METHOD OF HANDLING FRAGMENTED BLOCKS OF A DISK

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a method of handling fragmented blocks of a disk and particularly, though not exclusively, to such a method for allocating a spare area for disk defect management.

2. Description of the Related Art

In order to manage defects on a general recordable/rewritable disc, slipping replacement for skipping defects without providing logical sector numbers to the defects, is used for defects (primary defects) generated upon initialization of the disc, and linear replacement for replacing error correction code (ECC) blocks of an erroneous zone with normal blocks in a spare area, is used for defects (secondary defects) generated during use of the disc.

That is, slipping replacement is used to minimize a reduction in the recording or reproduction speed due to defects, in which a logical sector number to be provided to a sector which is determined to be defective during a certification process for inspecting defects of a disc when the disc is initialized, is provided to a sector next to the defective sector, that is, data is recorded or reproduced by slipping a sector where a defect is generated during recording or reproduction. Here, an actual physical sector number is shifted by the sector number designated by skipping the defective sector. Such a shifting-backwards phenomenon is solved by using as many sectors as there are defects in a spare area located at the end portion of a corresponding recording area (group or zone). According to the specifications, the position of a defective sector replaced by slipping replacement is prescribed to be recorded in a primary defect list (PDL) in a defect management area (DMA) on a disc.

Slipping replacement cannot be used for a defect which is generated while a disc is being used. When a defective portion is disregarded or skipped, discontinuity is introduced into the logical sector numbering, which means that slipping replacement violates file system rules.

Thus, linear replacement is used for defects generated during use of the disc, in which an ECC block including a defective sector is replaced by an ECC block existing in a spare area. The location of the defective block replaced by linear replacement is prescribed to be recorded in a secondary defect list (SDL) in a defect management area on a disc. When linear replacement is used, logical sector numbering is not interrupted. However, when there is a defect, the positions of sectors on a disc are discontinuous, and real data for a defective ECC block exists in a spare area.

Meanwhile, a digital versatile disc random access memory (DVD-RAM) according to the DVD-RAM standard version 1.0 is comprised of a plurality of groups each having a user area and a spare area which are constant in each zone. FIG. 1A is a half plan view of a disc showing a user area and a guard area and spare area, and FIG. 1 B one-dimensionally shows several zones on a disc. Each zone is comprised of a guard area, a user area, a spare area, and a guard area which are sequentially arranged.

A disc is segmented into zones to solve inaccurate recording due to a change in the speed of a spindle during recording and to use a zone constant linear velocity (ZCLV) method in order to increase the search speed with respect to a constant linear velocity method.

That is, when defects are managed by the linear replacement, linear replacement within a defective zone as possible increases the search speed since there is no change in the linear velocity of a disc. Thus, the DVD-RAM allocates a certain amount of spare area to each zone as shown in FIG. 1 B, to accomplish linear replacement.

In this existing defect management method, each zone acts as a group, and a spare area is allocated at the end of each group. Each group is managed as a defect management area. Also, since the start sector number of each group is predetermined, an ECC block is supposed to start at the start position of a zone which is a unit for physically segmenting an area.

The start logical sector number of each group is designated as described above. Thus, when defects are managed by slipping replacement, slipping replacement must be performed only within a corresponding group. In order to replace defects generated in a corresponding group using the slipping replacement, the number of defective sectors that are slipped must be less than the number of usable sectors in a spear area in the corresponding group. Accordingly, a restriction that a large defect generated in one group must be processed within the group limits the maximum size of a defect that can be replaced by the slipping replacement.

If the size of defects to be replaced by slipping replacement is greater than the size of a spare area in a corresponding group, a spare area in another group must be used by linear replacement. However, when linear replacement is used, defects are managed not in units of sectors but in, units of ECC blocks, that is, in units of 16 sectors. Thus, a spare area of 16 sectors is required to process one defective sector, which degrades the efficiency of defect management.

Also, a standard size of a spare area for defect management is predetermined, so that spare areas of the same size must be also allocated in applications to which defect management using linear replacement cannot be applied, such as real time recording. Therefore, the efficiency of area utilization of a disc is degraded.

