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MAGNETIC DISC STORAGE SYSTEM

BACKGROUND OF THE INVENTION

The present invention relates in general to a magnetic disk storage system including a dual element head in which an element for writing data and an element for reading data are separately provided, and more particularly to a magnetic disk storage system in which both the arrangement error in lithography process in manufacturing the write element and the read element and the errors of the positional offset between the write element and the read element, and a track due to inclination of a slider when carrying out the positioning of the head using a rotary type actuator are corrected, thereby increasing the track density of a radial direction of a disk.

A magnetic disk storage system moves a head in a radial direction of a rotating disk to read/write the data from/to a data region of an objective sector. For this purpose, the accurate positional information of the head on the disk needs to be obtained by some method or other. As the technology which has been conventionally widely adopted, there is well known a method wherein both a pattern representing the track number and a specific staggered pattern are previously written to the magnetic disk, and the head is moved to the position where the objective data region is present on the basis

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of the two positional information. The positional information is provided in a servo region 81 in a schematic view showing a sector structure of a prior art example shown in Fig. 8.

Further, as shown in Fig. 8, in order to write/read surely the data to/from the objective data region, in general, just before each of the data regions 83, an identification (ID) region 82 having address information of the corresponding data region 83 is arranged through a gap region 84-2. Now, prior to the operation of writing/reading the data to/from the data region 83, the data is read out from the ID region 82 to confirm the address information, thereby judging finally whether or not a head 11 is moved to the objective data region 83. The reason that the technology for positioning the head including the ID region as described above has been conventionally adopted for many magnetic disk storage systems is that there is the high reliability in certainty of the operation of writing/reading the data to/from the objective sector.

In particular, in recent years, in order to increase the recording density of the magnetic disk storage system, there has been adopted the technology of employing the head having a high readback sensitivity. For example, there has been well known the technology of employing an MR element utilizing the magneto-resistance effect of iron-nickel alloy as the read head. Since the magnetoresistive element typified by the MR element can

not carry out the write operation, a head for the write operation needs to be additionally provided. An inductive head in which the magnetic field is generated by the coil current is employed as the head for writing data. As a result, the heads are used which are respectively dedicated to the write operation and the read operation, and hence in general, the offset occurs between the position of the write element of the head for the write operation and the position of the read element of the head for the read operation. In the magnetic disk storage system employing the rotary actuator as shown in Fig. 9, since the inclination of the slider with respect to the track direction becomes large in the position of the outer diameter of the disk or the inner diameter of the disk, that offset becomes particularly remarkable. An example in which the slider is inclined in the outer diameter of the disk is shown in Fig. 10. As shown in the figure, the vertical offset to the track direction occurs between the center of the read element and the center of the write element. In addition, an example in which the slider is inclined in the inner diameter of the disk is shown in Fig. 11. As apparent from Fig. 11, the offset occurs between the center of the read element and the center of the write element in a direction opposite to that of Fig. 10. This offset occurs in the opposite direction to that of the offset shown in Fig. 10.

As for the technology for correcting that offset, for example, there are well known the methods proposed in JP-A-63-142513 and JP-A-4-232610. Those methods are such that the positioning of the head in the write operation is changed from that in the read operation by the amount corresponding to the above-mentioned positional offset between the element of the head for the write operation and the read element of the head for the read operation, or the positions of both the elements are previously shifted from each other so as for the offset between the read element and the write element in the mean inclined angle of the slider to become zero. Therefore, those methods are the effective technologies in order to increase the track density.

However, in the above-mentioned prior art, the operation of reading the data from the ID region before the operation of writing the data to the data region can not be carried out stably due to the offset between the write element of the head for the write operation and the read element of the head for the read operation. That is, as shown in Fig. 13 useful in explaining the head position in the conventional write operation, in the prior art, in the state in which the write element 121 is positioned at the center of the data track or data region in order to carry out the operation of writing the data to the data region 83, the position of the read element 120 of the head deviates from the center of the ID region 82. Therefore, the operation of

writing the data to the data field 83 with the write element positioned at the center of the data region 83 is required just after carrying out the operation of reading the data from the ID region with the read element positioned at the center of the ID region 82. However, since the much longer time is required as compared with the data transfer rate in order to carry out accurately the positioning, it is difficult in practical use to carry out the positioning again in the gap region between the ID region 82 and the data region 83. The read errors per bits read of the ID region due to the offset between the position of the write element and the position of the read element is not kept within the tolerance in the track density exceeding 5kTPI(track per inch) in particular. Therefore, this is a serious problem in designing the magnetic disk storage system.

In order to solve the above-mentioned problem associated with the prior art, U.S. Patent No. 5,257,149 proposes the 2ID sector format method wherein the ID region dedicated to the write operation and the ID region dedicated to the read operation are duplicately provided, and also the ID region dedicated to the write operation is provided in the position which is offset by the offset distance between the write element and the read element in a direction perpendicular to the track. In this method, there is provided a disadvantage that while the problem of the positional offset between the write element and the read element of the head is

effectively solved, the storage capacity of the disk is excessively consumed since the ID regions which the user can not utilize are duplicately provided.

In addition, as the no ID sector format disclosed in U.S. Patent No. 5,438,559, there is also proposed the technology in which the above-mentioned ID regions are excluded. This no ID sector format is such that the information required for recognizing uniquely the sector is produced from both the track information which is embedded in the serve region and the numeric value which is obtained by counting the number of passed sectors from the head position of the track. According to this method, no problem due to the positional offset between the write element and the read element of the head occurs since the operation of reading the data from the ID region is not carried out at all. However, since it is can not be confirmed on the basis of the address information of the ID region whether or not the head is properly positioned in the objective sector as used heretofore generally, in particular, there arises a problem that the reliability in the operation of writing the data to the data region is poor.

SUMMARY OF THE INVENTION

Therefore, the development of the new technology is expected which is capable of carrying out stably the operation of reading the data from the ID region before the operation of writing/reading the data

to/from the data region and which does not require the large amount of additional information which consumes largely the storage capacity of the disk.

In order to attain the above-mentioned object, according to the present invention, first address information is provided in an ID region, second address information is provided together with user data in a data region, and the ID region is offset vertically from the center of a track by the amount approximately equal to an offset distance between a write element and a read element of a dual element head corresponding to the radial position of a disk and in a direction perpendicular to a track. Then, the read element of the head is positioned in the position of the ID region when writing the data to the data region, and the read element of the head is positioned in the position in a track width direction of the data region when reading the data from the data region, whereby the address information is surely read out in the operation of writing/reading the data to/from the data track without the positional offset. The data relating to the vertical offset distance is stored either magnetically on the surface of the disk, or electrically in a storage element on a circuit board.

