

MAGNETIC MEDIUM TRANSFER QUALITY CONTROL DEVICE

Field of the Invention

This invention relates to a magnetic disk medium quality control method, and more particularly to a magnetic medium transfer quality control device that detects an abnormal condition of a magnetic disk medium, which stores servo information required for controlling a head position of a magnetic disk device, in a magnetic transfer process.

Background of the Invention

A magnetic disk device is widely used as a storage device for storing a variety of digital data. A magnetic disk and a magnetic head are provided in the magnetic disk device. The magnetic head stores and regenerates data on and from the magnetic disk. The magnetic disk must perform a servo operation in which the head is moved to a desired track so as to read out a desired recording track and is positioned at a center of the track. This servo operation stores a servo pattern, which is used for acquiring data about the position of the head, on the magnetic disk. Normally, a device called a servo writer writes this servo pattern after a magnetic disk device manufacturer assembles a magnetic disk, a magnetic head and the like in one body. The servo writer writes the servo pattern by gradually moving the head from outside. Recently, however, the storage capacity of the magnetic disk device has been rapidly increasing, and accordingly, the number of tracks in the disk device has also been increasing. This increases a period of

time required for writing the servo pattern, and results in the increase in a manufacturing cost for the disk device.

To address this problem, there have been developed methods of writing the servo pattern by magnetic transfer. In one example of known methods, a so-called master disk in which a servo pattern has already been written is adhered to a magnetic disk from which a servo pattern has already been erased. In another example, a master disk in which a pattern is structurally formed by a ferromagnetic substance is adhered to a magnetic disk, and a magnetic field is applied to the magnetic disk from the outside of the master disk.

Although a disk device manufacturer can perform the magnetic transfer process, it is preferable for a magnetic disk medium manufacturer to perform the magnetic transfer process in one step of a magnetic disk manufacturing process because a disk is only used before it is incorporated into a disk device and there is the need for a clean room. Hereinafter, a disk that is a subject of magnetic transfer in the magnetic transfer process will be called a transfer disk, and a transfer disk as a magnetic disk product in which a servo signal is normally written by the magnetic transfer will be called a magnetic transfer disk.

Summary of the Invention

If such a magnetic transfer process is added to the medium manufacturing process, there is a problem in testing the medium. The

problem will be described hereinbelow.

Fig. 4 shows an example of a manufacturing process after a magnetic film is formed on a magnetic disk in the case where the magnetic transfer is not performed. In this example, a magnetic film is formed by sputtering and a lubricant is then coated (refer to ① and ②), a tape cleaning is performed so as to remove particles on a surface (refer to ③), and a total test is finally conducted. The testing process is comprised of a glide height test (refer to ④), a read/write test (refer to ⑤) and a visual test (refer to ⑥). In the glide height test, it is determined whether there is such a bump as to conflict with a head provided with a piezoelectric element by using the head. In the read/write test, how many defects there are on a disk is determined by writing and reading a signal in or from the disk with use of the same head as in a disk device. In the visual test, whether there is any scratch or pit on the surface of a disk is determined visually or using an optical testing device. These testing processes assure the quality of shipped products because nothing touches the recording surfaces of disks in these processes, which are performed at the final stage of the medium manufacturing process.

On the other hand, Fig. 5 shows an example of a manufacturing process after a magnetic film is formed on a magnetic disk in the case where the magnetic transfer process is added.

If the read/write test is conducted after the magnetic transfer process, a servo pattern written by the magnetic transfer is erased. To solve this problem, the read/write test (refer to S5) must be conducted prior to the

magnetic transfer (refer to S7). The glide height test does not have to be conducted prior to the magnetic transfer. If the glide height test is not conducted prior to the read/write test, however, the read/write test is conducted in the state wherein a disk has such a bump as to conflict with the head, which is the glide height defect. This causes the number of damages in a test head to increase in the read/write test, and results in the increase in a testing cost. Moreover, one testing device conducts the glide height test and the read/write test in many cases. For these reasons, the glide height test and the read/write test should unavoidably be conducted prior to the magnetic transfer process as shown in Fig. 5. To the contrary, since a servo pattern written by the magnetic transfer is not erased in the visual test (refer to S8), the visual test may be performed at the final stage after the magnetic transfer process.

In the magnetic transfer process as stated above, the master disk is adhered to the magnetic disk to be manufactured (the transfer disk). This may damage the surface of the transfer disk, and the damage on the disk may affect the read/write action. Particularly if particles are put between the master disk and the transfer disk during the magnetic transfer, the distance between the master disk and the transfer disk increases around the particles first. This may inhibit a magnetic transfer signal from being recorded normally. Further, the particles may damage the master disk and the transfer disk.

