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Title of the Invention

Glass Plate Surface Etching Method, Glass Plate Etching Apparatus, Glass Plate for Flat Panel Display, and Flat Panel Display

Field of the Invention

The present invention relates to a glass plate surface etching method, a glass plate etching apparatus used in the method, a glass plate for a flat panel display, and a flat panel display.

Background of the Invention

In the art of image display, efforts have been made to produce a display of lower profile. A flat panel display (FPD) is one of the displays having a low profile, and examples of the FPD include an electroluminescent display (ELD), a liquid crystal display (LCD) and a plasma display (PDP).

A display panel used in the FPD includes a glass plate as its constituent. Figs. 9A and 9B show one example of an ELD panel which is one of the FPDs. Fig. 9A is a perspective view of the ELD panel, and Fig. 9B is a schematic sectional view taken along line E-E in Fig. 9A. The ELD panel shown in Figs. 9A and 9B has a transparent plate 26, and an EL device 29 laminated on the surface of the transparent plate 26 which is to become an image display surface. This EL device 29 is connected to leads 27, 28 for connecting between the EL device 29 and an external power source. The EL device 29 is sealed from outside via a cap 25.

The cap 25 is made of a material such as metal, organic polymer and glass. When the EL device 29 on the surface of the transparent plate 26 is sealed with a glass cap made of glass, the glass cap may be produced by

forming a recess on the surface of the glass plate by etching. JP-A 2004-22291 discloses a method of producing a glass cap by etching a surface of a glass plate.

According to the method disclosed in JP-A 2004-22291, a glass cap is produced by performing an etching process in the following manner. After covering the surface of the glass plate with a predetermined pattern of a masking agent, the glass plate is immersed in an etchant to cause a recess to be formed on the surface of the glass plate which is not covered with the masking agent.

If a glass plate is subjected to etching, in order to stably form a recess on the surface of the glass plate, it is necessary to keep the temperature distribution in the etchant uniform, as well as to control the temperature of the etchant to be constant. In order to keep the temperature distribution in the etchant uniform, mechanical stirring, generation of bubbles in the etchant or the like stirring method is employed. When the method disclosed in JP-A 2004-22291 is carried out while stirring the etchant, the two problems, curving of the bottom surface of the recess of the glass surface and peeling of the masking agent, as will be described later are likely to occur.

Figs. 10A and 10B are schematic sectional views showing changes on the glass surface in the case where the glass plate is etched by immersion in the etchant. Fig. 10A shows a process in which a glass plate 30 covered with a masking agent 31 is immersed in an etchant to result in formation of a recess on the surface of the glass plate 30. Fig. 10B shows the glass plate 30 formed with a recess on its surface. Figs. 11A and 11B are enlarged views of the parts enclosed in the broken lines in Figs. 10A and 10B. Fig.

11A is an enlarged view of the part enclosed in the broken line in Fig. 10A. Fig. 11B is an enlarged view of the part enclosed in the broken line in Fig. 10B.

As shown in Fig. 11A, in the process of etching the surface of the glass plate 30 by immersing in the etchant the glass plate 30 covered with the masking agent 31, an etchant flow 34 flows along the lateral face of the recess being formed. A part of the etchant flow 34 vertically collides with the bottom surface of the recess, while the remaining part of the etchant flow 34 flows in the shape of quadrant arch drawing a gentle arch because of the presence of the masking agent which will not be etched.

When the etchant flow 34 flows in the shape of quadrant arch, the etchant in the vicinity of a corner 32 of the bottom of the recess on the glass surface being formed flows slowly in comparison to the remainder of the etchant and, additionally, the glass dissolved by the etching is concentrated. As a result, the etching speed decreases at the corner 32 of the recess. This decreased speed will cause the problem of curving in the recess formed on the surface of the glass plate.

On the other hand, peeling of the masking agent 31 covering the surface of the glass plate 30 is caused by the etchant to enter a small gap 33 between the glass plate 30 and the masking agent 31. Peeling of the masking agent brings the problem that the surface of the glass plate 30 that is not intended to be etched is etched.

If etching is performed by immersing a glass plate in an etchant under stirring in the manner as described above, the two problems, curving of the bottom surface of the recess in the glass surface and peeling of the masking agent, are likely to occur. If these problems occur, the shape of the

recess on the surface of the glass plate 30 becomes an unpredictable shape, so that the uniformity of the shape of the formed recess is deteriorated.

