

[Name of Document] Description

[Title of Invention] SYSTEM FOR PRODUCING ULTRAPURE WATER
AND METHOD FOR PRODUCING ULTRAPURE WATER

[Technical Field]

5 [0001]

The present invention relates to an ultrapure water production system which can efficiently reduce boron present in water to be treated, and a method for producing ultrapure water using the ultrapure water production system.

10 [Background Art]

[0002]

Conventionally, in the field of manufacturing electronic devices, such as semiconductors or liquid crystal panels, ultrapure water having an extremely low content of impurities, such as organic matter, particles, and ionic substances, has been used to clean a system. Especially in a semiconductor manufacturing process, with miniaturization and an increase in capacity of semiconductors, ultrapure water to be used is required to have an extremely high purity.

[0003]

Such ultrapure water used in the semiconductor manufacturing process is mainly produced by an ultrapure water production system including a pre-treatment system, a primary pure water system, and a secondary pure water system, and the ultrapure water is supplied to a point of usage. The pre-treatment system is provided for removing turbidity from raw water using a turbidity removal treatment device, which performs treatment through flocculation filtration, a microfiltration membrane (MF membrane), an ultrafiltration membrane (UF membrane) and the like, and using a dechlorination treatment device, which performs treatment by activated carbon or the like.

The primary pure water system is provided for removing impurities contained in pretreated water, such as ion components and TOC components, using a two-bed-three-tower ion exchange device, a reverse osmosis membrane (RO membrane) device and the like. The secondary pure water system is also referred to as "subsystem". The secondary pure water system is provided for removing impurities in primary pure water, such as an extremely small amount of particles and a small amount of ions, particularly a small amount of organic matter having a low molecular weight, using an ultraviolet oxidation device (UV device), a mixed bed ion exchange device, a membrane type deaerator, an ultrafiltration membrane device (UF device) and the like, thus producing ultrapure water with a higher purity. In general, such an ultrapure water production system includes a water supply pipe and a return pipe, the water supply pipe allowing ultrapure water to pass therethrough from the subsystem to a point of usage, and the return pipe being provided for returning ultrapure water which is not used at the point of usage to the upstream end of the subsystem, thus circulating the ultrapure water.

[0004]

Recently, adverse influence on semiconductor products caused by ions, particularly boron, contained in ultrapure water has been a problem, and to reduce the concentration of boron in ultrapure water is an important task. When a large amount of ion components and TOC components is contained in water to be treated (primary pure water) supplied to the subsystem, it becomes necessary to frequently regenerate an ion exchange resin of a mixed bed ion exchange device, forming the subsystem, thus leading to an increase in cost of the entire ultrapure water production system. For this reason, the large amount of

ion components and TOC components is not preferable. Accordingly, usually, most of ion components and TOC components contained in water to be treated are removed in the primary pure water system.

5 [0005]

Boron contained in water to be treated can also be removed by a general ion exchange resin (a strongly basic anion exchange resin or the like, for example). However, boron is present as a boric acid with a very weak acid in aqueous solution. Accordingly, boron has a smaller ion exchange capacity than that of silica (silicic acid) or other anions and hence, boron breaks through an ion exchange resin at a relatively early stage, thus leaking into treated water. For this reason, to reduce boron to the concentration required for ultrapure water using such a general ion exchange resin, it is necessary to regenerate the ion exchange resin frequently and hence, high cost is required for chemicals for regeneration.

[0006]

20 To prevent the above-mentioned increase in cost caused by chemicals for regeneration used in a so-called ion exchange device of a regenerable type, for example, Patent Document 1 discloses a method which uses a boron-selective ion exchange resin having a larger ion exchange capacity than an anion exchange resin in an ultrapure water production apparatus which includes no ion exchange device of a regenerable type. Patent Document 2 discloses a method which uses an organic porous material having boron selective adsorption capacity. Patent Document 3 discloses a method which uses ion exchange fiber having boron selective removability. However, methods disclosed in Patent Documents 1 to 3 require additional facilities. In addition to the above, water to be treated containing TOC

components eluted from a member is supplied to a subsystem in a later stage. Accordingly, there is a problem that it becomes necessary to reduce TOC components to a level required for ultrapure water in the subsystem, thus leading to an increase in cost of the entire ultrapure water production system.

[0007]

Boron contained in water to be treated can also be removed by a general reverse osmosis membrane (RO membrane). However, as described above, boric acid in aqueous solution is very weak acid and hence, only a part of the boron is dissociated, and most of the boron is present while remaining in the form of H_3BO_4 . Accordingly, the rate of removal of boron by the RO membrane is extremely low and hence, to reduce boron to the concentration required for ultrapure water, the RO membrane device per se becomes heavy whereby such a method is not practical in terms of cost.

