

DESCRIPTION

ULTRAPURE WATER PRODUCTION APPARATUS AND METHOD FOR
OPERATING ULTRAPURE WATER PRODUCTION APPARATUS

5

TECHNICAL FIELD

[0001]

The present invention relates to an ultrapure water production apparatus for producing ultrapure water used
10 in electronic industry field, such as a semiconductor and liquid crystal, and a method for operating the ultrapure water production apparatus. It particularly relates to an ultrapure water production apparatus capable of removing boron efficiently and preventing leakage thereof and the
15 operation method.

BACKGROUND ART

[0002]

Conventionally, ultrapure water used in the
20 semiconductor and other electronic industry field is produced by treating raw water by an ultrapure water production apparatus configured by a pre-treatment system, a primary pure water system and a subsystem for treating primary pure water.

25

[0003]

In the ultrapure water production system, a pre-treatment system is configured by coagulating, pressure floating (deposition) and filtration (membrane filtration) device, etc. and removes suspended substances and colloidal substances in raw water. In this process, polymer-based organics, hydrophobic organics, etc. can be also removed. Also, a primary pure water system is basically provided with a reverse osmosis (RO) membrane separation device and a regenerating ion exchange device (mixed bed-type or four-bed five-tower type, etc.), and the RO membrane separation device removes salts as well as ionic and colloidal TOC. The regenerating ion exchange device removes salts as well as TOC components by adsorption or ion exchange using an ion exchange resin.

[0004]

Furthermore, a subsystem basically comprises a low-pressure ultraviolet (UV) oxidation device, non-regenerating mixed bed-type ion exchange device and ultrafiltration (UF) membrane separation device and furthermore improves purity of primary pure water to provide ultrapure water. In the low-pressure UV oxidation device, TOC is decomposed to organic acids and furthermore to CO_2 by using 185nm ultraviolet ray emitted from a low-pressure ultraviolet lamp. Organics and CO_2 generated by the decomposition are removed in the non-

regenerating mixed bed-type ion exchange device in the following step. In the UF membrane separation device, fine particles are removed and particles flew out from the ion exchange resin are also removed.

5 [0005]

In a subsystem of a conventional ultrapure water production apparatus as such, when weak ion components, boron ions in particular, leak from the primary pure water system, they are removed in the non-regenerating
10 mixed bed-type ion exchange device, however, the non-regenerating mixed bed-type ion exchange device needs to be changed after adsorbing boron ions to a certain extent. In recent years, a boron concentration required to ultrapure water is getting furthermore lower as 0.1ppt or
15 less, but the boron removal efficiency is poor in a low concentration range in the non-regenerating mixed bed-type ion exchange device, so that the non-regenerating mixed bed-type ion exchange device needs to be changed ahead of time for maintaining the required water quality
20 concerning boron and the exchange term becomes shorter, which has been a problem. Thus, providing an electric deionization device to the subsystem as described in the patent article 1 may be considered.

[Prior Art Documents]

25 [Patent Article]

[0006]

[Patent Article 1] Japanese Patent Publication
(Kokai) No. H07-8948

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DISCLOSURE OF THE INVENTION

[Problem to be Solved by the Invention]

[0007]

When providing an electric deionization device to
the subsystem as described in the patent article 1,
10 however, since highly pure water nearly ultrapure water
is treated in the subsystem, electricity is hard to flow
and electric resistance for deionization increases, which
results in problems such that current efficiency declines
and a load on the electric deionization device increases.
15 Also, in the electric deionization device, a supply
pressure of water under treatment cannot be very high in
consideration of its pressure resistance and an outlet
pressure of treated water becomes furthermore lower than
the supply pressure, so that a treatment in a step after
20 the electric deionization device becomes unstable and
stability of water quality cannot be secured. Moreover,
there is another problem that a water pressure for
supplying ultrapure water to a use point becomes
insufficient. Thus, a supply device, such as a booster
25 pump, is provided separately after the electric

deionization device, however, a treatment of eluted substance from the booster pump has to be considered and the subsystem is liable to be larger, which are problems.

[0008]

5 Furthermore, in an ultrapure water production apparatus with any configuration, it is necessary to detect leakage of boron to ultrapure water to be supplied from the subsystem with speed, however, there is a problem that no means to measure a boron concentration at
10 0.1ppt level on site is available and it is difficult to detect.