By the way, a glass plate is also used in an LCD panel. An LCD panel can be produced to have a lower profile by immersing the glass plate in an etchant. Figs. 12A and 12B are schematic sectional views of a glass plate representing the progress of etching when the glass plate is immersed in an etchant. Fig. 12A shows a flat glass panel 35 immediately after immersed in the etchant wherein on the glass surface etchant flows 36 of quadrant arch and reversed quadrant arch flow due to stirring of the etchant. Fig. 12B shows the state that the surface of the glass plate 35 in Fig. 12A is etched. As can be seen from Fig. 12B, waved recesses and projections are generated on the surface of the glass plate 35 due to the etchant flow. In other words, when the surface of the glass plate is etched by immersing in the etchant, the flatness of the surface of the glass plate that is required in a glass plate for LCD panel may be impaired, so that there is an expectation for providing an etching technique which suppresses the impairment of the flatness.

Summary of the Invention

In consideration of the aforementioned circumstances, it is a primary object of the present invention to provide an etching method enabling uniform etching by uniformly supplying an etchant onto a glass surface in the process of etching the glass surface, and to provide an etching apparatus which is suitable for the method.

It is a secondary object of the present invention to provide an etching method capable of preventing the masking agent from peeling due to

an etchant flowing into the gap between the glass plate and the masking agent even when the surface of the glass plate is covered with the masking agent having a predetermined pattern, and an apparatus which is suitable for the method.

The present invention provides a method for etching a surface of a glass plate, comprising the steps of: etching the surface of the glass plate by spraying an etchant on the surface of the glass plate; and removing the sprayed etchant from the glass plate. Preferably, the etchant is sprayed in the form of a mist.

Preferably, the etching method etches the surface of the glass plate that is accommodated in a glass plate accommodation unit having an opening and accommodating the glass plate while holding and fixing ends of the glass plate. According to the etching method which etches the glass plate placed in the glass plate accommodation unit while being fixedly held at its ends, since the etching is performed while the glass plate does not come into contact with the external, it is possible to prevent the glass plate from being damaged during etching. Additionally, since the glass plate is prevented from moving in the glass plate accommodation unit, it is possible to prevent the glass plate from coming into collision with the glass plate accommodation unit and from being damaged.

The above etching method may further comprises the step of covering the surface of the glass plate with a predetermined pattern of a masking agent, prior to the etching step. When the method is used, the part of glass surface which is not covered with the masking agent becomes a recess as a result of etching.

Preferably, in the etching step, the surface of the glass plate is

etched by spraying the etchant on a bottom surface of the glass plate which is placed in a substantially horizontal state. When the glass plate is covered with a predetermined pattern of the masking agent, preferably, the glass plate is placed in a substantially horizontal state so that the surface of the glass plate which is covered with the masking agent is a bottom surface. Also, the side opposite to the bottom surface of the glass plate may be sprayed with the etchant to etch the surface of the glass plate. Preferably, the glass plate is placed in a real horizontal state.

Preferably, in the etching step, the surface of the glass plate is etched by spraying the etchant on the surface of the glass plate which is placed in a substantially vertical state. At this time, the etchant may be sprayed on the surface to be etched.

The present invention also provides an apparatus for etching a glass plate, comprising: a glass plate supporting member capable of supporting a glass plate; an etchant spraying nozzle for spraying an etchant toward the glass plate supported by the supporting member; an etchant reservoir for reserving the etchant while controlling temperature of the etchant; and an etchant recovering device for recovering the sprayed etchant.

Preferably, the glass plate supporting member can support the glass plate in a substantially horizontal state, and the etchant spraying nozzle sprays the etchant on the bottom surface of the glass plate from a position below the glass. Furthermore, the nozzle may spray the etchant toward the opposite side of the bottom surface of the glass plate from a position above the glass plate.

Preferably, the supporting member supports ends of the glass plate. In this case, it is possible to prevent the etchant from being hindered from

sprayed on the glass plate. The supporting member is desirably a conveyer capable of conveying the glass plate.

Preferably, the conveyer is conveying rollers that support each end of the glass plate from right and left of the conveying direction. These conveyer rollers are able to convey the glass plate in a stable manner, as well as ensure that the surface area of the glass plate on which the etchant can be sprayed at maximum.

Preferably, each of the conveying rollers includes a base having a flat surface with a substantially cylindrical roller having a diameter smaller than a flat span of the base, connected at the flat surface of the base and the flat surface of the roller, and the roller having a smaller diameter supports the glass plate. These rollers can minimize the lateral oscillation of the conveyed glass plate if occurs.