To avoid this problem, whether any particles are put on the transfer disk is preferably determined in a test for particles (refer to S6) just

before the magnetic transfer. In an example of this test for particles, a laser beam is radiated to the disk so as to determine whether any particles are put on the disk according to the presence of scattered light. In this method, however, it is impossible to completely prevent particles, which are adhered to the disk between the test for particles and the magnetic transfer, and fine particles, which have passed the test for particles, from accumulating on the master disk and becoming larger particles.

If the particles are adhered to the master disk as stated above, all the transfer disks are thereafter unsatisfactorily manufactured due to the magnetic transfer process. Further, since the read/write test cannot be conducted after the magnetic transfer process as stated above, the read/write test cannot assure the quality of the magnetic transfer disk.

Object of the Invention

It is therefore an object of the present invention to assure the quality of the magnetic transfer disk.

To attain the above object, the invention set forth in claim 1 comprises: a first read/write testing means provided at the front section of a magnetic transfer device, the first read/write testing means conducting a glide height test and a read/write test; a particle testing means; an optical surface testing means provided at the rear section of the magnetic transfer device; a second read/write testing means for conducting a sampling glide height test and a sampling read/write test; an information collecting means

for collecting at least one of test results obtained by the respective testing means; and a determination means for making a predetermined determination according to the collected information about the test results to determine whether there are any abnormal conditions in the magnetic transfer process.

The most serious problem occurring in the magnetic transfer process is that the consecutive disks are made defective due to the particles adhered to the master disk or put between the master disk and the transfer disk. The damages on the transfer disk can be detected by the optical testing means after the magnetic transfer. Thus, the optical testing device monitors whether a plurality of continuous transfer disks is defective or not. If yes, an alarm is given for example.

If the particles put between the master disk and the transfer disk cause only a minor damage, a problem does not necessarily occur in operating the disk device. If the optical testing device determines the transfer disk as being defective due to such a minor defect, the ratio of non-defectives is lowered. To address this problem, the results of the sampling glide height test and read/write test are compared with the results of the optical test so as to check whether there are defects at the same position or not. Whether the standards for the optical test should be stricter or more flexible is determined according to the result of checking.

On the other hand, the greatest reason why the particles are put between the master disk and the transfer disk is that the particles are

adhered to the transfer disk subject of the magnetic transfer. To prevent this, the test for particles is conducted before the magnetic transfer process as stated above. It is, however, impossible to detect all defects including fine particles and remove the transfer disks to which such fine particles are adhered. Ordinarily, if the ratio of non-defectives in the test for particles is low, an increasing amount of particles are omitted from the test for particles. It is therefore important to give an alarm when the ratio of non-defectives in the test for particles becomes lower than a predetermined value.

According to the present invention, one or more above-mentioned methods are used to assure a desired quality of the magnetic transfer disk.

Brief Description of the Drawings

Fig. 1 is a block diagram showing an embodiment of the present invention.

Fig. 2 is a flow chart showing an example of a method for determining whether there is an abnormal condition in a magnetic transfer process in Fig. 1.

Fig. 3 is a flow chart showing another example of a method for determining whether there is an abnormal condition in a magnetic transfer process in Fig. 1.

Fig. 4 is a diagram of assistance in explaining a process for manufacturing a magnetic disk that does not perform magnetic transfer.

Fig. 5 is a diagram of assistance in explaining a process for manufacturing a magnetic disk that performs magnetic transfer.

Detailed Description of the Preferred Embodiment

Fig. 1 is a block diagram showing an embodiment of the present invention.

As stated previously, a glide height test and a read/write test are conducted out prior to a magnetic transfer process. One read/write tester 11 conducts these two tests. Data about the number of defects in the glide height test and the positions thereof on each surface of a transfer disk, data about the number of defects and the positions thereof in the read/write test, and so forth can be obtained from the read/write tester 11. Such data about the test results are read from the read-write tester 11 and stored on a transfer quality control personal computer 4.

A magnetic transfer device 2 then records a servo pattern. As stated above, the adhesion of particles to a master disk causes problems. To avoid the problems, a test for particles is conducted prior to the magnetic transfer process so as to determine whether particles are adhered to the transfer disk or not. The results of this test for particles such as the number of particles are forwarded to the transfer quality control personal computer 4.

Particles are adhered to the surface of a disk that is determined as being defective in the test for particles. Most of the particles, however,

can be removed easily. Thus, the disks that are determined as being defective in the test for particles are stored for a while. If a certain amount of such disks have been accumulated, the disks go again through the entire process beginning a tape cleaning process in Fig. 1. This enables many disks to pass the test for particles, so that the magnetic transfer can be performed for these disks.