[0008]

To increase the above-mentioned rate of removal of boron by the RO membrane, for example, Patent Document 4 discloses a method where the pH of water to be treated introduced into an RO device is set to alkaline pH to ionize weak ion components of boron, thus removing ionized boron by the RO device. However, the method disclosed in Patent Document 4 has a problem that a facility becomes necessary for adding chemicals to make the pH of water to be treated introduced into the RO device alkaline. In addition to the above, there is also a problem that an increase in use amount of chemicals is directly connected to an increase in cost. Further, when the pH is set to a high value, hardness components (Ca, Mg and the like) in water are precipitated as hydroxide and hence, there is a

possibility of the RO membrane being clogged.

[Prior Art Document]

[Patent Document]

[0009]

5 [Patent Document 1] JPH9-192661A

[Patent Document 2] JP2004-066153A

[Patent Document 3] JP2005-246126A

[Patent Document 4] JP2004-283710A

[Summary of the Invention]

10 [Problems to be solved by the Invention]

[0010]

The present invention has been made under such circumstances, and it is an object of the present invention to provide an ultrapure water production system and a method for producing ultrapure water where water to be
15 treated is subjected to a reduction in boron and TOC components by a primary pure water system and, thereafter, is supplied to a subsystem so that it is possible to stably obtain ultrapure water with reduced concentration of boron without applying a TOC load on the subsystem.

20

[Means for solving the Problems]

[0011]

To overcome the above-mentioned problems, first, the present invention provides an ultrapure water production
25 system including, in this order: a pre-treatment system; a primary pure water system; and a secondary pure water system, wherein the primary pure water system includes an ion exchange device which performs treatment on water to be treated containing boron with an ion exchange resin, the
30 ion exchange device includes: a housing portion into which the ion exchange resin is packed; a supply portion through which water to be treated is supplied to the housing portion; and a discharge portion through which treated

water is discharged from the housing portion, and a boron-selective ion exchange resin is packed into a portion of the housing portion on a side of the supply portion, and an ion exchange resin other than the boron-selective ion exchange resin is packed into a portion of the housing portion on a side of the discharge portion of the housing portion (Invention 1).

[0012]

According to the above invention (Invention 1), in the ion exchange device included in the primary pure water system, a boron-selective ion exchange resin is packed into a portion of the housing portion on a side of the supply portion, and an ion exchange resin other than the boron-selective ion exchange resin is packed into a portion of the housing portion on a side of the discharge portion. Accordingly, first, boron is adsorbed and removed by the boron-selective ion exchange resin from water to be treated which is supplied and which contains boron and, thereafter, TOC components eluted from the boron-selective ion exchange resin are adsorbed and removed by the ion exchange resin other than the boron-selective ion exchange resin. With such a configuration, it is possible to supply primary treated water with reduced concentration of boron without applying a TOC load on a subsystem in a later stage. Accordingly, it is possible to stably obtain ultrapure water with reduced concentration of boron. Further, it is also possible to reduce treatment cost caused by an increase in TOC load on the subsystem.

[0013]

In the above invention (Invention 1), it is preferable that the housing portion be mounted in an erected manner, and the supply portion be provided at an upper side of the housing portion, and the discharge portion be provided at a

lower side of the housing portion (Invention 2).

[0014]

According to the above invention (Invention 2), water to be treated can be supplied to the housing portion, into which the ion exchange resin is packed, from the supply portion such that the flow direction is directed toward the lower side from the upper side of the housing portion. Accordingly, water to be treated and the ion exchange resins can be efficiently brought into contact with each other and hence, the respective ion exchange resins can exhibit high adsorption capacity. Therefore, boron contained in water to be treated and TOC components eluted from the boron-selective ion exchange resin can be effectively removed.

15 [0015]

In the above invention (Invention 1, 2), it is preferable that the ion exchange resin have a structure in which the boron-selective ion exchange resin and the ion exchange resin other than the boron-selective ion exchange resin are stacked (Invention 3).

[0016]

According to the above invention (Invention 3), the ion exchange resin has a two layered structure formed of a boron-selective ion exchange resin and an ion exchange resin other than the boron-selective ion exchange resin. With such a configuration, adsorption efficiency of the above-mentioned respective ion exchange resins can be easily predicted and hence, treatment can be efficiently performed with the ion exchange resins.

30 [0017]

In the above invention (Invention 1 to 3), it is preferable that the ion exchange device be provided at a downstream end of the primary pure water system (Invention

4) .

