

TITLE OF THE INVENTION

METHOD FOR MANUFACTURING NANOHOLES AND FILTER

MANUFACTURED BY THE SAME

5 BACKGROUND OF THE INVENTION

(a) Field of the Invention

The present invention relates to a method for manufacturing nanoholes and a filter manufactured by the same, and more particularly, to a method for manufacturing nanoholes, the method being capable of easily manufacturing
10 nanoholes with a size of several to hundreds of nanometers, and to a filter manufactured by the same.

(b) Description of the Related Art

A nanohole refers to a pore or passage having a nanoscale width, and is used in various fields, such as for a computing device and a memory device.

15 It has been reported until now that such nanoholes are arranged by colloidal lithographic etching, nanoimprint lithography, the use of an anodic aluminum oxide template, and block copolymer-based optical lithographic patterning processes.

However, such methods employ separate apparatuses or methods
20 enabling nanoscale patterning, and thus have problems of requiring a lot of time and complicated processes, and there are technical and commercial limitations in manufacturing nanoholes with a diameter of 20 nm or smaller.

For example, in cases where nanoholes are manufactured through mechanical processing, the sizes of tools are restricted, and in cases of

photolithography, the shape limit of a photosensitive film is at least 1 μm due to optical diffraction of a photo-mask. Therefore, it is, in fact, difficult to realize several nanometer-sized nanoholes through the above techniques.

Moreover, when a filter capable of collecting nanoscale particles is
5 manufactured, current techniques enable the manufacture of holes of tens of nanometers, but it is difficult to manufacture filters having holes with a size of below such sizes, that is, of several nanometers.

<Related cited document 1> Korean Patent Registration No. 10-1408194

10 <Related cited document 2> Korean Patent Registration No. 10-10-1399459

The above information disclosed in this Background section is only for enhancement of understanding of the background of the invention and therefore it may contain information that does not form the prior art that is already known
15 in this country to a person of ordinary skill in the art.

SUMMARY OF THE INVENTION

The present invention has been made in an effort to provide a method for manufacturing nanoholes and a filter manufactured by the same, having advantages of easily and simply manufacturing nanoholes with a scale of
20 several nanometers or less.

An exemplary embodiment of the present invention provides a method for manufacturing nanoholes, the method including: a preparing step of preparing a body having a through-hole which passes through two facing surfaces and has a nano- or micro-scale diameter; and a particle injecting step

of injecting particles with a smaller diameter than the through-hole into the through-hole to form nanoholes with a smaller scale than the through-hole.

In the particle injecting step, a plurality of kinds of particles with different sizes may be injected into the through-hole.

5 In the particle injecting step, the same kind of particles with the same size may be injected into the through-hole.

In the particle injecting step, electrically or chemically treated particles may be injected.

10 An inlet, through which the particles are injected in the particle injecting step, and an outlet, which is opposite to the inlet, may be formed in an asymmetric structure so that the particles injected in the particle injecting step do not leave the through-hole.

In the through-hole, the diameter of the inlet may be larger than that of the outlet.

15 An inlet, to which the particles are injected in the particle injecting step, and an outlet, which is opposite to the inlet, may be formed in a symmetric structure, and the method may further include an outlet reducing step of reducing the diameter of the outlet of the through-hole, between the preparing step and the particle injecting step.

20 Another embodiment of the present invention provides a filter including: a filter part having a through-hole which penetrates two facing surfaces and has a nano- or micro-scale diameter; and particles inserted into the through-hole and having a smaller diameter than the through-hole, wherein the filter part has nanoholes with a smaller scale than the through-hole by the particles injected

into the through-hole.

The size of the nanoholes may be controlled by adjusting the size of particles injected into the through-hole.

The particles may have electrically positive or negative polarity by
5 binding to a functional group.

A surface of the particles may be positively or negatively charged so that an electrically charged electric double layer is formed on the surface of the particle or a region adjacent to the surface.

In the through-hole, the diameter of an inlet, through which the particles
10 are injected, may be larger than that of an outlet, which is opposite to the inlet.

The filter part may be an anodic aluminum oxide (AAO) membrane.