The glass plate supporting member may support the glass plate in a substantially vertical state. In this case, it may be a conveyer capable of conveying the glass plate.

Preferably, the recovering device feeds the recovered etchant to the etchant reservoir. Preferably, the recovering device has at least one sludge remover and can remove sludge in the etchant. The sludge remover can be implemented by a filter, a filter press, a liquid cyclone and a settling tank, for example.

The present invention also provides a glass plate for a flat panel display etched by the above method. This glass plate includes not only those consisting solely of a glass plate but also glass plates in which a member constituting a flat panel display is laminated on the glass surface.

The present invention also provides a flat panel display using the

above glass plate for a flat pane display.

According to the inventive etching method of the above configuration, since the etching is performed by uniformly spraying the etchant on the surface of the glass plate rather than immersing the glass plate into the etchant, it is possible to uniformly etch the glass surface. In the case where the glass plate is covered with the masking agent, the masking agent is pressed by the etchant being sprayed, so that the masking agent is prevented from peeling during etching.

Furthermore, according to the etching apparatus having the above configuration, since the etching is performed by uniformly spraying the etchant on the surface of the glass plate rather than immersing the glass plate into the etchant, the etching apparatus can realize etching of the glass surface with high uniformity. In the case where the glass plate is covered with the masking agent, the etching apparatus prevents the masking agent from peeling during etching by the pressure generated by spraying the masking agent with the etchant.

Brief Description of the Drawings

Fig. 1 is a schematic view of an etching apparatus according to the present invention;

Figs. 2A and 2B respectively show a glass plate covered with a masking agent;

Figs. 3A and 3B respectively illustrate a glass plate accommodation unit which accommodates the glass plate covered with the masking agent shown in Figs. 2A and 2B;

Fig. 4 is a plan view showing the state that the glass plate

accommodation unit is conveyed in a glass etching chamber by a conveyer;

Fig. 5 is a schematic sectional view taken along line B-B in Fig. 4;

Figs. 6A to 6C respectively illustrate a process in which the glass plate surface is etched;

Fig. 7 is an enlarged view of the part enclosed by the broken line in Fig. 6B;

Figs. 8A and 8B respectively illustrate the glass plate accommodation unit accommodating a glass plate not covered with a masking agent;

Figs. 9A and 9B respectively illustrate one example of an ELD panel which is one of FPDs;

Figs. 10A and 10B are schematic sectional views each showing changes in the glass surface when the glass plate is etched by immersion in the etchant;

Figs. 11A and 11B are enlarged views of the part enclosed by the broken line in Figs. 10A and 10B, respectively; and

Figs. 12A and 12B are schematic sectional views of the glass plate each showing progress of the etching when the glass plate is immersed in the etchant.

Description of the Preferred Embodiments

The etching method of the glass plate surface according to the present invention is accomplished by the following steps: a masking agent covering step of covering the surface of the glass plate with a predetermined pattern of a masking agent; an etching step of etching a surface of the glass plate by spraying an etchant on the surface of the glass plate which is

covered with the predetermined pattern of the masking agent; an etchant removing step of removing the sprayed etchant from the glass plate; and a masking agent removing step of removing the masking agent covering the surface of the glass plate. In the etching step, the etchant is preferably sprayed substantially vertically to the surface of the glass plate.

Figs. 2A and 2B illustrate a glass plate 19 covered with a masking agent 20. Fig. 2A is a plan view of the glass plate 19, and Fig. 2B is a sectional view taken along line A-A in Fig. 2A. The glass plate 19 in Figs. 2A and 2B is covered with the masking agent 20 so that nine rectangular openings not masked are arranged in predetermined positions. If the side opposite to this surface of the glass plate 19 covered with the masking agent 20 needs not to be etched, the opposite side may be covered with a masking agent. When a predetermined recess pattern is formed on the opposite side, a masking agent corresponding to the recess pattern can be used for covering.

In the masking agent covering step, covering with the masking agent can be accomplished by a screen printing method, a laminate film method or a resist coating photolithography. Other known methods for covering with a masking agent may also be employed.