[0018]

In general, to allow a boron-selective ion exchange resin to exhibit maximum adsorption capacity, it is preferable that only boron is a load of supplied water to be treated. According to the above invention (Invention 4), the ion exchange device having the boron-selective ion exchange resin is provided to the downstream end of the primary pure water system and hence, water to be treated where a load other than a load of boron is reduced can be supplied to the above-mentioned ion exchange device. Accordingly, the boron-selective ion exchange resin can exhibit maximum adsorption capacity so that efficiency of removing boron can be improved.

15 [0019]

In the above invention (Invention 1 to 4), it is preferable that the ion exchange resin other than the boron-selective ion exchange resin be at least one kind selected from a strongly basic anion exchange resin, a mixture of an anion exchange resin and a cation exchange resin, and an amphoteric ion exchange resin (Invention 5).

[0020]

According to the above invention (Invention 5), TOC components eluted from the boron-selective ion exchange resin can be more efficiently adsorbed and removed.

[0021]

Second, the present invention provides a method for producing ultrapure water using the ultrapure water production system (Invention 6).

30 [Effect of the Invention]

[0022]

According to the ultrapure water production system and the method for producing ultrapure water of the present

invention, water to be treated is subjected to a reduction in boron and TOC components by the primary pure water system and, thereafter, is supplied to a subsystem (secondary pure water system). Accordingly, it is possible to stably obtain ultrapure water with reduced concentration of boron without applying a TOC load on the subsystem.

[Brief Description of Drawings]

[0023]

FIG. 1 is a block diagram showing an ultrapure water production system according to one embodiment of the present invention.

FIG. 2 is a schematic view showing an ion exchange device included in the ultrapure water production system according to one embodiment of the present invention, and having a boron-selective ion exchange resin.

[Embodiments for Carrying out the Invention]

[0024]

Hereinafter, an embodiment of an ultrapure water production system and a method for producing ultrapure water according to the present invention is described with reference to drawings as needed. The embodiment described hereinafter is provided for facilitating the understanding of the present invention, and does not limit the present invention at all.

[0025]

(Ultrapure water)

It is preferable that ultrapure water produced in this embodiment have a concentration of boron of between 0.5 ppt and 50 ppt. When the concentration of boron falls outside the above-mentioned range, there is a possibility that boron adversely affects semiconductor products at the time of cleaning a system in a semiconductor product manufacturing process. Accordingly, such a concentration

is not preferable.

[0026]

(Water to be treated)

Water to be treated which is used in this embodiment
5 and which contains boron is not particularly limited.
Usually, water to be treated (pretreated water) which is
subjected to turbidity removal treatment by a pre-treatment
system, that is, water to be treated supplied to a primary
treatment system contains approximately 30 ppb of boron.
10 Boron is present mainly in the form of boric acid ($B(OH)_3$)
in water to be treated.

[0027]

[Ultrapure water production system]

FIG. 1 is a block diagram showing the ultrapure water
15 production system according to one embodiment of the
present invention. An ultrapure water production system 1
shown in FIG. 1 includes a pre-treatment system 2, a
primary pure water system 3, and a secondary pure water
system (subsystem) 4 in this order. Raw water supplied to
20 the pre-treatment system 2 is subjected to turbidity
removal treatment, which is performed through flocculation
filtration, an MF membrane (microfiltration membrane), a UF
membrane (ultrafiltration membrane) and the like, and is
subjected to dechlorination treatment, which is performed
25 by activated carbon or the like. Thereafter, the raw water
is supplied to the primary pure water system 3 through a
water supply pipe L1. After impurities, such as ion
components and TOC components, are removed from pretreated
water supplied to the primary pure water system 3, the
30 pretreated water is supplied to the subsystem 4 through a
water supply pipe L2. In the subsystem 4, impurities in
water to be treated, such as an extremely small amount of
particles and a small amount of ion components,

particularly a small amount of organic matter having a low molecular weight, are removed so that ultrapure water with a higher purity is produced. Ultrapure water produced in the subsystem 4 is supplied to a point of usage 5 through a water supply pipe L3.