After the magnetic transfer process, an optical testing device 3 carries out a visual test for all disks. In the visual test, it is determined whether there are any abnormalities on the surfaces of the disks such as pits, scratches and bumps. The optical testing device 3 tests the entire surface of the disk including the part at inner diameter and the part at outer diameter as well as a data zone. For example, it is known that the optical testing device 3 irradiates a laser beam onto the surface of the disk and detects the variations in the quantity of reflected light and scattered light of the laser beam so as to determine whether or not there are any abnormalities on the surface. If the particles are put between the master disk and the transfer disk in the magnetic transfer, a pit is formed on the disk and a bump is formed around the pit. The optical testing device 3 needs to detect these defects.

Even if the optical testing device 3 detects the pit or the bump, it is impossible to determine whether they are formed in the magnetic transfer process or not. Even if the particles are put between a certain transfer disk and the master disk, however, there is no big problem since this transfer disk should only be determined as being defective if the particles fall without

adhering to the master disk. The particles put in the magnetic transfer process cause a big problem only in the case where the particles continue adhering to the master disk and form pits or bumps around them in all the transfer disks. To avoid this, the adhesion of the particles to the master disk in the magnetic transfer process needs to be detected quickly, and a manufacturing line must be stopped temporarily so as to clean the master disk or replace the master disk with another.

In the easiest method for determining whether or not the particles are adhered to the master disk, the transfer quality control personal computer 4 gives an alarm when the optical testing device 3 determines a plurality of consecutive transfer disks as being defective (refer to ①-④). In this method, it is impossible to distinguish whether a plurality of consecutive transfer disks is made defective in any other process than the magnetic transfer process or in the magnetic transfer process. An operator who receives the alarm must make this determination.

Fig. 3 shows a method that is a determination algorithm for limiting the conditions.

First, whether a plurality of consecutive transfer disks is defective or not is determined as is described with reference to Fig. 2. If a plurality of consecutive transfer disks is defective, it is determined whether the type of the defect detected by the optical testing device is a pit or a bump (refer to ①). It is then determined whether the defects are located at the same position (refer to ②). If all of these conditions are satisfied, it is determined

that the abnormal conditions such as the adhesion of particles occur in the master disk (refer to ③-⑤). Positional information about the defects can be obtained with respect to positions in a radius direction and an angular direction of disks. A reference position in the angular direction, however, cannot necessarily be maintained at the same position if the disk moves to another testing device. For this reason, whether the defects are located at the same position or not is determined according to whether the defects are located at the same position in the radius direction (refer to ②). Although there is a slight possibility that the pits or the bumps are formed on a plurality of consecutive disks due to any other process than the magnetic transfer process, such defects occur mainly in the magnetic transfer process. Therefore, there is hardly any problem if it is determined that the magnetic transfer process causes the defects.

If a plurality of consecutive transfer disks is determined as being defective due to the adhesion of particles to the master disk in the above-described determination method, the transfer quality control personal computer 4 gives an alarm to an operator in a manufacturing line. For example, an alarm sound is given and a message indicating that the adhesion of particles causes a plurality of consecutive transfer disks to be defective is displayed on a monitor screen of the transfer quality control personal computer 4 so as to urge the operator to clean the master disk or replace the master disk with another.

The optical testing device 3 cannot find all defects of magnetic disks, and the read/write test cannot be conducted after the magnetic transfer. For

this reason, according to the embodiment shown in Fig. 1, the glide height test and the read/write test are conducted for several sampled disks after the magnetic transfer process so as to confirm the quality of final products (refer to the read/write tester 12). Servo signals written by the magnetic transfer process are erased from the samples disks, but disks that are determined as being non-defective in the sampling read/write test can undergo the tests beginning from the magnetic transfer process.

Of course, the results of the sampling glide height test and read/write test can be handled in the same manner as the results of the visual test conducted by the optical testing device. In this case, if a plurality of consecutive disks has defects at the same position, it is determined that the disks are made defective due to the magnetic transfer. In the case of the read/write test, however, it is impossible to clearly determine that the magnetic transfer causes the abnormalities, compared with the case where the results of the visual test are used, because even non-defective disks have some defects and the type of defects cannot be determined clearly compared with the visual test. If the read/write test is conducted prior to the magnetic transfer as shown in Fig. 1, media that are determined as being defective in the read/write test after the magnetic transfer are made defective in the magnetic transfer process with the highest possibility. It is therefore more preferable to determine that the magnetic transfer causes the abnormalities of disks on the basis of the fact that the defective disks are consecutively detected in the sampling glide height test and the read/write test after the magnetic transfer.

