[1] A composite substrate for forming a nanocarbon film comprising a single-crystal silicon carbide thin film having a thickness of not more than 1 μm, a handle substrate which supports the single-crystal silicon carbide thin film and is made of a heat-resistant material (exclusive of single-crystal silicon carbide) that is heat resistant to at least 1,100°C, and an intervening layer having a thickness of more than 200 nm and not more than 1 μm that is provided between the single-crystal silicon carbide thin film and the handle substrate and is made of at least one metallic material selected from the group consisting of titanium, gold, silver, copper, nickel, cobalt, iron, chromium, zirconium, molybdenum, tantalum and tungsten.

[2] The composite substrate of [1], wherein the handle substrate is made of amorphous silicon carbide, polycrystalline silicon carbide, quartz glass, sapphire, silicon nitride, aluminum nitride, silicon or diamond.

[3] A composite substrate for forming a nanocarbon film comprising a single-crystal silicon carbide thin film having a thickness of not more than 1 μm, a handle substrate which supports the single-crystal silicon carbide thin film and is made of a heat-resistant material (exclusive of single-crystal silicon carbide) that is heat resistant to at least 1,100°C, and an intervening layer having a thickness of more than 400 nm and not more than 1 μm that is provided between the single-crystal silicon carbide thin film and the handle substrate and is made of at least one material selected from the group consisting of silicon oxide, silicon nitride, aluminum oxide, aluminum nitride, zirconium oxide, silicon and silicon carbide.

[4] The composite substrate of [3], wherein said intervening layer is made of a least one material selected from silicon oxide, silicon nitride, aluminum oxide, zirconium oxide, silicon and silicon carbide.

[5] The composite substrate of [3], wherein the handle substrate is made of amorphous silicon carbide, polycrystalline silicon carbide or quartz glass.

[6] The composite substrate of any one of [1] to [5], wherein the single-crystal silicon carbide thin film is formed from a single-crystal silicon carbide substrate by exfoliation of a portion thereof.

[7] A method of forming a nanocarbon film, comprising the step of heating the composite substrate of [1] or [2] and thereby sublimating silicon atoms from the single-crystal silicon carbide thin film so as to obtain a nanocarbon film.

[8] A method of forming a nanocarbon film, comprising the step of heating the composite substrate of [3] or [5] and thereby sublimating silicon atoms from the single-crystal silicon carbide thin film so as to obtain a nanocarbon film.

[9] A nanocarbon film obtained by the nanocarbon film-forming method of [7] or [8].

[10] The nanocarbon film of [9], wherein the number of defects found by surface examination under an optical microscope at 1,000× is not more than 4,000 defects/cm^2.

ADVANTAGEOUS EFFECTS OF THE INVENTION

[0011]

One advantage of the invention is that, by placing an intervening layer which has a thickness of not more than 1 μm and is made of a given material between a single-crystal silicon carbide thin film having a thickness of not more than 1 μm and a handle substrate, a composite substrate in which the single-crystal silicon carbide thin film is bonded so as to adhere well to the handle substrate can be provided and a nanocarbon film having few defects can be formed at this composite substrate. A further advantage is that, by transferring a single-crystal silicon carbide film in the state of a thin-film to a handle substrate, the need to prepare a large number of costly single-crystal silicon carbide substrates is eliminated, making it possible to provide a composite substrate that enables the formation of nanocarbon films at low cost.

BRIEF DESCRIPTION OF THE DIAGRAMS

[0012]

[FIG. 1] FIG. 1 is sectional view showing the construction of a composite substrate according to this invention.

[FIG. 2] FIG. 2 shows schematic diagrams depicting a number of steps in a method for producing the composite substrate of the invention, FIG. 2A being a sectional view of an ion-implanted single-crystal silicon carbide substrate, FIG. 2B being a sectional view showing a thin film formed on the ion implantation side of the single-crystal silicon carbide substrate, FIG. 2C being a sectional view showing a thin film formed on a principal surface of a handle substrate, FIG. 2D being a sectional view showing the single-crystal silicon carbide substrate and the handle substrate bonded together, FIG. 2E being a sectional view showing a single-crystal silicon carbide substrate exfoliated at an ion implant region, and FIG. 2F being a sectional view of the composite substrate.

[FIG. 3] FIG. 3 is a graph showing the results from Working Example 1.

[FIG. 4] FIG. 4 is a graph showing the results from Working Example 2.

CLAIMS:

1. A composite substrate for forming a nanocarbon film comprising a single-crystal silicon carbide thin film having a thickness of not more than 1 μm, a handle substrate which supports the single-crystal silicon carbide thin film and is made of a heat-resistant material (exclusive of single-crystal silicon carbide) that is heat resistant to at least 1,100°C, and an intervening layer having a thickness of more than 200 nm and not more than 1 μm that is provided between the single-crystal silicon carbide thin film and the handle substrate and is made of at least one metallic material selected from the group consisting of titanium, gold, silver, copper, nickel, cobalt, iron, chromium, zirconium, molybdenum, tantalum and tungsten.

2. The composite substrate of claim 1, wherein the handle substrate is made of amorphous silicon carbide, polycrystalline silicon carbide, quartz glass, sapphire, silicon nitride, aluminum nitride, silicon or diamond.

3. A composite substrate for forming a nanocarbon film comprising a single-crystal silicon carbide thin film having a thickness of not more than 1 μm, a handle substrate which supports the single-crystal silicon carbide thin film and is made of a heat-resistant material (exclusive of single-crystal silicon carbide) that is heat resistant to at least 1,100°C, and an intervening layer having a thickness of more than 400 nm and not more than 1 μm that is provided between the single-crystal silicon carbide thin film and the handle substrate and is made of at least one material selected from the group consisting of silicon oxide, silicon nitride, aluminum oxide, aluminum nitride, zirconium oxide, silicon and silicon carbide.

4. The composite substrate of claim 3, wherein said intervening layer is made of a least one material selected from silicon oxide, silicon nitride, aluminum oxide, zirconium oxide, silicon and silicon carbide.

5. The composite substrate of claim 3, wherein the handle substrate is made of amorphous silicon carbide, polycrystalline silicon carbide or quartz glass.

6. The composite substrate of any one of claims 1 to 5, wherein the single-crystal silicon carbide thin film is formed from a single-crystal silicon carbide substrate by exfoliation of a portion thereof.

7. A method of forming a nanocarbon film, comprising the step of heating the composite substrate of claim 1 or 2 and thereby sublimating silicon atoms from the single-crystal silicon carbide thin film so as to obtain a nanocarbon film.

8. A method of forming a nanocarbon film, comprising the step of heating the composite substrate of claim 3 or 5 and thereby sublimating silicon atoms from the single-crystal silicon carbide thin film so as to obtain a nanocarbon film.

9. A nanocarbon film obtained by the nanocarbon film-forming method of claim 7 or 8.

10. The nanocarbon film of claim 9, wherein the number of defects found by surface examination under an optical microscope at 1,000× is not more than 4,000 defects/cm^2.