DESCRIPTION

Title of the Invention: SEALING MATERIAL-FORMING MATERIAL, SEALING MATERIAL, AND METHOD FOR PRODUCING SEALING MATERIAL

Technical Field

[0001]

The present invention relates to a sealing material-forming material, a sealing material, and a method for producing a sealing material.

Background Art

[0002]

Conventionally, a sealing material has been widely used in various applications, and among these applications, one example of applications in which a sealing material is most heavily loaded is a sealing material used in, for example, a semiconductor manufacturing apparatus.

[0003]

For such a sealing material, a crosslinkable fluoroelastomer such as a fluoroelastomer (FKM) or a perfluoroelastomer (FFKM) is used because a sealing material excellent in plasma resistance and radical resistance can be obtained, and in particular, FFKM is used, for example, when high temperature or severe chemicals are used.

[0004]

The sealing material made of a crosslinkable fluoroelastomer as described above is generally used as a sealing material formed by using an elastomer composition obtained by blending additives such as a crosslinking agent and a crosslinking aid into the crosslinkable fluoroelastomer, and molding and crosslinking the elastomer composition.

[0005]

The sealing material, like a general molded product, may require a treatment of, for example, a scrap (flash) or a defective product generated during molding, or a used molded product. However, the crosslinked fluoroelastomer has conventionally been discarded by, for example, landfilling as its excellent properties paradoxically obstruct, for example, a chemical treatment, and its incineration produces a corrosive decomposition product, making thermal recycling also not easy.

[0006]

However, in recent years, with the growing awareness of, for example, environmental protection through, for example, reduction of landfill volume, and effective utilization of resources, there has been a demand for the development of a method for reusing a crosslinked

fluoroelastomer that has conventionally been discarded.

[0007]

As a molded product obtained by reusing such a crosslinked fluoroelastomer, for example, Patent Literature 1 discloses a molded product obtained by decrosslinking a crosslinked fluorine-containing polymer in a supercritical fluid or a subcritical fluid of a compound having active hydrogen, and crosslinking the obtained decrosslinked fluorine-containing polymer.

Patent Literature 2 discloses a sealing material containing a treated perfluoropolymer obtained by decomposing a crosslinking point of a crosslinked iodine- or bromine-containing perfluoropolymer.

Citation List

Patent Literature

[0008]

Patent Literature 1: JP 2007-63334 A

Patent Literature 2: JP 6134293 B2

Summary of Invention

Technical Problem

[0009]

However, the method described in Patent Literature 1,

in which a supercritical fluid or a subcritical fluid is used, does not lend itself to easy processing and does not allow for simple reuse of a crosslinked fluoroelastomer, and therefore there has been room for improvement.

Further, as a result of intensive studies by the present inventors, it has been found that in the sealing material described in Patent Literature 2, when a treated perfluoropolymer to be used is obtained, the perfluoropolymer is decomposed and the mass of the perfluoropolymer is greatly reduced, and further, it has been found that the resulting sealing material has a large compression set and is poor in heat resistance and plasma resistance.

[0010]

The present invention has been made in view of the above, and an object of the present invention is to provide a sealing material-forming material which is capable of easily reusing a crosslinked perfluoro(co)polymer, and is capable of forming a sealing material having a small compression set and excellent heat resistance and plasma resistance.

Solution to Problem

[0011]

As a result of intensive studies to solve the above problems, the present inventor has found that the above

problems can be solved according to the following configuration examples, and has completed the present invention.

The configuration examples of the present invention are as follows.

[0012]

[1] A sealing material-forming material containing a regenerated perfluoro(co)polymer, in which

the regenerated perfluoro(co)polymer is a (co)polymer in which at least some crosslinking sites are regenerated by a heat treatment of a crosslinked perfluoro(co)polymer obtained by crosslinking a perfluoro(co)polymer having a nitrile group as a crosslinking site, and

the perfluoro(co)polymer having a nitrile group contains a structural unit derived from at least one type selected from perfluoroolefin and perfluorovinyl ether, and a structural unit having a nitrile group.

[0013]

[2] The sealing material-forming material according to [1], in which the regenerated perfluoro(co)polymer is a (co)polymer having at least one crosslinked structure selected from a triazine structure, an oxazole structure, an amidine structure, and an imidazole structure.

[0014]

[3] The sealing material-forming material according to [1] or [2], further containing a crosslinking agent having a functional group capable of reacting with a nitrile group.

[0015]

[4] The sealing material-forming material according to any one of [1] to [3], further containing an uncrosslinked perfluoro(co)polymer.

[5] The sealing material-forming material according to [4], in which a content of the regenerated perfluoro(co)polymer is 0.5 parts by mass or more with respect to 100 parts by mass of the uncrosslinked perfluoro(co)polymer.

[0016]

[6] A sealing material formed by crosslinking and molding the sealing material-forming material according to any one of [1] to [5].

[0017]

[7] A method for producing a sealing material, including a step of crosslinking the sealing material-forming material according to any one of [1] to [5].

[0018]

[8] The method for producing a sealing material according to [7], including a step of obtaining a regenerated perfluoro(co)polymer by regenerating at least some crosslinking sites by a heat treatment of a crosslinked

perfluoro(co)polymer obtained by crosslinking a perfluoro(co)polymer having a nitrile group as a crosslinking site.

Advantageous Effects of Invention

[0019]

According to the present invention, it is possible to provide a sealing material-forming material which is capable of easily reusing a crosslinked perfluoro(co)polymer, and is capable of forming a sealing material having a small compression set and excellent heat resistance and plasma resistance.

Further, according to the present invention, it is also possible to provide a sealing material-forming material excellent in molding processability into a sealing material having desired physical properties.

Description of Embodiments

[0020]

<<Sealing material-forming material>>

A sealing material-forming material according to the present invention (hereinafter also referred to as “present material”) contains a regenerated perfluoro(co)polymer (hereinafter also referred to as “regenerated product”) in

which at least some crosslinking sites are regenerated by a heat treatment of a crosslinked perfluoro(co)polymer obtained by crosslinking a perfluoro(co)polymer having a nitrile group as a crosslinking site.

Since the present material contains such a regenerated product, it is possible to form a sealing material having a small compression set and excellent heat resistance and plasma resistance as compared with a sealing material obtained using a heat-treated product formed by a heat treatment of a crosslinked perfluoro(co)polymer obtained by crosslinking a perfluoro(co)polymer having a halogen atom (example: an iodine atom or a bromine atom) as a crosslinking site, which is crosslinked using a peroxide-based crosslinking agent, and furthermore, it is excellent in kneadability of each component used upon formation of the sealing material and is excellent in molding processability into a sealing material having desired physical properties as compared with a sealing material-forming material containing the heat-treated product.