In the screen printing method, a screen having the part where the masking agent can pass and the part where the masking agent can not pass is brought into abutment against the surface of the glass plate, and the masking agent is extruded through the part of the screen where the masking agent can pass, thereby covering the surface of the glass plate with the masking agent. In the laminate film method, a film having an adhesive layer on one side is used as a masking agent, and the film is joined to the

glass surface. The resist coating photolithography is a masking method in which after coating the surface of the glass plate with a photo resist, the coating photo resist is irradiated with light. Preferably, covering with the masking agent is performed using the screen printing method.

In the etching step, it is preferred that the glass plate 19 is placed in a substantially horizontal state so that the surface of the glass plate 19 which is covered with the masking agent 20 is a bottom surface, and that the etchant is sprayed on the bottom surface of the glass plate 19 so as to etch the surface of the glass plate. In the case of etching the opposite side of the bottom surface of the glass plate 19 placed in a substantially horizontal state, the etchant may be sprayed on this opposite side.

The etching step may be performed by spraying the etchant on the surface of the glass plate 19 that is placed in a substantially vertical state. In this case, the etching is performed by spraying the etchant on the surface to be etched.

Preferably, the etching step and the etchant removing step are performed using an etching apparatus according to the present invention. Fig. 1 is a schematic view of the etching apparatus of the present invention. The etching apparatus shown in Fig. 1 has an etching chamber 1 in which a surface of a glass plate is etched, an etchant reservoir 3 for reserving an etchant to be fed into the etching chamber 1, an etchant recovering device 4 for recovering the etchant after use from the etching chamber 1, an etchant removing chamber 2, and a water reservoir 5 for reserving water to be fed into the etchant removing chamber 2.

In the etching chamber 1 are provided a glass plate supporting member and an etchant spraying nozzle 8 for spraying the etchant toward

the glass plate. In the vicinity of an outlet in the etching chamber 1, an air knife for deliquefying the etchant is provided so as to be able to blow air on the etched glass plate. The bottom surface in the etching chamber 1 is inclined so as to be able to efficiently recover the etchant sprayed from the nozzle 8 onto the glass plate.

The glass plate supporting member can support the glass plate fixedly or in a movable manner. Preferably, the glass plate supporting member can support the glass plate in a substantially horizontal or vertical state. In particular, those capable of supporting the glass plate in a substantially horizontal state are preferred. The glass plate supporting member can advantageously support the glass plate accommodated in a glass plate accommodation unit 6 as will be described later. The glass plate supporting member in the etching chamber 1 of the present invention is provided with conveying rollers 7 serving as a glass plate conveyer and capable of conveying the glass plate accommodation unit 6 accommodating the glass plate in a horizontal state.

The conveying rollers are designed to support the right and left ends along the conveying direction of the glass plate accommodation unit 6. This is because if the conveying rollers support the glass plate accommodation unit 6 in the fore-and-aft direction along the conveying direction, there is a possibility that the glass plate accommodation unit 6 drops between the conveying rollers and, additionally, the surface area of the glass plate on which the etchant can be sprayed is reduced. In the present embodiment, the conveying rollers 7 are disposed at an appropriate distance so that they can convey the glass plate accommodation unit 6 while supporting the bottom surface ends of the glass plate accommodation unit 6.

Each conveying roller 7 is made up of a cylindrical roller serving as a base and a cylindrical roller having a smaller diameter connected with each other at the flat surfaces thereof. Central axes of the two cylindrical rollers constituting the conveying roller are in alignment. The rollers of smaller diameter of the conveying rollers 7 support the glass plate accommodation unit 6. Although the conveying rollers 7 of the present embodiment are disposed to support the bottom surface ends of the glass plate accommodation unit 6, other conveying roller may be provided so as to oppose to the conveying rollers 7 supporting the bottom surface ends of the glass plate accommodation unit 6 in order to convey the glass plate accommodation unit 6 in a held state. In this case, it is possible to prevent the glass plate accommodation unit 6 from moving due to the etchant.

As the etchant spraying nozzle 8, a nozzle capable of spraying the etchant in the form of a mist can be selected, and either a single fluid nozzle that sprays only an etchant or a dual fluid nozzle that sprays an etchant and a gas after mixing can be used.

The nozzle 8 is disposed so that it can spray the etchant to the glass plate from a position below the glass plate being conveyed. Preferably, the nozzle is disposed so that the etchant is sprayed onto the surface of the glass plate from the direction which is substantially orthogonal to the surface of the glass plate. The nozzle 8 is appropriately provided so that the etchant can be sprayed uniformly on the entire surface to be etched of the glass plate. The nozzle 8 may also be disposed so as to spray from a position above the glass plate being conveyed. When the glass plate is supported or conveyed in a substantially vertical state, the arrangement of nozzles 8 may be changed so that etchant can be uniformly sprayed on the surface of the

glass plate. Also the nozzle 8 may be provided so as to be able to reciprocate in the direction parallel to the surface of the glass plate.

