

Title of the Invention

METHOD FOR GRINDING OF GLASS SUBSTRATE

Background of the Invention

(1) Field of the Invention

The present invention relates to a method for grinding a glass substrate for use in a hard disc used mainly as an information recording medium of computer.

(2) Description of Related Art

In recent years, use of computers has rapidly become popular. Keeping pace therewith, OS (operation system) soft wares necessary for computer operation as well as soft wares of programs running on operation systems have come to have a large number of codes. Further, these programs have come to produce larger amounts of data.

Hence, in development of a hard disc used as an information recording medium capable of quickly recording and reading a large amount of information, it has become popular to use a glass substrate superior in hardness and smoothness, particularly a crystallized glass substrate in place of a conventional aluminum metal substrate.

In producing a glass substrate such as mentioned above, thickness processing consisting of three steps, i.e. rough lapping, fine lapping and primary (rough) polishing has ordinarily been conducted in order to obtain a glass substrate of high thickness precision and high flatness.

In this thickness processing, however, the starting glass substrate must have a sufficient thickness in order to prevent the deformation which may take place in the operation conducted for correction of warpage or distortion; in the primary (rough) polishing, a thickness amounting to at least 50 to 60 μm must be removed because the pits locally generated in the rough and fine lapping steps need be removed completely.

Thus, in order to obtain a glass substrate product of desired thickness, according to the above thickness processing, a large thickness must be removed from the starting glass substrate and a long processing time is required.

Hence, the present applicant developed and proposed a method for grinding of glass substrate, wherein a starting glass substrate free from warpage is used and grinding steps are used in place of lapping steps.

In the method, since it is not necessary to process the starting glass substrate so as to have flatness, the starting glass substrate can have a very small thickness and further the thickness processing thereof can be conducted efficiently.

In the method, however, since there is no change in the number of thickness processing steps (that is, there are conducted rough grinding, fine grinding and rough polishing), the reduction in processing steps and the efficiency of processing are not sufficient.

In order to alleviate the problem, it is preferred to conduct thickness processing in one step. However, when a starting glass substrate having warpage is processed in one step, at least three hours are necessary to obtain a satisfactorily processed glass substrate to be subjected to secondary (fine) polishing; and such a long time is not practical.

When a starting glass substrate having no warpage is used, there can be obtained, by polishing using a polyurethane pad and cerium oxide, a glass substrate to be subjected to secondary polishing, having a required flatness and a required surface roughness (Ra); however, the glass substrate to be subjected to secondary polishing is not satisfactory in fine undulation and roll-off (the shapes of internal and outer diameters of glass substrate).

Rotary surface grinding wherein the both sides of a starting glass substrate are subjected to grinding sequentially, gives a processed glass substrate before secondary polishing, not satisfactory in any of fine undulation, roll-off and surface roughness (Ra).

Diamond pellets grinding wherein the both sides of a glass substrate are subjected to grinding simultaneously, can give a processed glass substrate before secondary polishing, satisfactory in flatness, fine undulation and roll-off, but is unable to allow the processed glass substrate before secondary polishing to have a surface roughness (Ra) of 0.05 μm or less (which is necessary for a glass substrate before secondary polishing) because the surface roughness (Ra) cannot be reduced below 0.2 μm owing to (a) the sieving limitation of the particle sizes of diamond pellets abrasive and (b) the no dressing conducted for the abrasive.

Summary of the Invention

In view of the above-mentioned problems of the prior art, the present invention aims at providing a method for grinding of glass substrate which can conduct thickness processing of glass substrate only in one step and thereby can bring about significant reductions in material cost, cost of processing equipment, cost of material lost in processing, processing time, etc. and accordingly a significant reduction in cost of final glass substrate product.

According to the present invention, there is provided a method for grinding a glass substrate, which comprises:

(1) interposing a glass substrate held by a plurality of carriers, between an upper surface plate and a lower surface plate both constituted by fixed abrasive particles, and

(2) applying, to the glass substrate, a pressure and a rotary motion by the two plates to grind the both sides of the glass substrate, to obtain the glass substrate having a flatness of 10 μm or less and a surface roughness (Ra) of 0.0005 to 0.05 μm , after the grinding.

In the present invention, the fixed abrasive particles are preferably an elastic grindstone containing at least one kind of abrasive particles selected from the group consisting of cerium oxide particles, manganese oxide particles, aluminum oxide particles, silicon nitride particles, silicon carbide particles and

zirconium oxide particles; and the particles of the fixed abrasive particles preferably have an average particle diameter of 1.0 to 8.0 μm .