[0021]

<Regenerated product>

The regenerated product is a (co)polymer in which at least some nitrile groups as crosslinking sites are regenerated by a heat treatment of a crosslinked

perfluoro(co)polymer (hereinafter also referred to as "material to be regenerated") obtained by crosslinking a perfluoro(co)polymer having a nitrile group as a crosslinking site (hereinafter also referred to as "uncrosslinked perfluoro(co)polymer").

The regenerated product used for the present material may be of one type or two or more types.

[0022]

Examples of the material to be regenerated include a crosslinked perfluoro(co)polymer having at least one crosslinked structure selected from a triazine structure, an oxazole structure, an amidine structure, and an imidazole structure. The material to be regenerated may have one type of crosslinked structure or two or more types of crosslinked structures.

Examples of the crosslinked perfluoro(co)polymer having a triazine structure include a (co)polymer having a structure represented by the left side of the following formula (1), and examples of the crosslinked perfluoro(co)polymer having an oxazole structure include a (co)polymer having a structure represented by the left side of the following formula (2).

In the present description, ~-R-C≡N represents a perfluoro(co)polymer having a nitrile group as a crosslinking

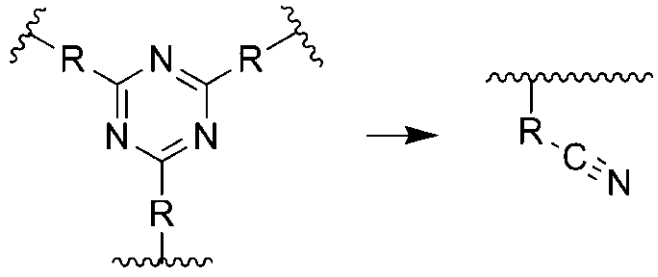
site.

[0023]

The reaction formula when a heat treatment of the crosslinked perfluoro(co)polymer having a triazine structure is performed can be represented by, for example, the following formula (1). The reaction formula when a heat treatment of the crosslinked perfluoro(co)polymer having an oxazole structure is performed can be represented by, for example, the following formula (2).

[0024]

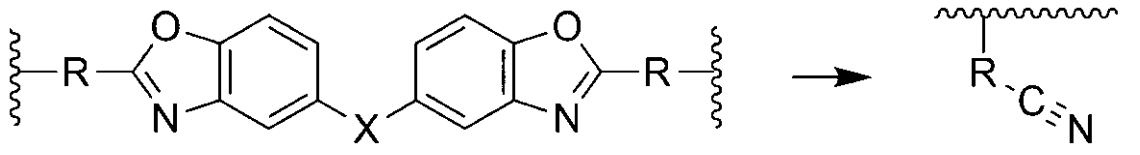
[Chem. 1]



...(1)

[0025]

[Chem. 2]



...(2)

[In the formula (2), X is a structure derived from an oxazole-based crosslinking agent, and examples thereof include a hexafluoropropane-2,2-diyl group, a sulfonyl group, and 9,9-fluorenyl.]

[0026]

The regenerated product is a perfluoro(co)polymer having a nitrile group as a crosslinking site, in which a nitrile group as a crosslinking site is regenerated by a heat treatment of the material to be regenerated.

As described above, since a perfluoro(co)polymer having a nitrile group → crosslinking → yields a perfluoro(co)polymer having a nitrile group, this cycle can be performed a plurality of times (recycling can be performed a plurality of times) in the case of a perfluoro(co)polymer having a nitrile group.

[0027]

On the other hand, a perfluoro(co)polymer having a halogen atom (example: an iodine atom or a bromine atom) as a crosslinking site is usually crosslinked using a peroxide-based crosslinking agent. When such a crosslinked perfluoro(co)polymer obtained by crosslinking a perfluoro(co)polymer having a halogen atom as a crosslinking site is subjected to a heat treatment, the crosslinked structure is “decomposed” to generate a C=C bond or a carboxyl group, and the C=C bond or the carboxyl group becomes a crosslinking site at the time of re-crosslinking.

[0028]

That is, in a perfluoro(co)polymer having a nitrile

group as a crosslinking site, as in the following formula (3) or (4), a nitrile group as a crosslinking site reacts to form a crosslinked perfluoro(co)polymer, and the nitrile group as a crosslinking site is “regenerated” by a heat treatment, whereas in a perfluoro(co)polymer having a halogen atom as a crosslinking site, a halogen atom as a crosslinking site reacts to form a crosslinked perfluoro(co)polymer, and a crosslinked structure is “decomposed” by a heat treatment to form a C=C bond or a carboxyl group, and a halogen atom as a crosslinking site is not regenerated. Therefore, the “perfluoro(co)polymer having a nitrile group as a crosslinking site” and the “perfluoro(co)polymer having a halogen atom as a crosslinking site” are completely different from each other in the mechanism in which the crosslinking site is regenerated, and the effect on heat resistance and compression set is different in the sealing material obtained using the regenerated product.

[0029]

It is preferred that the regenerated product is not a (co)polymer in which all of the crosslinking sites of the material to be regenerated are regenerated. That is, the regenerated product preferably has a crosslinked structure in at least a part thereof, and more preferably has at least one type of crosslinked structure selected from the above-

mentioned triazine structure, oxazole structure, amidine structure, and imidazole structure.

[0030]

When the content of the nitrile group in the material to be regenerated is taken as 100%, the content of the nitrile group in the regenerated product is preferably 101% or more, more preferably 200% or more, and the upper limit is not particularly limited, but is an amount equal to or less than the content of the nitrile group contained in the uncrosslinked perfluoro(co)polymer before the material to be regenerated is crosslinked, specifically 15,000% or less, and more preferably 7,000% or less.

Use of a regenerated product in which the content of the nitrile group is within the above range allows easy formation of a sealing material having a smaller compression set.

The content of the nitrile group can be measured using FT-IR, specifically, by the method described in the following examples.

[0031]

The mass reduction rate due to the heat treatment, specifically, the mass reduction rate represented by the following formula (A) is preferably 10% or less, and more preferably 3% or less from the viewpoint that, for example, a

sealing material having desired physical properties can be easily formed using the obtained regenerated product.

Mass reduction rate (%) = [(mass of material to be regenerated - mass of regenerated product)/mass of material to be regenerated] × 100 (A)

[0032]

In consideration of the balance between the viewpoint of the environmental protection and the effective utilization of resources and the viewpoint that a sealing material having desired physical properties can be easily formed, the amount of the regenerated product used is preferably 0.5 to 100 mass%, more preferably 1 to 90 mass%, and still more preferably 10 to 80 mass% with respect to 100 mass% of the present material.

When an uncrosslinked perfluoro(co)polymer is used for the present material, the amount of the regenerated product used is preferably 0.5 parts by mass or more, more preferably 0.5 to 100 parts by mass, still more preferably 1 to 90 parts by mass, and particularly preferably 10 to 80 parts by mass with respect to 100 parts by mass of the uncrosslinked perfluoro(co)polymer from the viewpoint that, for example, a sealing material having desired physical properties can be easily formed.