The nozzle 8 connects to the etchant reservoir 3 via piping. In the course of the piping connecting the nozzle 8 and the etchant reservoir 3 is provided a pump 9 for feeding the etchant within the etchant reservoir 3 to the nozzle 8.

The etchant reservoir 3 has a pump 11 and a filter 12 serving as a sludge remover for removing sludge generated in the etchant within the etchant reservoir 3. Since the filter 12 is provided for removing sludge, the filter 12 may be replaced with the one selected from a filter, filter press, liquid cyclone and a settling tank which are capable of removing sludge.

The etchant reservoir 3 further has a stirrer 10 capable of stirring the etchant within the etchant reservoir 3. Although not illustrated in the figure, also provided are a heater and a cooler for etchant that control temperature of the etchant and keep it constant. By keeping the temperature of the etchant constant, the etching speed of the glass surface is stabilized.

The pump 11 and the filter 12 are provided outside the etchant reservoir 3 together with the piping so as to allow circulation of the etchant. The etchant within the reservoir 3 is sucked and fed to the filter 12 by the pump 11, and flown into the reservoir 3 after passed through the filter 12. By letting the etchant pass through the filter 12, it is possible to remove the sludge having precipitated ex-post in the etchant reservoir 3.

The etchant reservoir 3 reserves an aqueous solution containing a glass dissolving agent as an etchant. As the glass dissolving agent, an aqueous solution containing a fluoride is preferably used, and examples of

the fluoride include hydrogen fluoride, ammonium fluoride, potassium fluoride, sodium fluoride and the like. The etchant may contain an inorganic acid and/or an organic acid. As the inorganic acid, one or more kinds selected from hydrochloric acid, sulfuric acid, phosphoric acid, nitric acid and the like can be used, and as the organic acid, one or more kinds selected from acetic acid, succinic acid and the like can be used. The etchant may be added with one or more kind of anionic surfactants and amphoteric surfactants. As the anionic surfactants, sulfonate-based surfactants can be exemplified. As the amphoteric surfactants, amine-based surfactants can be exemplified. The etchant is kept at a constant temperature in the temperature range of 10 to 50°C.

The etchant recovering device 4 is configured by a pump 13 for feeding the etchant from the etching chamber 1, open/close valves 15a, 15b and filters 14a, 14b connected by piping. One end of the piping connects to the bottom of the etching chamber 1. The other end of the piping connects to the etchant reservoir 3 or an etchant recovering tank (not shown). In the present embodiment, it connects to the etchant reservoir 3. The pump 13, the open/close valves 14 and the filters 15 are arranged in this sequence from the side of the etching chamber 1. Accordingly, in the case of feeding and recovering the etchant within the etching chamber 1 into the etchant reservoir using the present etching apparatus, it is possible to remove the sludge in the etchant by the filters 15a and 15b.

The open/close valves and filters in the etching apparatus are provided in plural, and in the present embodiment, two open/close valves 15a, 15b and two filters 14a, 14b are provided. One open/close valve 15a is connected in series with one filter 14a, and the other open/close valve 15b is

connected in series with the other filters 14b. Then, the serially connected open/close valve 15a and filter 14a, and the serially connected open/close valve 15b and filter 14b are connected in parallel. In the case of using the etching apparatus according to the present embodiment, when one of the open/close valves is open, the other of the open/close valves is used in a closed state. Therefore, it is possible to recover the etchant within the etching chamber 1 without interruption.

Since the filter used in the etchant recovering device 4 is for removing the sludge present in the used etchant, this filter may be replaced with other sludge remover. As the sludge remover, for example, a filter, a filter press, a liquid cyclone and a sludge settling tank can be used.

In the etchant removing chamber 2 is provided a conveying roller 18 capable of conveying the glass plate accommodation unit 6 having fed out from the etching chamber 1 in a horizontal state. Also a nozzle 16 for cleaning the glass plate by spraying water from positions above and below the glass plate conveying unit 6 being conveyed is appropriately formed so as to uniformly spray water to the glass plate conveying unit 6 and the glass plate accommodated in the unit. The bottom in the etchant removing chamber 2 is inclined so as to efficiently recover the water sprayed on the glass plate from the nozzle 16.