SUMMARY OF THE INVENTION

The present invention therefore provides a method of handling fragmented blocks of a disk, including allocating a spare area for disk defect management, the method comprising; forming a group out of a plurality of zones on a disk, the group including a user data area including a data block; allocating a primary spare area for the group; and skipping a fragmented data units at the rearmost area of a zone when the data block is fragmented by a boundary between the plurality of zones.

Preferably, data blocks are reallocated from the beginning of the next zone after skipping the fragmented data units at the rearmost area of the zone.

BRIEF DESCRIPTION OF THE DRAWINGS

The above objects and advantages of the present invention will become more apparent by describing in detail a preferred embodiment thereof with reference to the attached drawings in which:

FIG. 1A is a half plan view of a disc having a user area, a guard area and a spare area, and FIG. 1B shows the one-dimensional structure of several zones of a DVD-RAM disc;

FIGS. 2A and 2B are views for explaining allocation of spare areas upon initialization according to the present invention, and FIG. 2C is a view for explaining allocation of spare areas during use after initialization;

FIGS. 3A and 3B are views illustrating the discontinuity of an ECC block within zones by a defective sector upon slipping replacement;

FIG. 4 is a flow chart illustrating a method of allocating spare areas during initialization according to an embodiment of the present invention; and

FIG. 5 is a flow chart illustrating a method of allocating spare areas during use after initialization according to an embodiment of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Spare areas on a disc for defect management according to the present invention include a primary spare area, a secondary spare area and a supplementary spare area.

The primary spare area is first allocated for defect replacement when a disc is initialized, and is first used for slipping replacement. The spare area remaining after slipping replacement can be used as a secondary spare area for linear replacement. The secondary spare area, for linearly replacing defects generated during use of the disc, denotes the area remaining after the primary spare area is used for slipping replacement during initialization. The secondary spare area can also denote a separately-allocated spare area. The supplementary spare area, for

linearly replacing defects generated while the disc is being used, denotes a spare area additionally allocated while a disc is being used after being initialized.

That is, in the present invention as shown in FIG. 2A, a plurality of zones on a disc forms a group, and a spare area (primary spare area) for slipping replacement is first allocated at the end of each group during initialization. The slipping replacement performs replacement in units of sectors, thus increasing the efficiency of utilization of the spare area. However, in the slipping replacement, defective areas are merely not used, and data starts being recorded in the next normal sector, so that the defective areas cannot be used after initialization.

During initialization, as much spare area as possible is allocated as the primary spare area for slipping replacement, but the primary spare area remaining after slipping replacement can be used as a secondary spare area for linear replacement. When it is determined that linear replacement cannot be sufficiently performed by using only the secondary spare area allocated within the primary spare area after slipping replacement is completed upon initialization of a disc, a secondary spare area for linear replacement is further allocated to zones in units of zones, as shown in FIG. 2B. The secondary spare area has no logical sector number, and information on the secondary spare area allocation is stored in and managed by a defect management area (DMA). The secondary spare area allocated during initialization is essentially disposed at the end of a zone, though the secondary spare area is not necessarily allocated in every zone. Since the spare area for linear replacement is allocated at the end of a zone, it is easily controlled. Also, since the spare area is controlled in units of a zone, a spare area in a zone closest to where a defect is generated can be easily found. Furthermore, modification of existing DMA information can be minimized.

The secondary spare area can be disposed before a guard area which is the last part of a zone. When the secondary spare area is disposed in each zone, its size can be predetermined as a relative size or an absolute size according to a numerical expression (for example, 3% of each zone).

While a disc is being used after being initialized, when a spare area for linear replacement allocated in units of zones is insufficient, a predetermined amount of supplementary spare area for linear replacement is allocated starting from the highest portion of a logical file area in a file system, as shown in FIG. 2C. During linear replacement, the supplementary spare area is used in reverse order starting from the rearmost of the logical file area, thus solving discontinuity of the logical file area.

Linear replacement is performed in units of ECC blocks, so that an entire spare area of an ECC block is used even when one sector is defective. In the linear replacement, a defective block is replaced by a physically-isolated spare area, so that the search speed is lowered when a defective zone is searched for. However, the linear replacement can respond to defects generated while a disc is being used, so that it is used with respect to secondary defects generated during use of the disc.