According to an embodiment of the present invention, a method for manufacturing nanoholes can be provided, the method being capable of easily manufacturing nanoholes with a scale of several nanometers or less.

15 Furthermore, the size and arrangement of nanoholes can be controlled by adjusting the size of injected particles.

In addition, surface-functionalized nanoholes can be manufactured by performing a chemical or electric treatment on injected particles.

According to an embodiment of the present invention, a filter capable of
20 easily collecting particles even with a size of several nanometers can be provided.

Furthermore, even particles with a smaller size than nanoholes can be easily collected by surface-functionalizing particles injected in the nanoholes.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a process flowchart schematically showing a method for manufacturing nanoholes according a first embodiment of the present invention;

FIG. 2 is a front view schematically illustrating a preparing step in the method for manufacturing nanoholes shown in FIG. 1;

5 FIG. 3 is a view illustrating a state in which particles with the same size are injected in the particle injecting step in the method for manufacturing nanoholes shown in FIG. 1;

FIG. 4 is a view illustrating a state in which particles with different sizes are injected in the particle injecting step in the method for manufacturing
10 nanoholes shown in FIG. 1;

FIG. 5 is a view schematically showing the binding of a functional group to a particle surface in the particle injecting step in the method for manufacturing nanoholes shown in FIG. 1;

FIG. 6 is a view schematically showing a state in which an electric
15 double layer is formed by injecting charged particles in the particle injecting step in the method for manufacturing nanoholes shown in FIG. 1;

FIG. 7 is a process flowchart schematically showing a method for manufacturing nanoholes according a second embodiment of the present invention;

20 FIG. 8 is a view schematically illustrating an outlet reducing step in the method for manufacturing nanoholes shown in FIG. 7;

FIG. 9 is a view schematically showing a filter according to an embodiment of the present invention; and

FIG. 10 is an image showing an enlarged external surface of anodic

aluminum oxide used as a filter part of the filter shown in FIG. 9.

- Explanation of reference numerals -

10: body

20: particle

S100: nanohole preparing step

S110: preparing step

5 S120: particle injecting step

S200: nanohole preparing step

S215: outlet reducing step

300: filter

310: filter part

320: particle

10 **DETAILED DESCRIPTION OF THE EMBODIMENTS**

The present invention will be described more fully hereinafter with reference to the accompanying drawings, in which embodiments of the invention are shown. As those skilled in the art would realize, the described embodiments may be modified in various different ways, all without departing
15 from the spirit or scope of the present invention. The drawings and description are to be regarded as illustrative in nature and not restrictive. Like reference numerals designate like elements throughout the specification.

Prior to descriptions, in the embodiments, elements having the same configuration are denoted by the same reference numerals and will be
20 described representatively in a first embodiment, and only configurations different from those of the first embodiment will be described in the other embodiments.

Hereinafter, a method S100 for manufacturing nanoholes according to a

first embodiment of the present invention will be described with reference to the accompanying drawings.

FIG. 1 is a process flowchart schematically showing a method for manufacturing nanoholes according a first embodiment of the present invention.

5 Referring to FIG. 1, according to the method S100 for manufacturing nanoholes according to the first embodiment of the present invention, particles with a smaller size than a nano- or micro-scale through-hole 11 are injected into the through-hole 11, and as a result, nanoholes 30 with a size of several nanometers or smaller can be manufactured, wherein the method comprises a
10 preparing step S110 and a particle injecting step S120.

FIG. 2 is a front view schematically illustrating a preparing step in the method for manufacturing nanoholes shown in FIG. 1.

Referring to FIG. 2, in the preparing step S110, a body 10 which passes through two facing surfaces and has a through-hole 11 with a nano- or micro-
15 scale diameter is prepared.

Here, the through-hole 11 may be formed to pass through upper and lower surfaces of the body 10, or right and left surfaces of the body 10.

In the first embodiment of the present invention, the through-hole 11 is prepared such that, based on a direction in which particles 20 are injected in the
20 below-described particle injecting step S120, an inlet 11a, through which the particles 20 are injected, and an outlet 11b, which is opposite to the inlet 11a, are asymmetric.

More specifically, the shape of the inlet 11a and the shape of the outlet

11b may be asymmetric to each other by differently preparing the diameter of the inlet 11a and the diameter of the outlet 11b.