[0028]

<Primary pure water system>

The primary pure water system 3 includes a two-bed-three-tower ion exchange device (first ion exchange device) 31, a reverse osmosis membrane (RO membrane) device 32, a mixed bed ion exchange device (second ion exchange device) 33, and an ion exchange device (third ion exchange device) 34, having a boron-selective ion exchange resin, in this order. The first ion exchange device 31 includes a cation exchange tower (H tower), a decarbonation tower, and an anion exchange tower (OH column) in this order. The first ion exchange device 31 is provided for desalting water to be treated supplied from the pre-treatment system 2. The reverse osmosis membrane (RO membrane) device 32 is provided for removing impurities in water to be treated, such as ion components and TOC components. With the desalting treatment performed by the first ion exchange device 31, water to be treated with reduced salt concentration is supplied to the reverse osmosis membrane (RO membrane) device 32. Accordingly, a water recovery rate at the reverse osmosis membrane (RO membrane) device 32 is improved and, along with such improvement of the water recovery rate, the rate of removal of impurities contained in water to be treated, such as ion components and TOC components, is also improved. The second ion exchange device 33 includes a tower into which an anion exchange resin and a cation exchange resin are packed in a uniformly mixed state. The second ion exchange device 33

is provided for removing cations and anions which have a low molecular weight and are present in water to be treated, thus increasing purity of treated water.

[0029]

5 The mixed bed ion exchange device included in the primary pure water system may be of either a regenerable type or a non-regenerable type. However, it is preferable that the mixed bed ion exchange device be an ion exchange device of a non-regenerable type. This is because if an
10 ion exchange device of a regenerable type is used in the primary pure water system, in addition to that costs increase due to chemicals used for regenerating an ion exchange resin, the amount of drainage easily increases due to chemicals required for regeneration of the ion exchange
15 resin. Usually, when an ion exchange device of a non-regenerable type is used in the primary pure water system, as in the case of this embodiment, the ion exchange device of a non-regenerable type is used in combination with a reverse osmosis membrane (RO membrane) device and the like,
20 thus improving the rate of removal of ion component.

[0030]

(Ion exchange device having boron-selective ion exchange resin)

Next, also with reference to FIG. 2, the detailed
25 description is made with respect to the ion exchange device (third ion exchange device) 34 included in the primary pure water system 3 in this embodiment, and having a boron-selective ion exchange resin.

[0031]

30 The third ion exchange device 34 is provided for removing boron contained in water to be treated by a boron-selective ion exchange resin, and for removing TOC components, eluted from the boron-selective ion exchange

resin, by an ion exchange resin other than the boron-selective ion exchange resin. To allow the boron-selective ion exchange resin to exhibit a maximum adsorption capacity, it is desirable that only boron be a load of water to be
5 treated which is supplied to the third ion exchange device 34. For this reason, the third ion exchange device 34 is installed at the downstream end of the primary pure water system 3. An ultraviolet oxidation device (UV device) 41 is installed at the upstream end of the subsystem 4 in a
10 later stage. The ultraviolet oxidation device (UV device) 41 is a device having a large size and bulk and a high cost, thus being required to reduce the scale as much as possible. To realize the above, it is desirable that as many TOC components in water to be treated be removed as possible in
15 the third ion exchange device 34, installed at the downstream end of the primary pure water system 3, thus preventing a TOC load from being applied to the ultraviolet oxidation device (UV device) 41, installed at the upstream end of the subsystem 4.

20 [0032]

FIG. 2 is a schematic view showing the configuration of the third ion exchange device 34 according to this embodiment. The third ion exchange device 34 includes a housing portion 341 into which an ion exchange resin A is
25 packed, a supply portion 342 through which water to be treated is supplied to the housing portion 341, and a discharge portion 343 through which treated water is discharged from the housing portion 341. The housing portion 341 is mounted in an erected manner. The supply
30 portion 342 is provided at the upper side of the housing portion 341, and the discharge portion 343 is provided at the lower side of the housing portion 341. A boron-selective ion exchange resin A1 is packed into a portion of

the housing portion 341 on a side of the supply portion 342. An ion exchange resin A2 other than the boron-selective ion exchange resin is packed into a portion of the housing portion 341 on a side of the discharge portion 343.

5 [0033]

The boron-selective ion exchange resin A1 is packed into the portion of the third ion exchange device 34 on a side of the supply portion 342, and the ion exchange resin A2 other than the boron-selective ion exchange resin is
10 packed into the portion of the third ion exchange device 34 on a side of the discharge portion 343. Accordingly, first, boron is adsorbed and removed by the boron-selective ion exchange resin A1 from water to be treated which is supplied to the housing portion 341 and which contains
15 boron. Thereafter, TOC components eluted from the boron-selective ion exchange resin A1 are adsorbed and removed by the ion exchange resin A2 other than the boron-selective ion exchange resin. With such a configuration, primary treated water with reduced concentration of boron can be
20 supplied to the subsystem 4 in a later stage without applying a TOC load on the subsystem 4. Suppressing the TOC load on the subsystem 4 can also prevent an increase in cost of the entire ultrapure water production system.