[0033]

<Material to be regenerated>

The material to be regenerated is a crosslinked perfluoro(co)polymer obtained by crosslinking a perfluoro(co)polymer having a nitrile group as a crosslinking site, and examples thereof include a crosslinked perfluoro(co)polymer contained in, for example, an (unused) molded body such as a sealing material formed using a conventional uncrosslinked perfluoro(co)polymer (virgin product), a scrap (flash) or a defective product generated during the production of such a molded body, and a used molded body.

Examples of the used molded body include not only a used molded body used in a semiconductor manufacturing apparatus, but also a used molded body used in, for example, a chemical plant, and various industrial machinery.

As the raw material to be subjected to a heat treatment, the crosslinked perfluoro(co)polymer itself may be used, or the (unused) molded body, the scrap (flash) or defective product, or the used molded body may be used.

[0034]

The crosslinked perfluoro(co)polymer in the material to be regenerated is a crosslinked body obtained by crosslinking the following uncrosslinked perfluoro(co)polymer (virgin product) by a conventionally known method.

Examples of the conventionally known method include crosslinking using a crosslinking agent, and examples of the crosslinking agent include a triazine-based crosslinking agent, an oxazole-based crosslinking agent, and an imidazole-based crosslinking agent. That is, examples of the material to be regenerated include a crosslinked perfluoro(co)polymer having at least one type of crosslinked structure selected from crosslinked structures derived from such crosslinking agents, specifically, a triazine structure, an oxazole structure, an imidazole structure, and intermediate structures upon formation of such crosslinked structures (example: an amidine structure upon formation of an oxazole structure).

The degree of crosslinking in the material to be regenerated is not particularly limited as long as it is comparable to the degree of crosslinking when a molded body such as a sealing material is formed.

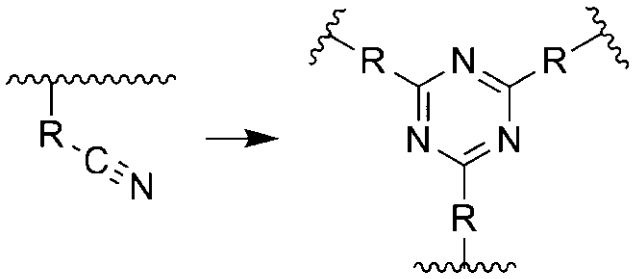
[0035]

The crosslinking (triazine structure) using the triazine-based crosslinking agent can be represented by, for example, the following formula (3), and the crosslinking (oxazole structure) using the oxazole-based crosslinking agent can be represented by, for example, the following formula (4).

In addition, the crosslinked structure using the oxazole-based crosslinking agent may be an amidine structure which is an intermediate structure thereof, in addition to the oxazole structure finally obtained in the following formula (4).

[0036]

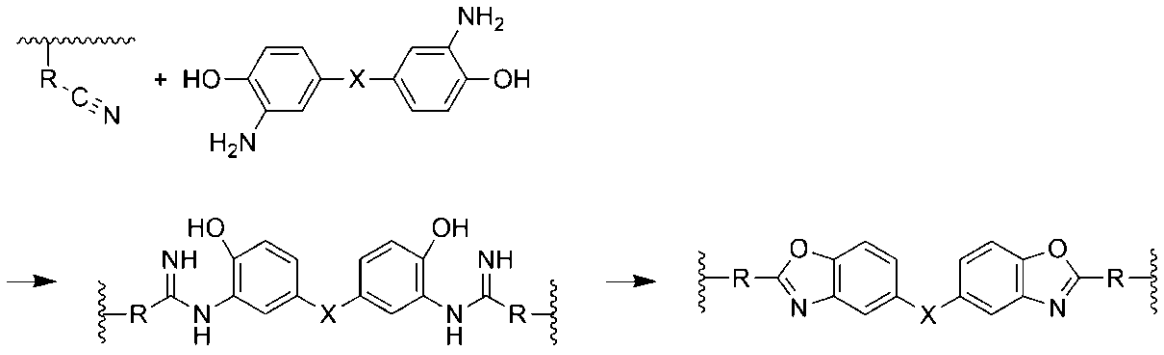
[Chem. 3]



...(3)

[0037]

[Chem. 4]



...(4)

[In the formula (4), X is a structure derived from an oxazole-based crosslinking agent, and examples thereof include a hexafluoropropane-2,2-diyl group, a sulfonyl group, and 9,9-fluorenyl.]

[0038]

[Uncrosslinked perfluoro(co)polymer]

The uncrosslinked perfluoro(co)polymer contains a structural unit derived from at least one type selected from perfluoroolefin and perfluorovinyl ether, and a structural unit having a nitrile group.

The uncrosslinked perfluoro(co)polymer is a perfluoro(co)polymer having a nitrile group as a crosslinking site before crosslinking, and can also be referred to as "virgin product".

[0039]

The uncrosslinked perfluoro(co)polymer is preferably a perfluoroelastomer (FFKM).

Further, it is preferred that the uncrosslinked perfluoro(co)polymer is a (co)polymer that does not contain a carbon-hydrogen bond in a main chain of the (co)polymer.

The perfluoroolefin is preferably tetrafluoroethylene.

[0040]

The FFKM is not particularly limited, and examples thereof include a tetrafluoroethylene (TFE)-perfluorovinyl ether-based copolymer having a nitrile group as a crosslinking site, and a copolymer that contains a TFE-derived structural unit and a perfluorovinyl ether-derived structural unit, and further contains a nitrile group-containing monomer-derived structural unit as necessary is

preferred.

[0041]

Preferred examples of the perfluorovinyl ether include perfluoro(alkyl vinyl ether) and perfluoro(alkoxyalkyl vinyl ether).

[0042]

Examples of the perfluoro(alkyl vinyl ether) include a compound whose alkyl group has, for example, 1 to 10 carbon atoms, specific examples thereof include perfluoro(methyl vinyl ether), perfluoro(ethyl vinyl ether), and perfluoro(propyl vinyl ether), and perfluoro(methyl vinyl ether) is preferred.

[0043]

Examples of the perfluoro(alkoxyalkyl vinyl ether) include a compound whose group bonded to a vinyl ether group (CF_2=CFO-) has 3 to 15 carbon atoms, and specific examples thereof include the following compounds.

CF_2=$CFOCF_2CF(CF_3)OC_nF_{2n+1}$

CF_2=$CFO(CF_2)_3OC_nF_{2n+1}$

CF_2=$CFOCF_2CF(CF_3)O(CF_2O)_mC_nF_{2n+1}$

CF_2=$CFO(CF_2)_2OC_nF_{2n+1}$

In these formulae, each n is independently, for example, 1 to 5, and m is, for example, 1 to 3.