[0009]

The present invention was made in consideration of the above circumstances and has an object thereof to
15 provide an ultrapure water production apparatus capable of removing boron efficiently and preventing leakage thereof promptly. Also, another object of the present invention is to provide a method for operating the ultrapure water production apparatus.

20 [Summary of Invention]

[0009a]

In one aspect, there is provided an ultrapure water production apparatus, comprising a primary pure water system and a subsystem provided with an ion exchange
25 device and an UF membrane device for treating primary

pure water obtained from the primary pure water system,
the ultrapure water production apparatus comprising a
boron concentration measuring means and an electric
deionization device provided after the primary pure water
5 system and before the subsystem, and a mean for
determining whether the ion exchange device of the
subsystem has to be changed or not by assuming that the
boron concentration of the primary pure water detected by
the boron concentration measuring means multiplied by the
10 boron removal rate in the electric deionization device
for the primary pure water measured in advance is a boron
concentration of water supplied to the subsystem.

[0009b]

In another aspect, there is provided a method for
15 operating an ultrapure water production apparatus
comprising a primary pure water system and a subsystem
provided with an ion exchange device and an UF membrane
device for treating primary pure water obtained from the
primary pure water system, wherein a boron concentration
20 measuring means and an electric deionization device are
provided after the primary pure water system and before
the subsystem: wherein, when producing ultrapure water by
continuously passing water to be treated to the primary
pure water system and the subsystem, it is determined
25 whether the ion exchange device of the subsystem has to

be changed or not by assuming that the boron
concentration of the primary pure water detected by the
boron concentration measuring means multiplied by the
boron removal rate in the electric deionization device
5 for the primary pure water measured in advance is a boron
concentration of water supplied to the subsystem.

[Means to Solve the Problems]

[0010]

In view of the above objects, firstly, the present
10 invention provides an ultrapure water production
apparatus, comprising a primary pure water system and a
subsystem provided with an ion exchange device and an UF

membrane device for treating primary pure water obtained from the primary pure water system, wherein a boron concentration measuring means and an electric deionization device are provided after the primary pure water system and before the subsystem (Invention 1).

[0011]

According to the invention (Invention 1) above, a boron removal rate in the electric deionization device is measured for primary pure water in advance, and a boron concentration of the primary water is continuously monitored by the boron concentration measuring means. A boron detection level of a boron detection means, such as a general-purpose boron monitor, is at 10ppb and a read value is at 1ppb level, and it can be assumed that the boron concentration detected by the boron concentration measuring means multiplied by the boron removal rate in the electric deionization device is a boron concentration of treated water of the electric deionization device. Since a boron concentration of ultrapure water treated by the subsystem becomes lower than at least that in the treated water of the electric deionization device, the boron concentration of the ultrapure water treated by the subsystem is determined based on the boron concentration of treated water of the electric deionization device and, when the boron concentration of primary pure water is

stable, the operation continues. The boron concentration of the treated water (ultrapure water) of the subsystem is precisely analyzed arbitrarily and, when a rising rate thereof becomes large, it is determined that breakthrough
5 of the ion exchange device in the subsystem comes soon and then by changing the ion exchange device, boron can be removed efficiently and leakage of boron can be prevented promptly.

[0012]

10 In the invention (Invention 1) above, preferably, the primary pure water system comprises a reverse osmosis membrane device and an ion exchange device (Invention 2).

[0013]

According to the invention (Invention 2) above,
15 boron can be removed efficiently in the primary pure water system.

[0014]

In the inventions (Inventions 1 and 2) above, preferably, the electric deionization device comprises a
20 negative electrode, a positive electrode, a cation exchange membrane and an anion exchange membrane arranged between the negative electrode and the positive electrode, and a desalting chamber and a concentration chamber formed by being sectionalized by the cation exchange
25 membrane and the anion exchange membrane, ion exchangers

are filled in the desalting chamber and the concentration chamber, and a concentrated water passing means for passing concentrated water to the concentration chamber and a means for passing raw water to the desalting
5 chamber and taking out deionized water are provided (Invention 3).

[0015]

According to the invention (Invention 3) above, the electric deionization device having the configuration as
10 above exhibits a high boron removal rate and is able to maintain an approximately constant removal rate, so that it is possible to assume with accuracy that the boron concentration detected by the boron concentration measuring means multiplied by the boron removal rate of
15 the electric deionization device as a boron concentration of treated water of the electric deionization device.

