

SPECIFICATION**Title of the Invention*****POLISHING APPARATUS OF SUBSTRATE END
FACE AND POLISHING DETERMINING METHOD*****BACKGROUND OF THE INVENTION****Field of the Invention**

The present invention relates to a polishing work apparatus for polishing an end face of a glass substrate for a liquid crystal substrate or the like, and a method of determining whether a polishing finish is good or bad.

Description of the Conventional Art

In the glass substrate used for the liquid crystal substrate or the like, since very little concavity and convexity and a crack exist in a cut end face, a dust generation is suppressed by finishing the end face as a mirror finished surface in addition to chamfering of a ridge line portion, and a polishing work is applied for the purpose of improving a strength of the end face.

A diamond abrasive grain, a silicon carbide abrasive grain, a cubic boron nitride (CBN) abrasive grain, or a cerium oxide abrasive grain is used in a polishing wheel used for polishing an end face of a hard brittle material such as the glass substrate as

a mirror finished surface, however, in order to prevent a very little crack or chip of a polished surface, a polishing wheel in which a peripheral edge portion is rich in an elasticity is preferably used.

For example, as the polishing wheel, there is used a structure in which a resin is filled in a fiber, and an abrasive grain is dispersed in the resin.

However, if the end face of the glass substrate is polished by the polishing wheel which is rich in the elasticity as mentioned above, a conformability exists at a time of cutting the end face of the substrate, and the end face is finished as a mirror finished surface in which the very little crack or the like is suppressed, however, an abrasion groove is formed in an outer peripheral surface of the polishing wheel on the basis of an increase of the number of polishing works.

If the abrasion groove is formed in the outer peripheral surface of the polishing wheel, a range of the polishing wheel coming into contact with the end face of the glass substrate is expanded to contact with parts of front and back faces of the glass substrate, for example, as shown by reference symbols 1c and 1d in Fig. 2B, in addition to the end face of the glass substrate.

In other words, since a contact range (a contact

area) with the polishing wheel is expanded at such a degree that groove side faces of the abrasion groove formed in the polishing wheel come into contact with parts of the front and back faces of the substrate, a contact resistance is enlarged.

Conventionally, in the polishing work of the end face of the glass substrate by the polishing wheel, the polishing work of the end face of the glass substrate is controlled on the basis of a load current value of a polishing wheel drive motor at a time when the polishing wheel comes into contact with the end face of the glass substrate, and a previously set load current value.

For example, as schematically shown in Fig. 7, a feed length of the polishing wheel coming into contact with the end face of the glass substrate is controlled by setting separately the load current value into a load lower limit value: LL, a load proper region value: L-H, and a load upper limit value: HH before starting a production of the glass substrate, and determining which set region the measured load current value corresponds to.

In this control method, if the load current value measured during the polishing work is between L and H, for example, as shown by (a), the polishing work

is normally carried out, the contact pressure of the polishing wheel is determined to be proper, and the feed length of the polishing wheel to the end face of the glass substrate is continuously maintained.

If the load current value is in a region between H and HH , the contact pressure of the polishing wheel with the end face of the glass substrate is determined to be excess, and a position of the polishing wheel is moved backward (in a direction of moving away from the end face of the glass substrate) in the next polishing work. If the load current value is in a region between L and LL , the contact pressure of the polishing wheel is determined to be short, and the position of the polishing wheel is moved forward (in a direction of moving close to the end face of the glass substrate) in the next polishing work. Further, in the case that the load current value is more than HH or less than LL , the polishing work is determined to be excess or short, and the polishing work is stopped.

However, in the conventional method mentioned above, since only the first value which deflects from the L - H region in the immediately preceding polishing work of the end face of the glass substrate is fed back for the determination of the feed length of the polishing wheel, there is a problem that the feed length of the

polishing wheel does not come into line with the actual polish condition. For example, in the case that the load current value deflects from the L-H region by one or several abnormal values, the one abnormal value or the first abnormal value is fed back by priority even if the polishing is normally carried out actually, and the polishing wheel is moved forward or backward unnecessarily. Further, for example, in the case that the load current value exists in the HH-H region just after starting the polishing, as shown by (b), and the load current value exists in the LL-L region just before finishing the polishing, the first value in the HH-H region is fed back by priority and the polishing wheel is moved backward in spite that the contact pressure of the polishing wheel is actually under a low state.