In the present invention, the glass substrate is preferably subjected to rotation and revolution during the grinding.

Brief Description of the Drawings

Fig. 1 is a schematic view showing one example of the grinding machine used in the present method for grinding of glass substrate.

Fig. 2 is a schematic perspective view showing the upper surface plate, lower surface plate, carriers, etc. used in the grinding machine of Fig. 1.

Description of the Preferred Embodiment

The present method for grinding a glass substrate comprises (1) interposing a glass substrate held by a plurality of carriers, between an upper surface plate and a lower surface plate both constituted by fixed abrasive particles and (2) applying, to the glass substrate, a pressure and a rotary motion by the two plates to grind the both sides of the glass substrate; in the method, the glass substrate is allowed to have, after the grinding, a flatness of 10 μm or less and a surface roughness (Ra) of 0.0005 to 0.05 μm .

The present method for grinding a glass substrate can shorten the conventional steps of thickness processing of glass substrate to one step; thereby, can bring about significant reductions in material cost, cost of processing equipment, cost of material lost in processing, processing time, etc.; as a result, can reduce the cost of final glass substrate product significantly.

The present invention is hereinafter described in detail with reference to the accompanying drawings.

Fig. 1 is a schematic view showing one example of the grinding machine used in the present method for grinding of glass substrate.

The grinding machine shown in Figs. 1 and 2 comprises an upper surface plate 11 constituted by fixed abrasive particles; a lower surface plate

12 constituted by fixed abrasive particles, which is provided so as to face the upper surface plate 11 and which can be rotated by a motor (not shown) or the like; a plurality of disc-shaped carriers 13 interposed between the upper surface plate 11 and the lower surface plate 12; and a grinding liquid-feeding means 14 for feeding a grinding liquid for removal of chips and abrasive particles and suppression of heat generation by grinding. The grinding machine can apply a pressure F owing mainly to the self weight of the upper surface plate 11.

As shown in Fig. 2, each carrier 13 has a plurality (4 in Fig. 2) of holes 13a. Glass substrates 15 to be subjected to grinding are held in the holes 13a and, in this state, are interposed between the upper surface plate 11 and the lower surface plate 12.

In the centers of the upper surface plate 11 and the lower surface plate 12 is provided a sun gear 16 which can be rotated independently from the lower surface plate 12. The sun gear 16 is meshed with each gear 13c formed at the circumference of each carrier 13.

Each gear 13c is meshed also with an internal gear 17 provided independently in the vicinity of the circumference of the lower surface plate 12.

When the carriers 13 are rotated by a carrier-rotating means consisting of the sun gear 16, the internal gear 17, etc., there occurs the rotation of the upper surface plate 11, the lower surface plate 12 and the carriers 13; as a result, relative planetary rotation takes place between the upper surface plate 11 and the lower surface plate 12, and each glass substrate 15 to be subjected to grinding moves in a planetary orbit covering the whole surfaces of the plates 11 and 12.

It is preferred that the glass substrates 15 held in the holes 13a of the carriers 13 can make smooth rotation and revolution in the rotational direction of carrier 13 so that the damage of circumference of glass substrate 15 can be suppressed greatly.

The main feature of the present method for grinding of glass substrate

lies in that there is used, as the fixed abrasive particles constituting the upper surface plate 11 and the lower surface plate 12, an elastic grindstone containing at least one kind of abrasive particles selected from the group consisting of cerium oxide particles, manganese oxide particles, aluminum oxide particles, silicon nitride particles, silicon carbide particles and zirconium oxide particles.

As a result, it is possible to obtain, from a starting glass substrate free from warpage, a glass substrate before secondary (fine) polishing, satisfactory in flatness, surface roughness, fine undulation, roll-off, etc., only in one grinding step mentioned above.

In the present method, it is also preferred that the particles of the bonded abrasive particles have an average particle diameter of 1.0 to 8.0 μm . With such an average particle diameter, the surface roughness (Ra) of the processed glass substrate can reliably be in a range of 0.0005 to 0.05 μm .

Further, in the present method, by using an elastic grindstone as the fixed abrasive particles, the cutting depth by abrasive particles is made uniform; the glass surface has no deep cut; and the abrasive particles can have good intimacy with the glass surface. Therefore, an excellent finish surface (a mirror surface) and a excellent processing precision can be obtained; heat generation by grinding and loading can be suppressed; and stable long-hour continuous grinding is made possible.

The present invention is described in detail below by way of Examples. However, the present invention is in no way restricted by these Examples.

