

SPECIFICATION

TITLE OF THE INVENTION

METHOD AND APPARATUS FOR CHEMICALLY POLISHING
LIQUID CRYSTAL GLASS SUBSTRATE

5

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to methods for chemically polishing liquid crystal glass substrates in which the outer surface
10 of a liquid crystal glass substrate or of a combination of a pair of liquid crystal glass substrates laminated together, which are used for liquid crystal displays, is polished. The invention relates also to chemical polishing apparatus to be used for the execution of such methods.

15 Description of the Related Art

A liquid crystal display device is generally manufactured as described below.

Each device partition of a pair of glass substrates, which have areas for several liquid crystal display devices, is respectively
20 covered with transparent electrode and alignment layer for displaying. A pair of glass substrates is laminated together by epoxy resin through sealant, which is printed on one glass substrate, enclosing a liquid crystal sealing region of each device partition respectively, to give a device assembly, which has several liquid
25 crystal display devices. The device assembly of a pair of glass

substrates is separated to provide several liquid crystal display devices. Pouring liquid crystal therein completes each separated liquid crystal display device. The glass substrate used for a liquid crystal display is called "a liquid crystal glass substrate" in the following.

A liquid crystal glass substrate or a pair of liquid crystal glass substrates laminated together by epoxy resin as described above is polished to reduce the thickness, smoothen the surface, and remove scratches originally existing in the surface.

In addition, a liquid crystal glass substrate, which has become defective in manufacturing process of a liquid crystal display, can be reused for the liquid crystal display by peeling a patterned coating off and polishing the surface to remove the marks of patterns.

Conventional methods for polishing liquid crystal glass substrates include mechanical polishing and chemical polishing. Recently, there are demands for improvement in qualities of liquid crystal glass substrates as mentioned below:

- (1) To remove scratches originally existing in the surface of a liquid crystal glass substrate;
- (2) To remove remaining marks of patterns on the substrate after peeling a patterned coating off;
- (3) To reduce the thickness of a liquid crystal glass substrate and also to improve the smoothness of the surface thereof;
- (4) To remove scratches originally existing in the outer surface of a

pair of liquid crystal glass substrates after the lamination thereof;
and

- (5) To reduce the thickness of the outer surface of a pair of liquid crystal glass substrates after the lamination thereof, and also to
5 improve the smoothness of the surface thereof.

Contrary to the above-mentioned demands for quality improvement, the conventional mechanical polishing has some unavoidable problems such as the shortage of smoothness, the occurrence of cracks and scratches in a surface, the remaining of
10 polished patterns, and a limit of polishing power. In particular, the recent large-sized substrates show a marked tendency.

On the other hand, it is difficult for the conventional chemical polishing to remove the scratches originally existing in the surface of a liquid crystal glass substrate and marks of patterns.
15 Even when the thickness of substrates is reduced, various problems arise as described in the following examples and it is difficult to ensure qualities equivalent to or higher than those of mother glass.

For example, Examined Japanese Patent Publication No.2722798 discloses a method in which the outer surface of a pair
20 of liquid crystal glass substrates is etched. A device assembly, fabricated by laminating a pair of liquid crystal glass substrates together, which have areas for several liquid crystal display devices, through sealant enclosing each liquid crystal sealing region of each device partition, is immersed in an etchant containing
25 hydrofluoric acid as the primary component. This method can

realize the reduction of the thickness of the liquid crystal glass substrate, but has a problem of forming defects as described below.

For another example, Unexamined Japanese Patent Publication 2000-147474 discloses an invention of automatic etching equipment equipped with a bubble generator provided at the bottom of an etchant tank for accumulating an etchant containing hydrofluoric acid, wherein the surface of a glass plate put in the etchant tank is etched through stirring the etchant with the bubbles generated from the bubble generator. However, there arises a problem with this equipment of the occurrence of defects described below when the outer surface of a liquid crystal glass substrate is polished in a 15 to 17% hydrofluoric acid.