[0044]

Examples of the nitrile group-containing monomer include nitrile group-containing perfluorovinyl ether, and specific examples thereof include the following compounds.

$CF_2=CFO(CF_2)_nOCF(CF_3)CN$ (n is, for example, 2 to 4)

$CF_2=CFO(CF_2)_nCN$ (n is, for example, 2 to 12)

$CF_2=CFO[CF_2CF(CF_3)O]_m(CF_2)_nCN$ (n is, for example, 1 to 4, and m is, for example, 1 to 5)

$CF_2=CFO[CF_2CF(CF_3)O]_nCF_2CF(CF_3)CN$ (n is, for example, 0 to 4)

$CF_2=CF(CF_2)_nCN$ (n is, for example, an integer of 1 to 8)

$CF_2=CFCF_2(OCF_2)_nCN$ (n is, for example, an integer of 0 to 5)

$CF_2=CFCF_2(OCF(CF_3)CF_2)_m$-CN (m is, for example, an integer of 0 to 5, and n is, for example, an integer of 0 to 5)

$CF_2=CF(OCF_2CF(CF_3))_mO(CF_2)_n$-CN (m is, for example, an integer of 0 to 5, and n is, for example, an integer of 1 to 8)

$CF_2=CF(OCF_2CF(CF_3))_m$-CN (m is, for example, an integer of 1 to 5)

$CF_2=CFOCF_2(CF(CF_3)OCF_2)_nCF(-CN)CF_3$ (n is, for example, an integer of 1 to 4)

$CF_2=CFO(CF_2)_nOCF(CF_3)$-CN (n is, for example, an integer

of 2 to 5)

$CF_2=CF(OCF_2CF(CF_3))_nOCF_2CF(CF_3)$-CN (n is, for example, an integer of 1 to 2)

$CF_2=CFO(CF_2CF(CF_3)O)_m(CF_2)_n$-CN (m is, for example, an integer of 0 to 5, and n is, for example, an integer of 1 to 3)

$CF_2=CFO(CF_2CF(CF_3)O)_mCF_2CF(CF_3)$-CN (m is an integer of 0 or more)

$CF_2=CFOCF(CF_3)CF_2O(CF_2)_n$-CN (n is an integer of 1 or more)

$CF_2=CFOCF_2OCF_2CF(CF_3)OCF_2$-CN

[0045]

In FFKM, the content of the TFE-derived structural unit is preferably 50.0 to 79.9 mol%, the content of the perfluorovinyl ether-derived structural unit is preferably 20.0 to 46.9 mol%, and the content of the nitrile group-containing monomer-derived structural unit is preferably 0.1 to 2.0 mol%.

[0046]

<Heat treatment conditions and others>

The heat treatment is not particularly limited as long as it is a heat treatment in which a nitrile group as a crosslinking site is regenerated in a material to be regenerated.

The heat treatment may be performed in a gas atmosphere containing oxygen, or may be performed in an inert gas atmosphere. However, the heat treatment is preferably performed in an inert gas atmosphere from the viewpoint that, for example, when a regenerated product is obtained from a material to be regenerated, for example, decomposition of the material to be regenerated can be suppressed, mass reduction of a perfluoro(co)polymer can be suppressed, and a regenerated product having a large regeneration amount of the nitrile group as the crosslinking site can be easily obtained.

[0047]

Examples of the gas containing oxygen include a gas in which the content of oxygen is preferably 5 vol% or more with respect to the entire gas, and specific examples thereof include air.

Specific examples of the inert gas include nitrogen gas, argon gas, and helium gas, and among these, nitrogen gas is preferred.

As the inert gas, one type may be used or two or more types may be used.

The inert gas is preferably a gas containing no oxygen or a gas containing a small amount of oxygen from the viewpoint that, for example, the effect of the present

invention is further exhibited.

The gas containing a small amount of oxygen is desirably a gas in which the content of oxygen is preferably less than 5 vol%, more preferably 3 vol% or less, and still more preferably 1 vol% or less with respect to the entire gas because thermal decomposition of the material to be regenerated easily proceeds when the content of oxygen is large.

[0048]

The temperature and time during the heat treatment are not particularly limited as long as the temperature and time are such that the nitrile group as the crosslinking site is regenerated in the material to be regenerated.

The temperature during the heat treatment is usually a temperature higher than the temperature upon crosslinking of the uncrosslinked perfluoro(co)polymer (virgin product) by a conventionally known method, and is preferably 300 to 400°C, more preferably 320 to 390°C, and still more preferably 350 to 380°C.

The time during the heat treatment depends on the heat treatment temperature, but is preferably 30 minutes to 5 hours, and more preferably 1 to 3 hours.

The pressure during the heat treatment is not particularly limited, but it is preferred to perform the heat

treatment under normal pressure.

[0049]

<Other Components>

The present material is not particularly limited as long as it contains the regenerated product, and may be a material substantially composed only of the regenerated product, but may contain other conventionally known components that have conventionally been blended in a molded body such as a sealing material as necessary.

Examples of the other components include: an uncrosslinked perfluoro(co)polymer (virgin product); a crosslinking agent; a crosslinking aid; an ethylenically unsaturated bond-containing compound; a reactive organosilicon compound having two or more hydrosilyl groups in the molecule; perfluoropolyether; a non-adhesive agent such as fluorine oil; a catalyst; a polyol-based compound; a (co)polymer other than the perfluoro(co)polymer (example: fluororesin); an acid acceptor such as magnesium oxide or calcium hydroxide; an organic pigment such as an anthraquinone-based pigment, a perylene-based pigment, or a dioxazine-based pigment; a processing aid; a vulcanization accelerator; an anti-aging agent; an antioxidant; an inorganic filler; and an organic filler.

As each of the other components, only one type may be

used or two or more types may be used.

[0050]

<Uncrosslinked perfluoro(co)polymer>

As the present material, an uncrosslinked perfluoro(co)polymer (virgin product) is preferably used from the viewpoint that, for example, the present material excellent in molding processability can be easily obtained, and a sealing material having desired physical properties (hardness, tensile strength, elongation at break, compression set, and plasma resistance) can be easily formed.

Examples of the uncrosslinked perfluoro(co)polymer include (co)polymers similar to the uncrosslinked perfluoro(co)polymer described in the above-mentioned section of material to be regenerated.

As the uncrosslinked perfluoro(co)polymer, a perfluoro(co)polymer having a crosslinking site other than a nitrile group may be used, but a perfluoro(co)polymer having a nitrile group is preferably used.

[0051]

When an uncrosslinked perfluoro(co)polymer is used as the present material, the amount of the uncrosslinked perfluoro(co)polymer used is preferably 0.5 to 99.5 mass%, more preferably 1 to 90 mass%, and still more preferably 10 to 80 mass% with respect to 100 mass% of the present material

from the viewpoint that, for example, a sealing material having desired physical properties can be easily formed.