In the followings, the quality requirements for processed glass substrate before secondary (fine) polishing are as follows.

- (1) Flatness: 10 μm or less
- (2) Surface roughness (Ra): 0.05 μm or less
- (3) Fine undulation: 0.05 μm or less (at a distance of 4 mm)

(4) Roll-off: +0.05 to -0.1 μm

Example 1

A polyester as a binder was added to a cerium oxide powder having an average particle diameter of 1.0 μm ; the resulting mixture was molded by hot pressing at a predetermined temperature to form an elastic grindstone; the elastic grindstone was fitted to a cast iron plate to produce an upper surface plate and a lower surface plate.

Using a grinding machine of Fig. 1 comprising the above surface plates, a glass substrate free from warpage (flatness: below 5 μm) and subjected to processing of inner and outer diameters (thickness: 0.700 mm; inner diameter: 20.0 mm; outer diameter: 65.0 mm) was subjected to grinding under the conditions shown in Table 1, until the thickness became 0.640 mm. The results are shown in Table 6.

Example 2

A polyester as a binder was added to a mixed powder consisting of 70% of silicon carbide having an average particle diameter of 8.0 μm and 30% of cerium oxide having an average particle diameter of 3.0 μm ; the resulting mixture was molded by hot pressing at a predetermined temperature to form an elastic grindstone; the elastic grindstone was fitted to a cast iron plate to produce an upper surface plate and a lower surface plate.

Using a grinding machine of Fig. 1 comprising the above surface plates, a glass substrate free from warpage (flatness: below 5 μm) and subjected to processing of inner and outer diameters (thickness: 0.700 mm; inner diameter: 20.0 mm; outer diameter: 65.0 mm) was subjected to grinding under the conditions shown in Table 2, until the thickness became 0.640 mm. The results are shown in Table 6.

Comparative Example 1

A pad obtained by impregnating cerium oxide into a polyurethane was fitted to a cast iron plate to produce an upper surface plate and a lower surface plate.

Using a polishing machine comprising the above surface plates and pouring a cerium oxide slurry, a glass substrate free from warpage (flatness: below 5 μm) and subjected to processing of inner and outer diameters (thickness: 0.700 mm; inner diameter: 20.0 mm; outer diameter: 65.0 mm) was subjected to polishing under the conditions shown in Table 5, until the thickness became 0.640 mm. The results are shown in Table 6.

Comparative Example 2

Diamond pellets (#1500) were fitted to a cast iron plate at given intervals to produce an upper surface plate and a lower surface plate.

Using a grinding machine of Fig. 1 comprising the above surface plates, a glass substrate free from warpage (flatness: below 5 μm) and subjected to processing of inner and outer diameters (thickness: 0.700 mm; inner diameter: 20.0 mm; outer diameter: 65.0 mm) was subjected to grinding under the conditions shown in Table 4, until the thickness became 0.640 mm. The results are shown in Table 6.

Comparative Example 3

Diamond pellets were fitted to a cast iron plate at given intervals to produce an upper surface plate and a lower surface plate.

Using a grinding machine of Fig. 1 comprising the above surface plates, a glass substrate having warpage (thickness: 1.30 mm; inner diameter: 19.0 mm; outer diameter: 66.0 mm) was subjected to rough grinding under the conditions shown in Table 3, until the thickness became 0.860 mm. Then, chamfering of inner and outer diameters and edge polishing were conducted.

Then, the resulting glass substrate (thickness: 0.860 mm; inner diameter: 20.0 mm; outer diameter: 65.0 mm) was subjected to fine grinding under the conditions shown in Table 4, until the thickness became 0.690 mm.

Lastly, the resulting glass substrate was subjected to primary (rough) polishing under the conditions shown in Table 5, until the thickness became 0.640 mm.

The results are shown in Table 6.

Table 1

Abrasive particles used in surface plates of elastic grindstone	1.0 μm CeO_2
Rotation of lower surface plate (rpm)	20
Rotation of upper surface plate (rpm)	7
Carrier rotation (rpm)	5
Carrier revolution (rpm)	7
Pressure applied (g/cm^2)	100
Rate of processing ($\mu\text{m}/\text{min}$)	1.5

Table 2

Abrasive particles used in surface plates of elastic grindstone	8.0 μm SiC + 3.0 μm CeO_2
Rotation of lower surface plate (rpm)	20
Rotation of upper surface plate (rpm)	7
Carrier rotation (rpm)	5
Carrier revolution (rpm)	7
Pressure applied (g/cm^2)	100
Rate of processing ($\mu\text{m}/\text{min}$)	7

