Brief Technical Information

Bad Block Management and Isolated in SSD

About Bad Blocks

Bad blocks are blocks that contain one or more invalid bits whose reliability is not guaranteed. Bad blocks may be present as below items: 1> the factory-generated bad blocks; 2> new developed during the lifetime of the devices; 3> false bad blocks misjudged by Controller due to abnormal power-off during operation.

A bad block does not affect the performance of valid blocks because it is isolated from the bit line and common source line by a select transistor.

Recognizing Bad Blocks

NAND Flash devices are supplied with all the locations inside valid blocks erased (FFh). The bad block information is written prior to shiping.

For single-level cell (SLC) small page (528-byte) devices, any block where the sixth byte/ first word, in the spare area of the first page does not contain FFh is a bad block.

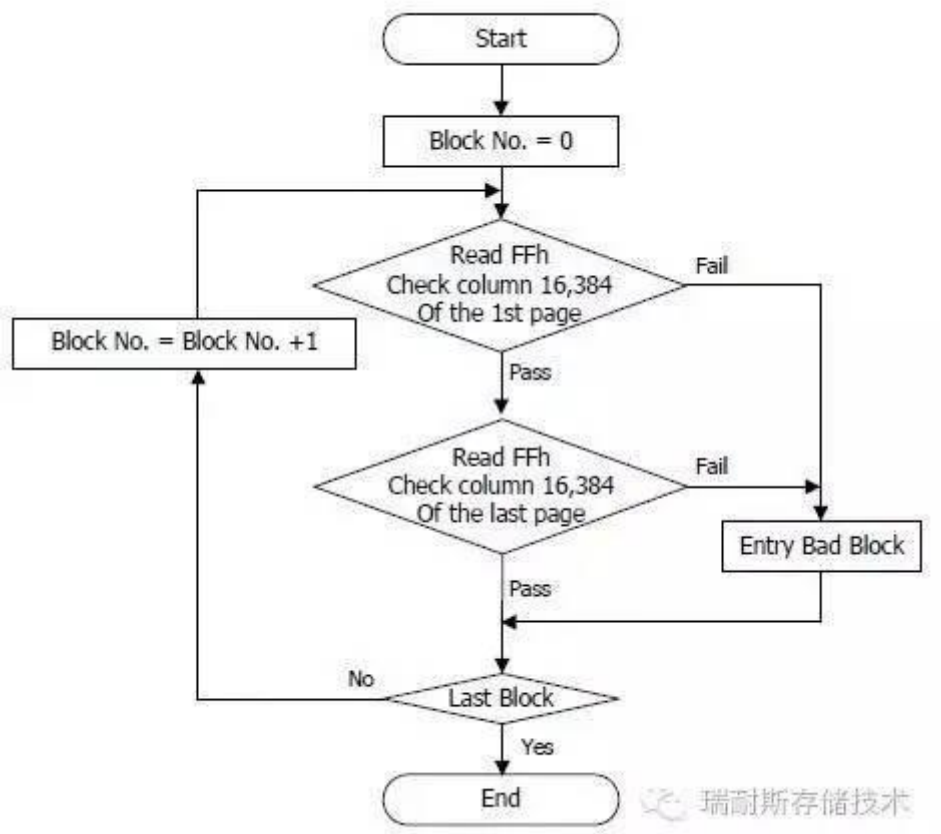
For SLC large page (greater than 2112-byte) devices, any block where the first and sixth bytes/ first word in the spare area of the first page does not contain FFh is a bad block.

For multilevel cell (MLC) devices, any block where the first byte in the spare area of the last page does not contain FFh is a bad block.

The bad block tale is created by reading all the spare areas in the NAND Flash memory. The bad block recognition methods that build the bad block table without using the original bad block information provided in the spare areas of the memory are not equally effective.

Once created, the bad block table is saved to a good block so that on rebooting the NAND Flash memory the bad block table is loaded into RAM. The blocks contained in the bad blocks table are not addressable. So, if the flash translation layer (FTL) addresses one of the bad blocks, the bad block management software redirects it to a good block.

Figure 1: Bad block Management Flow Chart (take one Flash from Hynix for example)



Bad block Management Method

The bad blocks are managed through building and updating the Bad Block Table (BBT). NAND devices have a status register that indicates whether an operation is successful. Additional bad blocks are identified when attempts to PROGRAM or ERASE give errors in the status register.

As the failure of a PAGE PROGRAM operation does not affect the data in other pages in the same block, the block can be replaced by reprogramming the current data and copying the rest of the replaced block to an available valid block.

Blocks can be marked as bad and new blocks allocated using two general methods:

- Skip block
- Reserve block

Slip Block Method

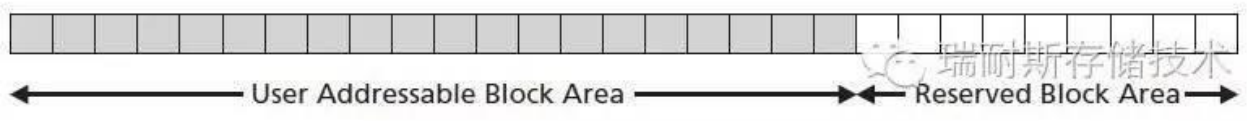
In the skip block method the algorithm creates the bad block table and when the target address corresponds to a bad block address, the data is stored in the next good block, skipping the bad block.

When a bad block is generated during the lifetime of the NAND Flash device, its data is also stored in the next good block. In this case, the information that indicates which good block corresponds to each developed bad block must also be stored in the NAND Flash device.

Reserve Block Method

In the reserve block method, the bad blocks are not skipped but replaced by good blocks by redirecting the FTL to a known free good block. For that purpose, the bad block management software creates two areas in the NAND Flash: The user addressable block area and the reserved block area (normally 2% of the total capacity) as shown in Figure 2.

Figure 2: Reserved Block Method



The FTL can use the user addressable block area to stone data whereas the reserved block area is only used for bad block replacement and to save the bad block table, which also keeps track of the remapped developed bad blocks.

Each time the FTL writes a logical sector, it calculates the physical address of the block to which it will write. Then, before the FTL starts writing, the bad block management software checks whether the block is bad or not. It if is bad, it returns the address of the good block to which the sector is remapped. If the block becomes bad during the Flash devices lifetime, the bad block management software remaps the bad block and copies the data it contains to the block that will replace it.

Bad Block Effect on drive's Read/Wrote Performance

The factory-generated bad blocks are isolated in bit line, which will not affect the performance of other blocks. But if the new developed bad blocks during lifetime of SSD achieve a certain amount, the usable blocks are reduced correspondingly, which results in increasing of garbage collection operation. Meanwhile, the decreased capacity of Over Provision also affects the efficiency of garbage collection. Therefore, the performance of SSD must be affected (degradation of performance) when bad blocks achieve a high amount, especially in continued programming operation.