[0016]

In the invention (Invention 3) above, preferably, the concentrated water passing means passes deionized
20 water passed through the desalting chamber as concentrated water (Invention 4).

[0017]

According to the invention (Invention 4) above, as a result of passing deionized water passed through the
25 desalting chamber to the concentration chamber, because

the desalted water itself has a very small amount of ion components, a difference of ion concentrations between the concentration chamber and the desalting chamber can be reduced and the boron removal rate can be high.

5 Therefore, it is not necessary to change the ion exchange device of the subsystem for a long time.

[0018]

In the invention (Invention 4) above, preferably, the concentrated water passing means introduces the
10 concentrated water into the concentration chamber from the side close to an outlet of deionized water of the desalting chamber and discharges from the side close to a raw water inlet of the desalting chamber (Invention 5).

[0019]

15 According to the invention (Invention 5) above, in the electric deionization device, the ion concentration declines as getting closer to the outlet of deionized water in the desalting chamber, so that by supplying deionized water in the opposite way to the concentration
20 chamber from the side close to the outlet of deionized water, difference of ion concentrations between the desalting chamber and the concentration chamber can be reduced in the entire areas of the desalting chamber and the concentration chamber. Therefore, the effect of
25 improving the removal rate of boron ions is large and the

boron removal rate can be furthermore higher, so that it is not necessary to change the ion exchange device of the subsystem for a long time.

[0020]

5 Also, secondary, the present invention provides a method for operating an ultrapure water production apparatus comprising a primary pure water system and a subsystem provided with an ion exchange device and an UF membrane device for treating primary pure water obtained
10 from the primary pure water system, wherein a boron concentration measuring means and an electric deionization device are provided after the primary pure water system and before the subsystem, wherein, when producing ultrapure water by continuously passing water
15 to be treated to the primary pure water system and the subsystem, a boron ion removal rate of the electric deionization device and a boron concentration measured by the boron concentration measuring means are used for determining whether the ion exchange device of the
20 subsystem has to be changed or not (Invention 6).

[0021]

 According to the invention (Invention 6) above, a boron removal rate in the electric deionization device for primary pure water is measured in advance, and a
25 boron concentration of the primary pure water is

continuously monitored by the boron concentration measuring means. A boron detection level of a boron detection means, such as a general-purpose boron monitor, is at 10ppb and a read value is at 1ppb level, and it is
5 assumed that the boron concentration detected by the boron concentration measuring means multiplied by the boron removal rate in the electric deionization device is a boron concentration of treated water of the electric deionization device. Whether the ion exchange device has
10 to be changed or not can be determined based on the boron concentration and the boron concentration of ultrapure water of the subsystem.

[0022]

In the invention (Invention 6) above, preferably,
15 the primary pure water system comprises a reverse osmosis membrane device and an ion exchange device (Invention 7).

[0023]

According to the invention (Invention 7) above, boron can be removed efficiently in the primary pure
20 water system.

[0024]

In the inventions (Inventions 6 and 7) above, preferably, the electric deionization device comprises a negative electrode, a positive electrode, a cation
25 exchange membrane and an anion exchange membrane arranged

between the negative electrode and the positive electrode,
and a desalting chamber and a concentration chamber
formed by being sectionalized by the cation exchange
membrane and the anion exchange membrane, ion exchangers
5 are filled in the desalting chamber and the concentration
chamber, and a concentrated water passing means for
passing concentrated water to the concentration chamber
and a means for passing raw water to the desalting
chamber and taking out deionized water are provided
10 (Invention 8).

[0025]

According to the invention (Invention 8) above, by
passing deionized water passed through the desalting
chamber to the concentration chamber, because ion
15 components are in a very small amount in desalted water
itself, ion concentration difference between the
concentration chamber and desalting chamber can be
reduced. Therefore, the removal rate of boron can be
improved and it is not necessary to change the ion
20 exchange device of the subsystem for a long time.

[0026]

In the invention (Invention 8) above, preferably,
the concentrated water passing means introduces part of
treated water passed through the desalting chamber as the
25 concentrated water (Invention 9).

[0027]

According to the invention (Invention 9) above, by passing deionized water passed through the desalting chamber to the concentration chamber, because ion
5 components are in a very small amount in desalted water itself, ion concentration difference between the concentration chamber and the desalting chamber can be reduced. Therefore, the removal rate of boron can be improved and it is not necessary to change the ion
10 exchange device of the subsystem for a long time.