This invention attempts to achieve uniform polishing of a glass surface by stirring a polishing liquid with an ascending flow of nitrogen gas. However, there is a problem that the surface can not be polished uniformly since the descending flow caused when the bubbles and polishing liquid ascended arrive at the surface of the polishing liquid prevents the uniformity of the ascending flow.

The following are problems which arise when a liquid crystal glass substrate is polished by 50 to 300 μm by the two conventional chemical polishing methods described in the above two examples:

(1) Cloudiness, which can be observed even under a fluorescent lamp, appears.

(2) Pits with diameters not greater than 0.2 mm are formed. FIG. 14 is a graph showing the result of examining the surface after

polishing, with a surface roughness meter.

(3) The diameter of pits becomes greater with the increase of the thickness polished. FIG. 15 is a graph showing the relationship between the diameter of pits and the thickness polished.

5 (4) Pits appear in a density of 50 pits/cm² at most. FIG. 16 is a graph showing the relationship between the number of pits per unit area and the thickness polished. FIG. 16 reveals that the number of pits per unit area increases with the increase of the thickness polished.

10 (5) Waviness, which is visible under a fluorescent lamp, appears. FIG. 17 is a graph illustrating the waviness conditions of a surface after polishing.

(6) The difference between a maximum and a minimum of the thickness ranges 20 to 100 μ m and is uneven.

15 (7) Polishing makes surface scratches, intentionally formed before the polishing, greater in their depth and width (see FIGS. 18 and 19.) FIG. 18 is a graph illustrating the cross section of a surface before polishing, the surface having scratches formed intentionally. FIG. 19 is a graph illustrating the cross section of the surface after
20 polishing.

Furthermore, for example, when liquid crystal glass substrate sputtered with Cr and provided with patterns of pixels for color filters has become defective, the substrate will generally be reused as mother glass by peeling the patterned Cr off and
25 polishing the surface mechanically to remove the marks of patterns.

However, there is a problem that when the conventional chemical polishing is carried out in place of the mechanical polishing, the marks of patterns are not be removed and the substrate can not be reused as mother glass.

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SUMMARY OF THE INVENTION

The present invention has been made with the aim of solving the above problems.

It is an object of the present invention to provide a method
10 for chemically polishing a liquid crystal glass substrate wherein by immersing a liquid crystal glass substrate in a chemical polishing liquid containing a mixed liquid of hydrofluoric acid and fluorinated substances, inorganic acids, organic acids, anionic surfactants and ampholytic surfactants, and polishing the outer surface of the liquid
15 crystal glass substrate at a rate of 0.5 to 10 $\mu\text{m}/\text{minute}$, a liquid crystal glass substrate surface with a high smoothness can be obtained without allowing the reaction products such as silicofluorides to reattach to the surface of the liquid crystal glass substrate.

20 It is another object of the present invention to provide a method and apparatus for chemically polishing a liquid crystal glass substrate, wherein a fresh polishing liquid is continuously supplied to the surface of a liquid crystal glass substrate, reaction products are prevented from their physical attachment onto the surface of
25 the liquid crystal glass substrate, the surface of the liquid crystal

glass substrate is uniformly smoothened while the thickness of the liquid crystal glass substrate is reduced, surface scratches are removed, and the glass can be reused, through generating bubbles from the bottom of a chemical polishing liquid accumulation tank, thereby generating a uniform ascending liquid flow, followed by allowing the ascending flow to overflow the chemical polishing liquid accumulation tank from the periphery thereof, followed by causing the overflow to pass through a filter, thereby removing the reaction products, followed by supplying the overflow to the chemical polishing liquid accumulation tank again.

It is still another object of the present invention to provide chemical polishing apparatus which can simultaneously polish uniformly a plurality of liquid crystal glass substrates or combinations of a pair of liquid crystal glass substrates laminated together through being equipped with a liquid crystal glass substrate carrier for installing therein at least one liquid crystal glass substrate or at least one combination of a pair of liquid crystal glass substrates laminated together.