The conveying roller 18 in the etchant removing chamber 2 can support the right and left ends of the conveying direction of the glass plate accommodation unit 6. This conveying roller 18 is arranged so as to be able to support the accommodation unit 6 from the bottom surface thereof. Also conveying rollers may be provided so as to be opposite to each other in the vertical direction at an appropriate distance in order that the glass plate

accommodation unit 6 can be conveyed while being held at upper and lower portions of the ends of the glass plate accommodation unit 6 as is the case of the conveying roller in the etching chamber 1.

The nozzle 16 in the etchant removing chamber 2 is connected with the water reservoir 5 via piping. In the course of the piping connecting the nozzle 16 and the etching water reservoir 5 is provided a pump 17 for feeding the etchant within the water reservoir 5 to the nozzle 16.

Using the above etching apparatus, the surface of the glass plate is etched and the etchant is removed from the glass plate. The surface of the glass plate is etched by conveying the glass plate on which the masking agent is applied in the etching chamber 1 of the glass etching apparatus. On the other hand, the etchant is removed from the glass plate by conveying the glass plate accommodation unit 6 in the etchant removing chamber 2 after conveying in the etching chamber 1. In the present embodiment, etching on the surface of the glass plate and removal of the etchant from the glass plate are accomplished by conveying the glass plate accommodated in the glass plate accommodation unit 6 in the etching chamber 1 and in the etchant removing chamber 2.

Figs. 3A and 3B illustrate the glass plate accommodation unit 6 accommodating the glass plate 19 which is covered with the masking agent 20 of Figs. 2A and 2B. Fig. 3A is an exploded view of the glass plate accommodation unit 6 accommodating the glass plate 19 which is covered with the masking agent 20 of Figs. 2A and 2B, and Fig. 3B is a sectional view taken along line B-B of a container 6b of the glass plate accommodation unit 6 shown in Fig. 3A. The glass plate accommodation unit 6 consists of a container 6b having a bottom portion which is slightly

larger than that of the glass plate 19 covered with the masking agent 20 and having an opening 6c on the bottom portion, and a presser plate 6a for fixing the glass plate 19 after placing the glass plate 19 in the container 6b. The glass plate 19 is conveyed with being accommodated in the accommodation unit 6 by the conveying roller 7, so that the surface of the glass plate 19 will not come into contact with the conveying roller 7. Therefore, the surface of the glass plate 19 is prevented from being damaged. Furthermore, since the glass plate 19 is pressed and fixed at its ends by the presser plate 6a after the glass plate 19 is accommodated in the container 6b, the glass plate 19 is prevented from moving in the glass plate accommodation unit 6, with the result that it is also possible to prevent the glass plate 19 from being damaged at its ends.

The opening 6c of the bottom portion of the container 6b is formed by designing the bottom portion of the container 6b to have a grid pattern as to allow the surface area of the glass plate 19 not covered with the masking agent 20 to be sprayed with the etchant. In the present embodiment, since there are nine areas on the surface of the glass plate 19 not covered with the masking agent 20, nine openings 6c are evenly arranged in the bottom portion of the container 6b. In the case where the surface of the glass plate is etched without covered with the masking agent 20, the opening 6c can be provided in a large area on the bottom surface of the container 6b as far as the glass plate can be supported.

The presser plate 6a is a single plate not having a through hole. In the case where the glass plate 19 needs to be etched on the side opposite to the surface covered with the masking agent 20, an opening may be formed on this opposite side.

For accommodating the glass plate 19 in the glass plate accommodation unit 6, the glass plate 19 is placed in the container 6b so that the surface covered with the masking agent 20 is a bottom surface, and the glass plate 19 is pressed by the presser plate 6a, whereby the glass plate accommodation unit is assembled. The glass plate 19 is accommodated in the glass plate accommodation unit 6 so that the glass plate is conveyed in a horizontal state in the etching chamber 1.

The glass plate is subjected to the etching and removal of etchant while the glass accommodation unit 6 is conveyed in the etching chamber 1 and the etchant removing chamber 2 of the etching apparatus where the following operations are conducted.

An etchant reserved in the etchant reservoir 3 and kept at a predetermined temperature is supplied to the nozzle 8 in the etching chamber 1 by means of the pump 9. The nozzle 8 supplied with the etchant sprays the etchant onto the surface of the glass plate uniformly and substantially vertically. The etchant having sprayed collects at the bottom of the etching chamber 1, and then is sucked by the pump 13 of the etchant recovering device 4 from inside the etching chamber 1. The etchant discharged from the pump 13 is then fed to the etchant reservoir 3 after passing through the filter 14a or 14b.