[0052]

<Crosslinking agent>

The present material can be crosslinked without using a crosslinking agent, but it is preferred to use a crosslinking agent appropriate to the type of the regenerated product used or the uncrosslinked perfluoro(co)polymer for the present material, and it is more preferred to use a crosslinking agent having a functional group capable of reacting with a nitrile group from the viewpoint that, for example, a sealing material which is sufficiently crosslinked and is excellent in balance among hardness, tensile strength, elongation at break, and tensile stress at 100% elongation (100% Mo) can be easily formed.

[0053]

As the crosslinking agent having a functional group capable of reacting with a nitrile group, for example, a conventionally known crosslinking agent such as a crosslinking agent described in JP 5278312 B2 can be used without particular limitation, and specific examples thereof include a triazine-based crosslinking agent, an oxazole-based crosslinking agent, an imidazole-based crosslinking agent, a thiazole-based crosslinking agent, an amidoxime-based

crosslinking agent, and an amidrazone-based crosslinking agent. Among these, a triazine-based crosslinking agent, an oxazole-based crosslinking agent, and an imidazole crosslinking agent are preferred.

[0054]

Examples of the triazine-based crosslinking agent include 2,4,6-trimercapto-1,3,5-triazine, 2-hexylamino-4,6-dimercaptotriazine, 2-diethylamino-4,6-dimercaptotriazine, 2-cyclohexylamino-4,6-dimercaptotriazine, 2-dibutylamino-4,6-dimercaptotriazine, 2-anilino-4,6-dimercaptotriazine, and 2-phenylamino-4,6-dimercaptotriazine.

In addition, the triazine crosslinking agent may be a compound that can serve as a catalyst for forming a triazine ring only with a nitrile group contained in the regenerated product or an uncrosslinked perfluoro(co)polymer as with an organotin compound such as tetraphenyltin or triphenyltin.

[0055]

Examples of the oxazole-based crosslinking agent include a crosslinking agent that reacts with a nitrile group to form an oxazole ring or an amidine structure, thereby providing a crosslinked product, and specific examples thereof include 2,2-bis(3-amino-4-hydroxyphenyl)hexafluoropropane (BOAP), 4,4'-sulfonylbis(2-aminophenol), and 9,9-bis(3-amino-4-hydroxyphenyl)fluorene.

[0056]

Examples of the imidazole crosslinking agent include a crosslinking agent that reacts with a nitrile group to form an imidazole ring, thereby providing a crosslinked product, and specific examples thereof include 2,2-bis(3,4-diaminophenyl)hexafluoropropane, 2,2-bis[3-amino-4-(N-methylamino)phenyl]hexafluoropropane, 2,2-bis[3-amino-4-(N-ethylamino)phenyl]hexafluoropropane, 2,2-bis[3-amino-4-(N-propylamino)phenyl]hexafluoropropane, 2,2-bis[3-amino-4-(N-phenylamino)phenyl]hexafluoropropane, 2,2-bis[3-amino-4-(N-perfluorophenylamino)phenyl]hexafluoropropane, and 2,2-bis[3-amino-4-(N-benzylamino)phenyl]hexafluoropropane.

[0057]

When a crosslinking agent is used for the present material, the amount of the crosslinking agent used is preferably 0.2 to 4 parts by mass, and more preferably 0.2 to 2.5 parts by mass with respect to 100 parts by mass of the total of the regenerated product and the uncrosslinked perfluoro(co)polymer, from the viewpoint that, for example, the crosslinking reaction sufficiently proceeds, and a sealing material excellent in balance among hardness, tensile strength, elongation at break, and 100% Mo can be easily formed.

[0058]

<Ethylenically unsaturated bond-containing compound>

Examples of the ethylenically unsaturated bond-containing compound include compounds described in, for example, WO 2022/065054 A, JP 2003-183402 A, and JP H11-116684 A.

[0059]

<Reactive organosilicon compound>

Examples of the reactive organosilicon compound include compounds which are similar to the organosilicon compounds described in, for example, JP 2003-183402 A and JP H11-116684 A.

[0060]

<Catalyst>

Examples of the catalyst include catalysts which are similar to the catalysts described in, for example, JP 2003-183402 A and JP H11-116684 A.

[0061]

<Organic pigment>

Examples of the organic pigment include organic pigments which are similar to the organic pigments described in, for example, WO 2016/043100 A, JP 4720501 B2, WO 2004/094527 A, and JP 5278312 B2.

[0062]

<Filler>

Examples of the inorganic filler include particulate (powdery) inorganic materials of, for example, carbon black, silica, barium sulfate, titanium oxide, and aluminum oxide.

Examples of the organic filler include particulate (powdery) organic materials of, for example, fluororesins such as PTFE, PFA, FEP, ETFE, and PVDF, polyethylene, polyimide, polyamideimide, polyetherimide, polyether ether ketone, polyether ketone, a silicone resin, and a melamine resin.

[0063]

<Method for preparing present material>

The present material can be prepared by mixing (kneading) the regenerated product and the above-mentioned other components as necessary.

When the regenerated product and the above-mentioned other components are mixed, the mixing order thereof is not particularly limited. These may be sequentially mixed (kneaded) in any order, or may be mixed (kneaded) all at once, but it is preferred that these are sequentially mixed (kneaded) such that the respective components are uniform.

[0064]

When performing the mixing (kneading), a conventionally known mixing (kneading) machine can be used, and examples thereof include an open roll, a Banbury mixer, a

biaxial roll, and a kneader.

Further, when performing the mixing (kneading), the mixing (kneading) may be performed under heating or cooling as necessary depending on a mixing (kneading) machine.

[0065]

<<Sealing material>>

The sealing material according to the present invention (hereinafter also referred to as "present sealing material") is a crosslinked body of the present material formed by crosslinking and molding the present material.

Despite using a regenerated perfluoro(co)polymer, the present sealing material is a sealing material having physical properties (hardness, tensile strength, elongation at break, compression set, and plasma resistance) comparable to those obtained when using a virgin product (uncrosslinked perfluoro(co)polymer), and in particular, is a sealing material having a small compression set and excellent heat resistance and plasma resistance.

[0066]

The tensile strength of the present sealing material measured by the method described in the following examples is preferably 7 MPa or more, and more preferably 8 MPa or more.

The elongation at break of the present sealing material measured by the method described in the following

examples is preferably 120% or more, and more preferably 130% or more.

The compression set (200°C × 72 hours, compression rate: 25%) of the present sealing material measured based on JIS K 6262:2013 is preferably 10% or less, more preferably 5% or less, and the lower limit thereof is not particularly limited, but is, for example, 0%.

The compression set (260°C × 72 hours, compression rate: 20%) of the present sealing material measured based on JIS K 6262:2013 is preferably 15% or less, more preferably 10% or less, and the lower limit thereof is not particularly limited, but is, for example, 0%.