[0034]

25 Further, the housing portion 341 is mounted in an erected manner. The supply portion 342 is provided at the upper side of the housing portion 341, and the discharge portion 343 is provided at the lower side of the housing portion 341. With such a configuration, water to be
30 treated can be supplied from the supply portion 342 such that the flow direction is directed toward the lower side from the upper side of the housing portion 341. Accordingly, the ion exchange resin A is prevented from

being easily stirred by the water to be treated so that it is possible to maintain the two layered structure formed of the boron-selective ion exchange resin A1 and the ion exchange resin A2 other than the boron-selective ion exchange resin. Accordingly, water to be treated and respective ion exchange resins A1, A2 can be efficiently brought into contact with each other and hence, the respective ion exchange resins A1, A2 can exhibit high adsorption capacity. Therefore, boron contained in water to be treated and TOC components eluted from the boron-selective ion exchange resin A1 can be effectively removed.

[0035]

The ion exchange resin A packed into the housing portion 341 may have a structure where the boron-selective ion exchange resin A1 and the ion exchange resin A2 other than the boron-selective ion exchange resin are stacked. By allowing the ion exchange resin A to have the above-mentioned two layered structure, adsorption efficiency of the above-mentioned respective ion exchange resins A1, A2 can be easily predicted and hence, treatment can be efficiently performed.

[0036]

The housing portion 341 may include a partition plate therein for dividing the boron-selective ion exchange resin A1 from the ion exchange resin A2 other than the boron-selective ion exchange resin. Allowing the housing portion 341 to include such a partition plate can prevent the ion exchange resins A1, A2 from being mixed with each other or from flowing out in the upward direction or downward direction. Alternatively, the housing portion 341 may have a structure where a sub-housing portion 3411 (not shown in the drawing) and a sub-housing portion 3412 (not shown in the drawing) are connected in series, for example, the

boron-selective ion exchange resin A1 being packed into the sub-housing portion 3411, and the ion exchange resin A2 other than the boron-selective ion exchange resin being packed into the sub-housing portion 3412.

5 [0037]

The height of layer of the boron-selective ion exchange resin A1 is not particularly limited, and may be suitably set as required. However, the height of layer of the boron-selective ion exchange resin A1 is preferably set
10 to 800 mm or more, and is more preferably set to 1000 mm or more. Setting the height of layer to 800 mm or more improves adsorption efficiency of the boron-selective ion exchange resin A1. The height of layer of the ion exchange resin A2 other than the boron-selective ion exchange resin
15 is not also particularly limited, and may be suitably set as required. However, the height of layer of the ion exchange resin A2 other than the boron-selective ion exchange resin is preferably set to 100 mm or more, and is more preferably set to 500 mm or more. Setting the height
20 of layer to 100 mm or more improves adsorption efficiency of the ion exchange resin A2 other than the boron-selective ion exchange resin.

[0038]

(Boron-selective ion exchange resin)

25 Any anion exchange resin (chelating resin) may be used as the boron-selective ion exchange resin A1 provided that the anion exchange resin has an N-methylglucamine group having boron selectivity as a functional group in place of the ion-exchange group of the anion exchange resin.
30 However, there is no possibility that an introduction ratio of a chelating group having boron selectivity into an anion exchange resin reach 100% and hence, other ions adsorb to remaining anion groups whereby the adsorption rate may be

reduced. In view of the above, to prevent such a phenomenon, it is preferable to use, as the boron-selective ion exchange resin A1, a chelating resin where the small amount of TOC components is eluded, and the concentration of TOC is not increased as much as possible between before and after water is passed. Examples of such a chelating resin include a chelating resin used for producing ultrapure water, a chelating resin cleaned with ultrapure water and the like. It is preferable to use a chelating resin having the N-methylglucamine group as such a chelating resin, and CRB03 made by Mitsubishi Chemical Corporation or the like may be used, for example.

[0039]

(Ion exchange resin other than boron-selective ion exchange resin)

The ion exchange resin A2 other than the boron-selective ion exchange resin is not particularly limited. However, it is preferable to use an ion exchange resin where the small amount of TOC components is eluded, and an increase amount (Δ TOC) of TOC concentration between before and after water is passed is less than approximately 1 to 3 ppb. Examples of such an ion exchange resin include an ion exchange resin used for producing ultrapure water, an ion exchange resin cleaned with ultrapure water and the like. Such an ion exchange resin is preferably at least one kind selected from a strongly basic anion exchange resin, a mixture of an anion exchange resin and a cation exchange resin, and an amphoteric ion exchange resin. The ion exchange resin is more preferably the strongly basic anion exchange resin, and SAT10L made by Mitsubishi Chemical Corporation or the like may be used, for example.