[0028]

In the invention (Invention 9) above, preferably, the concentrated water is introduced to the concentration chamber from the side close to an outlet of deionized
15 water of the desalting chamber and discharged from the concentration chamber from the side close to a raw water inlet of the desalting chamber (Invention 10).

[0029]

According to the invention (Invention 10) above, in
20 the electric deionization device, an ion concentration becomes lower as getting closer to the outlet of deionized water in the desalting chamber, so that by supplying deionized water in the opposite way to the concentration chamber from the side close to the outlet
25 of deionized water, ion concentration difference between

the desalting chamber and the concentration chamber can be reduced in the entire areas of the desalting chamber and the concentration chamber. Therefore, the effect of improving the removal rate of boron ions is large and the boron removal rate can be furthermore higher, so that it is not necessary to change the ion exchange device of the subsystem for a long time.

[Effects of the Invention]

[0030]

10 According to the present invention, by providing a boron concentration measuring means and an electric deionization device after the primary pure water system, continuously monitoring a boron concentration of primary pure water by the boron concentration measuring means, 15 assuming a product of a boron concentration measured by the boron concentration measuring means and a boron removal rate in the electric deionization device is the boron concentration of the treated water of the electric deionization device, comparing an actual measurement 20 value of a boron concentration of secondary pure water (ultrapure water) treated in the subsystem with the boron concentration of the electric deionization device treated water as the standard, and exchanging the ion exchange device of the subsystem when the actual measurement value 25 becomes larger than a predetermined value, the ion

exchange device in the subsystem can be changed efficiently without resulting in any leakage of boron.

BRIEF DESCRIPTION OF DRAWINGS

5 [0031]

[FIG. 1] A flowchart showing an ultrapure water production apparatus according to the first embodiment of the present invention.

[FIG. 2] A schematic sectional diagram showing the
10 configuration of the electric deionization device used in the ultrapure water production apparatus according to the same embodiment.

[FIG. 3] A system diagram showing the electric deionization device in FIG. 2.

15 [FIG. 4] A flowchart showing the ultrapure water production apparatus according to the second embodiment of the present invention.

MODE FOR CARRYING OUT THE INVENTION

20 [0032]

Below, the ultrapure water production apparatus according to the first embodiment of the present invention will be explained with reference to the attached drawings.

25 [0033]

FIG. 1 is a flowchart showing the ultrapure water production apparatus according to the first embodiment of the present invention. In FIG. 1, the ultrapure water production apparatus 1 comprises a primary pure water system 2 and a subsystem 3, wherein the primary pure water system 2 has a reverse osmosis (RO) membrane device 4 and a regenerating mixed bed-type ion exchange device 5, a boron monitor 6 as a boron concentration measuring means and an electric deionization device 7 are provided after the regenerating mixed bed-type ion exchange device 5, and the electric deionization device 7 is connected to the subsystem 3 via a nitrogen-sealed sub-tank 8. The subsystem 3 has a sub-tank 8, a supply pump P, an UV oxidation device 9, a non-regenerating mixed bed-type ion exchange device 10 and an ultrafiltration membrane (UF membrane) 11 and is configured that water circulates from the ultrafiltration membrane (UF membrane) 11 and returns to the sub-tank 8 via a use point UP.

[0034]

In the ultrapure water production apparatus 1, as the boron monitor 6, a general-purpose boron monitor capable of measuring a boron concentration at 10ppb level and a read value at 1ppb level and, for example, SIEVERS ultrapure water measurement online boron analyzer available from Central Kagaku Corp. may be used.

[0035]

As the electric deionization device 7, those configured as shown in FIG. 2 and FIG. 3 may be used preferably.

5 [0036]

In FIG. 2, the electric deionization device 7 is configured by alternately arranging a plurality of anion exchange membranes 23 and cation exchange membranes 24 to form concentration chambers 25 and desalting chambers 26
10 alternately, wherein ion exchangers (anion exchangers and cation exchangers) composed of an ion exchange resin, ion exchange fiber or graft exchanger, etc. are filled in the desalting chambers 26 in a mixed or layered way. Ion exchangers are also filled in the concentration chambers
15 25, positive electrode chamber 27 and negative electrode chamber 28.