The mass reduction rate of the present sealing material measured by the method described in the following examples is preferably 5% or less, more preferably 3% or less, and the lower limit thereof is not particularly limited, but is, for example, 0%.

[0067]

The present sealing material is not particularly limited, but can be used as, for example, a gasket or a packing for various members, and especially can be suitably used as a sealing material for a semiconductor manufacturing apparatus or a sealing material for a plasma processing apparatus, and particularly as a sealing material for a drive

unit including a gate valve used for an opening of a plasma processing chamber unit.

Examples of the present sealing material include an O-ring, a square-ring, a gasket, a packing, an oil seal, a bearing seal, and a lip seal.

The present sealing material has, for example, a shape that may be appropriately selected according to the intended use.

[0068]

The semiconductor manufacturing apparatus is not particularly limited to an apparatus for manufacturing a semiconductor, and broadly includes all manufacturing apparatus used in the semiconductor field requiring a high degree of cleanliness, such as an apparatus for manufacturing, for example, a liquid crystal panel, or a plasma panel, and specific examples thereof include an apparatus described in, for example, JP 5278312 B2.

[0069]

<<Method for producing sealing material>>

A method for producing a sealing material according to the present invention (hereinafter also referred to as “present sealing material production method”) includes a step I of crosslinking the present material.

[0070]

When a sealing material is formed from the present material, it is preferred to perform a sheeting step from the viewpoint of, for example, improving the efficiency of the molding operation and reducing the defect rate. This sheeting step is usually performed using, for example, a roll, and is usually also a step of preliminarily molding the present material into a sheet.

[0071]

The sheet obtained in the sheeting step is preferably preliminarily molded into a desired sealing material shape before the crosslinking step.

In this preliminary molding, a desired sealing material shape may be directly formed from the sheet obtained in the sheeting step, or the sheet obtained in the sheeting step may be formed into, for example, a rope shape (also synonymous with, for example, a ribbon shape or a noodle shape) by, for example, cutting or extrusion molding, and then the obtained rope-shaped product may be formed into a desired sealing material shape.

[0072]

<Step I>

The step I more preferably includes a primary crosslinking step and a secondary crosslinking step.

The step I is preferably performed using a

preliminarily molded body having a desired sealing material shape that is obtained by the preliminary molding.

[0073]

The primary crosslinking step is preferably a step of heating and pressurizing the preliminarily molded body having a desired sealing material shape that is obtained by the preliminary molding, and specific examples thereof include a step of casting the preliminarily molded body into a mold, followed by crosslinking at a temperature of, for example, 150 to 200°C for, for example, about 5 minutes to 1 hour under a pressure of about 2 to 15 MPa by, for example, a heat press.

[0074]

The secondary crosslinking step is preferably a step of heating the molded body obtained in the primary crosslinking step, and specific examples thereof include a step of heating the molded body at a temperature of, for example, 150 to 300°C for about 1 to 48 hours, more preferably about 3 to 24 hours using various ovens, preferably a vacuum oven, under normal pressure to reduced pressure.

By this secondary crosslinking step, crosslinking can be promoted, or even if an unreacted component remains after the primary crosslinking step, the unreacted component can be

decomposed and volatilized, and a sealing material with less generation of release gas can be formed.

[0075]

In the present sealing material production method, a step of performing irradiation with radiation (step of irradiating with radiation) may be performed after the crosslinking step from the viewpoint that, for example, a crack that may occur in the sealing material, for example, in a plasma atmosphere can be more easily suppressed. The sealing material obtained through the step of irradiation with radiation can be considered as a radiation-treated product.

[0076]

The radiation used for irradiation in the step of irradiation with radiation is not particularly limited, and examples thereof include an X-ray, a gamma ray, an electron beam, a proton beam, a neutron beam, a heavy particle beam, an alpha ray, and a beta ray, and among these, a gamma ray and an electron beam are preferred.

The radiation used for the irradiation may be of one type alone or two or more types.

[0077]

Upon irradiation with radiation, it is desirable to perform irradiation with radiation so that the absorbed dose

is preferably 1 to 120 kGy and more preferably 20 to 100 kGy. When irradiation with radiation is performed at such a dose, it is possible to reduce unreacted components that can be particles or released gas, and it is possible to easily form a sealing material excellent in, for example, plasma resistance and crack resistance without excessively reducing the molecular weights of the regenerated product and the uncrosslinked perfluoro(co)polymer.

The step of irradiation with radiation may be performed in two or more stages with the conditions changed.

[0078]

Upon irradiation with radiation, the irradiation may be performed in air. However, when oxygen is present during irradiation with radiation, the crosslinking reaction may be inhibited, and the mechanical strength of the obtained sealing material may be reduced or the surface of the obtained sealing material may become sticky. Thus, the step of irradiation with radiation is preferably performed in an atmosphere of an inert gas such as nitrogen or argon.

[0079]

<Step II>

The present sealing material production method preferably includes, before the step I and the sheeting step, a step II of obtaining a regenerated perfluoro(co)polymer

(regenerated product) by a heat treatment of a crosslinked perfluoro(co)polymer (material to be treated) obtained by crosslinking a perfluoro(co)polymer having a nitrile group as a crosslinking site to regenerate at least some crosslinking sites.

The material to be treated used in the step II, the regenerated product obtained in the step II, the heat treatment conditions in the step II, and others are as described in the section of the sealing material-forming material.

Examples

[0080]

Next, the present invention will be described in more detail with reference to examples, but the present invention is not limited thereto.

[0081]

<Uncrosslinked perfluoro(co)polymer (virgin product)>

The uncrosslinked perfluoro(co)polymer (virgin product) used in the following examples and comparative examples is as follows.

· “Uncrosslinked perfluoro(co)polymer-1”: PFE 131T (manufactured by 3M Company, a perfluoro(co)polymer in which a crosslinking site is a nitrile group)

· "Uncrosslinked perfluoro(co)polymer-c1": Tecnoflon PFR94 (manufactured by Solvay S.A., a perfluoro(co)polymer in which a crosslinking site is a halogen atom)

[0082]

<Crosslinked perfluoro(co)polymer (material to be regenerated)>

The crosslinked perfluoro(co)polymer (material to be regenerated) used in the following preparation examples is as follows.

· "Crosslinked perfluoro(co)polymer-1": A molded body (O-ring) (corresponding to an unused or used molded body) produced by kneading 100 parts by mass of a perfluoroelastomer (PFE 131T [manufactured by 3M Company]), and 0.5 parts by mass of an oxazole-based crosslinking agent (BOAP, 2,2-bis(3-amino-4-hydroxyphenyl)hexafluoropropane, manufactured by Tokyo Chemical Industry Co., Ltd.) with an open roll, then filling an O-ring-shaped mold with the resulting massive elastomer composition, and performing press-molding at 180°C for 30 minutes under a pressure of 5 MPa using a compression vacuum press (primary crosslinking), and subsequently heating the press-molded sheet in an oven at 250°C for 24 hours (secondary crosslinking).

