CH_2; two Zs represent NH, O, or CH_2, respectively; and in Y and Z, a nitrogen atom in NH, an oxygen atom in O, and carbon atoms in CH_2 and CH_2-CH_2 are atoms of the second element.

6. The method of Claim 1, wherein in the compound, the first element is silicon, the second element is nitrogen, oxygen, or carbon, and the compound contains at least one selected from the group of Si-N-Si bond, Si-N-Si-N-Si bond, Si-O-Si bond, Si-O-Si-O-Si bond, Si-C-Si bond, Si-C-Si-C-Si bond, and Si-C-C-Si bond.

7. The method of Claim 1, wherein (b) includes:

performing a cycle a predetermined number of times, the cycle including:

(b1) supplying the precursor gas to the substrate; and

(b2) supplying a reaction gas including a molecular structure different from a molecular structure of the precursor gas to the substrate.

8. The method of Claim 1, wherein in (a), the fluorine-containing gas as the modifying gas is used to terminate the surface of the first base with fluorine.

9. The method of Claim 1, wherein an aminosilane-based gas is used as the silicon-containing gas.

10. The method of Claim 1, wherein the silicon-containing gas is a gas of a compound containing one amino group in one molecule.

11. The method of Claim 1, wherein in (a), a hydrocarbon group-containing gas is used as the modifying gas to terminate the surface of the first base with a hydrocarbon group.

12. The method of Claim 11, wherein a gas of a compound containing the hydrocarbon group and an amino group is used as the hydrocarbon group-containing gas.

13. The method of Claim 11, wherein an alkylaminosilane-based gas is used as the hydrocarbon group-containing gas.

14. The method of Claim 11, wherein the hydrocarbon group-containing gas is a gas of a compound containing one amino group and three hydrocarbon groups in one molecule.

15. The method of Claim 8, further comprising (c) removing fluorine termination formed on the surface of the first base after (b).

16. The method of Claim 11, further comprising (c) removing hydrocarbon group-termination formed on the surface of the first base after (b).

17. The method of Claim 1, wherein the first base is an oxide film, and the second base is a film other than the oxide film.

18. The method of Claim 1, wherein (a) and (b) are performed under a non-plasma atmosphere.

19. A substrate processing apparatus comprising:

a process chamber in which a substrate is processed;

a modifying gas supply system configured to supply a modifying gas to the substrate in the process chamber;

a precursor gas supply system configured to supply a precursor gas to the substrate in the process chamber, the precursor gas containing a compound in which two or more atoms of a first element are contained in one molecule, at least one atom of a second element different from the first element is interposed between two atoms of the first element, and each of the two atoms of the first element is directly bonded to one of the at least one atom of the second element;

a temperature regulator configured to regulate a temperature of the substrate in the process chamber; and

a controller configured to be capable of controlling the modifying gas supply system, the precursor gas supply system, and the temperature regulator to perform, in the process chamber, a process including:

(a) modifying a surface of a first base exposed on a surface of the substrate by supplying the modifying gas to the substrate including the first base and a second base exposed on the surface of the substrate; and

(b) selectively forming a film containing at least the first element and the second element on a surface of the second base by supplying the precursor gas to the substrate after the surface of the first base is modified, under a condition that a film-forming reaction by thermal decomposition of the precursor gas does not substantially occur,

wherein in (a), a fluorine-containing gas and a silicon-containing gas are used as the modifying gas,

wherein (a) includes:

(a1) supplying the silicon-containing gas to the substrate; and

(a2) supplying the fluorine-containing gas to the substrate, and

wherein (a1) and (a2) are performed in this order.

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

(a) modifying a surface of a first base exposed on a surface of a substrate by supplying a modifying gas to the substrate including the first base and a second base exposed on the surface of the substrate; and

(b) selectively forming a film containing at least a first element and a second element different from the first element on a surface of the second base by supplying a precursor gas to the substrate after the surface of the first base is modified, under a condition that a film-forming reaction by thermal decomposition of the precursor gas does not substantially occur, the precursor gas containing a compound in which two or more atoms of the first element are contained in one molecule, at least one atom of the second element is interposed between two atoms of the first element, and each of the two atoms of the first element is directly bonded to one of the at least one atom of the second element,

wherein in (a), a fluorine-containing gas and a silicon-containing gas are used as the modifying gas,

wherein (a) includes:

(a1) supplying the silicon-containing gas to the substrate; and

(a2) supplying the fluorine-containing gas to the substrate, and

wherein (a1) and (a2) are performed in this order.

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

(a) modifying a surface of a first base exposed on a surface of a substrate by supplying a modifying gas to the substrate including the first base and a second base exposed on the surface of the substrate; and

(b) selectively forming a film containing at least a first element and a second element different from the first element on a surface of the second base by supplying a precursor gas to the substrate after the surface of the first base is modified, under a condition that a film-forming reaction by thermal decomposition of the precursor gas does not substantially occur, the precursor gas containing a compound in which two or more atoms of the first element are contained in one molecule, at least one atom of the second element is interposed between two atoms of the first element, and each of the two atoms of the first element is directly bonded to one of the at least one atom of the second element,

wherein in (a), a fluorine-containing gas and a silicon-containing gas are used as the modifying gas,

wherein (a) includes:

(a1) supplying the silicon-containing gas to the substrate; and

(a2) supplying the fluorine-containing gas to the substrate, and

wherein (a1) and (a2) are performed in this order.