That is, the diameter of the inlet 11a and the diameter of the outlet 11b are differently prepared, and more preferably, the diameter of the inlet 11a is prepared to be larger than the diameter of the outlet 11b, thereby preventing the particles 20 injected in the particle injecting step S120 from leaving through the outlet 11b.

Here, the diameter of the outlet 11b may be preferably smaller than the diameter of the particles 20 injected in the below-described particle injecting step S120, but is not limited thereto.

In the particle injecting step S120, particles with a smaller diameter than the through-hole 11 are injected into the through-hole 11, thereby manufacturing nanoholes with a smaller scale than the through-hole 11.

That is, the particles 20 are injected into the through-hole 11, and thus nanoholes 30 are manufactured by pores formed between the particles 20.

Here, nanoholes 30 with a user-desired size can be manufactured by selecting the kind of injected particles 20.

FIG. 3 is a view illustrating a state in which particles with the same size are injected in the particle injecting step in the method for manufacturing nanoholes shown in FIG. 1, and FIG. 4 is a view illustrating a state in which particles with different sizes are injected in the particle injecting step in the method for manufacturing nanoholes shown in FIG. 1.

For example, as shown in FIG. 3, when it is assumed that the particles

20 injected into the through-hole 11 have the same size, nanoholes 30 having a constant size that is smaller than the diameter of the injected particles 20 can be manufactured.

That, when it is assumed that the particles 20 have a completely circular
5 shape, nanoholes 30 with a user-desired size can be manufactured by selecting the size of injected particles 20

According to the first embodiment of the present invention, the particles injected in the particle injecting step S120 may be a plurality of kinds of particles with different sizes.

10 For example, as shown in FIG. 4, first particles 21 and second particles 22 having a smaller diameter than the first particles 21 may be simultaneously or sequentially injected into the through-hole 11. As such, when the first particles 21 and the second particles 22 are injected into the through-hole 11, the second particles 22 are disposed in pores formed in a state in which the first
15 particles 21 are arranged, and thus nanoholes 30 with a more minute scale can be formed when compared with the case in which only the first particles are injected.

Here, for the convenience of description, the present embodiment exemplifies the provision of two kinds of particles, that is, the first particles 21
20 and the second particles 22 having different sizes, but it is not limited thereto, and thus more minute nanoholes 30 can be manufactured by using two or more kinds of particles.

Further, when the injected particles 20 are several nanometer-level nanoparticles, the nanoholes 30 formed in the first embodiment of the present

invention may have a pico-scale size.

According to the first embodiment of the present invention, the particles injected in the particle injecting step S120 may be electrically or chemically treated particles. That is, particles that are surface-functionalized by an electrical or chemical treatment may be injected into the through-hole 11.

Here, for the particles that are surface-functionalized by an electrical or chemical treatment, several methods that are conventionally disclosed may be utilized.

As one example of the chemical treatment, the surfaces of the particles 20 may be positively charged using a peptide. That is, the peptide may bind to the surfaces of the particles 20 by providing a functional group, such as a hydroxyl group (OH) or a carboxyl group (COOH), to the surfaces of the particles 20.

FIG. 5 is a view schematically showing the binding of a functional group to a particle surface in the particle injecting step in the method for manufacturing nanoholes shown in FIG. 1.

Such a peptide has electrically positive (+) polarity since hydrogen is separated from a functional group, such as a hydroxyl group (OH) or a carboxyl group (COOH), and thus can limit the kind of particles which can pass through nanoholes 30.

As one example of the electrical treatment, the particles 20 may be injected into the through-hole 11 while the particles are charged, so that an electrically charged electric double layer is formed on surfaces of the particles.

FIG. 6 is a view schematically showing a state in which an electric double layer is formed by injecting charged particles in the particle injecting step in the method for manufacturing nanoholes shown in FIG. 1.

Referring to FIG. 6, the term electric double layer refers to a phenomenon in which charges are naturally formed along the particle, and a phenomenon in which charges having opposite polarity to charges formed on the particle form a layer around the charge. For example, when the surface of the particle 20 is positively (+) charged, a layer having negative (-) polarity is formed around the particle 20.