In addition, the present invention includes means for recording a servo pattern using the write element and carrying out the positioning for the servo pattern using the read element when it is difficult to

measure directly the positional offset distance between the write element and the read element of the dual element head corresponding to the radial position of the disk and in a direction perpendicular to the track, thereby measuring indirectly the positional offset amount between the write element and the read element. In addition, the present invention is designed in such a way that in order to arrange the servo region or the ID region with a high accuracy, the operation of writing the data to the servo region or the ID region is carried out in the servo track write process in the process of manufacturing the magnetic disk storage system, or the servo region or the ID region is formed in the form of the irregularity pattern on the disk. In addition, the present invention includes a giant magnetoresistive element, and the track density is made equal to or more than 10kTPI or the shock resistance in the operation is made equal to or more than 500G, thereby providing a magnetic disk storage system which is capable of being used as a portable storage device for image information.

In addition, in the operation of writing the data to the data region, after confirming whether or not the address information obtained from the ID region matches with the address information of the data region, the address information is written together with the user data to the data region, whereby the data is surely written to the objective sector. On the other hand, the operation of reading the data from the data region, when

reading the data from the data region or after completing the operation of reading the data from the data region, it is confirmed whether or not the address information contained in the read data matches with the address information of the objective data region, whereby the data is surely read from the objective sector.

In addition, since the information of the ID region is not required for the read operation, the ID address mark field and the data address mark field are formed by using the codes different from each other, and hence waiting for detection of the data address mark field is carried out immediately after head seek, whereby the data has not to be forcedly read from the ID region in the positional offset state. As a result, it is possible to prevent occurrence of the ID read error. In addition, by providing means for stopping the operation of a read amplifier and a data detector circuitry while the read element of the head is passed through the ID region, suppressing the output of an ID read error signal, or carrying out the operation of reading forcedly the data from the data region when the ID read error signal is outputted, the magnetic disk storage system is provided which has low power consumption and which is excellent in the access performance.

In addition, after completing the judgement and correction of the data read error on the basis of an

error detection code added to the data region, it is confirmed whether or not the address information contained in the read data matches with the address information of the objective data region. Therefore, a semiconductor memory is included which has the storage capacity with which the two or more data regions can be stored, and the data read from the data region is temporarily transferred to the semiconductor memory, whereby it becomes unnecessary that the processing waiting time is inserted into the read operation in order to confirm the address information. Alternatively, the error detection code for checking for errors in the reading of the address information is inserted into the middle of the data region, whereby the address information can be confirmed without waiting completion of the operation of reading the data from the data region. Thus, the magnetic disk storage system is provided which is capable of increasing the processing speed.

According to the present invention, since in the operation of writing the data to the data region, the write element is positioned in the data region, whereby the position of the read element of the head can be made match with the position of the ID region, the address information of the corresponding section can be obtained with a sufficient signal to noise ratio and reliability. On the other hand, in the operation of reading the data from the data region, the read element

of the head is positioned in the data region to read the data from the data region, whereby the address information of the corresponding sector can be obtained with a sufficient signal to noise ratio and reliability. Since by the above-mentioned operation, the ID error rate can be reduced in both the write operation and the read operation, the magnetic disk in which the track density is increased can be readily designed and hence the storage capacity can be remarkably increased as compared with the conventional magnetic disk storage system. In addition, since the accuracy required for the following vibration and the settling vibration can also be reduced, the serve control system can be readily designed and the access performance in the magnetic disk storage system can be improved. In addition, the safety against the vibration which is applied from the outside in the operation can be enhanced. In particular, in the magnetic disk storage system having the track density of 10kTPI or more, the effects of the present invention are remarkable.

In implementing the present invention, the data which must be added to the prior art format is the ID information in the data region, and the information amount of about 10 bytes is sufficient for the ID information. Therefore, the excessive consumption of the disk storage capacity due to addition of the ID information can be kept equal to or less than 2%. In addition, according to the present invention, the offset

distance between the center of the write element and the center of the read element due to the arrangement error in lithography process is corrected, whereby the yield in the head fabrication can be enhanced, and also the productivity can be remarkably enhanced. In addition, the code which is different from the error detection code added to the ID information in the data region, and the number of bits are employed for the error detection code added to the ID information in the ID region, whereby in particular, the reliability for the write operation can be enhanced. Therefore, it is also possible to provide the portable magnetic disk storage system for personal use having the shock resistance of 500G or more.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other objects as well as advantages of the present invention will become clear by the following description of the preferred embodiments of the present invention with reference to the accompanying drawings, wherein:

Fig. 1 is a cross sectional view showing the construction of an example of a magnetic disk storage system according to the present invention;

Fig. 2 is a plan view, partly broken away to show the interior construction, of the magnetic disk storage system of the present invention;

Fig. 3 is a schematic view showing a structure of an example of a sector structure of the present invention;

Fig. 4 is a schematic view showing a structure of an example of a servo region in the present invention;

Fig. 5 is a schematic view showing a structure of an example of an ID region in the present invention;

Fig. 6 is a schematic view showing a structure of an example of a data region in the present invention;

Fig. 7 is a schematic view showing a structure of another example of the data region in the present invention;

Fig. 8 is a schematic view showing a sector structure of the prior art;

Fig. 9 is a plan view useful in explaining that a slider is inclined depending on the position of an actuator;

Fig. 10 is a schematic view useful in explaining inclination of the slider in the position of an outer diameter of a magnetic disk;

Fig. 11 is a schematic view useful in explaining inclination of the slider in the position of an inner diameter of a magnetic disk;

Fig. 12 is a schematic view useful in explaining the head position in the write operation in the present invention;

Fig. 13 is a schematic view useful in explaining the head position in the write operation in the prior art;

Fig. 14 is a schematic view useful in explaining the head position in the read operation in the present invention;

Fig. 15 is a schematic view useful in explaining the head position in the read operation in the prior art;

Fig. 16 is a flow chart useful in explaining the flow in the write/read operation; and

Fig. 17 is a block diagram showing a configuration of an example of a circuit according to the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The preferred embodiments of the present invention will hereinafter be described in detail with reference to the accompanying drawings.

<Embodiment 1>

A first embodiment of a magnetic disk storage system according to the present invention will hereinbelow be described with reference to the figures. Fig. 1 is a cross sectional view showing schematic construction of the present magnetic disk storage system, and Fig. 2 is a plan view when a part of the present system is viewed from the upper side. The magnetic disk storage system of the present embodiment

includes a dual element head 11 having an inductive element as a write element and a magnetoresistive element as a read element, and a rotary actuator 12 and is designed in such a way as to carry out the embedded servo using the positional information embedded in the data surface of each magnetic disk 13. During carrying out the write operation or the read operation, an electric power is supplied to a voice coil motor 14 in accordance with an instruction issued from a CPU (central control unit) such that the dual element head 11 is moved onto an objective track 15 through the rotary actuator 12. Thereafter, the address of the objective sector is retrieved through a read/write circuitry and then the operation of writing or reading the data to or from the data field is carried out.