· "Crosslinked perfluoro(co)polymer-2": A primarily crosslinked molded body that protruded from the parting line

of the mold (flash) during primary crosslinking in a mold in the production process of the "crosslinked perfluoro(co)polymer-1".

· "Crosslinked perfluoro(co)polymer-c1": A molded body (O-ring) (corresponding to an unused or used molded body) produced by kneading 100 parts by mass of a perfluoroelastomer (Tecnoflon PFR94 [manufactured by Solvay S.A.]), 1 part by mass of TAIC (triallyl isocyanurate manufactured by Mitsubishi Chemical Corporation), and 0.5 parts by mass of PERHEXA 25B (manufactured by NOF Corporation) with an open roll, then filling an O-ring-shaped mold with the resulting massive elastomer composition, and performing press-molding at 170°C for 10 minutes under a pressure of 5 MPa using a compression vacuum press (primary crosslinking), and subsequently heating the press-molded sheet in an oven at 200°C for 4 hours (secondary crosslinking).

[0083]

[Preparation Example 1]

The crosslinked perfluoro(co)polymer-1 (material to be regenerated) was placed in KDF-75Plus manufactured by Yamato Scientific Co., Ltd. and subjected to a heat treatment at 380°C and 1 atm for 1 hour in a nitrogen atmosphere to obtain a regenerated perfluoro(co)polymer-1 (regenerated product).

[0084]

<Content of crosslinking site>

The content of the crosslinking site in each of the crosslinked perfluoro(co)polymer-1 (material to be regenerated) and the regenerated perfluoro(co)polymer-1 (regenerated product) was measured using FT-IR (HYPERION 3000, manufactured by Bruker Corporation) under the conditions of a resolution of 4 cm^{-1}, a scan number of 32, a transmission method, and a measurement range of 400 to 4000 cm^{-1}.

Specifically, the content of the crosslinking site (nitrile group) was defined as a value obtained by dividing the maximum intensity when a baseline was drawn by connecting the intensities at 2230-2290 cm^{-1} by the intensity at 2500 cm^{-1} when a baseline was drawn by connecting the intensities at 2200-2700 cm^{-1}. However, when the calculation result (content of crosslinking site (nitrile group)) was less than 0.01, the content of the crosslinking site (nitrile group) was taken to be 0.01.

[0085]

The content of the crosslinking site (nitrile group) in the crosslinked perfluoro(co)polymer-1 (material to be regenerated) was 0.1, and the content of the crosslinking site (nitrile group) in the regenerated perfluoro(co)polymer-

1 (regenerated product) was 0.35.

[0086]

<Mass reduction rate>

The mass of the crosslinked perfluoro(co)polymer-1 (material to be regenerated) was measured, and the mass of the obtained regenerated perfluoro(co)polymer-1 (regenerated product) was measured, and the mass reduction rate (%) was determined by the following formula (A). The mass reduction rate was 0.6%.

Mass reduction rate (%) = [(mass of material to be regenerated - mass of regenerated product)/mass of material to be regenerated] × 100 (A)

[0087]

[Preparation Example 2]

A regenerated perfluoro(co)polymer-2 (regenerated product) was obtained in the same manner as in Preparation Example 1 except that the heat treatment was performed in air instead of the nitrogen atmosphere in Preparation Example 1.

The content of the crosslinking site (nitrile group) in the regenerated perfluoro(co)polymer-2 (regenerated product) was measured in the same manner as in Preparation Example 1, and found to be 0.22.

In addition, the mass reduction rate was measured in the same manner as in Preparation Example 1, and found to be

2.3%.

[0088]

[Preparation Example 3]

A regenerated perfluoro(co)polymer-3 (regenerated product) was obtained in the same manner as in Preparation Example 1 except that the crosslinked perfluoro(co)polymer-2 (material to be regenerated) was used instead of the crosslinked perfluoro(co)polymer-1 in Preparation Example 1.

The content of the crosslinking site (nitrile group) in the crosslinked perfluoro(co)polymer-2 (material to be regenerated) was measured in the same manner as in Preparation Example 1, and found to be 0.01, and the content of the crosslinking site (nitrile group) in the regenerated perfluoro(co)polymer-3 (regenerated product) was measured and found to be 0.6.

In addition, the mass reduction rate was measured in the same manner as in Preparation Example 1, and found to be 2.3%.

[0089]

[Preparation Example 4]

A regenerated perfluoro(co)polymer-4 (regenerated product) was obtained in the same manner as in Preparation Example 3 except that the heat treatment was performed in air instead of the nitrogen atmosphere in Preparation Example 3.

The content of the crosslinking site (nitrile group) in the regenerated perfluoro(co)polymer-4 (regenerated product) was measured in the same manner as in Preparation Example 1, and found to be 0.61.

In addition, the mass reduction rate was measured in the same manner as in Preparation Example 1, and found to be 4.1%.

[0090]

[Preparation Example 5]

A regenerated perfluoro(co)polymer-c1 (regenerated product) was obtained in the same manner as in Preparation Example 1 except that the crosslinked perfluoro(co)polymer-c1 (material to be regenerated) was used instead of the crosslinked perfluoro(co)polymer-1 in Preparation Example 1.

The mass reduction rate was measured in the same manner as in Preparation Example 1, and found to be 0.9%.

[0091]

[Preparation Example 6]

A regenerated perfluoro(co)polymer-c2 (regenerated product) was obtained in the same manner as in Preparation Example 5 except that the heat treatment was performed in air instead of the nitrogen atmosphere in Preparation Example 5.

The mass reduction rate was measured in the same manner as in Preparation Example 1, and found to be 2.4%.

[0092]

[Example 1]

A massive elastomer composition was obtained by kneading 60 parts by mass of the uncrosslinked perfluoro(co)polymer-1 (virgin product), 40 parts by mass of the regenerated perfluoro(co)polymer-1 (regenerated product), and 0.5 parts by mass of an oxazole-based crosslinking agent (BOAP, 2,2-bis(3-amino-4-hydroxyphenyl)hexafluoropropane, manufactured by Tokyo Chemical Industry Co., Ltd.) with an open roll.

The resulting massive elastomer composition was subjected to a sheeting step (sheet forming step) using a roll (roll interval: 8 mm, temperature: 50°C).

The sheet obtained in the sheeting step was press-molded at 180°C for 30 minutes under a pressure of 5 MPa using a compression vacuum press (primary crosslinking), and then the press-molded sheet was heated at 250°C for 24 hours in an oven (secondary crosslinking) to obtain a molded body (O-ring).