Further, since the regions HH, L-H and LL are previously set on the basis of the state of the polishing wheel before starting the production of the glass substrate in the conventional control method mentioned above, there is a problem that they do not come into line with the load current value in a state in which the groove of the polishing wheel becomes deeper in accordance with a continuous operation. For example, in the polishing wheel after polishing work of a certain amount of the glass substrates, the groove becomes

deeper than that at a time of starting the production, and the load current is increased on the basis of an increase of the contact area between the groove shaped surface and the glass plate.

Accordingly, even if the contact pressure of the polishing wheel is actually insufficient, the feed length is maintained or the polishing wheel is moved backward, so that there is a problem that the glass substrate in which the end face is insufficiently polished or is not polished at all is fed to the next step.

Further, for example, even in the case that the load current is determined to be an abnormal value (over the value HH in this case) on the basis of the increase of the contact area between the groove-shaped surface and the glass plate, an alarm is sounded and a polishing work line is controlled so as to be stopped, so that there is a problem that the line is stopped in spite that it is not an abnormal value (an excess polishing in this case) actually.

In order to cope with the problem of the groove-shaped surface, it is necessary for an operator to change the set value on the basis of an experience each time when the polishing work of a certain amount of the glass plates is finished in the continuous

operation, and there is a case that an operation efficiency is lowered.

As mentioned above, in accordance with the conventional method, there has been problems that the product is not polished at all, a polishing amount of the product is small, and the polishing amount of the product is large inversely, and that an abrasion of the polishing wheel is fast and a service life becomes short.

Patent documents 1 and 2 disclose a technique regulating a cutting speed on the basis of an electric power value of a grinding stone drive motor, and patent document 3 discloses a technique calculating an average value of a working load in a final stage of the work so as to compensate the cutting amount, however, none of them reflects a depth of a groove formed in the polishing wheel to the cutting amount.

Patent Document 1: Japanese Unexamined Patent Publication No. 2004-122259

Patent Document 2: Japanese Unexamined Patent Publication No. 7-171742

Patent Document 3: Japanese Unexamined Patent Publication No. 2003-25149

SUMMARY OF THE INVENTION

Problem to be Solved by the Invention

An object of the present invention is to provide a polishing apparatus of a substrate end face in accordance with an adaptive control incorporating a depth of an abrasion groove of a polishing wheel into a compensation element and having a high reliability, and a method of determining whether the polishing of the substrate is good or bad.

Means for Solving the Problem

In accordance with the present invention, there is provided a polishing apparatus of a substrate end face comprising:

a polishing wheel for polishing an end face of the substrate;

a rotational driving means of the polishing wheel;
and

a cutting edge feeding means of the polishing wheel,

wherein the rotational driving means of the polishing wheel has a load current detecting means on the basis of an end face contact of the substrate, and a compensating means of a load current generated by a contact of groove side faces of an abrasion groove formed in the polishing wheel with the substrate.

Further, it is preferable that the apparatus has a comparing means for comparing with proper upper and

lower limit currents on the basis of the load current detected by the load current detecting means, and the cutting edge feeding means of the polishing wheel has a regulating means for regulating a feed length on the basis of a result of comparison with the proper upper and lower limit currents.

In this case, a hard brittle substrate is targeted, and a glass substrate is typically targeted.

The polishing wheel is a disc-shaped rotary body, and has an abrasive grain in a peripheral edge portion constructing an outer periphery thereof.

Various methods are provided as a method of holding the abrasive grain, however, the present invention is effective in the case that the peripheral edge portion is made of a material having an elasticity, and the polishing abrasive grain is included in the material, and is preferably applied particularly to a use of a polishing wheel in which a peripheral edge portion of the polishing wheel is manufactured by filling a resin obtained by adding the polishing abrasive grain to a fiber.

Since the present invention employs the structure of the polishing apparatus as mentioned above, the present invention provides a method of determining a substrate end face polishing work by employing the

polishing apparatus comprising:

a polishing wheel for polishing an end face of a substrate;

a rotational driving means of the polishing wheel;
and

a cutting edge feeding means of the polishing wheel,

wherein the rotational driving means of the polishing wheel has a load current detecting means on the basis of an end face contact of the substrate, an upper limit and a lower limit of a proper load current are set by compensation of a load current component on the basis of a groove-shaped surface contact between groove side faces of an abrasion groove formed in the polishing wheel in accordance with the number of polishing works and the substrate, and thereby the substrate, for which the load current at a polishing time detected by the load current detecting means is between the upper and lower limits, is determined as a good product.