Just as much supplementary spare area as the size of an empty continuous area at the rear of the logical file area is allocated. The maximum size of the supplementary spare area must be smaller than the area of a final zone. Here, the logical file area denotes a logical area among the total area used in a file system, where a user data file can be recorded/reproduced.

In a disc having a diameter of 80mm, the radius of a user data area must be 38mm at the most since the 80mm-diameter disc is affected by rapid double refraction from around a 38mm radius due to injection of a disc.

When a spare area for slipping replacement is allocated at the end of a disc by forming a group out of a plurality of zones according to the present invention, a spare area having a size large enough to be processed in a group is allocated for, at most, 7679 items (for fifteen sectors), which are the maximum number of defects that are processed using a primary defect list (PDL). In this case, a spare area (a spare area used for controlling block positions) must be further allocated to prevent an ECC block from not starting at the start position of a zone due to the shifted-backwards phenomenon of the logical sector number at the boundary between zones caused by slipping replacement.

For example, when a disc applied to the present invention is a 1.46GB(Giga Bytes) DVD-RAM, a primary spare area allows PDL entries for eight sectors and 64 SDL entries to be processed, thus preventing the generation of a warning immediately after formatting due to a lack of primary spare area. Here, the warning level is generated when a spare area is smaller than 32 ECC blocks. Accordingly, more than 3% of each zone is allocated as a primary spare area in consideration of the number of defects generated in the spare area and the size of a spare area in each zone for preventing discontinuity of an ECC block.

A PDL entry that can be processed by the primary spare area corresponds to between one sector and eight sectors, and an SDL entry is for between one sector and eight sectors. A spare area for processing the PDL entry (S_{PDL}) and a spare are for processing the SDL entry (S_{SDL}) can be expressed by the following Inequality 1:

$$1 \leq S_{PDL} \leq 8 \qquad 1 \leq S_{SDL} \leq 8 \qquad \text{... (1)}$$

The shifted-backwards phenomenon of the logical sector number due to slipping replacement, which can occur at the boundary between zones, will now be described with reference to FIGS. 3A and 3B.

In a group formed of a plurality of zones as proposed by the present invention, when a defective sector exists in a zone #n as shown in FIG. 3A, remaining sectors not forming an ECC block unit are located at the end of the zone due to slipping replacement. When data is written to the remaining sectors not forming an ECC block unit, the shifted-backwards phenomenon of the logical sector number due to slipping replacement occurs at the boundary between zones, so that discontinuity of an ECC block can be generated at the boundary between zones as shown in FIG. 3B. That is, one ECC block can be located over two zones. In this case, problems can occur, in that a disc must be driven at different speeds to read or write one ECC block located over two zones, and a user area and a guard area must be separately processed since a physical

sector number is continuous between them. The guard area is a buffering area for preventing driving from becoming unstable due to the difference in the rotating speed between zones.

In the present invention, when less sectors than the number of sectors (16 sectors) for forming one ECC block remain at the end of a zone due to generation of defective sectors, they are not used and skipped. A size as large as expressed by the following Equation 2 must be allocated to a spare area used for controlling an ECC block to start at the start position of a zone in response to the shifted-backwards phenomenon of a logical sector number that may occur at the boundary between zones due to slipping replacement:

spare area for block position control = (number of zones - 1) **x** (number sectors for each error correction block - 1) ... (2)

In a DVD-RAM disc, an ECC block has 16 sectors, so that a maximum of 15 sectors can remain at the end of a zone if an ECC block does not start at the beginning of a zone. Remaining sectors at the end of each zone which do not form an ECC block, must also be skipped in order to match the start position of an ECC block with the start position of a zone, so that a spare area as large as the skipped sectors is further required. The number of boundaries between zones is obtained by subtracting one from the number of zones. That is, where there are two zones, the number of connection portions between zones is one, and where there are three zones, the number of connection portions between zones is two. A spare area for block position control which is as large as one ECC block, can be substantially allocated to each zone.

Thus, it is preferable that one disc has only one group for slipping replacement. In this case, a spare area for slipping replacement can be allocated at the end of the disc in consideration of the number of entries that can be processed using PDL and SDL, and the size of a spare area (here, a maximum of 32 ECC blocks) for controlling the start position of an ECC block on the boundary between zones.