[0037]

The electric deionization device 7 is configured that the desalting chamber 26 is provided with a water
20 passing means (not shown) for passing primary pure water W1 of the regenerating mixed bed-type ion exchange device 5 and taking out treated water W2 and that the concentration chamber 25 is provided with a concentrated water passing means (not shown) for passing concentrated
25 water W3 to the concentration chamber 5, wherein, in the

present embodiment, the concentrated water W3 is introduced to inside the concentration chamber 25 from the side close to an outlet of treated water W2 of the desalting chamber 26 and discharged from the side close to the raw water inlet of the desalting chamber 26. Namely, the concentrated water W3 is introduced to the concentration chamber 25 from the opposite direction from the flowing direction of the primary pure water W1 in the desalting chamber 26, and concentrated waste water W4 is discharged.

[0038]

Specifically, as shown in FIG. 3, it is preferable that part of treated water W2 obtained from the desalting chamber 26 is introduced to the concentration chamber 25 and the treated water W2 is used as concentrated water W3, thereby, concentrated water W3 with a reduced ion concentration is obtained.

[0039]

Furthermore, as the UV oxidation device 9 of the subsystem 3, normally, an UV oxidation device for irradiating UV having a wavelength around 185nm used for ultrapure water production apparatuses, for example, an UV oxidation apparatus using a low-pressure mercury lamp may be used.

[0040]

An operation method of the ultrapure water production apparatus having the configuration as above will be explained. First, water under treatment W subjected to pre-treatment by a not shown pre-treatment means in accordance with need is supplied to the primary pure water system 2 and treated in the reverse osmosis (RO) membrane device 4 and the regenerating mixed bed-type ion exchange device 5. In the reverse osmosis (RO) membrane device 4, ionic and colloidal TOC are removed in addition to removing salts. In the regenerating mixed bed-type ion exchange device 5, TOC components adsorbed or ion exchanged by an ion exchange resin are removed in addition to removing salts so as to produce primary pure water W1.

[0041]

In the present embodiment, a boron concentration [B] of primary pure water W1 of the regenerating mixed bed-type ion exchange device 5 is continuously monitored by the boron monitor 6 with a boron detection level at 10ppb and reading value at 1ppb level. Then, after treating the primary pure water W1 in the electric deionization device 7, obtained treated water W2 is supplied to the sub-tank 8.

[0042]

During this, a boron removal rate is calculated in

advance by measuring a boron concentration in the treated water W2 of the electric deionization device 7 obtained by treating primary pure water W1 having already-known predetermined boron concentration. Preferably, the boron removal rate of the electric deionization device 7 is 99% or higher, particularly 99.99% or higher. The electric deionization device as shown in FIG. 2 and FIG. 3 in particular is suitable for attaining the boron removal rate of 99.99% or higher. Also, a product of the boron concentration of the primary pure water W1 and the boron removal rate of the electric deionization device 7 can be assumed as a boron concentration [B1] of the treated water W2 (for example, if the boron concentration [B] of the primary pure water W1 is 1ppb or lower and the boron removal rate of the electric deionization device 7 is 99.99%, the boron concentration [B1] of the treated water W2 can be assumed to be 0.1ppt or lower). In this way, even if the boron concentration of the treated water W2 to be supplied to the subsystem 3 is 1ppb or lower, it can be monitored continuously.

[0043]

Subsequently, the treated water W2 supplied to the sub-tank 8 is supplied by a pump P and subjected to a treatment. In the subsystem 3, treatments are performed by the UV oxidation device 9, the non-regenerating mixed

bed-type ion exchange device 10 and the ultrafiltration membrane 11. The UV oxidation device 9 decomposes TOC to organic acid and furthermore to the CO₂ level by an ultraviolet ray at a wavelength of 185nm emitted from the UV lamp. The decomposed organic acid and CO₂ are removed in the subsequent non-regenerating mixed bed-type ion exchange device 10. In the ultrafiltration membrane 11, fine particles are removed and eluted particles from the non-regenerating mixed bed-type ion exchange device 10 is also removed so as to obtain secondary pure water (ultrapure water) W5. The secondary pure water W5 is supplied to a use point UP and, then, unused part is returned to the sub-tank 8.