It is a further object of the present invention to provide chemical polishing apparatus which can stir a chemical polishing liquid more uniformly through being equipped with an ultrasonic transducer or an oscillatory stirring fan.

The above and further objects and features of the invention will more fully be apparent from the following detailed description with accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a section view of chemical polishing apparatus according to an embodiment of the present invention;

5 FIG. 2 is a perspective view of a bubble generating section according to an embodiment of the present invention;

FIG. 3 is a perspective view of another bubble generating section according to an embodiment of the present invention;

FIG. 4 is a plan view of a chemical polishing liquid
10 accumulation tank and a liquid crystal glass substrate carrier holder according to an embodiment of the present invention;

FIG. 5 is a perspective view of a chemical polishing liquid discharging section according to an embodiment of the present invention;

15 FIG. 6 is a graph showing the relationship between the polishing rate and the addition ratio of the ten ingredients of the chemical polishing liquid;

FIG. 7 is a graph showing the relationship between the polishing rate and the temperature;

20 FIG. 8 is a plan view showing the positions at which the thickness of the glass substrate (2) is measured;

FIG. 9 is a plan view showing the result of checking the presence of surface scratches before and after chemical polishing;

25 FIG. 10 is a graph showing the result of examining the surface conditions of the glass substrate (2) with a surface

roughness meter;

FIG. 11 is a plan view showing the result of checking the presence of scratches before and after chemical polishing;

FIG. 12 is a plan view showing the positions at which the thickness of the outer front surface of a combination of two glass substrates (2) laminated together is measured;

FIG. 13 is a plan view showing the positions at which the thickness of the outer rear surface of a combination of two glass substrates (2) laminated together are measured;

FIG. 14 is a graph showing the result of examining the surface after polishing by the conventional polishing method;

FIG. 15 is a graph showing the relationship between the diameter of pits and the thickness polished;

FIG. 16 is a graph showing the relationship between the number of pits per unit area and the thickness polished;

FIG. 17 is a graph illustrating the winding conditions of the surface after polishing;

FIG. 18 is a graph illustrating the cross section of a surface provided with intentional scratches formed before polishing; and

FIG. 19 is a graph illustrating the cross section of the surface after the polishing.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Hereinafter, the present invention is concretely described on the basis of the drawings which show the embodiments thereof.

FIG. 1 is a section view of chemical polishing apparatus according to an embodiment of the present invention; in the drawing, numeral 1 denotes chemical polishing apparatus.

The chemical polishing apparatus 1 has a chemical polishing liquid accumulation tank 11. In the bottom of the chemical polishing liquid accumulation tank 11 is provided a bubble generating section 12 such that a gas is introduced therein and is discharged from a bubble discharging element 12a made up of porous material. Above the bubble generating section 12 is provided a liquid crystal glass substrate carrier 18 for holding a liquid crystal glass substrate or a combination of a pair of liquid crystal glass substrates laminated together inserted vertically. The liquid crystal glass substrate carrier 18 is installed in a liquid crystal glass substrate carrier holder 17.

The chemical polishing liquid accumulation tank 11 is charged with a chemical polishing liquid containing a mixed liquid of hydrofluoric acid and a fluorinated substance comprising one or a plurality of species selected from ammonium fluoride, potassium fluoride and sodium fluoride, an inorganic acid comprising one or a plurality of species selected from hydrochloric acid, sulfuric acid, phosphoric acid and nitric acid, an organic acid comprising one or a plurality of species selected from acetic acid and succinic acid, an anionic surfactant containing a sulfonate-based surfactant, and an amine-type ampholytic surfactant.

