radical process of causing radicals to react with the surface protective layer, and a transportation apparatus configured to transport the substrate from the ta-C film forming apparatus to the radical process apparatus without exposing the substrate to atmosphere, wherein the radical process apparatus comprises a radical process chamber in which the substrate is arranged, a radical generation unit configured to generate radicals from a process gas, and a radical introduction unit configured to introduce the radicals generated by the radical generation unit into the radical process.

[0008] A vacuum process method for a vacuum process apparatus including a ta-C film forming apparatus configured to form a surface protective layer made of a ta-C film on a substrate; a radical process apparatus configured to perform a radical process of causing radicals to react with the surface protective layer; and a transportation apparatus configured to transport the substrate from the ta-C film forming apparatus to the radical process apparatus without exposing the substrate to atmosphere, wherein the radical process apparatus comprises a radical process chamber in which the substrate is arranged, a radical generation unit configured to generate radicals from a process gas, and a radical introduction unit configured to introduce the radicals generated by the radical generation unit into

the radical process chamber, wherein the vacuum process method for a magnetic recording medium having a surface protective layer for protecting a magnetic recording layer formed on a substrate, comprises a ta-C film forming step of forming a ta-C film on the magnetic recording layer, a transport step of transporting a substrate on which the ta-C film is formed, a radical generation step of generating radicals by exciting a process gas, and a radical process step of irradiating a surface of the ta-C film with the radicals.

ADVANTAGEOUS EFFECTS OF INVENTION

[0009] The surface treatment method of the present invention can remove a layer having a low sp^3 bonding ratio without degrading the innate property of a surface protective layer. In addition, this method can make a surface after a surface treatment have desired chemical properties. Alternatively, the surface treatment method according to the present invention can provide a new function to a surface. The surface treatment method according to the present invention performs chemical etching by using radicals, and hence

WHAT IS CLAIMED IS:

1. A vacuum process apparatus comprising:

a ta-C film forming apparatus configured to form a surface protective layer made of a ta-C film on a substrate;

a radical process apparatus configured to perform a radical process of causing radicals to react with the surface protective layer; and

a transportation apparatus configured to transport the substrate from the ta-C film forming apparatus to the radical process apparatus without exposing the substrate to atmosphere,

wherein the radical process apparatus comprises

a radical process chamber in which the substrate is arranged,

a radical generation unit configured to generate radicals from a process gas, and

a radical introduction unit configured to introduce the radicals generated by the radical generation unit into the radical process chamber.

2. The vacuum process apparatus according to claim 1, wherein the vacuum process apparatus includes a plurality of chambers, each configured to perform a predetermined process with respect to the substrate, connected to each other in an endless rectangular form,

the plurality of chambers include a direction changing chamber arranged at a position of a corner of

the rectangular form to change a transport direction of the substrate, a ta-C film formation chamber including the ta-C film forming apparatus, and a radical process chamber including the radical process apparatus, and

the direction changing chamber, the ta-C film formation chamber, and the radical process chamber are sequentially arranged toward the transport direction of the substrate in the order named.

3. The vacuum process apparatus according to claim 1, wherein the vacuum process apparatus including a plurality of chambers, each configured to perform a predetermined process with respect to the substrate, connected to each other in an endless rectangular form,

the plurality of chambers include a direction changing chamber arranged at a position of a corner of the rectangular form to change a transport direction of the substrate, a load lock chamber configured to supply the substrate to the vacuum process apparatus, an unload chamber configured to unload the substrate from the vacuum process apparatus, a ta-C film formation chamber including the ta-C film forming apparatus, and the radical process apparatus, and

the radical process apparatus is integrally formed with the unload chamber.

4. The vacuum process apparatus according to claim 3, wherein the radical process apparatus comprises a cassette configured to accommodate the plurality of

substrates in a radical process chamber.

5. The vacuum process apparatus according to any one of claims 1 to 4, wherein the transportation apparatus is integrally formed with the radical process apparatus and the ta-C film forming apparatus.

6. The vacuum process apparatus according to claim 1, wherein process gas contains at least one of O_2 gas and H_2 gas.

7. The vacuum process apparatus according to claim 1, wherein process gas contains at least one of N_2, NO, N_2O, and NH_3.

8. The vacuum process apparatus according to claim 1, wherein process gas contains at least one of CF_4, C_2F_6, and C_3F_8.

9. A vacuum process method for a vacuum process apparatus including a ta-C film forming apparatus configured to form a surface protective layer made of a ta-C film on a substrate; a radical process apparatus configured to perform a radical process of causing radicals to react with the surface protective layer; and a transportation apparatus configured to transport the substrate from the ta-C film forming apparatus to the radical process apparatus without exposing the substrate to atmosphere,

wherein the radical process apparatus comprises

a radical process chamber in which the substrate is arranged, a radical generation unit configured to

generate radicals from a process gas, and a radical introduction unit configured to introduce the radicals generated by the radical generation unit into the radical process chamber,

wherein the vacuum process method for a magnetic recording medium having a surface protective layer for protecting a magnetic recording layer formed on a substrate, the method comprising:

a ta-C film forming step of forming a ta-C film on the magnetic recording layer;

a transport step of transporting a substrate on which the ta-C film is formed;

a radical generation step of generating radicals by exciting a process gas; and

a radical process step of irradiating a surface of the ta-C film with the radicals.

10. The vacuum process method according to claim 9, wherein process gas contains at least one of O_2 gas and H_2 gas.

11. The vacuum process method according to claim 9, wherein process gas contains at least one of N_2, NO, N_2O, and NH_3.

12. The vacuum process method according to claim 9, wherein process gas contains at least one of CF_4, C_2F_6, and C_3F_8.