[0044]

In an operation of the ultrapure water production apparatus 1 as above, a boron concentration of the secondary pure water (ultrapure water) W5, which is a treated water of the subsystem 3, normally becomes largely lower than the boron concentration [B1] in the treated water W2, so that when the boron concentration [B1] of the treated water W2 of the electric deionization device 7 is lower than a level, at which a demanded water quality can be obtained, considering the amount of reduction in the subsystem 3, it is determined as "no problem" in terms of water quality and the operation may

continue. For example, in the case where a demanded
quality of boron of the secondary pure water W5 is 0.1ppt,
a boron removal rate of the electric deionization device
7 is 99.99% and boron can be reduced to 1/10 in the
5 subsystem 3, when the boron concentration of the primary
pure water W1 is 10ppb or lower, the operation can be
continued.

[0045]

Due to long-term usage, the boron removal
10 capability of the non-regenerating mixed bed-type ion
exchange device 10 declines and it becomes liable that
boron leaks to the secondary pure water W5, so that it is
preferable to perform a precision analysis of the
secondary pure water W5 regularly and to measure an
15 actual boron concentration of the secondary pure water W5.
The actual measurement value [B2] of the boron
concentration and the boron concentration [B1] of the
treated water W2 are compared and when the actual
measurement value [B2] of the boron concentration
20 exhibits a tendency that a reduction rate with respect to
the boron concentration [B1] of the treated water W2
declines, it is preferable to change the non-regenerating
mixed bed-type ion exchange device 10 even if the boron
concentration [B2] does not exceed 0.1ppt yet. By doing
25 so, leakage of boron to the secondary pure water W5 can

be prevented in advance. Moreover, the non-regenerating mixed bed-type ion exchange device 10 is changed after the tendency is observed that the performance of the non-regenerating mixed bed-type ion exchange device 10 declines actually, so that the frequency of changing can be low, which is economically efficient.

[0046]

Particularly, in the present embodiment, in the electric deionization device 7, part of the treated water W2 is passed as concentrated water W3 to the concentration chamber 25 in a countercurrent single-pass manner in the opposite direction from the water-flow direction in the desalting chamber 26, and concentrated waste water W4 is discharged from the concentration chamber 25 to outside the system. Therefore, an ion concentration in the concentrated water W3 in the concentration chamber 25 becomes lower as getting closer to the outlet side of the desalting chamber 26, and the effect of concentration diffusion on the desalting chamber 26 becomes smaller, so that the boron removal rate is improved. Also, since water supply to the electric deionization device 7 is primary pure water W1, there are a small amount of ions (for example, electric resistance is $18\text{M}\Omega\cdot\text{cm}$, which is large), so that a large amount of current is required. However, by filling ion

exchangers in both of the desalting chamber 26 and the concentration chamber 25, electric resistance in the desalting chamber 26 and the concentration chamber 25 can be reduced, so that an operation cost can be reduced.

5 [0047]

Furthermore, in the present embodiment, nitrogen-sealed tank is used as the sub-tank 8, so that dissolving of carbon dioxide and oxygen in the air can be suppressed and a decline of resistivity of the secondary pure water
10 W5 can be suppressed.

[0048]

Next, the ultrapure water production apparatus according to the second embodiment of the present invention will be explained based on FIG. 4.

15 [0049]

The ultrapure water production apparatus of the second embodiment is configured to comprise the primary pure water system 2 and the subsystem 3 in the first embodiment explained above, wherein the subsystem 3
20 includes an UV oxidation device 9, an anion exchange resin device 12, a deaerator membrane 13, a non-regenerating mixed bed-type ion exchange device 10 and an ultrafiltration membrane (UF membrane) 11.

[0050]

25 By providing the anion exchange resin device 12 and

the deaerator membrane 13 to the subsystem 3 as above,
there is a risk that a trace of carbon dioxide or oxygen
may be mixed in the primary pure water W1 as the electric
deionization device 7 does not have airtightness itself,
5 however, CO₂ is removed by the anion exchange resin
device 12 and other residual gas components, such as
dissolved oxygen, can be removed by the deaerator
membrane 13, so that dissolved gas components can be
reduced.

10 [0051]

The present invention was explained above based on
the embodiments, however, the present invention is not
limited to the embodiments explained above and may be
implemented in variously modified ways, and the primary
15 pure water system 2 and the subsystem 3 are not limited
to the configurations in the present examples and may be
configured in various ways. For example, in the primary
pure water system 2, two of the reverse osmosis membrane
(RO) devices 4 may be connected serially. Also, in the
20 first embodiment, the subsystem 3 is provided with the UV
oxidation device 9 but the UV oxidation device 9 is not
necessarily provided depending on cases. Furthermore, a
nitrogen-sealed tank was used as the sub-tank 8, but it
may be a normal sub-tank or the sub-tank 8 is not
25 necessarily used depending on cases. Furthermore, for

measuring water quality of the secondary pure water W5,
other water quality analysis means, such as a resistivity
meter, may be provided to measure water quality of the
secondary pure water W5 on site, and when the resistivity
5 becomes lower than a predetermined set value, the non-
regenerating mixed bed-type ion exchange device 10 may be
changed.