Effect of the Invention

In the present invention, it is possible to accurately and easily determine whether the polishing work is good or bad, by paying attention to the abrasion groove formed in the outer peripheral surface of the

polishing wheel in accordance with an increase of the polishing work number, adding the load current increase to the rotational driving motor of the polishing wheel caused by the groove-shaped surface contact between the groove side faces of the abrasion groove with the front and back faces of the substrate as a compensating value, and setting the upper limit and the lower limit of the load current.

Further, since it is possible to inhibit the cutting edge feeding length of the polishing wheel from becoming more than necessary, it is possible to contribute to an improvement of a service life of the polishing wheel.

Further, the number of stops of a working line is reduced, and a productivity is improved.

BRIEF EXPLANATION OF DRAWINGS

Fig. 1 shows an example of a flow chart of a control in accordance with the present invention;

Figs. 2(A) and 2(B) show a control system of a polishing wheel and a change of an abrasion;

Fig. 3 shows an example of a load current chart;

Fig. 4 shows a perspective view of an outer appearance of a polishing apparatus;

Fig. 5 shows a driving portion of the polishing wheel;

Figs. 6(A) and 6(B) show the driving portion of the polishing wheel and a sectional view thereof; and

Fig. 7 shows a conventional method of determining whether a polishing work is good or bad.

Description of Reference Numerals

10 polishing wheel

14 groove portion

DETAILED DESCRIPTION OF PREFERRED EMBODIMENT

A description will be given below of an embodiment in accordance with the present invention with reference to the accompanying drawings.

Fig. 4 shows a perspective view of an outer appearance of a polishing apparatus in accordance with the present invention, and Fig. 5 shows a polishing mechanism portion.

Figs. 6(A) and 6(B) show a state in which a cover 14 of a polishing wheel is detached, and a sectional view along a line A-A.

The polishing wheel 10 is detachably mounted to a spindle 22, and is rotationally controlled by a rotational driving motor (a rotational driving means) 20 of the polishing wheel.

The polishing wheel 10 is coupled to a servo motor 30 serving as a cutting edge feeding means together with the rotational driving motor 20.

In the present embodiment, as shown in Fig. 4, the rotational driving motor is structured such as to simultaneously polish both side end faces of a glass substrate by providing a pair of rotational driving motors 20a and 20b and controlling their positions along directions (X-axis, Z-axis) and (U-axis, W-axis), however, the structure is not limited to this.

Further, the polishing wheel 10 used in the present embodiment is structured, as schematically shown in Fig. 2, such that a peripheral edge portion 11 is formed by filling a resin in a fiber, and a silicon carbide abrasive grain is dispersed into the resin.

The polishing wheel 10 is rotationally controlled by the rotational driving motor (M1) 20, and has a load current detecting portion 21.

In this case, a feed length of the polishing wheel is controlled by a cutting edge feeding servo motor (M2).

If a polishing work is carried out by bringing an outer peripheral surface of the peripheral edge portion 11 of the polishing wheel 10 into contact with an end face 1a of the glass substrate 1 as shown in Fig. 2(A), a load current chart as shown in Fig. 3 is obtained.

Fig. 3 is a chart in which a polishing work time

is indicated at a horizontal axis, and a load current value of the rotational driving motor 20 is indicated at a vertical axis.

It shows both the W-axis side and the X-axis side.

If the polishing wheel 10 comes into contact with the end face of the glass substrate, the load current rises, however, there is generally a tendency that peak currents tend to be generated at a contact start (s) and a contact end (e).

Further, since a groove portion 14 due to abrasion is formed in an outer peripheral surface of the polishing wheel in accordance with an increase of the number of polishing works as shown in Fig. 2 (B) from a state in which the polishing wheel 10 is new as shown in Fig. 2 (A), a contact area is increased, and the load current rises in accordance that the groove portion 14 becomes deeper, even if the polishing is normally carried out.

If the groove portion 14 is formed in the outer peripheral surface of the polishing wheel 10, a bottom portion 12 of the groove portion comes into contact with the end face 1a of the glass substrate, however, side faces 13 of the groove portion come into contact with a parts of front face 1c and a back face 1d of the glass substrate.

In the embodiment shown in Fig. 2, a chamfer 1b

is applied to a ridge line portion of the glass substrate 1, however, the chamfer is applied as occasion demands.

Further, in the glass substrate 1 shown in Fig. 2, a thickness thereof is expressed larger than an actual thickness, and the polishing wheel 10 is expressed extremely smaller. In practice, the polishing wheel 10 in Fig. 2 is used by shifting vertically and a plurality of grooves are formed.

The present invention is characterized by a point that the work is controlled by compensating the load current increase due to the groove-shaped contact.

A description will be given of an example of a control and a determining system of a good product and a defective product in accordance with the present invention with reference to a flow chart in Fig. 1.