[0040]

<Subsystem>

The subsystem 4 includes the ultraviolet oxidation device (UV device) 41, a membrane type deaerator 42, a mixed bed ion exchange device 43, and an ultrafiltration membrane device (UF device) 44 in this order. The
5 ultraviolet oxidation device (UV device) 41 is provided for, by oxidation treatment with ultraviolet irradiation, oxidizing and decomposing TOC components remaining in water to be treated. The membrane type deaerator 42 is provided for reducing the amount of dissolved oxygen in treated
10 water. The mixed bed ion exchange device 43 is provided for removing ionized components of the oxidized and decomposed TOC components in the treated water, thus increasing purity of the treated water. The ultrafiltration membrane device (UF device) 44 is provided
15 for removing particles and the like of an ion exchange resin flowing out from the mixed bed ion exchange device 43.

[0041]

In a general ultrapure water production system, there is a large difference in scale between a primary pure water
20 system and a subsystem, and the primary pure water system has a larger scale. Also in this embodiment, the respective devices included in the primary pure water system 3 have a larger scale compared with the scale of the respective devices included in the subsystem 4. For
25 example, it is not general to provide the third ion exchange device 34, provided to the downstream end of the primary pure water system 3, to the upstream end of the subsystem 4 having a difference scale. In the same manner, it is not also general to provide the ultraviolet oxidation
30 device (UV device) 41, provided to the upstream end of the subsystem 4, to the downstream end of the primary pure water system 3 having a difference scale.

[0042]

[Method for producing ultrapure water]

Next, the description is made with respect to a method for producing ultrapure water using the ultrapure water production system 1 of this embodiment having the above-mentioned configuration.

[0043]

Raw water supplied to the pre-treatment system 2 is subjected to turbidity removal treatment, which is performed through flocculation filtration, an MF membrane (microfiltration membrane), a UF membrane (ultrafiltration membrane) and the like, and is subjected to dechlorination treatment, which is performed by activated carbon or the like (pre-treatment step). Thereafter, the raw water is supplied to the primary pure water system 3 through the water supply pipe L1. Pretreated water supplied to the primary pure water system 3 is subjected to treatment to remove impurities, such as ion components and TOC components (primary pure water production step) and, thereafter, is supplied to the subsystem 4 through the water supply pipe L2. Impurities, such as an extremely small amount of particles and a small amount of ion components, particularly a small amount of organic matter having a low molecular weight, are removed from primary pure water supplied to the subsystem 4, thus producing ultrapure water with a higher purity (secondary pure water production step). Ultrapure water produced in the subsystem 4 is supplied to the point of usage 5 through the water feed pipe L3.

[0044]

(Treatment steps performed by ion exchange device having boron-selective ion exchange resin)

Next, also with reference to FIG. 2, the detailed description is made with respect to treatment steps

performed by the ion exchange device (third ion exchange device) 34 included in the primary pure water system 3 in this embodiment, and having a boron-selective ion exchange resin.

5 [0045]

First, water to be treated is supplied to the housing portion 341 from the supply portion 342 such that the flow direction is directed toward the lower side from the upper side of the housing portion 341. The housing portion 341
10 is mounted in an erected manner. The supply portion 342 is provided at the upper side of the housing portion 341, and the discharge portion 343 is provided at the lower side of the housing portion 341. The boron-selective ion exchange resin A1 is packed into a portion of the housing portion
15 341 on a side of the supply portion 342, and the ion exchange resin A2 other than the boron-selective ion exchange resin is packed into a portion of the housing portion 341 on a side of the discharge portion 343. First, boron ion is adsorbed and removed from water to be treated,
20 supplied to the housing portion 341, by the boron-selective ion exchange resin A1. Then, TOC components eluted from the boron-selective ion exchange resin A1 are adsorbed and removed by the ion exchange resin A2 other than the boron-selective ion exchange resin. Water to be treated from
25 which boron and TOC components are removed (primary treated water) is discharged from the discharge portion 343, and is transferred to a next step.

[0046]

As described above, the boron-selective ion exchange
30 resin A1 is packed into the portion on a side of the supply portion 342, and the ion exchange resin A2 other than the boron-selective ion exchange resin is packed into the portion on a side of the discharge portion 343.