If the magnetic transfer is performed, the optical testing device 3 must confirm the quality of final products after the magnetic transfer. It is therefore preferable to set the conditions of the optical testing device 3 to be as close as possible to those of a magnetic read/write test. Therefore, according to the present invention, the results of the sampling glide height test and the read/write test after the magnetic transfer and the results of the visual test conducted by the optical testing device 3 are collected in the transfer quality control personal computer 4 and are automatically compared with each other. This provides information that is useful in setting the conditions of the optical testing device. In one method of providing the information, the ratios of the following defects to the total number of defects detected by the respective testing devices are calculated, and the results of the calculation are displayed on the monitor screen of the transfer quality control personal computer:

- 1) defects detected at the same position in the glide height test or the read/write test and the visual test;
- 2) defects detected only in the glide height test;
- 3) defects detected only in the read/write test; and
- 4) defects detected only in the visual test.

If the ratios 2) and 3) are high, the conditions of the optical testing device are strictly set. If the ratio 4) is high, the conditions of the optical testing device are relaxed.

The results of the test for particles prior to the magnetic transfer are also collected in the transfer quality control personal computer 4 in Fig.

1. The number of particles adhered to each surface is required as the results of the test for particles. Although large particles can be detected as being defective in the glide height test, some of small particles cannot be detected in the glide height test. Even the small particles, however, may cause accumulation of particles. If the particles are increased in the environment of the manufacturing line due to the deterioration of the environment, particles are omitted from the detection in both the glide height test and the test for particles. This increases the number of particles coming into contact with the master disk. Finding such a situation as quickly as possible is therefore important in assuring the magnetic transfer quality. If the particles are increased due to the deterioration of surrounding environment as stated above, the particles that can be detected in the test for particles and the particles that cannot be detected in the test for particles are increased at the same time. Thus, it is possible to detect the increase in the number of adhered particles by time-series observing a histogram representing the number of adhered particles in the test for particles. In short, the ratio of non-defectives in the test for particles is monitored, and when the ratio of non-defectives becomes lower than a specified value, the transfer quality control personal computer 4 gives an alarm.

According to the embodiment shown in Fig. 1, the glide height test and the read/write test are conducted for all the media before the magnetic transfer process. If, however, the quality of media to be manufactured satisfies the required quality, it is possible to replace one or both of the glide height test and the read/write test with the visual test conducted by the

optical testing means. This would achieve the effects except for the above-stated effects relating to the glide height test or the read/write test before the magnetic transfer. It is also very important to optimize the conditions of the visual test by using the results of the glide height test and the read/write test after the magnetic transfer.

While the foregoing is directed to the preferred embodiment of the present invention, other and further embodiments of the invention may be devised without departing from the basic scope thereof, and the scope thereof is determined by the claims that follow herein.

Advantageous Effect of the Invention

According to the present invention, it is possible to quickly detect the abnormal conditions of consecutive transfer disks caused by the magnetic transfer in which the particles are adhered to the master disk, and detect the formation of damages on the transfer disks caused by the abnormal conditions. It is also possible to optimize the conditions of the optical testing device that confirms the quality after the magnetic transfer, and quickly detect the state wherein the deterioration in the environment of the manufacturing line increases the number of particles adhering to the master disk. The present invention therefore provides a transfer quality control system that is capable of maintaining the satisfactory quality in the magnetic transfer process.

Claims

1. A magnetic medium transfer quality control device for use in a magnetic disk manufacture line, in which a magnetic transfer process is performed by bringing a master disk, on which magnetic properties are previously formed in a predetermined pattern, into contact with a magnetic disk to write a magnetic servo pattern, said magnetic medium transfer quality control device comprising:

data collection means for collecting data on results of at least one of the following tests: a glide height test, a read/write test and a test for particles conducted before said magnetic transfer process; a visual test, a sampling glide height test and a sampling read/write test after said magnetic transfer process;

determination means for making a predetermined determination according to the collected data about test results to determine whether or not there is an abnormal condition in said magnetic transfer process.

2. A magnetic medium transfer quality control device according to claim 1, wherein said determination means determines a plurality of consecutive disks as being defective in said visual test, said sampling glide height test or said sampling read/write test after said magnetic transfer process.

3. A magnetic medium transfer quality control device according to claim 1, wherein said determination means compares the respective results of said sampling glide height test and said sampling read/write test after said



magnetic transfer process with the results of said visual test after said magnetic transfer process, thereby enabling output of data for use in optimizing a set value for determining whether magnetic disks are defective or not.

4. A magnetic medium transfer quality control device according to any one of claim 1 to claim 3, wherein said determination means is capable of determining that a result of test for particles before said magnetic transfer process is worse than a predetermined value.