The water reserved in the water reservoir 5 is supplied to the nozzle 16 via the pump 17. The supplied water is sprayed onto the glass plate via the nozzle 16. The water having sprayed collects at the bottom of the etchant removing chamber 2, and then is discharged from the etchant removing chamber by opening a valve provided in the bottom of the etchant removing chamber 2.

Fig. 4 is a plan view showing the state that the glass plate accommodation unit 6 is conveyed in the glass etching chamber by the conveying roller 7. Fig. 5 is a schematic sectional view taken along line C-C in Fig. 4. The glass plate accommodation unit 6 is conveyed while the bottom surface thereof is supported by the smaller-diameter cylindrical rollers of the conveying roller 7. At this time, the glass plate accommodation unit 6 is restrained from oscillating right and left in the traveling direction because the cylindrical rollers connected with the smaller-diameter cylindrical rollers restrict the range of right and left oscillation.

Furthermore, as the glass plate accommodation unit 6 is conveyed in a horizontal state, the glass plate 19 in the unit 6 is also conveyed in a horizontal state. Since the amount of etching of the glass surface is related with the time during which the glass surface and the etchant contact each other, the conveying speed is appropriately changed in accordance with the intended etching amount of the glass surface. The etchant is removed from the glass plate accommodation unit 6 by being conveyed in the etchant removing chamber 2 following the etching chamber 1.

Figs. 6A to 6C illustrate the process in which the surface of the glass plate 19 is etched. Fig. 6A is a view of the glass plate 19 covered with the masking agent 20 of Fig. 2B shown upside down. The glass plate 19 has a surface shape before etching.

Fig. 6B shows the state that the etchant is sprayed on the glass plate 19 covered with the masking agent 20. By spraying the etchant on the surface part of the glass plate 19 not covered with the masking agent 20, the part is etched and a recess is formed on the surface of the glass plate 19.

Fig. 7 is an enlarged view of the part enclosed by the broken line in Fig. 6B. Since the etchant is sprayed on the glass plate 19 as illustrated by the arrows 22, the etchant spreads into every corner of the formed recess. Accordingly, a recess in which curvature at the bottom surface is suppressed can be formed. Also sludge resulting from the reaction between the glass and the etchant and adhered in the formed recess can be immediately removed. Even if there is a space 21 between the glass plate 19 and the masking agent 20, the masking agent 20 is pressed by the spraying 22 of the etchant and the etchant enters the space 21, with the result that the space 21 is prevented from spreading. Consequently, the masking agent 20 is prevented from peeling.

Fig. 6C shows the glass plate 19 from which the etchant and the masking agent 20 are removed after etching of the surface of the glass plate 19 has completed.

The glass plate 19 having subjected to the etching as described above is cut in a predetermined cutting pattern for use as a glass cap of an ELD panel. Using the ELD panel adopting the glass cap, an ELD can be produced.

In the above embodiment, the surface of the glass plate is covered with the masking agent. However, the glass plate may not be covered with a masking agent. The glass plate not covered with a masking agent can be used in a LCD panel or a PDP panel.

Figs. 8A and 8B illustrate a glass plate accommodation unit 23 accommodating a glass plate 24 not covered with a masking agent. Fig. 8A is an exploded view of the glass plate accommodation unit 23 accommodating the glass plate 24; and Fig. 8B is a sectional view taken

along line D-D of a container 23b of the glass plate accommodation unit 23 shown in Fig. 8A. The glass plate that can be used in a LCD panel or PDP panel is etched, for example, by using the glass plate accommodation unite shown in Fig. 8. Likewise the accommodation unit 6 shown in Figs. 3A and 3B, the glass plate accommodation unit 23 consists of the container 23b capable of accommodating the glass plate 24, and a presser plate 23a for pressing the glass plate 24 accommodated in the container 23b. The container 23b is provided with an opening 23c so as to be able to spray an etchant to a glass plate. The accommodation unit 23 shown in Fig. 8 is as same as the accommodation unit 6 shown in Figs. 3A and 3B except that the opening 23c of the container 23b has the same rectangular shape.