Accordingly, first, boron is adsorbed and removed by the boron-selective ion exchange resin A1 from water to be treated which is supplied to the housing portion 341 and which contains boron. Thereafter, TOC components eluted
5 from the boron-selective ion exchange resin are adsorbed and removed by the ion exchange resin A2 other than the boron-selective ion exchange resin. With such a configuration, primary treated water with reduced concentration of boron can be supplied to the subsystem 4
10 in a later stage without applying a TOC load on the subsystem 4. Suppressing the TOC load on the subsystem 4 can also prevent an increase in cost of the entire ultrapure water production system.

[0047]

15 In the method for producing ultrapure water of this embodiment, the flow velocity of water to be treated supplied to the third ion exchange device 34 is not particularly limited. However, the flow velocity is preferably set to a value which falls within a range from
20 30/h to 180/h in terms of space velocity (SV), and is more preferably set to 60/h. When the flow velocity of water to be treated is less than 30/h, a speed at which treatment is performed by the third ion exchange device 34 is reduced and hence, such a flow velocity is not efficient. On the
25 other hand, when the flow velocity of water to be treated exceeds 180/h, treatment performed by the third ion exchange device 34 becomes insufficient so that it becomes difficult to sufficiently remove boron in the water to be treated.

30 [0048]

According to the method for producing ultrapure water using the ultrapure water production system 1 of this embodiment, water to be treated is subjected to a reduction

in boron and TOC components by the primary pure water system 3 and, thereafter, is supplied to the subsystem (secondary pure water system) 4. Accordingly, it is possible to stably obtain ultrapure water with reduced concentration of boron without applying a TOC load on the subsystem 4.

[0049]

The above-mentioned method for producing ultrapure water may be also considered as a method for producing ultrapure water, the method including: a pre-treatment step; a primary pure water production step; and a secondary pure water production step in this order, wherein the primary pure water production step includes a step of performing treatment on water to be treated containing boron with an ion exchange resin, and the step of performing the treatment with the ion exchange resin includes a first separation step and a second separation step, the water to be treated containing boron and a boron-selective ion exchange resin being brought into contact with each other, thus separating boron from the water to be treated in the first separation step, and the water to be treated subjected to the first separation step and an ion exchange resin other than the boron-selective ion exchange resin being brought into contact with each other, thus separating TOC components from the water to be treated subjected to the first separation step in the second separation step.

[0050]

The present invention has been described heretofore with reference to drawings. However, the present invention is not limited to the above-mentioned embodiment, and various modifications are conceivable.

[Example]

[0051]

Hereinafter, the present invention is described in more detail based on an example. However, the present invention is not limited to the following example.

5 [0052]

[Example 1]

Treatment was performed on water to be treated using the third ion exchange device 34 shown in FIG. 2. A cylindrical column having a diameter of 40 mm and made of acryl (hereinafter, simply referred to as "acrylic column") was used as the housing portion 341. A strongly basic anion exchange resin made by Mitsubishi Chemical Corporation was packed into the acrylic column such that the height of the layer is set to 100 mm. Further, a boron-selective ion exchange resin made by Mitsubishi Chemical Corporation was packed into a portion of the acrylic column at a position on the strongly basic anion exchange resin such that the height of the layer is set to 800 mm. The treatment was performed as follows. Water to be treated, where concentration of boron is 0.8 ppb, specific resistance is 18.2 MΩ·cm, and TOC component is 0.5 ppb, was passed through the acrylic column at 60/h (SV) such that the flow direction is directed downward. Concentration (ppt) of boron and concentration (ppb) of TOC of obtained treated water were measured.

[0053]

[Comparative Example 1]

Treatment was performed under the same conditions as Example 1 except that only a boron-selective ion exchange resin made by Mitsubishi Chemical Corporation was packed into an acrylic column such that the height of the layer is set to 800 mm. Concentration (ppt) of boron and concentration (ppb) of TOC of obtained treated water were

measured.

[0054]

[Comparative Example 2]

Treatment was performed under the same conditions as
5 Example 1 except that only a strongly basic anion exchange
resin made by Mitsubishi Chemical Corporation was packed
into an acrylic column such that the height of the layer is
set to 800 mm. Concentration (ppt) of boron and
concentration (ppb) of TOC of obtained treated water were
10 measured.

[0055]

[Result]

Temporal variations in the concentration (ppt) of
boron and concentration (ppb) of TOC in the treated water
15 are shown in Table 1. As can be understood from this
result, in Example 1, the concentration of boron in the
treated water can be maintained at a satisfactory level for
24 hours, and the concentration of TOC can be also
maintained without increasing significantly.