In the present invention, in order to correct the positional offset between the write element and the read element of the head, the following sector format is constructed. An example of a structure of the four sectors in the four adjacent tracks 15 formed on the disk is shown in Fig. 3 in the form of a schematic view. The structure is such that a plurality of different sectors are further provided before and after each of the sectors, and hence one track has a plurality of sectors. One sector can store the data of 512 bytes as a minimum unit for storing information.

One sector includes a servo region 31, an ID region 32 and a data region 33. A gap region 34 is

provided, as a gap for absorbing the controller processing time and the variations in spindle speed, between the regions, and between the region of interest and the subsequent sector. The regions are separated from each other through the gap region 34, and the length of the gap region 34 may be several bytes or more. The structure of each region will hereinbelow be described in detail.

The structure and the role of the servo region 31 are basically the same as those of the servo region 81 in a schematic view showing the conventional sector structure shown in Fig. 8. In Fig. 4, there is schematically shown a structure of the servo region 31. This servo region 31 includes a gain zone field 44, a marker field 41, a gray code field 42, a servo burst field 43 and a padding (PAD) field 44. The gain zone field 44 is a field for producing a servo clock and adjusting the gain of a read amplifier. The marker field 41 is a field for carrying out voltage control oscillator (VCO) synchronization when leading the subsequent information and producing index pulses and selector pulses. The gray code field 42 is a field in which the track number is represented using the gray code. The servo burst field 43 includes a staggered pattern and serves to compare the read signal amplitudes of the four fields 43-1 to 43-4 with each other to produce the positional information of the head.

Now, while the example is shown in which the width of the servo burst field 43 matches with the track pitch (the track interval), the width of the servo burst field 43 is preferably made narrower than the track pitch in terms of the positioning accuracy. For example, since if the width of the servo burst field 43 is set to about 70% of the track pitch, the head positioning error due to the non-linearity of the off-track profile of the head can be held to a minimum, and hence this is particularly preferable.

The ID region 32 is provided in order to confirm that the read operation is carried out prior to the operation of writing the data to the data field 33, and the write element of the head is properly positioned in the objective sector. In Fig. 5, a structure of the ID region 32 is schematically shown. The function of the ID region 32 is different from the function of the ID region 82 in the sector of the prior art example shown in Fig. 8, and serves as the ID information dedicated to the operation of writing the data from the data region 33 and hence is not used in the operation of reading the data from the data region 33. In addition, the position where the ID region 32 is arranged is offset from the central position of the track (data region) in a direction perpendicular to the track direction. The offset distances are different from one another depending on the track positions. More specifically, the offset distance which is equal to the

offset between the central of the write element and the central of the read element of the head occurring when carrying out the positioning operation using the rotary actuator is the optimal distance. The structure of the ID region 32 is basically the same as that of the ID region 82 of the prior art example shown in Fig. 8, and includes a VCO synchronization field 50, an ID address mark field 51, an ID data field 52, a cyclic redundancy check (CRC) field 53 and a PAD field 54. The VCO synchronization field 50 is a field for pulling in an oscillator frequency of the VCO to establish the clock synchronization and adjusting the gain of a read amplifier. The ID address mark field 51 is a field in which a specified bit pattern is formed in order to exhibit the beginning position of the subsequent information to carry out the synchronization for the read operation. The ID data field 52 includes the cylinder number of the associated sector, the head number and a flag as the additional information such as the sector number and the bad sector. The CRC field 53 is a field which is added in order to detect whether or not the error occurs in the operation of reading the data from the ID region 32. The PAD field 54 is a field which is added in order to carry out the read operation till the CRC field.

The data region 33 is a region for storing the user data and occupies much more area on the disk as compared with the servo region 31 and the ID region 32.

The structure of the data region 33 is schematically shown in Fig. 6. The data region 33 has a function of confirming whether or not the operation of reading the data from the objective sector has been properly carried out in addition to the function of the data region 83 of the prior art example shown in Fig. 8. This function is a function which is added in order to cope with that during the operation of reading the data from the data region, the read operation for the ID region is not carried out, and hence acts as the ID information dedicated to the read operation. For this reason, this function is such that the ID information for recognizing uniquely the sector is added to the structure of the data region 83 of the prior art example. As this information, the data line is employed which is substantially the same as the ID data field 52 of the ID region 32. When writing the data to the data region 33, the data is written continuously to the ID data field 62 and the data field 63. The data region 33 includes a VCO synchronization field 60, a data address mark field 61, an ID data field 62, a data field 63, an ECC field 64 and a PAD field 65. The functions of the VCO synchronization field 60, the data address mark field 61, the ID data field 62, the ECC field 64 and the PAD field 65 are respectively equal to those of the VCO synchronization field 50, the ID address mark field 51, the ID data field 52, the CRC field 53 and the PAD field 54 of the above-mentioned ID region 32. The data field

63 occupies 512 bytes in the data which the user stores in the magnetic disk storage system.

Next, the description will hereinbelow be given with respect to the positional relationship between the head and the track when carrying out the operation of writing the data to the sector of the present invention, with reference to Fig. 12. In the write operation, the positioning of the head is carried out so as for the position of the write element 121 of the head to match with the center of the data region 33. Since the ID region 32 is previously offset from the center of the track by the amount corresponding to the offset distance between the write element and the read element, the read element 120 of the head in that position matches with the center of the ID region 32. On the basis of this positional relationship, the operation of reading the data from the ID region 32 before the operation of writing the data to the data region 33 can be carried out without the head to track misregistration, and the address information can be surely confirmed. In addition, immediately after reading the data from the ID region 32, the data can be written to the data region without correcting the position of the head.

Fig. 14 is a schematic view useful in explaining the positional relationship between the head and the track when carrying out the read operation for the sector of the present invention. In the read

operation, the head is positioned so as for the position of the read element 120 of the head to match with the center of the data region 33. In this positional relationship, the read element 120 of the head is offset from the center of the ID region 32. However, the information of the ID region 32 is not required in the read operation in the present invention, and hence it is possible to remove the step of reading the data from the ID region 32 with the read element 120 offset from the center of the ID region 32. Since the address information required for confirming the objective sector is contained in the data region 33, the read operation can be carried out without the head to track misregistration.

By adopting the format of the present invention, even if the positioned location of the head in the write operation is changed from that of the head in the read operation, since the address information can always be read out without the positional offset, the occurrence of the address detection error can be largely reduced and hence the high performance magnetic disk storage system can be realized.

