Quality Comparison of SLC, MLC and eMLC.

Director of Engineer, InnoDisk

C.C. Wu
Agenda

• The features of SLC, MLC and eMLC.
  • Read, Write and Erase Time
• Read Bit Error VS P/E Cycle.
• Program/Erase Error VS P/E Cycle
• Bit Error with Power Cycling
<table>
<thead>
<tr>
<th></th>
<th>Read Page</th>
<th>Program Page</th>
<th>Erase Block</th>
<th>P/E Cycle</th>
<th>ECC</th>
</tr>
</thead>
<tbody>
<tr>
<td>SLC(5xnm) A</td>
<td>25us</td>
<td>200us</td>
<td>1.5ms</td>
<td>100,000</td>
<td>1Bit/512</td>
</tr>
<tr>
<td>SLC(4xnm) A</td>
<td>25us</td>
<td>250us</td>
<td>2ms</td>
<td>100,000</td>
<td>1Bit/512</td>
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<tr>
<td>SLC(3xnm) A</td>
<td>50us</td>
<td>500us</td>
<td>1.5ms</td>
<td>100,000</td>
<td>24Bits/1K</td>
</tr>
<tr>
<td>SLC(3xnm)</td>
<td>25us</td>
<td>230us</td>
<td>0.7ms</td>
<td>100,000</td>
<td>4Bit/512</td>
</tr>
<tr>
<td>SLC(2xnm)</td>
<td>35us</td>
<td>300us</td>
<td>0.7</td>
<td>100,000</td>
<td>8Bit/512</td>
</tr>
<tr>
<td>MLC(3xnm)</td>
<td>50us</td>
<td>900us</td>
<td>3ms</td>
<td>5,000</td>
<td>24Bits/1K</td>
</tr>
<tr>
<td>MLC(2xnm)</td>
<td>75us</td>
<td>1300</td>
<td>4ms</td>
<td>3,000</td>
<td>24Bits/1K</td>
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<tr>
<td>eMLC (3xnm)</td>
<td>50us</td>
<td>1600us</td>
<td>5.5ms</td>
<td>30,000</td>
<td>24Bits/1K</td>
</tr>
</tbody>
</table>
Flash test condition

- Test 2 to 5 blocks of each flash chip.
- The testing sample is not enough to approve flash quality.
- We just make comparison for different process of flash chip, but not going say the flash chip has such good quality according this report.
- 1K BCH16/24 ECC Engine for testing
Bit Error VS P/E Cycle
5xnm SLC (Brand A)

Error Bit

P/E Cycle

Spec. 100K

2M

Flash Memory Summit 2011
Santa Clara, CA

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Program Error VS P/E Cycle
5xnm SLC (Brand A)
Erase Error VS P/E Cycle
5xnm SLC (Brand A)

Erase Error

P/E Cycle

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Bit Error VS P/E Cycle
4xnm SLC (Brand A)
Program Error VS P/E Cycle
4xnm SLC (Brand A)
Erase Error VS P/E Cycle
4xnm SLC(Brand A)
Bit Error VS P/E Cycle
3xnm SLC (Brand A)

Error Bit

Spec. 100K

430K

P/E Cycle

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Monday, August 15, 2011
Program Error VS P/E Cycle
3xnm SLC (Brand A)
Erase Error VS P/E Cycle
3xnm SLC (Brand A)
Bit Error VS P/E Cycle
3xnm SLC (Brand B)

Error Bit

P/E Cycle

Spec. 100K

140K

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Bit Error VS P/E Cycle
2xnm SLC (Brand B)

Error Bit

P/E Cycle

Spec. 100K

60K
Program Error VS P/E Cycle
2xnm SLC (Brand B)
Erase Error VS P/E Cycle
2xnm SLC (Brand B)
Bit Error VS P/E Cycle  
3xnm MLC

Error Bit

Spec. 5K

50K

P/E Cycle

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Program Error VS P/E Cycle
3xnm MLC
Erase Error VS P/E Cycle
3xnm MLC
Bit Error VS P/E Cycle
3xnm eMLC

Error Bit

P/E Cycle

Spec. 30K

90K
Bit Error VS P/E Cycle
2xnm MLC

Spec. 3K

7K
Program/Erase Error VS P/E Cycle

• We get program/erase error with early bad block.
• We got every few program/erase error during testing.
SLC Quality (5x, 4x, 3x) in different process Brand A

Error Bit

370K/3x

1.7M/4x

5x

P/E Cycle
SLC Quality (3x, 2x) in different process Brand B

Error Bit

P/E Cycle

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MLC (3x, 2x) / eMLC (3x) Quality

Error Bit

P/E Cycle

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Bit Error of Power Cycling

- Cut the power while writing data to SSD
- The flash is MLC

Power Failure Error

Error Page

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Bit Error of Power Cycling

- Pair of page will be corrupted together

<table>
<thead>
<tr>
<th></th>
<th>Page1</th>
<th>Page2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0x26</td>
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<td>2</td>
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<td>0x11</td>
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<td>4</td>
<td>0x73</td>
<td>0x79</td>
</tr>
<tr>
<td>5</td>
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<td>0x61</td>
</tr>
</tbody>
</table>
Key of SSD’s quality

- A good ECC Engine to enhance SSD’s P/E Cycle.
- Select a good quality flash chip to extend SSD’s lifespan.
- Need a power cycling recover capability to cover MLC’s’s weakness.
• InnoDisk Corp. www.innodisk.com