Although the above embodiment is concerned with the etching method capable of being used for producing a glass cap used in an ELD panel, a variety of shapes of recess can be formed on the surface of the glass plate depending on the pattern of coverage by the masking agent. For example, it is possible to form a recess of cylindrical shape on the glass surface and to use the recess as an alignment mark.

Example

In the following, description will be made on a recess formed in an etching method according to the present invention on the basis of an example. After covering the surface of a glass plate of 400 mm × 500 mm × 0.7 mm with a masking agent, the processes of etching, removal of etchant and removal of masking agent were sequentially performed to form a recess on the glass surface. Operations of covering with a masking agent and etching will be described in detail below.

(Covering with masking agent)

One side of the glass surface was covered with a masking agent with the use of the screen printing method. At this time, a rectangular part which is not covered with the masking agent was formed.

(Etching)

After accommodating the glass plate which was covered with the masking agent in a glass plate accommodation unit consisting of a container having an opening and a presser plate, the rectangular part not covered with the masking agent was sprayed with an etchant in the form of a mist to thereby accomplish the etching.

The glass plate was accommodated in the glass plate accommodation unit by accommodating the glass plate in the container having the opening and holding and fixing the glass plate with the presser plate. The glass plate was accommodated in the container so that the surface side covered with the masking agent was on the side of the opening.

The etchant in the form of a mist was sprayed on the rectangular part not covered with the masking agent in such a manner that the etchant was sprayed onto the rectangular part substantially vertically with respect to the rectangular part while the glass plate accommodation unit was in a horizontal state and the opening thereof was on the bottom surface. The etchant was sprayed so that the etchant was perfectly sprayed on the surface of the glass plate in the rectangular part where the glass plate was exposed.

Using as the etchant an aqueous solution containing 4.0% by weight of hydrogen fluoride and 3.0% by weight of nitric acid, the etchant was sprayed via the nozzle at a speed of 3.2 L/min while keeping the

temperature at 25 ± 1°C, whereby etching was accomplished. At this time, the surface of the glass plate was etched about 300 μm.

In the glass surface having subjected to the etching, a recess was visually observed. As a result of the visual observation, it was confirmed that the masking agent was not pealed, and the corners of the bottom part of the formed recess were not curved.

Claims

1. A method for etching a surface of a glass plate, comprising the steps of:

covering the surface of the glass plate with a predetermined pattern of a masking agent;

etching the non-covered portion of the bottom surface of the glass plate by spraying an etchant from a position substantially vertically below the glass plate;

removing the sprayed etchant from the glass plate after a predetermined etching time; and then

removing the masking agent covering the surface of the glass plate;

whereby a predetermined recess pattern is formed at the non-covered portion of the bottom surface.

2. The method according to claim 1, wherein

a container accommodating the glass plate is used for the etching step, and

the container has an opening through which the non-covered portion is exposed to the exchant.

3. The method according to claim 2, wherein

both ends of the glass plate are held and fixed by the container and the presser plate placed on the glass plate.

4. An apparatus for etching a glass plate, comprising:

a conveyor capable of conveying a glass plate having a bottom surface covered with a predetermined pattern of a masking agent;

a first nozzle for spraying an etchant toward the non-covered portion of the bottom surface of the glass plate from a position substantially vertically below the glass plate; and

a second nozzle for removing the sprayed etchant from the glass plate after forming a predetermined recess pattern at the non-covered portion of the bottom surface;

wherein said first nozzles are placed half way under the conveying path of the conveyor.

5. The apparatus according to claim 4, further comprising:

an etchant reservoir for supplying the etchant to the first nozzle while controlling the temperature of the etchant.

6. The apparatus according to claim 4, wherein

the glass plate is accommodated in a container having an opening through which the non-covered portion of the bottom surface of the glass plate is exposed to the first nozzle.

7. The apparatus according to claim 4, wherein the conveyer has conveying rollers that support the glass plate at both ends of the glass plate.

8. The apparatus according to claim 7, wherein

each of the conveying rollers includes a first cylindrical roller serving as a base, and a second cylindrical roller having a smaller diameter than the

base and supporting the ends of the glass plate.

9. The apparatus according to claim 4, further comprising

a recovering device for recovering the sprayed etchant.

10. The apparatus according to claim 9, wherein

the recovering device feeds the recovered etchant to the etchant reservoir.

11. The apparatus according to claim 9, wherein

the recovering device has a sludge remover for removing sludge existing in the etchant.

12. A glass plate for a flat panel display, etched by the method according to claim 1.

13. A flat panel display using the glass plate according to claim 12.