The format of the present invention is greatly superior in the use efficiency of the disk area to the 2ID format having the doubled ID information disclosed in U.S.Patent No. 5,257,149. In the 2ID format, since each of the ID region dedicated to the write operation and the ID region dedicated to the read operation

requires the VCO synchronization field, the CRC field, the PAD field, and the gap region, the excessive storage capacity of about 50 bytes per sector is required. However, in the present invention, since the ID region for the read operation is processed together with the data region, the above-mentioned fields are not required at all, and hence the storage capacity of 10 bytes or less per sector has only to be added.

As described in the above-mentioned embodiment, in the magnetic disk storage system including the dual element head in which the write element and the read element are separately provided, the present invention provides a method of reducing largely the above-mentioned positional offset distance between the write and read elements. In this connection, the present invention can be widely applied to the system for storing the information having the sector format using the dual element head. For example, the present invention can also be readily applied to the information storing device such as a magneto-optical disk drive, a magnetic tape drive, and a magneto-optical tape drive.

<Embodiment 2>

In the conventional magnetic disk storage system, in both the write operation and the read operation, in order to judge that the head has been moved onto the objective sector, the data is read from the ID region 82 which is previously recorded on the disk, the address information contained in the ID region

82 is compared with the address information of the objective sector, and the coincidence therebetween is confirmed. On the other hand, in the magnetic disk storage system of the present invention, in the above-mentioned operation of confirming the address information, there is used for the write operation and the read operation the data which is recorded in the different positions on the disk. That is, in the write operation, the address information is produced from the read data of the ID region 32, while in the read operation, the address information is produced from the read data of the data region 33. The flow of the processing of the write operation for certain one sector in the magnetic disk storage system of the present invention will hereinbelow be described with reference to a flow chart of Fig. 16. After carrying out the seek operation (Step 3) of the head 11 on the basis of the position information of the servo region 31, the controller starts the operation of reading the data from the ID region 32 and waits for detection of the ID address mark field 51 (Step 4). After completing the operation of reading the data from the ID region 32 (Step 5) and carrying out the error check by the CRC field 53 of the ID region 32 (Step 6), it is confirmed whether or not the information of the ID data field 52 matches with the address information of the objective sector (Step 7). Then, if the match is confirmed, the operation of writing the data to the data region 33 is

started. Thereafter, the write operation is carried out for the VCO synchronization field (Step 8), the data address mark field 61 (Step 9), the ID data field 62 (Step 10), the data field 63 (Step 11), the ECC field 64 (Step 12), and the PAD field 65 (Step 13) in this order, thereby completing the write operation for one sector.

Next, the description will hereinbelow be given with respect to the flow of the processing of the read operation for certain one sector. Immediately after carrying out the seek operation (Step 3) of the head 11, the controller carries out the operation of reading the data from the data region 33. That is, the controller does not wait for detection of the ID address mark field 51, but waits for detection of the data address mark field 61 (Step 4). After completing the operation of reading the data from the data region 33 (Step 5) and carrying out the error check by the ECC field 64 of the data region (Step 6), it is confirmed whether or not the information of the ID data field 62 matches with the address information of the objective sector (Step 7), thereby completing the read operation for one sector.

In such a way, the two different address information is used appropriately in the write operation and the read operation, whereby the address information can be detected independently in the write operation and the read operation. Even if the information of the ID region of a certain sector is lost due to any cause,

since the address information is contained in the data region, it is possible to judge whether or not the read data is obtained from the objective sector, and hence the data of that sector can be read out by the same processing as that in the normal operation. In addition, even when the information of the data region of a certain sector is lost due to any cause and is registrated as the bad sector once, if the data can be properly read from the ID region, the data is written to the data region to recover that data region, whereby that data region can be utilized as the normal sector. In addition, the different coding schemes are employed for the error check codes relating to the two address information, and the error check bit streams having the different lengths are employed therefor, whereby the error rate when detecting the address information can be originally designed in the write operation and the read operation. For example, by strengthening the error detection in the write operation, the higher reliability in the write operation can be designed.

As described above, in the present embodiment, the data processing can be executed which is approximately the same as the data processing method of the conventional format shown in Fig. 8. Therefore, the present embodiment can be realized without changing largely the conventional control circuitry, address mark detector circuitry and the like, and hence the present invention can be adopted inexpensively.

In addition, the present embodiment is particularly combined with the embodiment 1, whereby it is possible to realize the high performance magnetic disk storage system. In this case, even if the positioned location in the write operation is changed from that in the read operation, it is possible to obtain always the address information from the read signal which is free from the positional offset, and also it is possible to realize the high performance magnetic disk storage system in which the storage density in the track direction is increased to increase the storage capacity.

<Embodiment 3>

An embodiment of the magnetic disk storage system in the case where the present invention is applied to the system will hereinbelow be described in detail with reference to Fig. 17. After the read data which has been read out from a magnetic disk 13 by a magnetic head 11 is amplified by a head amplifier 170 and then is subjected to the waveform shaping in an equalizer 171, the resultant signal is converted into a digital signal in a peak detector circuitry 172. The signal and the like of the VCO synchronization field for carrying out the clock synchronization are contained in that digital signal, and hence in order to recognize the beginning of the subsequent data, it is necessary to detect the address mark field as the specified bit pattern. In the conventional magnetic disk storage

system, even in both the write operation and the read operation, likewise, the ID address mark field is detected and the data is read out from the subsequent ID data field.

The magnetic disk storage system of the present invention is characterized in that in the write operation, the ID address mark field 51 is detected by an ID address mark detector circuitry 175 and the data is read out from the subsequent ID data field 52. In the read operation, the data address mark field 61 is detected by a data address mark detector circuitry 176, and the data is read out from the subsequent data field 62. In such a way, the two different address mark fields are used for the write operation and the read operation appropriately, whereby the address mark fields can be detected in the write operation and the read operation independently. In the conventional magnetic disk storage system, the processing of reading the data from the data region 83 can not proceed until after seek, the head is accurately positioned in the ID region 82 to succeed in detecting the ID address mark field. By applying the present invention to the magnetic disk storage system, even under the situation in which after seek, the ID address mark field 51 can not be detected due to the positional offset of the head, the processing of reading the data from the data region 33 can be executed, and therefore it is possible to enhance the performance of the system. In addition, since the ID

address mark field 51 and the data address mark field 61 can be detected independently in the write operation and the read operation, respectively, the positional relationship between the two address mark fields can be freely designed. This effect is particularly preferable when combining the present embodiment with the embodiment 1. Thus, even if the positioned location in the write operation is changed from that in the read operation, the address mark field can always be detected from the read signal which is free from the positional offset, and hence the high performance magnetic disk storage system can be realized in which the recording density in the track direction is increased so as to increase the storage capacity.