In this way, a plurality of zones are set as one group, and a spare area for slipping replacement is allocated at the end of the group. Thus, degradation of the capability to cope with a burst error generated by a large scratch is suppressed due to the small size of a spare area allocated in each group when there are a plurality of groups each having a plurality of zones.

For example, in a disc of about 4.7GB capacity having one group in each zone, one group includes about 1600 tracks, and the width of each track on a physical disc is about lmm, as shown in FIG. 1A. When a scratch larger than lmm is generated on the disc in the radial direction, about 1600 sectors become defective. However, if a spare area forms a group in each zone and is allocated at a certain ratio according to the capacity of the disc, it is determined that only about 1100 sectors can be slipping-replaced at the inner circumferential portion of the disc. Hence, about 400 to 500 remaining sectors cannot be replaced by slipping replacement, and are replaced by linear replacement instead. In this case, about 400 to 500 ECC blocks for spare areas are required, and the performance of the disc at a zone where the corresponding defect is generated is greatly degraded. However, when a large spare area is allocated with respect to the entire disc for slipping replacement as proposed by the present invention, slipping replacement can even be performed with respect to such a large defect.

FIG. 4 is a flow chart illustrating a method of allocating spare areas to a disc during initialization according to an embodiment of the present invention. Referring to FIG. 4, when an initialization command is received in step S101, one group is formed of a plurality of zones of a disc in response to the initialization command, and a primary spare area is allocated at the end of the group, in step Sl02. That is, the primary spare area for slipping replacement includes a spare area for defect management with respect to 7679 data sectors (480 ECC blocks), where 7679 is the maximum number of defect management entries that can be processed using PDL, and a spare area (here, a maximum of 32 ECC blocks) for controlling the start position of an ECC block at each boundary between zones.

Meanwhile, in a 1.46GB DVD-RAM disc, the primary spare area can process PDL entries for 8 sectors and 64 SDL entries, and is allocated in further consideration of the spare area for block position control.

When the primary spare area is allocated, a determination is made with respect to the entire disc area as to whether a defect is generated, and a generated defect is replaced by slipping replacement using the primary spare area allocated at the end of the group, in step Sl03. Here, if the primary spare area allocated while the defect is being replaced by slipping replacement is insufficient, the corresponding disc is determined to be defective, and a step for generating an initialization error message can be further included to prevent the disc from being used.

When slipping replacement is completed in step S103, the portion of the primary spare area not used during slipping replacement is allocated to a secondary spare area for linear replacement, and when it is determined that there is insufficient secondary spare area within the primary spare area to perform linear replacement, secondary spare areas are further allocated to zones in units of zones, in step Sl04. Information associated with allocation of the secondary spare areas for linear replacement allocated to zones in units of zones, is stored in a defect management area (DMA) on the disc. When allocation of the primary spare area, and allocation of the secondary spare areas for linear replacement are completed, initialization is completed. It is preferable that the secondary spare area within the first spare area used for linear replacement, and the secondary spare area allocated to each zone are used in reverse order from the rearmost of the respective spare areas to unify a method of managing a supplementary spare area for linear replacement.

FIG. 5 is a flow chart illustrating a method of allocating spare areas while a disc is being used after it has been initialized, according to an embodiment of the present invention. When the size of the secondary spare area for linear replacement allocated during initialization of a disc is insufficient to replace defects generated during use of the initialized disc, a supplementary spare area for linear replacement is allocated.

In FIG. 5, a determination is made as to whether a supplementary spare area for linear replacement is required during use of the disc, in step S201. If it is determined that the supplementary spare area is required, a determination is made as to whether a sufficient amount of continuous empty area exists at the rear portion of a logical file area, in step S202. If it is determined in step S202 that a sufficient amount of continuous empty area exists at the rear portion of the logical file area, a supplementary spare areas of a predetermined size is allocated for linear replacement starting from the rearmost portion of the logical file area, in step S203, and the step S201 is again performed.