Thus, electrically negative (-) particles have limitations in passing through the nanohole 30, and only electrically positive (+) or neutral particles can pass through the nanohole 30.

The above-described embodiment exemplifies that the particles 20 are surface-functionalized through an electric or chemical treatment, but is not limited thereto, and thus the conventionally known various methods can be utilized.

Next, a method S200 for manufacturing nanoholes according to a second embodiment of the present invention will be described.

FIG. 7 is a process flowchart schematically showing a method for manufacturing nanoholes according a second embodiment of the present invention.

Referring to FIG. 7, in the method S200 for manufacturing nanoholes according to the second embodiment of the present invention, particles with a

smaller size than a nano- or micro-scale through-hole 11 are injected into the through-hole 11, and as a result, nanoholes 30 with a size of several nanometers or smaller can be manufactured, wherein the method includes a preparing step S110, an inlet reducing step S215, and a particle injecting step
5 S120.

Since the preparing step S110 is substantially the same as that in the first embodiment, a description thereof will be omitted.

However, the present embodiment is different from the first embodiment in that a body 10 including a through-hole 11 of which an inlet 11a and an outlet
10 11b are symmetric to each other is utilized.

More specifically, the body 10 of the second embodiment includes the through-hole 11 having a structure in which the shape of the inlet 11a and the shape of the outlet 11b correspond to each other by forming the inlet 11a and the outlet 11b to have the same diameter.

15 Further, the through-hole 11 may be formed such that the diameter of the inlet 11a and the diameter of the outlet 11b are the same, and more preferably, the center of the inlet 11a and the center of the outlet 11b are on the same central axis.

However, according to such a structure, particles 20 injected in the
20 below-describing particle injecting step (S120) can naturally leave through the outlet 11b.

FIG. 8 is a view schematically illustrating an outlet reduction step in the method for manufacturing nanoholes shown in FIG. 7.

Referring to FIG. 8, in the outlet reducing step S215, as described above, in cases where the through-hole 11 has a symmetric structure, an outlet reducing member 12 for shielding a part of the outlet 11b is provided on a surface of the body in which the outlet 11b is formed, in order to prevent the particles from leaving through the outlet 11b.

According to the second embodiment of the present invention, in the outlet reducing step S215, the outlet reducing member 12 having a penetration hole formed on an external surface thereof is attached to the surface of the body 10 in which the outlet 11b is formed.

Here, the size of the penetration hole of the outlet reducing member 12 may be similar to or smaller than that of the outlet 11b. That is, the outlet reducing member 12 is attached to the surface of the body 10 in which the outlet 11b is formed, thereby shielding a part of the outlet 11b. Therefore, the outlet reducing member 12 prevents the particles 20 from passing through the outlet 11b and leaving the through-hole 11.

That is, without being limited thereto, if the penetration hole of the outlet reducing member 12 has a larger size than the outlet 11b, the size of the outlet 11b can be reduced by disposing the penetration hole of the outlet reducing member 12 and the outlet 11b to be oblique to each other, that is, partially overlapping the outlet 11b and a region of the outlet reducing member 12 in which the penetration hole is not formed.

However, the reducing of the size of the outlet is not limited to the above methods. The outlet reducing step S215 according to the second embodiment of the present invention may be performed as long as a predetermined material

is bonded on the edge of the outlet 11b or the size of the outlet 11b is reduced by any other method.

Since the particle injecting step S120 is substantially the same as that in the first embodiment, a description thereof will be omitted.

5 Next, a filter 300 according to an embodiment of the present invention will be described.

FIG. 9 is a view schematically showing a filter according to an embodiment of the present invention.

FIG. 10 is an image showing an enlarged external surface of anodic
10 aluminum oxide used as a filter part of the filter shown in FIG. 9.

Referring to FIG. 9, a filter 300 according to an embodiment of the present invention has nanoholes manufactured by the method for manufacturing nanoholes according to the above-described first or second embodiment, and includes a filter part 310 and particles 320.

15 Referring to FIG. 10, the filter part 310 has a plurality of through-holes 311 passing through external surfaces thereof, contaminants are filtered by the through-holes 311, and thus purified air can be exhausted.