<Embodiment 4>

In the present embodiment, the description will hereinbelow be given with respect to the magnetic disk storage system, described in the embodiment 1, including the means for offsetting the positioned target of the head in the write operation and the read operation, said system being characterized by including means for recording previously data of the positional offset amount (corrected amount) of the head in the write operation and the read operation on a boot track on the magnetic disk, and reading out the data when turning on the power supply of the magnetic disk storage system so as to use the data thus read out in the subsequent seek operation.

The above-mentioned data of the offset amount of the head in the write operation and the read operation has the different optimal values depending on the system, the head and the track due to the arrangement error in lithography process and the like, and hence is difficult to be obtained accurately from the yaw angle of the slider (an angle of inclination of the slider with respect to the track) and the distance between the write element and the read element of the head by calculation. In order to realize the magnetic disk storage system having the high track density by increasing the positioning accuracy, it is preferable that the system includes the function of measuring the positional offset amount by any method before shipment and storing the resultant data in the system itself. Now, when in the magnetic disk storage system which is made on an experimental basis on the basis of the embodiment 1, the operation of writing the data to certain one track is carried out and then the data is read out from that track, the error rate in reading the data becomes larger than 10 to the minus 6th power. On the other hand, when the present invention is applied to the system, and the same operation as that described above is carried out on the basis of the data of the positional offset amount stored on the disk surface, the error rate becomes a value smaller than 10 to the minus 9th power, and hence this result fulfills the error rate in the specification of the system.

As a method of keeping the offset data which is different from the above-mentioned example, the offset data may be stored in some kind of nonvolatile memory (e.g., PROM, EEPROM, a dielectrical memory or the like) provided on a circuit board of the magnetic disk storage system. In this case, even if what kind the storage means is, the same effect for the positioning accuracy of the system can be obtained. In the first method of recording the data of the positional offset amount of the head on the disk surface, the repair work may be carried out such that the circuit board of the magnetic disk storage system is detached from the mechanism portion to be exchanged with another circuit board. In addition, in the second method of storing the data of the positional offset amount of the head in the nonvolatile memory mounted on the circuit board, since the time required for the work of reading the data from the boot track can be shortened when activating the system, the excellent response can be obtained when activating the magnetic disk storage system.

<Embodiment 5>

In the present embodiment, the description will hereinbelow be given with respect to the magnetic disk storage system, described in the embodiment 1, including the means for offsetting the positioning target of the head in the write operation and the read operation, said system being characterized by including means for measuring the data of the positional offset

amount of the head, in the write operation and the read operation, in the process of manufacturing the system. The seek and following operation are carried out on the basis of the offset data, whereby the distance of the positional offset between the head and the center of the track can be reduced or neglected.

In order to attain that object, the offset data of the positioning target of the head needs to be decided before the seek operation. In order to simply realize this procedure, the roughly estimated values can be calculated on the basis of the designed values of the offset between the write element and the read element of the head, and the data of the yaw angle of the slider (the angle of inclination of the slider with respect to the track). But, in order to absorb efficiently the errors of the element positions in manufacturing the head and the processing errors of the positional relationship between the head, and the actuator and the spindle motor, it is desirable that the optimal value of the offset data is measured every head to be determined.

While the various processings can be considered as the measurement method, as one embodiment, the servo track write process of the manufacturing line of the magnetic disk storage system can be employed. More specifically, after a servo pattern has been recorded using the write element of the head incorporated in the products, the following for the servo pattern is carried out using the read element of

the same head, and this position is treated as a first head position. Then, a second servo pattern for measurement is recorded with the first head position as the reference, and the position which is obtained by carrying out the following for the second servo pattern is treated as a second head position. The difference between the first and second head positions becomes the offset data in the track position where the measurement is carried out. Now, in the magnetic disk storage system which was made on an experimental basis on the basis of the embodiment 1, the data is written to the data region 33, and the distance of the radial offset between the center of the data region 33 and the center of the track shown in the servo region 31 is measured on the basis of the Bitter method. Firstly, in the case where the data is written to the data region on the basis of the offset data obtained by calculation, the distance of that track offset is about 0.5 μm in the wide portion. On the other hand, when the present invention is applied, and the same operation as that described above is carried out on the basis of the offset data which is obtained by the measurement using the servo write process, the distance of the track offset becomes 0.1 μm or less in the wide portion. In particular, in the case of the head requiring the sense current in the read operation as represented by the MR head, in general, the physical center of the read element is different from the readback sensitivity

center when reading the magnetic information. In order to correct the influence of that center offset, it is preferable that the present invention is applied, and the pattern which is produced using the write element of each head is measured using the read element of the head itself.

That measurement is carried out in the several tracks from the outer periphery to the inner periphery, whereby it is possible to obtain the offset data which can correct sufficiently the various errors. That measurement does not must be necessarily carried out with respect to all the tracks. The positional offset amount of each of other tracks may be obtained by the linear approximation based on the measured values which are obtained by the measurement with respect to a small number of tracks.

While as the method of measuring the offset data, many means different from that of the above-mentioned embodiment can be considered, in the present invention, the offset data is measured using the write elements and the read elements of the individual heads themselves, and hence the present invention is not limited to the above-mentioned embodiment utilizing the servo track write process.

<Embodiment 6>

In the present embodiment, the description will hereinbelow be given with respect to the magnetic disk storage system, described in the embodiment 1, in

which the ID region 32 is offset radially from the center of the data region 33, said system being characterized by including means for writing the data to the ID region 32 or the data region 33 in the servo track write process in the process of manufacturing the system. In addition, the description will now be given with respect to the magnetic disk storage system characterized by including means for writing previously the data to the ID region 32 or the data region 33 in the form of the surface asperity, as a second embodiment.

The optimal value of the above-mentioned offset amount varies from system to system, from head to head and from track to track. In particular, in the magnetic disk storage system having a track pitch of 2 μm or less, in order to fulfill the specification of the error rate of the system, it is necessary to set the offset distance between the ID region 32 and the data region 33 with a very high accuracy. In order to attain this object, for example, the positioning of the head is carried out on the basis of the position information of the servo region 31 after assembling the parts into the magnetic disk storage system, and the operation of writing the data to the ID region 32 is automatically carried out every track. However, in the magnetic disk storage system having the increased track density, there is the possibility that it becomes difficult to ensure the accuracy of the offset distance, and the throughput

of the system may be reduced due to occurrence of the ID read error.

Then, in the present embodiment, in the manufacturing line of the magnetic disk storage system, at the stage of mounting the magnetic disks 13 to the magnetic disk storage system 16, the data is written to the ID region 32 as well as to the servo region 31 in the servo track write process, whereby the more suitable arrangement can be carried out. Since the existing manufacturing system is employed in the present embodiment, the present embodiment can be relatively readily introduced into the manufacturing process of the products. Alternatively, in order to form the more accurate pattern, the desired data may be recorded on the magnetic disk using the system for recording information with a high accuracy to which the air spindle, the air slider and the like are mounted.