20 [0056]

In Comparative Example 1, the concentration of boron
in the treated water can be maintained at a satisfactory
level for 24 hours. However, the concentration of TOC
significantly increases after a lapse of 1 hour, and no
25 significant decrease can be seen after a lapse of 24 hours.
This is because TOC components are eluted from the boron-
selective ion exchange resin. A trial calculation was
performed for a case where treated water (primary treated
water) in Comparative Example 1 is supplied to the
30 subsystem 4, and is subjected to treatment at a flow
velocity of 60/h (SV), thus stably obtaining treated water
with a TOC concentration of 1.0 ppb or less. As a result
of the trial calculation, it can be seen that, compared

with the case of Example 1, an extra cost corresponding to 10% of the cost of the entire subsystem 4 is additionally required.

[0057]

5 In Comparative Example 2, ion exchange capacity is low and hence, the concentration of boron in the treated water cannot be maintained at a satisfactory level for 24 hours. However, no significant increase can be seen in the concentration of TOC.

10 [0058]

[Table 1]

	Boron concentration (ppt) in treated water		TOC concentration (ppb) in treated water	
	Water passed for 1 hour	Water passed for 24 hours	Water passed for 1 hour	Water passed for 24 hours
Example 1	<0.5	<0.5	1.2	1.0
Comparative Example 1	<0.5	<0.5	78	50
Comparative Example 2	<0.5	54	1.0	0.7

[0059]

As described above, according to the ultrapure water
 15 production system and the method for producing ultrapure water of the present invention, water to be treated is subjected to a reduction in boron and TOC components by the primary pure water system and, thereafter, is supplied to the subsystem (secondary pure water system). Accordingly,
 20 it is possible to stably obtain ultrapure water with reduced concentration of boron without applying a TOC load on the subsystem.

[Industrial Applicability]

[0060]

25 The present invention can be effectively used as an ultrapure water production system and a method for

producing ultrapure water for stably obtaining ultrapure water with reduced concentration of boron.

[Description of Reference Numerals]

[0061]

- 5 1 Ultrapure water production system
- 2 Pre-treatment system
- 3 Primary pure water system
 - 31 Two-bed-three-tower ion exchange device (first ion exchange device)
 - 10 32 Reverse osmosis membrane (RO membrane) device
 - 33 Mixed bed ion exchange device (second ion exchange device)
 - 34 Ion exchange device (third ion exchange device) having boron-selective ion exchange resin
 - 15 341 Housing portion
 - 342 Supply portion
 - 343 Discharge portion
 - 4 Secondary pure water system (subsystem)
 - 41 Ultraviolet oxidation device (UV device)
 - 20 42 Membrane type deaerator
 - 43 Mixed bed ion exchange device
 - 44 Ultrafiltration membrane device (UF device)
 - 5 Point of usage
 - L1, L2, L3 Water supply pipe
 - 25 R1 Return pipe
 - A Ion exchange resin
 - A1 Boron-selective ion exchange resin
 - A2 Ion exchange resin other than boron-selective ion exchange resin

Claims

1. An ultrapure water production system comprising, in this order: a pre-treatment system; a primary pure water
5 system; and a secondary pure water system, wherein

the primary pure water system includes an ion exchange device which performs treatment on water to be treated containing boron with an ion exchange resin,

the ion exchange device includes:

10 a housing portion into which the ion exchange resin is packed;

a supply portion through which water to be treated is supplied to the housing portion; and

15 a discharge portion through which treated water is discharged from the housing portion, and

a boron-selective ion exchange resin is packed into a portion of the housing portion on a side of the supply portion, and an ion exchange resin other than the boron-selective ion exchange resin is packed into a portion of
20 the housing portion on a side of the discharge portion.

2. The ultrapure water production system according to claim 1, wherein

25 the housing portion is mounted in an erected manner, and

the supply portion is provided at an upper side of the housing portion, and the discharge portion is provided at a lower side of the housing portion.

30 3. The ultrapure water production system according to claim 1 or claim 2, wherein

the ion exchange resin has a structure in which the boron-selective ion exchange resin and the ion exchange

resin other than the boron-selective ion exchange resin are stacked.

4. The ultrapure water production system according to any
5 one of claim 1 to claim 3, wherein
the ion exchange device is provided at a downstream
end of the primary pure water system.

5. The ultrapure water production system according to any
10 one of claim 1 to claim 4, wherein
the ion exchange resin other than the boron-selective
ion exchange resin is at least one kind selected from a
strongly basic anion exchange resin, a mixture of an anion
exchange resin and a cation exchange resin, and an
15 amphoteric ion exchange resin.

6. A method for producing ultrapure water using the
ultrapure water production system according to any one of
claim 1 to claim 5.