First of all, a groove depth of the polishing wheel 10 is measured before starting the polishing work. A measuring means is not particularly limited, but a non-contact type automatic measurement is preferable.

A compensation is carried out in such a manner as to determine whether the load current is good or bad on the basis of 120 % of an initial set current in a case b that the groove depth is middle, and determine whether the load current is good or bad on the basis of 140 % of the initial set current in a case c that

the groove depth is large, for example, by setting the initial set current of the control current of the motor in a case a that the groove is hardly formed as a reference, in correspondence to a degree of the groove depth as shown by steps S1 and S2.

In this case, it is necessary to appropriately set the reference for determining good or bad in accordance with a material of the wheel and a magnitude of the substrate, and the reference is not limited to three levels like as the present embodiment, but may be set to more levels, or may be set proportionally in correspondence to the groove depth.

The polishing work of the glass substrate starts on the basis of a control current taking the groove depth into consideration (S3), the motor load current is measured at n times in time sequence from the start of the polishing to the end thereof (S4), a lower limit of the load current value for properly applying the polishing work is set on the basis of an average value (S5) and a dispersion thereof (S6), and an upper limit of the load current value in the case that the cutting edge feeding length of the polishing wheel 10 is too strong is set in the same manner (S7).

A determining precision is improved by setting on the basis of the average of the n data as mentioned

above.

Since the lower limit and the upper limit of the load current can be set in accordance with the groove depth by setting as mentioned above, an automatic polishing of the next glass substrate is carried on continuously as it is, in the case that the load current exists in the range (S8).

If the load current value gets over an upper control limit, it is possible to prevent an abnormal abrasion of the polishing wheel by reducing the feed length of the cutting edge feeding servo motor 30 of the next glass substrate.

On the other hand, in the case that the load current value becomes lower than the lower limit of the proper current value, a determination is made that the polishing amount is little, set the upper limit and the lower limit of the load current is on the basis of a re-polishing work set current value (S10), and re-polishing is carried out on the basis of the determination (S11).

In the case that the load current value is smaller than the rework set value, the feed length is regulated for controlling the pressurizing with respect to the glass substrate for the next time in correspondence to a degree thereof (S12).

In the case that the reworking is three times or more, a warning alarm rings, and in the case that the alarm rings, the setting of the apparatus is changed (S13).

Further, in this case, an automatic switching control may be carried out in such a manner that the polishing wheel is moved, instead of the alarm warning, and a new polishing groove is formed.

Automatic stops of the working line are reduced and a good product rate is improved by detecting a good product, a defective product and a feed length of the polishing work, by using the polishing apparatus as mentioned above.

What is claimed is:

1. A polishing apparatus of a substrate end face comprising:

a polishing wheel for polishing an end face of the substrate;

a rotational driving means of said polishing wheel; and

a cutting edge feeding means of said polishing wheel,

wherein the rotational driving means of the polishing wheel has a load current detecting means on the basis of an end face contact of the substrate, and a compensating means of a load current generated by a contact of groove side faces of an abrasion groove formed in the polishing wheel with the substrate.

2. A polishing apparatus of a substrate end face as claimed in claim 1, wherein the apparatus has a comparing means for comparing with proper upper and lower limit currents on the basis of the load current detected by said load current detecting means, and the cutting edge feeding means of the polishing wheel has a regulating means for regulating a feed length on the basis of a result of comparison with the proper upper and lower limit currents.

3. A method of determining a substrate end face polishing work by employing the polishing apparatus comprising:

a polishing wheel for polishing an end face of a substrate;

a rotational driving means of said polishing wheel; and

a cutting edge feeding means of said polishing wheel,

wherein the rotational driving means of the polishing wheel has a load current detecting means on the basis of an end face contact of the substrate, an upper limit and a lower limit of a proper load current are set by compensation of a load current component on the basis of a groove-shaped surface contact between groove side faces of an abrasion groove formed in the polishing wheel in accordance with the number of polishing works and the substrate, and thereby the substrate, for which the load current at a polishing time detected by said load current detecting means is between said upper and lower limits, is determined as a good product.

4. The method of determining a substrate end face

polishing work as claimed in claim 3, wherein the polishing wheel is structured such that the peripheral edge portion is made of a material having an elasticity, and polishing abrasive grain is included in the material.

5. The method of determining a substrate end face polishing work as claimed in claim 3, wherein the polishing wheel is structured such that the peripheral edge portion is manufactured by filling a resin obtained by adding the polishing abrasive grain to a fiber.