In addition, as a second embodiment, by utilizing the photolithography technology which is widely used in the manufacture of the semiconductor, the resist resin which has been applied to the disk is exposed using the reticle which was manufactured with a high accuracy to form the servo region 31 on the disk in the form of the surface asperity, whereby it is possible to realize the high resolution servo pattern. At this time, the ID region 32 is also previously formed on the disk in the form of the surface asperity through the same exposure process, whereby the accuracy of the

offset distance of the ID region 32 can be remarkably enhanced. The present embodiment is in particular suitable for the thin magnetic disk storage system having one sheet of self-contained magnetic disk.

<Embodiment 7>

In the present embodiment, the description will hereinbelow be given with respect to the magnetic disk storage system which has the giant magnetoresistive element, in which the rate of change of the magnetic resistance is increased by the multilayer structure of the magnetic films, as the read element of the head, and which has the radial track density of 10kTPI (track per inch) or more.

In the magnetic disk storage system described in the embodiment 1, the MR element which utilizes the magneto-resistance effect of permalloy as iron-nickel alloy is employed as the read element of the head. For this magnetic disk storage system, when the pattern having the track density exceeding 10kTPI is formed, the magnitude of the read signal of the above-mentioned offset ID region becomes weak, and also the error rate of the data becomes larger than 10 to the minus 7th power. As a result, the design specification of the system is not fulfilled. Then, in the present embodiment, in the magnetic disk storage system in which the track density is set to 11kTPI, there is employed the head in which the rate of change of the magnetic resistance is increased by the multilayer structure of

the magnetic films and the sensitivity in the read operation is made about 6 times as large as that of the MR element. With this system, when carrying out the operation of reading the data from the ID region, the read signal having the sufficient magnitude can be obtained and also the address information can be properly detected. As a result, the design specification of the system is fulfilled. In addition, the storage capacity of the system employing the disk with 1.8 inch diameter can be made equal to or larger than 500 M bytes by making the track density equal to or larger than 10kTPI. This magnetic disk storage system can record the moving picture for about one hour using the moving picture compression code of MPEG2, and hence the application thereof as the portable image/picture storage system is made possible.

<Embodiment 8>

In the present embodiment, the description will hereinbelow be given with respect to the magnetic disk storage system, described in the embodiment 1, in which the ID region 33 is offset from the center of the data region 33 in a radial direction of the disk, said system being characterized in that the shock resistance performance in the operation is made equal to or larger than 500G.

By enhancing the shock resistance performance in the operation, the reliability of the magnetic disk storage system can be greatly improved. In particular,

the phenomenon in which the system receives a shock from the outside during execution of the write operation such that the head is shifted from the objective data track to overwrite the data of the adjacent track is one of the significant causes by which the reliability of the magnetic disk storage system is extremely degraded.

In the conventional magnetic disk storage system, when carrying out the write operation, the waiting time period required for the settling vibration of the head to be sufficiently attenuated is inserted after the head seek has been carried out. In addition, in the no ID format, in which any ID region is omitted, disclosed in JP-A-05-174498 (corresponding to U.S. Patent No. 5,438,559), since the means for confirming that the head has been positioned in the objective sector is different from the processing method employing the conventional format shown in Fig. 8, in particular, there is the possibility that the waiting time period inserted into the write operation becomes long.

The format of the present invention is adopted, the ID information in the ID region 32 is confirmed prior to the write operation, and the shock resistance performance in the operation is made equal to or larger than 500G, whereby the room can be provided in the margin for the positioning accuracy. As a result, the excessive time period required for allowing for the margin for waiting for attenuation of the settling vibration is not required, and hence the seek time can

be shortened. From the above-mentioned reason, it is possible to provide the magnetic disk storage system including both the reliability of the data and the access performance which is superior to the system employing the conventional format example shown in Fig. 5.

In particular, in the magnetic disk storage system having the track density of 10kTPI or more which was described in the embodiment 7, the offset distance between the write element and the read element of the head becomes larger than the track pitch. Therefore, by combining the embodiment 7 with the present embodiment, it is possible to provide the higher performance magnetic disk storage system.

<Embodiment 9>

In the present embodiment, the description will hereinbelow be given with respect to the magnetic disk storage system, described in the embodiment 3, for reading the data from the ID region 32 and the data region 33 in the write operation and the read operation, respectively, to judge completion of the head seek, said system being characterized in that the ID address mark field 51 and the data address mark field 61 are formed using the codes different from each other.

In the magnetic disk storage system of the present invention, in the read operation, the data of the data region 33 is required, whereas the data of the ID region 32 is not required at all. Conversely, in the

write operation, the data of the ID region 32 is required, whereas the data of the data region 33 is not required at all. As a result, the positional offset relating to the arrangement of the ID region 32 and the data region 33 is allowed, and hence in the head position in the read operation, the data can not be basically properly read out from the ID region 32. But, if the skew angle between the slider and the data track fulfills the specific conditions on the basis of the angle of the actuator, the data may be properly read out from both the ID region 32 and the data region 33. In this case, there is required means for judging whether the read data corresponds to the ID region 32 or the data region 33. In the present invention, the address mark fields 51 and 52 which are added to the ID region 32 and the data region 33 are formed by the different bit streams, respectively, whereby if the address mark field in the read data stream has only to be referred, it is made possible to judge whether the read data corresponds to the ID region 32 or the data region 33. Heretofore, in the case where the two address mark fields are formed by the same bit stream, in order to judge whether the read data corresponds to the ID region 32 or the data region 33, the processing of managing the timing is carried out attendantly.

In the magnetic disk storage system of the present embodiment, a program on the CPU is used in a part of the above-mentioned processing. Firstly, the

data which has been read from the magnetic disk is temporarily transferred to a cache memory by the hardware. The CPU refers to the data stream on the cache memory in accordance with the self-contained program and reads the data corresponding to the address mark field. Then, the data thus read out is compared with the bit stream of the address mark field which is previously prepared, thereby judging whether the read data on the cache memory corresponds to the ID region or the data region.

In addition, a second embodiment can also be considered in which the above-mentioned series of processings are executed by the hardware. In this case, a circuit is configured which serves to make an address mark found (AMF) signal active when the read serial data is inputted to the shift register, and the serial data matches with the bit stream of the address mark field which is previously prepared, whereby the same processing as that of the above-mentioned embodiment can be realized. In this second embodiment, the burden on the CPU is reduced and the high speed processing is executed, whereby it is possible to provide the more preferable magnetic disk storage system.