On the periphery of the chemical polishing liquid

accumulation tank 11 is provided an overflow receiving tank 13 for receiving an overflow of the chemical polishing liquid from the chemical polishing liquid accumulation tank 11. To the overflow receiving tank 13 are connected with a filter 14 for removing
5 reaction products formed through polishing, and a pump 15 for pumping the chemical polishing liquid filtered through the filter 14 back to the chemical polishing liquid accumulation tank 11. The chemical polishing apparatus is designed so that the chemical polishing liquid is supplied to the chemical polishing liquid
10 accumulation tank 11 again from a chemical polishing liquid discharging section 16 having a chemical polishing liquid discharging element 16a with a number of pores through which the chemical polishing liquid pumped from the pump 15 is discharged toward the bottom of the chemical polishing liquid accumulation
15 tank 11. The chemical polishing liquid discharging section 16 is located below the bubble generating section 12.

The chemical polishing apparatus 1 may have an ultrasonic transducer or an oscillatory stirring fan (not shown). In such a case, the chemical polishing liquid can be stirred more uniformly.

20 FIG. 2 is a perspective view of the bubble generating section 12. The section has a gas introducing tube 12b for introducing a gas such as a nitrogen gas, and a plurality of pipe-like bubble discharging elements 12a, 12a, ... made up of porous material, the elements being connected perpendicularly to the gas introducing
25 tube 12b.

FIG. 3 is a perspective view of a bubble discharging element 12a of another type of bubble generating section 12. The bubble discharging element 12a of this type of bubble generating section 12 is made up of porous material and is in a plate-like form.

5 According to FIGS. 2 and 3, the pore diameter is preferable 10 to 500 μm of a glass surface or in the attachment of a sludge of the reaction m. Such a bubble generating section 12 is located below the liquid crystal glass substrate carrier holder 17 and fine bubbles are discharged upwardly. The bubbles cause the chemical
10 polishing liquid to ascend uniformly. This ascending liquid flow supplies a fresh chemical polishing liquid continuously to the surface of a liquid crystal glass substrate and also prevents the reaction products such as silicofluorides from re-attaching to the surface of the liquid crystal glass substrate.

15 After arriving at the surface of the chemical polishing liquid, the ascending flow containing fine bubbles overflows the chemical polishing liquid accumulation tank 11 from the periphery thereof, followed by being received in an overflow receiving tank 13. The overflow is thereafter allowed to pass through a filter 14, and then
20 supplied to the chemical polishing liquid accumulation tank 11 again.

 When the chemical polishing liquid is not allowed to overflow, a small cross sectional area of a portion where the ascending flow turns to a descending flow will cause the both liquid flows to
25 intersect each other. The intersection will make it unable to

ensure a uniform ascending liquid flow.

FIG. 4 is a plan view illustrating a chemical polishing liquid accumulation tank 11 and a liquid crystal glass substrate carrier holder 17. As shown in FIG. 4, it has been determined that a
5 uniform ascending liquid flow can be ensured when a passing cross sectional area of the descending liquid flow, which corresponds to the outside area of the liquid crystal glass substrate carrier holder 17, is from one to three times a passing cross sectional area of the ascending liquid flow, which corresponds to the inside area of the
10 liquid crystal glass substrate carrier holder 17.

The reaction products resulted from the ingredients of the liquid crystal glass substrate and silicofluorides and the like contained in the chemical polishing liquid ascend by the action of the ascending flow of fine bubbles. However, since the circulation
15 of the reaction products in the chemical polishing liquid accumulation tank 11 followed by accumulation thereof on the bottom of the tank will result in adverse effects on the discharge of fine bubbles, the reaction products should be prevented from their accumulation.

20 FIG. 5 is a perspective view of a chemical polishing liquid discharging section 16. This section has a plurality of chemical polishing liquid discharging elements 16a with a number of holes, the elements being provided in parallel to each other. The chemical polishing liquid discharging section 16 is constructed to
25 supply the chemical polishing liquid and to prevent the reaction

products from accumulation thereof by discharging the chemical polishing liquid, which is pumped from a pump 15, through the chemical polishing liquid discharging elements 16a downward or obliquely downward.

5 Methods for controlling the rate of polishing liquid crystal glass substrates include the changing of the composition of a polishing liquid and the changing of the temperature of the polishing liquid.