[EXAMPLES]

[0052]

10 Below, the present invention will be explained
furthermore specifically with examples and comparative
examples, however, the present invention is not limited
to those examples below.

[0053]

15 [Example 1]

City water (water to be treated) W of Yoshida-cho,
Haibara-gun in Shizuoka prefecture was treated by a
primary pure water system 2 comprising the reverse
osmosis (RO) membrane device 4 and the regenerating mixed
20 bed-type ion exchange device 5. A boron concentration of
the primary pure water W1 was measured by a boron monitor
6 while treating in the electric deionization device 7
and treated water W2 was stored in the sub-tank 8. The
treated water W2 in the sub-tank 8 was treated by passing
25 through the subsystem 3, wherein the UV oxidation device

9, anion exchange resin device 12, deaerator membrane 13,
non-regenerating mixed bed-type ion exchange device 10
and ultrafiltration membrane (UF membrane) 11 are
provided in this order, to produce secondary pure water
5 W5.

[0054]

Note that the following was used as the electric
deionization device 7.

Electric deionization device: made by Kurita Water
10 Industries Ltd. KCDI-UPz, wherein an ion exchange resin
was filled in desalting chambers 26, concentration
chambers 25 and electrode chambers 27 and 28, part of
treated water W2 was passed in a countercurrent flow
through the concentration chamber 25 and the boron
15 removal rate was 99.99%.

[0055]

When operation the ultrapure water production
apparatus, a value of the boron monitor 6 was 1 to 5ppb
and stable, and a boron concentration of the treated
20 water W2 was presumed to be 0.1ppt or lower, consequently,
the operation was continued. The boron concentration of
the treated water W2 was precisely analyzed once a month
and was stable as 0.1ppt or lower, and a boron
concentration of secondary pure water W5 was 0.1ppt or
25 lower, as well. A resistivity value of the secondary pure

water W5 was approximately 18.2MΩ·cm, which was an
ultrapure water level and stable even after three years,
and change of the non-regenerating mixed bed-type ion
exchange device 10 was not necessary in the subsystem 3
5 for three years.

[0056]

[Comparison Example 1]

In Example 1, the electric deionization device 7
was not used and the boron monitor 6 was provided after
10 the non-regenerating mixed bed-type ion exchange device
10 for monitoring.

[0057]

When operating the ultrapure water production
apparatus, a value of the boron monitor 6 exceeded 1ppb
15 after 3 weeks and the non-regenerating mixed bed-type ion
exchange device 10 had to be changed.

[0058]

[Comparison Example 2]

In Example 1, the boron monitor 6 was provided
20 after the non-regenerating mixed bed-type ion exchange
device 10 in the subsystem 3 for monitoring, but the
boron concentration could not be detected and it was
difficult to determine when to change the non-
regenerating mixed bed-type ion exchange device 10 due to
25 breakthrough.

[0059]

[Comparison Example 3]

In Example 1, other than not using the electric deionization device 7 in the primary pure water device 2 and arranging an electric deionization device after the UV oxidation device 9 in the subsystem 3, monitoring by the boron monitor 6 was done in the same way.

[0060]

When operating the ultrapure water production apparatus as explained above, a value of the boron monitor 6 was stable as 1 to 5ppb, but the boron concentration of the flow-in water of the subsystem 3 was high and a water pressure of treated water of the electric deionization device provided in the subsystem 3 was low and unstable, so that a treatment in the anion exchange resin device 12, etc. provided after thereof was also unstable, consequently, the boron concentration of the secondary pure water W5 fluctuated largely in a precise analysis held once a month, and it was difficult to determine when to change the non-regenerating mixed bed-type ion exchange device 10 due to breakthrough. Also, a decline of performance of the electric deionization device was also observed, which was assumed to be an effect of oxidized substances generated in the UV oxidation device 9.