<Embodiment 10>

In the present embodiment, the description will hereinbelow be given with respect to the magnetic disk storage system, described in the embodiment 3, for reading the data from the ID region 32 and the data

region 33 in the write operation and the read operation, respectively, to judge completion of the head seek, said system being characterized by stopping a part of the read circuit in the ID region 32.

The magnetic disk storage system of the present invention may provide that in the read operation, the data of the data region 33 is required, whereas the data of the ID region 32 is not required at all. Therefore, for a time period required for the read element of the head to pass through the ID region 32, the operation of a part of the read circuit is stopped and hence the mean power consumption of the system can be reduced by several %.

Now, the magnetic disk storage system including the magnetic disk with 2.5 inch diameter is made on an experimental basis, and then the mean power consumption of the system is measured. Firstly, when the read operation is carried out continuously as in the prior art example, the mean power consumption of the system is about 2.08 watt. Next, when the present invention is adopted, and the operation of the read circuit is stopped in the ID data field 32 during the read operation as described above, the mean power consumption of the system is about 1.97 watt. Therefore, it is possible to provide the more power saving magnetic disk storage system and hence it is possible to increase the continuous use time of the

portable information system supporting the battery drive.

<Embodiment 11>

In the present embodiment, the description will hereinbelow be given with respect to the magnetic disk storage system, described in the embodiment 3, for reading the data from the ID region 32 and the data region 33 in the write operation and the read operation, respectively, to judge completion of the head seek, said system being characterized by including a semiconductor memory for storing temporarily the read information.

According to the present invention, the means for judging that the head has been positioned in the objective sector is replaced by a different means in the write operation and the read operation, whereby the positional offset relating to the arrangement of the ID region 32 and the data region 33 is allowed and the high performance magnetic disk storage system is provided. In particular, in the read operation, it is confirmed that the address information of the objective sector matches with the address information contained in the data region 33 from which the data has been read, thereby judging whether or not the data is properly read from the objective sector. At this time, the ID data field 62 and the data field 63 are continuously contained in the read data, and for both the fields 62 and 63, the error correction is carried out by only one ECC field 64. In this connection, it is desirable from

a viewpoint of reliability of the information of the ID data field 62 that after completing the error correction by the ECC field 64, the information of the ID data field 62 is confirmed. However, the ECC field 64 is provided in the last of the data region, and hence the time when completion of the seek operation can be confirmed after completing the error correction by the ECC field 64 is approximately equal to the timing when the operation of reading the data from one sector has been completed. Delaying the confirmation of completion of the seek operation becomes the cause of degrading the access performance of the system.

The present embodiment is adopted and the semiconductor memory for storing temporarily the read data is provided, whereby even if completion of the seek operation is confirmed after the operation of reading the data from one sector has been completed, it is possible to prevent the access performance of the system from being degraded.

<Embodiment 12>

In the present embodiment, the description will hereinbelow be given with respect to the magnetic disk storage system, described in the embodiment 3, for reading the data from the ID region 32 and the data region 33 in the write operation and the read operation, respectively, to judge completion of the head seek operation, said system being characterized in that two

error check fields for error correction are provided in the data region, with reference to Fig. 7.

In the magnetic disk storage system shown in the embodiment 3, the address information of the ID data field 62 is confirmed, and it is judged that the seek operation has been completed after the operation of reading the data from the data region 33 has been completed. From a viewpoint of the performance of the magnetic disk storage system, it is preferable that the address information is confirmed at the early timing as much as possible. In order to attain that object, in the present embodiment, as shown in Fig. 7, in addition to the ECC field 72 corresponding to the conventional error detection code, a CRC field 71 is provided as a second error detection field relating to the ID data field 62. The structure of the data region 33 at this time includes two error correction codes as shown in Fig. 7. However, for those error correction codes, the same code schemes as those of the error correction which are called ECC and CRC do not need to be employed similarly to the above-mentioned example. Therefore, those error correction codes can be uniquely designed depending on the individual systems.

By adopting this structure, even if completion of the operation of reading the data from the data region 33 is not waited, it becomes possible that at a time point when the read operation for the ID data field 62 and the CRC field 71 has been carried out, the

address information of the ID data field 62 is confirmed and completion of the seek operation is judged. Since the ID information can be confirmed before the error check by the ECC field 72, the read processing can be more speedily executed and also it is possible to provide the high performance magnetic disk storage system which is excellent in the access performance.

In addition, since the error correction code dedicated to the ID data field 62 is provided, both detection and correction of the errors can be carried out independently in the ID data field 62. Therefore, the ability to correct the errors can be set to a level different from the data field 63. In particular, the bit length of the CRC field 71 is adjusted so as to strengthen the ability to correct the errors, whereby the address information of the ID data field 62 can be surely obtained and hence it is possible to provide the higher reliable magnetic disk storage system.

<Embodiment 13>

In the present embodiment, the description will hereinbelow be given with respect to the magnetic disk storage system for reading the data from the ID region 32 and the data region 33 in the write operation and the read operation, respectively, to judge completion of the head seek operation as described in the embodiment 3, said system being characterized in that the data is read from the data region with the output of the ID error signal in the head operation

fixed to off, or the output of the ID error signal disregarded.

The magnetic disk storage system adopting the format of the present invention is greatly characterized in that in the processing in the read operation, it is unnecessary to read the data from the ID region. In the case where the read operation is carried out by adopting the present invention, in many situations, as shown in Fig. 14, the position of the read element 120 of the head is offset from the center of the track of the ID region 32. In this positional relationship, when the read operation is carried out for the ID region 32 similarly to the conventional magnetic disk storage system, the possibility that the ID read error signal is outputted and the processing proceeds to the retry operation is increased due to the fact that the VCO synchronization field 50 can not de detected, the ID address mark field 51 can not be detected, the error correction by the CRC field 53 becomes impossible, the information of the ID data field 52 does not match with the address information of the objective sector, and so forth.

In order to prevent that phenomenon from occurring, in the magnetic disk storage system of the present embodiment, the ID read error signal is fixed to off during the read operation. As a result, since the controller can carry out the read operation for the data region 33 in succession, and the excessive retry

operation does not occur, the access performance of the magnetic disk storage system is improved. In addition, in the processing by the controller when the head is located in the ID region 32, the microprogram of the conventional controller does not need to be rewritten, and hence the present embodiment can be readily introduced into the products.

In addition, as a second embodiment for attaining that object, there can be considered a method wherein even in the case where the ID read error signal is outputted in the read operation, the output of the ID read error signal is disregarded and the read operation is carried out in succession. In this case, that method can be realized in such a way that the microprogram of the controller is rewritten so as not to fetch therein the ID read error signal in the read operation. In this second embodiment, since any circuit portion does not need to be changed, the second embodiment can be readily introduced into the products. In addition, since the retry operation due to occurrence of the ID read error can be suppressed, it is possible to provide the magnetic disk storage system which is capable of enhancing the access performance in the read operation.