Allocation of the supplementary spare area corresponds to redistribution of a logical file area generated after initialization, so the help of a file system is required. In this case, the supplementary spare area for linear replacement is not allocated to each zone but can be allocated in the direction from the rearmost of a logical file area, that is, from an area having the highest logical sector number in a logical file area where files can be recorded for user data, to an area having a lower logical sector number. When a secondary defect is generated and is replaced by the thus-allocated supplementary spare area by linear replacement, the search speed is barely degraded, but generation of a logical sector number area in the logical file area, that the file system cannot use, can be prevented. That is, discontinuity of the logical sector number can be prevented.

In a defect management method for existing linear replacement, a defective ECC block must be replaced by the first normal ECC block that is not used among ECC blocks within a spare area, so that defective blocks within the spare area are not managed even while the spare area is used in sequence from the head and the defective spare area is skipped. However, in the case that blocks in the supplementary spare area are sequentially used from the head as in the existing method, a problem occurs when the supplementary spare area is further increased. That is, whenever the size of the supplementary spare area increases, information on the increased supplementary spare area must be separately managed. To solve this problem, blocks in the supplementary spare area are used in reverse order from the rear. Hence, if only the

highest sector number from which the supplementary spare area starts, and the lowest sector number are detected, the entire supplementary spare area can be continuously managed. That is, a recording and/or reproducing apparatus does not need to know how often a supplementary spare area of a predetermined size is allocated, and can manage the supplementary spare area only if the start and end positions thereof are recognized. However, the maximum size of the supplementary spare area must be smaller than a final zone.

If it is determined in step S202 that no sufficient continuous empty area exists at the rear of the file system, the empty areas are arranged by the file system or an application program, in step S204. Thereafter, a determination is again made as to whether a sufficient amount of continuous empty area exists, in step S205. If there is a sufficient amount of continuous empty area, the step S203 of allocating a supplementary spare area is performed. If the amount of continuous empty area is insufficient even after the arrangement of the empty areas, a message "supplementary spare area cannot be allocated" is displayed, in step S206. Then, the process is terminated. If it is determined in step S201 that a supplementary spare area is not required, the process is also terminated.

Meanwhile, a small spare area for defect management can be allocated in special applications such as real time recording or the like, linear replacement with respect to secondary defects is restrictedly made, and most defects can be processed by the file system or application program. Also, it is preferable that secondary defects are processed by the file system or application program upon real time recording in order to obtain a minimum of transmission speed required by a corresponding application.

In this case, the recording and/or reproducing apparatus is also required to detect defects and make minimum management with respect to the detected defects. Here, the minimum management means management using SDL as to whether a generated defect has been linearly replaced.

For example, for defects generated during, use of a disc that has defect management information in which defect management using linear replacement is not used for real time recording, only the start sector number of each defective block is recorded in a secondary defect list (SDL), information representing that the defective block has not been replaced is recorded in a forced reallocating masking (FRM) bit in an SDL entry representing whether the defective block has been replaced, and information representing that the defective block has not been replaced is recorded in the start sector number of a replaced block in the SDL entry.

Since the recording and/or reproducing apparatus cannot recognize defect contents processed by the file system or application program when a corresponding disc is again initialized and used for another purpose, it can reinitialize the disc in disregard of generated defects. Accordingly, fast formatting cannot be performed, where the secondary defects (stored in the SDL entry) are simply changed into a PDL entry and processed by slipping replacement, so that the recording and/or reproducing apparatus must manage defects even when the secondary defects are managed by the file system or application program. Therefore, the generation or non-generation of defects must be controlled in all cases using the SDL regardless of performance or non-performance of linear replacement and the existence or non-existence of a spare area for linear replacement.

As described above, the present invention removes a restriction on the maximum size of a defect that can be replaced by slipping replacement, without violating a restriction that even a large defect generated in a group must be processed within the group, so that more efficient slipping replacement can be made. Also, the size of a spare area can be appropriately adjusted according to an application purpose, so that the disc area can be more effectively utilized.

What is claimed is:

1. A method of handling fragmented blocks of a disk, including allocating a spare area for disk defect management, the method comprising:

forming a group out of a plurality of zones on a disk, the group including a user data area including a data block;

allocating a primary spare area for the group; and

allocating additional spare areas to skip the data block when the data block would be fragmented by a boundary between the plurality of zones.