Table 3

Particle size of diamond pellets	#1000
Rotation of lower surface plate (rpm)	9.0
Rotation of upper surface plate (rpm)	3.0
Carrier rotation (rpm)	4.5
Carrier revolution (rpm)	3.0
Pressure applied (g/cm^2)	120
Rate of processing ($\mu\text{m}/\text{min}$)	25

Table 4

Particle size of diamond pellets	#1500
Rotation of lower surface plate (rpm)	6.0
Rotation of upper surface plate (rpm)	2.0
Carrier rotation (rpm)	2.5
Carrier revolution (rpm)	2.0
Pressure applied (g/cm ²)	150
Rate of processing (μm/min)	12

Table 5

Particle diameter of cerium oxide (μm)	1.2
Rotation of lower surface plate (rpm)	40
Rotation of upper surface plate (rpm)	13
Carrier rotation (rpm)	13
Carrier revolution (rpm)	10
Pressure applied (g/cm ²)	100
Rate of processing (μm/min)	0.8

Table 6

	Surface roughness (Ra)	Flatness (μm)	Fine undulation (μm)	Roll-off (μm)	Thickness removal from glass substrate during thickness processing (μm)	Time of thickness processing of glass substrate (min)*1
Ex. 1	0.0007 μm	≤ 5	≤ 0.05	-0.01	60	0.40
Ex. 2	0.04 μm	≤ 5	≤ 0.05	-0.03	60	0.09
Comp. Ex. 1	10 Å	≤ 5	0.35	-0.30	60	0.75
Comp. Ex. 2	0.2 μm	≤ 5	≤ 0.05	-0.02	60	0.13
Comp. Ex. 3	10 Å	≤ 5	≤ 0.05	-0.04	660	0.95*2

*1: Processing time per one glass substrate when 100 glass substrates each of 2.5" size was processed.

*2: Excludes the time taken for chamfering and edge polishing.

The followings are clear from the results shown in Table 6. In Examples 1 to 2, the quality requirements for glass substrate product after secondary (fine) polishing could be well satisfied; moreover, the thickness reduction from glass substrate during thickness processing and the time of thickness processing could be reduced significantly.

Meanwhile, in Comparative Example 1, the flatness and surface roughness (Ra) necessary for processed glass substrate before secondary polishing could be obtained; however, since the pad fitted to the upper and lower surface plates was too soft, polishing occurred along the shape of the glass substrate before processing and the quality requirements for fine undulation and roll-off could not be achieved.

In Comparative Example 2, the quality requirements for flatness, fine undulation and roll-off could be achieved; however, it was impossible to allow the processed glass substrate before secondary polishing to have a surface roughness (Ra) of 0.05 μm or less (which is necessary for a glass substrate before secondary polishing) because the surface roughness (Ra) could not be reduced below 0.2 μm owing to (a) the sieving limitation of the particle sizes of diamond pellets abrasive and (b) the no dressing conducted for the abrasive.

In Comparative Example 3, the quality requirements for glass substrate before secondary polishing could be well satisfied; however, since the thickness processing for glass substrate was conducted in three steps, the shortening of thickness processing steps and the efficiency of processing were not sufficient.

As described above, the present method for grinding of glass substrate can shorten the conventional steps of thickness processing of glass substrate to one step; thereby, can bring about significant reductions in material cost, cost of processing equipment, cost of material lost in processing, processing time, etc.; as a result, can reduce the cost of glass substrate product significantly.



What is claimed is:

1. A method for grinding a glass substrate, which comprises:
 - (1) interposing a glass substrate held by a plurality of carriers, between an upper surface plate and a lower surface plate both constituted by fixed abrasive particles, and
 - (2) applying, to the glass substrate, a pressure and a rotary motion by the two plates to grind the both sides of the glass substrate, to obtain the glass substrate having a flatness of 10 μm or less and a surface roughness (Ra) of 0.0005 to 0.05 μm , after the grinding.
2. A method for grinding a glass substrate according to Claim 1, wherein the fixed abrasive particles are an elastic grindstone containing at least one kind of abrasive particles selected from the group consisting of cerium oxide particles, manganese oxide particles, aluminum oxide particles, silicon nitride particles, silicon carbide particles and zirconium oxide particles.
3. A method for grinding a glass substrate according to Claim 1 or 2, wherein the particles of the fixed abrasive particles have an average particle diameter of 1.0 to 8.0 μm .
4. A method for grinding a glass substrate according to any of Claim 1 to 3, wherein the glass substrate is subjected to rotation and revolution during the grinding.