FIG. 6 is a graph showing the relationship between the
10 polishing rate and the addition ratio of the ten ingredients of the chemical polishing liquid. The chemical polishing liquid is an aqueous solution containing hydrofluoric acid, ammonium fluoride, potassium fluoride, hydrochloric acid, sulfuric acid, phosphoric acid, nitric acid, acetic acid, a sulfonate-based surfactant and an
15 amine-type surfactant.

FIG. 6 reveals that an addition ratio of the ten ingredients of the chemical polishing liquid as much as 10% provides a polishing rate of 1.1 $\mu\text{m}/\text{minute}$. The polishing rate increases as the addition ratio increases, and an addition ratio of 40% provides a maximum
20 polishing rate of 3.7 $\mu\text{m}/\text{minute}$. It is also revealed that the polishing rate decreases a little when the addition rate exceeds 40% and is kept at approximately 3 $\mu\text{m}/\text{minute}$ until the addition ratio reaches 90%.

Addition ratios of 30% or less result in slow polishing rates,
25 while addition ratios of 70% or more result in the cloudiness of a

glass surface or in the attachment of a sludge of the reaction products onto the glass surface. Accordingly, setting of the addition ratio at 30 to 60% is preferable as means of controlling the polishing rate.

5 It offers no problem that the polishing rate varies from 3.0 μ m/minute to 3.5 μ m/minute. When the variation of the thickness polished is limited successfully within the range as wide as 20 μ m, a variation of the polishing rate of 0.5 μ m/minute corresponds to a variation of the polishing time of 40 minutes (0.5
10 (μ m/minute) $\times$ 40 (minutes) = 20 (μ m)), which is included in an acceptable range.

FIG. 7 is a graph showing the relationship between the polishing rate and the temperature. In this graph, the horizontal axis indicates the deviation from a standard temperature and the
15 vertical axis indicates the polishing rate.

FIG. 7 reveals that the polishing rate increases gradually as the temperature increases, but the difference of the polishing rate between temperatures of -5° and 5° is only 0.5 μ m/minute.

Accordingly, if the variation of the thickness polished is
20 limited successfully within the range as wide as 20 μ m, the variations of the polishing time within a range as wide as up to 40 minutes are acceptable.

In practical operations, it is preferable to immerse a test sample in a chemical polishing liquid accumulation tank 11 and
25 thereafter determine a polishing rate based on the change of the

thickness of the test sample.

The polishing rate is determined by a diffusion rate and a reaction rate. At projecting portions of the surface of a liquid glass substrate, the polishing rate is determined by the reaction rate
5 since an active chemical polishing liquid is supplied incessantly by an ascending flow of bubbles. The polishing rate becomes great enough. On the other hand, in recessed portions of the surface of the liquid crystal substrate, the polishing liquid is in stagnant conditions. The polishing rate is therefore determined by the
10 diffusion rate and becomes slow. Accordingly, using ascending flows of bubbles can control the polishing rate, and it is possible to reduce the thickness of liquid glass substrate and to smoothen the surface of the liquid glass substrate.

The present invention will be described concretely with
15 reference to examples below; however, these examples are intended to illustrate the invention and are not to be construed to limit the scope of the invention.

Example 1

20 By using chemical polishing apparatus 1 according to the present invention was conducted chemical polishing of mother glasses sized (1) $320 \times 400 \times 1.1$ (mm) and (2) $400 \times 500 \times 0.7$ (mm), respectively. The desired thickness to be polished was 0.3 mm and 0.2 mm, respectively.

25 The effect of the polishing rate on the surface conditions of

the glass was examined by varying the compositions of chemical polishing liquids. The results are summarized in Table 1.