Here, the through-holes 311 have a scale of tens to hundreds of nanometers, and can filter minute particles with a larger scale than the through-
20 holes 311.

Referring to FIG. 10, according to an embodiment of the present invention, the filter part 310 may be prepared by an anodic aluminum oxidation filter. Here, in the anodic aluminum oxide filter, an inlet 311a and an outlet

311b of the through-hole 311 are asymmetric, and thus even though particles 320 are injected through the inlet 311a, the particles 320 do not leave through the outlet 311b due to the structural characteristics of the through-hole 311.

Without being limited to, a through-hole 311 having a symmetric
5 structure as described in the methods (S100 and S200) for manufacturing nanoholes according to the first and second embodiments may be used.

The particles 320 are inserted into the through-hole 311 to reduce the scale of the through-hole 311 to the several nano-scales or pico-scales. As described in the methods S100 and S200 for manufacturing nanoholes
10 according to the first and second embodiments, a part of the through-hole 311 is shielded by the particles 310 placed inside the through-hole 311, and thus nanoholes 330 having a smaller scale than the through-hole 311 are manufactured.

Here, the particles may be placed inside the through-hole 311 while
15 being surface-functionalized, and this feature is substantially the same as those in the methods S100 and S200 for manufacturing nanoholes according to the first and second embodiments, and thus a detailed description thereof will be omitted.

However, as for the functional effect thereof, the particles 320 have
20 electrically positive (+) or negative (-) polarity by an electrical or chemical treatment, and thus the filter part 310 can selectively pass through only predetermined materials in air.

While this invention has been described in connection with what is presently considered to be practical exemplary embodiments, it is to be

understood that the invention is not limited to the disclosed embodiments, but, on the contrary, is intended to cover various modifications and equivalent arrangements included within the scope of the appended claims.

WHAT IS CLAIMED IS:

1. A method for manufacturing nanoholes, the method comprising:
a preparing step of preparing a body having a through-hole which
5 passes through two facing surfaces and has a nano- or micro-scale diameter;
and
a particle injecting step of injecting particles with a smaller diameter than
the through-hole into the through-hole to form nanoholes with a smaller scale
than the through-hole.
10
2. The method of claim 1, wherein in the particle injecting step, a
plurality of kinds of particles with different sizes are injected into the through-
hole.
- 15 3. The method of claim 1, wherein in the particle injecting step, the
same kind of particles with the same size are injected into the through-hole.
4. The method of claim 1, wherein in the particle injecting step,
electrically or chemically treated particles are injected.
20
5. The method of any one of claims 1 to 4, wherein an inlet,
through which the particles are injected in the particle injecting step, and an
outlet, which is opposite to the inlet, are formed in an asymmetric structure so

that the particles injected in the particle injecting step do not leave the through-hole.

6. The method of claim 5, wherein in the through-hole, the diameter
5 of the inlet is larger than that of the outlet.

7. The method of any one of claims 1 to 4, wherein an inlet, to
which the particles are injected in the particle injecting step, and an outlet,
which is opposite to the inlet, are formed in a symmetric structure, and
10 wherein the method further comprises an outlet reducing step of
reducing the diameter of the outlet of the through-hole, between the preparing
step and the particle injecting step.

8. A filter comprising:
15 a filter part having a through-hole which penetrates two facing surfaces
and has a nano- or micro-scale diameter; and
particles inserted into the through-hole and having a smaller diameter
than the through-hole,
wherein the filter part has nanoholes with a smaller scale than the
20 through-hole by the particles injected into the through-hole.

9. The filter of claim 8, wherein the size of the nanoholes is
controlled by adjusting the size of particles injected into the through-hole.

10. The filter of claim 8, wherein the particles have electrically positive or negative polarity by binding to a functional group.

5 11. The filter of claim 8, wherein a surface of the particles is positively or negatively charged so that an electrically charged electric double layer is formed on the surface of the particle or a region adjacent to the surface.

12. The filter of any one of claims 1 to 11, wherein in the through-
10 hole, the diameter of an inlet, through which the particles are injected, is larger than that of an outlet, which is opposite to the inlet.

13. The filter of claim 12, wherein the filter part is an anodic aluminum oxide (AAO) membrane.

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