2. The method of claim 1, further comprising utilizing the primary spare area in slipping replacement of the group.

3. The method of claim 1, further comprising allocating the additional spare areas when the fragmentation of the data block is caused by a shifted-backwards phenomenon of a logical sector number caused by slipping replacement of a zone within the group.

4. The method of claim 1, wherein the data block is an ECC data block.

5. The method of claim 1, wherein the boundary between the plurality of zones corresponds to a guard area of the disk.

6. The method of claim 1, wherein a total of additional spare areas for the entire block is equal to (number of zones-1)*(number of sectors for the data block-1).

7. The method of claim 6, wherein the data block has 16 sectors.

8. The method of claim 1, further comprising:

performing slipping replacement using the primary spare area; and

allocating a secondary spare area for linear replacement according to a size of an area of the primary spare area remaining after the primary spare area is used for slipping replacement.

9. The method of claim 1, further comprising:

allocating a supplementary spare area of a predetermined size utilized in linearly replacing secondary defects generated during use of the disc after an initialization of the disc, in a forward direction from a highest logical number of a logical file area of the disc.

10. The method of claim 9, wherein a size of the allocated supplementary spare area is smaller than a final one of the zones.

11. The method of claim 9, wherein a size of the allocated supplementary spare areas is as large as a continuous empty area at a rear of the logical file area.

12. The method of claim 9, further comprising allocating empty areas of the disc when there is an insufficient continuous empty area at a rear of the logical file area in allocating the supplementary spare area.

13. The method of claim 12, further comprising generating a message representing that the supplementary spare area cannot be allocated, if a size of the continuous empty area is insufficient, even after the arranging of the empty areas.

14. The method of claim 9, further comprising storing information associated with the allocation of the supplementary spare area in a defect management area of the disc.

15. The method of claim 14, wherein the information associated with allocation of the supplementary spare area includes information on start and end positions of the supplementary spare area.

16. The method of claim 9, further comprising using the supplementary spare area in reverse order from a rearmost of the logical file area allocated as the supplementary spare area.

17. The method of claim 1, further comprising:

determining that the disc is defective if an amount of the primary spare

area is insufficient while defects are being replaced by a slipping replacement; and

generating an initialization error message if the disc is determined to be defective.

18. The method of claim 1, further comprising allocating a secondary spare area in a zone for linear replacement of the data block, the data block corresponding to said zone.

19. The method of claim 18, wherein the secondary spare area is allocated in reverse order from a rearmost portion of the secondary spare area.

20. The method of claim 1, wherein said data block is skipped to the start position of a zone.

21. A method of handling fragmented blocks of a disk, which includes allocating a primary spare area for a group of zones of the disk, the method comprising:

allocating additional spare areas to a first zone to skip a data block to a second zone when the data block is fragmented between the first and second zones by a slipping replacement of the first zone.

22. The method of claim 21, wherein the fragmentation of the data block is caused by a shifted-backwards phenomenon of a logical sector number of the disc caused by the slipping replacement.

23. The method of claim 21, wherein the data block is an ECC data block.

24. The method of claim 21, wherein the boundary between the first and second zones corresponds to a guard area of the disk.

25. The method of claim 21, further comprising allocating a supplementary spare area of a predetermined size utilized in linearly replacing secondary defects generated during use of the disc after an initialization of the disc, in a forward direction from a highest logical number of a logical file area of the disc.

26. The method of claim 21, further comprising allocating a secondary spare area in one of the zones of the group of zones for linear replacement of an ECC block, the ECC block corresponding said one zone.

27. The method of claim 26, further comprising allocating the secondary spare area in reverse order from a rearmost portion of the secondary spare area.

28. The method of claim 21, wherein said skipping of a data to a second zone includes skipping the data block to a start position of the second zone.

29. A method of handling fragmented blocks of a disk, including allocating a spare area for disk defect management, the method comprising:

forming a group out of a plurality of zones on a disk, the group including a user data area including a data block;

allocating a primary spare area for the group; and

skipping fragmented data units at a rearmost area of a zone when the data block would be fragmented by a boundary between the plurality of zones.

30. The method of claim 29, wherein the method further comprises reallocating data blocks from the beginning of a next zone after skipping the fragmented data units at the rearmost area of the zone.