Table 1

5	POLISHING RATE ($\mu\text{m}/\text{minute}$)	0.5	1.0	3.0	5.0	10.0	13.0	15.0
	PITS	NOT EXIST	NOT EXIST	NOT EXIST	NOT EXIST	NOT EXIST	EXIST	EXIST
	WAVINESS	NOT EXIST	NOT EXIST	NOT EXIST	NOT EXIST	NOT EXIST	EXIST	EXIST
	DISPERSION OF BOARD THICKNESS	SMALL	SMALL	SMALL	SMALL	SMALL	MEDIUM	GREAT
10	ORIGINAL SCRATCHES	NOT EXIST	NOT EXIST	NOT EXIST	NOT EXIST	NOT EXIST	EXIST	EXIST

In Table 1, the presence of pits, waviness and original scratches indicate the results obtained by visual observation under a fluorescent lamp in a dark clean room.

FIG. 8 is a plan view showing positions at which the thickness of glass substrate (2) was measured. In Table 1 are given the results obtained by measuring the thickness of the glass substrate with an ultrasonic thickness meter at each position shown in FIG. 8 and calculating, as a variation, a difference between the maximum and the minimum of the measurements. In the table, "small" indicates a variation not greater than $50\mu\text{m}$, "medium" indicates that of 100 to $200\mu\text{m}$, and "great" indicates that not less than $200\mu\text{m}$.

From the results provided in Table 1, it is revealed that from

the viewpoints of quality and productivity, polishing rates of 0.5 to 10 μ m/minute are preferable and, in particular, the best are 1 to 5 μ m/minute.

5 About the glass substrate (2), the presence of scratches before and after the polishing according to the present invention was checked with the polishing rate controlled at 2 to 3 μ m/minute.

FIG. 9 is a plan view showing the results of checking the presence of scratches before and after the chemical polishing.

10 FIG. 9 shows that the scratches observed before the polishing have disappeared through the polishing.

In Table 2 are given the results of measuring the thickness of glass substrates (1) and (2) with an ultrasonic thickness meter at each position shown in FIG. 8 with the polishing rate controlled at 2 to 3 μ m/minute.

Table 2

(mm)

		DESIRED THICKNESS		1	2	3	4	5	
20	(1)	320×400×1.1t	0.3		0.83	0.80	0.81	0.82	0.80
	(2)	400×500×0.7t	0.2		0.53	0.52	0.53	0.53	0.52
			6	7	8	9	DISPERSION		
	(1)	320×400×1.1t	0.81	0.82	0.81	0.80	0.026		
	(2)	400×500×0.7t	0.53	0.53	0.52	0.54	0.016		

FIG. 10 is a graph showing the result of checking the surface conditions of glass substrate (2) with a surface roughness meter.

From Table 2 and FIG. 10, it is shown that the glass substrates were polished by desired amounts uniformly at their
5 each position and their surfaces were smoothened by the chemical polishing method according to the present invention.

Example 2

Since a substrate having pixels for color filters patterned
10 with Cr had become defective, the Cr was peeled and polishing was conducted with chemical polishing apparatus 1 according to the present invention in order to remove the marks of patterns. The depth of the patterns was approximately 1 μ m. The visual
15 observation of the marks of patterns under an about 10,000 lux light source in a dark clean room confirmed the disappearance of the marks of patterns.

Example 3

A combination of two glass substrates (2) laminated together
20 was polished with chemical polishing equipment 1 according to the present invention. The desired thickness to be polished was 0.2 mm.

FIG. 11 is a plan view showing the result of checking the presence of scratches before and after the chemical polishing.

25 FIG. 11 shows that the scratches observed before the

polishing have disappeared through the polishing.

FIG. 12 is a plan view showing the positions at which the thickness of the outer front surface of the combination of two glass substrates (2) laminated together was measured. FIG. 13 is a plan view showing the positions at which the thickness of the outer rear surface of the combination of two glass substrates (2) laminated together were measured.

The result of measuring the thickness of the front surface and those of the rear surface are given in Table 3 and Table 4, respectively.

Table 3

(mm)

POSITION	1	2	3	4	5
BOARD THICKNESS	0.510	0.508	0.500	0.503	0.504
POSITION	6	7	8	9	DISPERSION
BOARD THICKNESS	0.508	0.506	0.510	0.508	0.010

Table 4

(mm)

POSITION	11	12	13	14	15
BOARD THICKNESS	0.506	0.500	0.505	0.505	0.500
POSITION	16	17	18	19	DISPERSION
BOARD THICKNESS	0.510	0.506	0.508	0.512	0.012

From Tables 3 and 4, it is shown that the surfaces were polished uniformly by the chemical polishing method according to the present invention.