As set forth hereinabove, according to the present invention, in the magnetic disk storage system employing the dual element head in which the write element and the read element are separately provided, the ID information dedicated to the write operation and

the ID information dedicated to the read operation are respectively provided, whereby both the arrangement error in lithography process in manufacturing the write element and the read element, and the errors of the positional offset between the write element and the read element, and the track due to inclination of the slider when carrying out the positioning using the rotary actuator can be corrected, and therefore, it is possible to realize promotion of the high performance of the magnetic disk storage system.

While the invention has been described in its preferred embodiments, it is to be understood that the words which have been used are words of description rather than limitation and that changes within the purview of the appended claims may be made without departing from the true scope and spirit of the invention in its broader aspects.



WHAT IS CLAIMED IS:

1. A magnetic disk storage system having at least one dual element head in which a write element and a read element are separately provided, and a disk in which a plurality of tracks are formed, wherein address information relating to write operation is provided in an ID region on the disk, at least address information relating to read operation is provided in a data region, and said ID region is arranged so as to be offset from said data region in a direction perpendicular to the track by the amount approximately equal to the positional offset distance between the write element and the read element of the head corresponding to the radial position of the disk and in a direction perpendicular to the track.

2. A magnetic disk storage system according to claim 1, wherein in the operation of writing data to said data region, the head is positioned so as for the position of the write element to match substantially with a center of said data region in the direction perpendicular to the track, and in the operation of reading data from data region, the head is positioned so as for the position of the read element to match substantially with the center of said data region in the track width direction.

3. A magnetic disk storage system according to claim 2, wherein the positional offset distance between the write element and the read element in the direction

perpendicular to the track is magnetically written on the disk surface or electrically written to a storage device self-contained in said magnetic disk storage system, and on the basis of the positional offset distance, the head is positioned.

4. A magnetic disk storage system according to claim 2, wherein the step of determining the offset distance between said ID region and the data region corresponding to the radial position of the disk and in the direction perpendicular to the track includes the step of recording a pattern on the disk incorporated in a product using the head incorporated in the product, and the step of carrying out the positioning for the pattern using the head incorporated in the product.

5. A magnetic disk storage system according to claim 1, wherein the data is written to a servo region (31) or said ID region every track or predetermined track in a servo track write process in factory of said magnetic disk storage system.

6. A magnetic disk storage system according to claim 1, wherein the data is previously written to said servo region or ID region in the form of a surface asperity of the disk, and the data is magnetically or optically read from the irregularity pattern.

7. A magnetic disk storage system according to claim 1, wherein said at least one dual element head includes at least one dual element head having the write element and the read element separately provided therein

and in which the read element is a giant magneto-resistive element made of magnetic multilayered films of at least double or more layers, and the track density of a radial direction of the disk in a plurality of tracks formed on the disk is equal to or larger than 10kTPI.

8. A magnetic disk storage system according to claim 1, wherein a shock resistance in the operation is equal to or larger than 500G.

9. A magnetic disk storage system having at least one dual element head in which a write element and a read element are separately provided, and a disk in which a plurality of tracks are formed, wherein the plurality of tracks are divided into a plurality of sectors, and each of the plurality of sectors has at least a data region and may have an ID region, and each of said ID region and said data region includes address information of the corresponding sector, and said ID region is arranged so as to be offset from said data region in a direction perpendicular to the track by the amount which is approximately equal to the positional offset distance between the write element and the read element corresponding to the radial direction of the disk and in a direction perpendicular to the track.

10. A magnetic disk storage system according to claim 9, wherein in the operation of writing data to said data region, the head is positioned so as for the position of the write element to match substantially with a center of said data region in the track width

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direction, and in the operation of reading data from data region, the head is positioned so as for the position of the read element to match substantially with the center of said data region in the track width direction.

11. A magnetic disk storage system according to claim 10, wherein the positional offset distance between the write element and the read element in the direction perpendicular to the track is magnetically written on the disk surface or electrically written to a storage device self-contained in said magnetic disk storage system, and on the basis of the positional offset distance, the head is positioned.

12. A magnetic disk storage system according to claim 10, wherein the step of determining the offset distance between said ID region and the data region corresponding to the radial position of the disk and in the direction perpendicular to the track includes the step of recording a pattern on the disk incorporated in a product using the head incorporated in the product, and the step of carrying out the positioning for the pattern using the head incorporated in the product.

13. A magnetic disk storage system according to claim 9, wherein the data is written to a servo region (31) or said ID region every track or predetermined track in a servo track write process in factory of said magnetic disk storage system.

14. A magnetic disk storage system according to claim 9, wherein the data is previously written to said

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servo region or ID region in the form of a surface asperity of the disk, and the data is magnetically or optically read from the irregularity pattern.

15. A magnetic disk storage system according to claim 9, wherein said at least one dual element head includes at least one dual element head having the write element and the read element separately provided therein and in which the read element is a giant magneto-resistive element made of magnetic multilayered films of at least double or more layers, and the track density of a radial direction of the disk in a plurality of tracks formed on the disk is equal to or larger than 10kTPI.

16. A magnetic disk storage system according to claim 9, wherein a shock resistance in the operation is equal to or larger than 500G.

17. A magnetic disk storage system in which a plurality of tracks are formed on a disk, the plurality of tracks are divided into a plurality of sectors, and each of the plurality of sectors has at least a data region and may have an ID region, said system comprising means for waiting for detection of said ID region after head seek in write operation and waiting for detection of said data region after head seek in read operation.

18. A magnetic disk storage system according to claim 17, wherein an ID address mark field representing the beginning position of data of said ID region, and a data address mark field representing the beginning position of data of said data region are formed using

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codes different from each other.

19. A magnetic disk storage system according to claim 17, further comprising means for stopping at least a part of the operation of a decoder circuitry to reduce the power consumption while a read element of the head is passed through said ID region in the operation of reading the data from said data region.

20. A magnetic disk storage system according to claim 17, further comprising a semiconductor memory having a storage capacity with which the data of at least two or more data regions can be stored, wherein the data which has been read from said data region is transferred to said semiconductor memory.

21. A magnetic disk storage system according to claim 17, further comprising a first error check field relating to an ID data field in the form of a data stream for correcting errors contained in said data region, and a second error check field relating to a data field.

22. A magnetic disk storage system according to claim 17, wherein in the operation of reading data from said data region, the output of an ID read error signal is fixed to off.

23. A magnetic disk storage system according to claim 17, wherein in the operation of reading data from said data region, when an ID error signal is outputted, the read operation is carried out in succession to read forcedly data from said data region.