[Explanation of Reference Numbers]

[0061]

- 1... ultrapure water production apparatus
- 5 2... primary pure water system
- 3... subsystem
- 4... reverse osmosis membrane (RO) device
- 5... regenerating mixed bed-type ion exchange device
- 6... boron monitor (boron concentration measuring means)
- 10 7... electric deionization device
- 8... sub-tank
- 9... UV oxidation device
- 10... non-regenerating mixed bed-type ion exchange device
- 11... ultrafiltration membrane (UF membrane)
- 15 12... anion exchange resin device
- 13... deaerator membrane
- W... water to be treated
- W1... primary pure water
- W2... treated water
- 20 W3... concentrated water
- W4... concentrated waste water
- W5... secondary pure water (ultrapure water)

CLAIMS

[Claim 1]

An ultrapure water production apparatus, comprising
a primary pure water system and a subsystem provided with
5 an ion exchange device and an UF membrane device for
treating primary pure water obtained from the primary
pure water system,

the ultrapure water production apparatus comprising
a boron concentration measuring means and an electric
10 deionization device provided after the primary pure water
system and before the subsystem, and

a mean for determining whether the ion exchange
device of the subsystem has to be changed or not by
assuming that the boron concentration of the primary pure
15 water detected by the boron concentration measuring means
multiplied by the boron removal rate in the electric
deionization device for the primary pure water measured
in advance is a boron concentration of water supplied to
the subsystem.

20 [Claim 2]

The ultrapure water production apparatus according
to claim 1, wherein the primary pure water system
comprises a reverse osmosis membrane device and an ion
exchange device.

25 [Claim 3]

The ultrapure water production apparatus according

to claim 1 or 2, wherein the electric deionization device comprises a negative electrode, a positive electrode, a cation exchange membrane and an anion exchange membrane arranged between the negative electrode and the positive
5 electrode, and a desalting chamber and a concentration chamber formed by being sectionalized by the cation exchange membrane and the anion exchange membrane, ion exchangers are filled in the desalting chamber and the concentration chamber, and a concentrated water passing
10 means for passing concentrated water to the concentration chamber and a means for passing raw water to the desalting chamber and taking out deionized water are provided.

[Claim 4]

15 The ultrapure water production apparatus according to claim 3, wherein the concentrated water passing means passes deionized water passed through the desalting chamber as concentrated water.

[Claim 5]

20 The ultrapure water production apparatus according to claim 4, wherein the concentrated water passing means introduces the concentrated water into the concentration chamber from the side close to an outlet of deionized water of the desalting chamber and discharges from the
25 side close to a raw water inlet of the desalting chamber.

[Claim 6]

A method for operating an ultrapure water production apparatus comprising a primary pure water system and a subsystem provided with an ion exchange device and an UF membrane device for treating primary
5 pure water obtained from the primary pure water system, wherein a boron concentration measuring means and an electric deionization device are provided after the primary pure water system and before the subsystem:

wherein, when producing ultrapure water by
10 continuously passing water to be treated to the primary pure water system and the subsystem, it is determined whether the ion exchange device of the subsystem has to be changed or not by assuming that the boron concentration of the primary pure water detected by the
15 boron concentration measuring means multiplied by the boron removal rate in the electric deionization device for the primary pure water measured in advance is a boron concentration of water supplied to the subsystem.

[Claim 7]

20 The method for operating the ultrapure water production apparatus according to claim 6, wherein the primary pure water system comprises a reverse osmosis membrane device and an ion exchange device.

[Claim 8]

25 The method for operating the ultrapure water production apparatus according to claim 6 or 7, wherein

the electric deionization device comprises a negative electrode, a positive electrode, a cation exchange membrane and an anion exchange membrane arranged between the negative electrode and the positive electrode, and a
5 desalting chamber and a concentration chamber formed by being sectionalized by the cation exchange membrane and the anion exchange membrane, ion exchangers are filled in the desalting chamber and the concentration chamber, and a concentrated water passing means for passing
10 concentrated water to the concentration chamber and a means for passing raw water to the desalting chamber and taking out deionized water are provided.

[Claim 9]

The method for operating the ultrapure water
15 production apparatus according to claim 8, wherein the concentrated water passing means introduces part of treated water passed through the desalting chamber as the concentrated water.

[Claim 10]

20 The method for operating the ultrapure water production apparatus according to claim 9, wherein the concentrated water is introduced to the concentration chamber from the side close to an outlet of deionized water of the desalting chamber and discharged from the
25 concentration chamber from the side close to a raw water inlet of the desalting chamber.