5 As described above, it has been determined that, by polishing chemically with chemical polishing apparatus 1 according to the present invention, the surface of a liquid crystal glass substrate can be smoothened while the thickness thereof is reduced.

Furthermore, the apparatus can remove scratches originally
10 existing in the surface of a liquid crystal glass substrate and makes it possible to reuse the glass.

In addition, by the chemical polishing method according to the present invention, polishing can be carried out with a high productivity regardless of the size of the liquid crystal glass
15 substrate.

Chemical polishing apparatus 1 according to the present invention is not limited to those described in the section of "DESCRIPTION OF THE PREFERRED EMBODIMENTS" and various modifications to the design thereof may be made.



CLAIMS

1. A method for chemically polishing a liquid crystal glass substrate comprising the steps of:

5 immersing the liquid crystal glass substrate in a chemical polishing liquid including:

 a mixed liquid of hydrofluoric acid and a fluorinated substance containing at least one species selected from a group of ammonium fluoride, potassium fluoride and sodium fluoride;

10 an inorganic acid containing at least one species selected from a group of hydrochloric acid, sulfuric acid, phosphoric acid and nitric acid;

 an organic acid containing at least one species selected from a group of acetic acid and succinic acid;

15 an anionic surfactant containing a sulfonate-based surfactant; and

 an amine-type ampholytic surfactant; and

 polishing an outer surface of the liquid crystal glass substrate at a rate of 0.5 to 10 μ m/minute.

20

2. A method for chemically polishing a liquid crystal glass substrate according to claim 1, wherein an ascending liquid flow is generated by generating bubbles from the bottom of a chemical polishing liquid accumulation tank (11) for accumulating the

25 chemical polishing liquid therein.



3. A method for chemically polishing a liquid crystal glass substrate according to claim 2, wherein the ascending liquid flow is caused to overflow the chemical polishing liquid tank (11) from periphery thereof.

5

4. A method for chemically polishing a liquid crystal glass substrate according to claim 3, wherein the chemical polishing liquid overflow from the periphery is supplied to the chemical polishing liquid accumulation tank (11) again.

10

5. A method for chemically polishing a liquid crystal glass substrate according to claim 4, wherein the chemical polishing liquid overflow from the periphery is caused to pass a filter (14) to remove a reaction product formed by the polishing and thereafter is supplied to the chemical polishing liquid accumulation tank (11).

15

6. A chemical polishing apparatus equipped with a chemical polishing liquid accumulation tank (11) for accumulating a chemical polishing liquid, comprising:

20

a bubble generating section (12) designed so that a gas is introduced therein and is discharged from a bubble-discharging element (12a) made up of porous material;

an overflow receiving tank (13) which is located on the periphery of the chemical polishing liquid accumulation tank (11)

25

and which receives the chemical polishing liquid that overflowed



the chemical polishing liquid accumulation tank (11);

a filter (14) for removing a reaction product formed by polishing;

a pump (15) for pumping the chemical polishing liquid
5 filtered with the filter (14) to the chemical polishing liquid
accumulation tank (11) again; and

a chemical polishing liquid discharging section (16) located
below the bubble generating section (12), the section having a
number of pores through which the chemical polishing liquid
10 pumped from the pump (15) is discharged toward the bottom of the
chemical polishing liquid accumulation tank (11).

7. A chemical polishing apparatus (1) according to claim 6,
comprising a liquid crystal glass substrate carrier (18) for installing
15 therein at least one liquid crystal glass substrates or combination of
a pair of liquid crystal glass substrates laminated together.

8. A chemical polishing apparatus (1) according to claim 6
or 7, comprising an ultrasonic transducer or an oscillatory stirring
20 fan.