[0093]

[Examples 2 to 4 and Comparative Example 1]

A molded body was obtained in the same manner as in Example 1 except that the (co)polymers of the types and amounts (numerical values: parts by mass) shown in Table 1

were used as the uncrosslinked perfluoro(co)polymer and the regenerated perfluoro(co)polymer in Example 1.

[0094]

[Comparative Example 2]

A massive elastomer composition was obtained by kneading 60 parts by mass of the uncrosslinked perfluoro(co)polymer-c1 (virgin product), 40 parts by mass of the regenerated perfluoro(co)polymer-c1 (regenerated product), 10 parts by mass of PTFE particles (Lubron L5 (manufactured by Daikin Industries, Ltd.)), 0.5 parts by mass of PERHEXA 25B (manufactured by NOF CORPORATION), and 1 part by mass of TAIC (triallyl isocyanurate, manufactured by Mitsubishi Chemical Corporation) with an open roll.

A molded body (O-ring) was obtained by filling an O-ring-shaped mold with the obtained massive elastomer composition, followed by press-molding at 170°C for 10 minutes under a pressure of 5 MPa using a compression vacuum press (primary crosslinking), and then heating the press-molded sheet at 200°C for 4 hours in an oven (secondary crosslinking).

[0095]

[Comparative Examples 3 and 4]

A molded body was obtained in the same manner as in Comparative Example 2 except that the (co)polymers of the

types and amounts (numerical values: parts by mass) shown in Table 1 were used as the uncrosslinked perfluoro(co)polymer and the regenerated perfluoro(co)polymer in Comparative Example 2.

[0096]

<Tensile strength and elongation at break>

The obtained molded body (O-ring) was pulled at 500 mm/min, and the tensile strength and the elongation at break were measured at 23°C using a Shopper type tensile tester. The results are shown in Table 1.

[0097]

<Compression set>

The compression set of the sealing material was determined in accordance with JIS K 6262:2013.

The obtained molded body was held at 200°C for 72 hours at a compression rate of 25%, then the pressure was released, and the molded body was allowed to cool at a standard temperature in a test chamber for 30 minutes, and then the thickness of the molded body was measured.

Further, the obtained molded body was held at 260°C for 72 hours at a compression rate of 20%, then the pressure was released, and the molded body was allowed to cool at a standard temperature in a testing room for 30 minutes, and then the thickness of the molded body was measured.

The compression set rate (CS) was calculated based on the following formula. The results are shown in Table 1.

Compression set rate (%) = {(h0 - h1)/(h0 - h2)} × 100

[h0: thickness (mm) of molded body before compression, h1: thickness (mm) of molded body after cooling for 30 minutes, h2: thickness (height) of spacer (mm)]

[0098]

<Mass reduction rate (plasma resistance)>

The obtained molded body was measured for the plasma resistance (mass reduction rate). Specifically, measurement was performed as follows. The results are shown in Table 1.

A fluorine radical exposure test was performed in which the obtained molded body (O-ring) was exposed to fluorine radicals generated from NF_3 by remote plasma under the following conditions. The mass of the molded body (O-ring) was measured before and after the test, and the mass reduction rate was determined by the following formula to evaluate the plasma resistance. It can be said that the smaller the mass reduction rate is, the better the plasma resistance is.

Mass reduction rate (%) = {(mass before test - mass after test)/(mass before test)} × 100

[0099]

(Conditions)

· Plasma source: remote plasma source

· Plasma output: 5000 W

· Gas flow rate: NF_3; 1.5 SLM, Argon; 1.5 SLM

· Vacuum degree: 7 torr

· Test temperature: 250°C

· Test time: 5 hours

[0100]

[Table 1]

	Example 1	Example 2	Example 3	Example 4	Comparative Example 1	Comparative Example 2	Comparative Example 3	Comparative Example 4
Uncrosslinked perfluoro(co)polymer-1	60	60	60	60	100			
Uncrosslinked perfluoro(co)polymer-c1						60	60	100
Regenerated perfluoro(co)polymer-1	40							
Regenerated perfluoro(co)polymer-2		40						
Regenerated perfluoro(co)polymer-3			40					
Regenerated perfluoro(co)polymer-4				40				
Regenerated perfluoro(co)polymer-c1						40		
Regenerated perfluoro(co)polymer-c2							40	
Tensile strength (MPa)	8.6	8.2	9.4	9.3	10.4	8.6	10.6	8.8
Elongation at break (%)	187	203	208	223	185	195	225	205
CS (%) at compression of 25%, 200°C × 72 h	2	3	3	5	2	41	46	41
CS (%) at compression of 20%, 260°C × 72 h	7	9	9	14	10	104	104	101
Mass reduction rate (%)	0.11	0.17	0.11	0.19	0.11	0.48	0.61	0.45

[0101]

In Examples 1 to 4, it was possible to obtain a molded body having physical properties similar to those in Comparative Example 1 using only a virgin product, and it was

possible to obtain a molded body having a smaller compression set and exhibiting superior heat resistance and plasma resistance (smaller mass reduction rate) as compared with Comparative Examples 2 to 4.

CLAIMS

[Claim 1]

A sealing material-forming material comprising a regenerated perfluoro(co)polymer, wherein

the regenerated perfluoro(co)polymer is a (co)polymer in which at least some crosslinking sites are regenerated by a heat treatment of a crosslinked perfluoro(co)polymer obtained by crosslinking a perfluoro(co)polymer having a nitrile group as a crosslinking site, and

the perfluoro(co)polymer having a nitrile group comprises a structural unit derived from at least one type selected from perfluoroolefin and perfluorovinyl ether, and a structural unit having a nitrile group.

[Claim 2]

The sealing material-forming material according to claim 1, wherein the regenerated perfluoro(co)polymer is a (co)polymer having at least one crosslinked structure selected from a triazine structure, an oxazole structure, an amidine structure, and an imidazole structure.

[Claim 3]

The sealing material-forming material according to claim 1, further comprising a crosslinking agent having a functional group capable of reacting with a nitrile group.

[Claim 4]

The sealing material-forming material according to claim 1, further comprising an uncrosslinked perfluoro(co)polymer.

[Claim 5]

The sealing material-forming material according to claim 4, wherein a content of the regenerated perfluoro(co)polymer is 0.5 parts by mass or more with respect to 100 parts by mass of the uncrosslinked perfluoro(co)polymer.

[Claim 6]

A sealing material formed by crosslinking and molding the sealing material-forming material according to any one of claims 1 to 5.

[Claim 7]

A method for producing a sealing material, comprising a step of crosslinking the sealing material-forming material according to any one of claims 1 to 5.

[Claim 8]

The method for producing a sealing material according to claim 7, comprising a step of obtaining a regenerated perfluoro(co)polymer by regenerating at least some crosslinking sites by a heat treatment of a crosslinked perfluoro(co)polymer obtained by crosslinking a

perfluoro(co)polymer having a nitrile group as a crosslinking site.