Maximizing Cost Efficiency with True 16K LDPC for Advanced 3D NAND

MAO-RUEI LI, PhD.

Storage research Dept. Project Deputy Manager

Silicon Motion Technology Corp.

FMS the Future of Memory and Storage

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Agenda

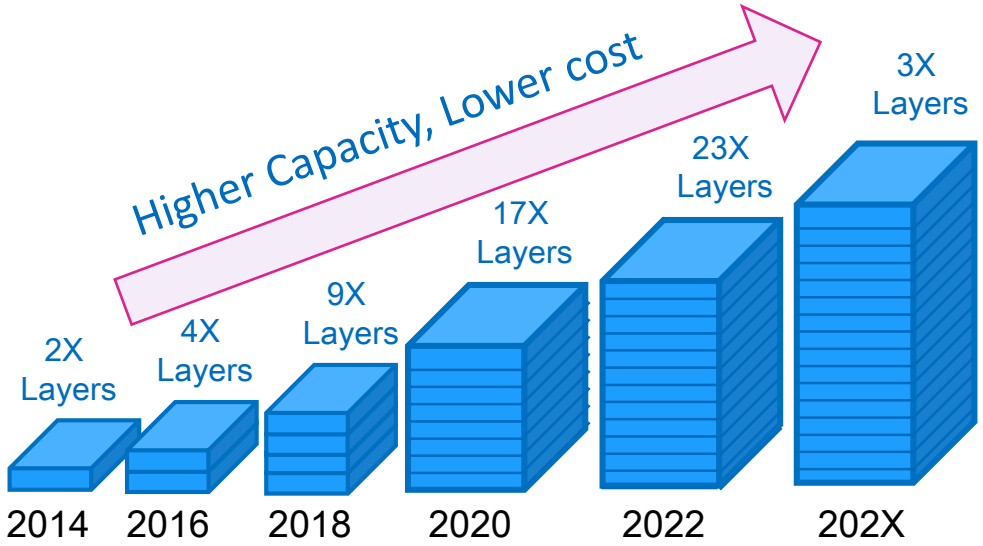
- Background
  - ✓ NAND Development
  - ✓ Challenges of 16K LDPC
- SMI's Solution of 16K LDPC
  - ✓ CoCo Technique
  - ✓ Feature and Performance
- Summary

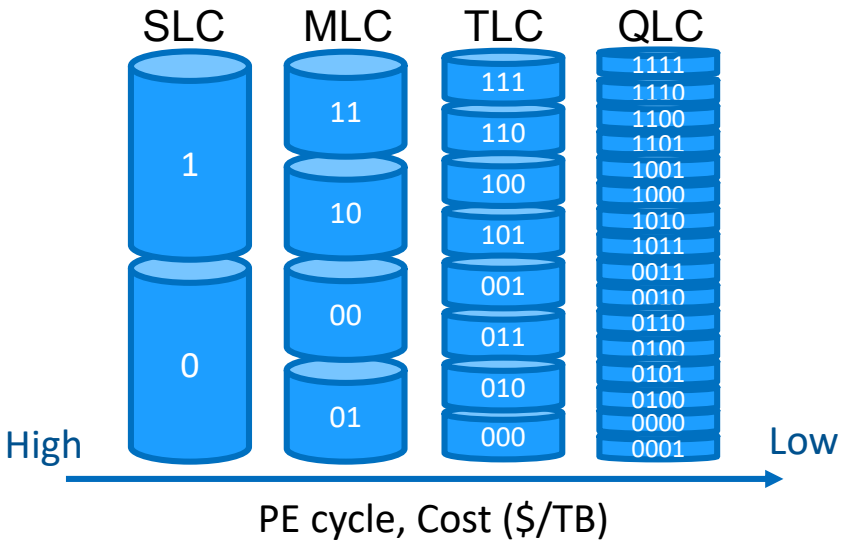
NAND Flash Develop

- 3D NAND: More layers, More innovation, More advanced
- Challenge:

  Density vs Reliability

- SMI provide
  - ✓ Better error recover algorithm
  - ✓ Advanced error correcting code



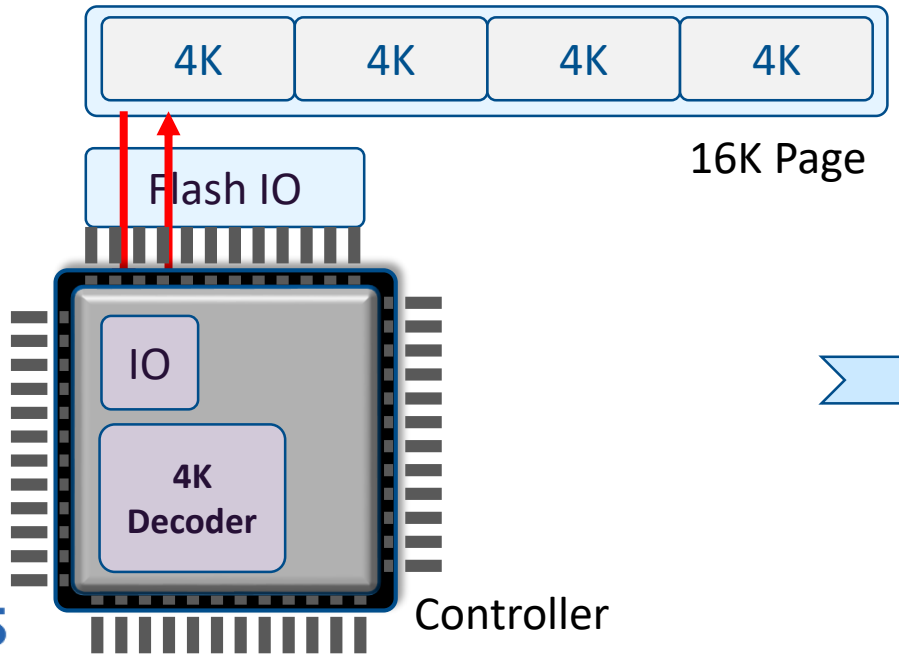


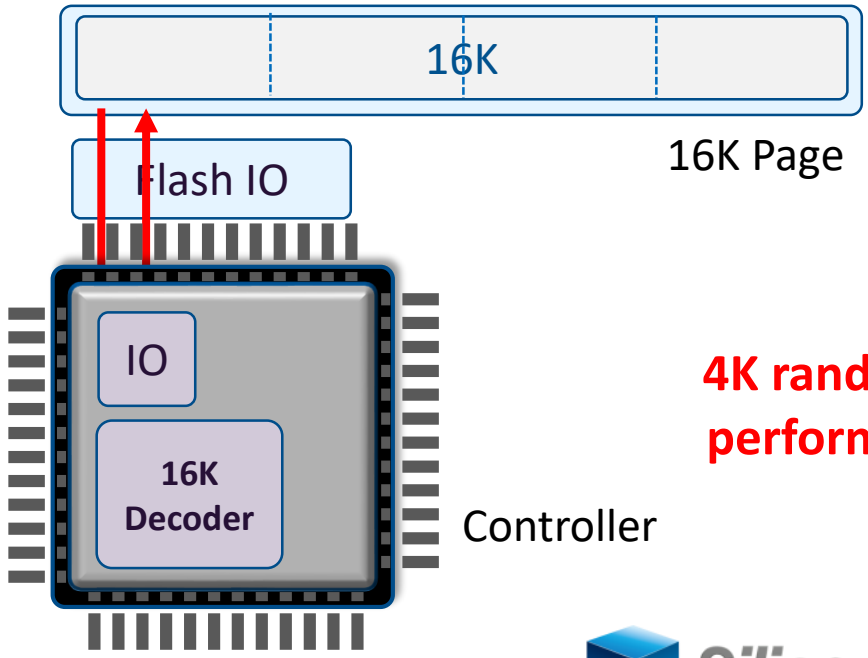
About 16K LDPC

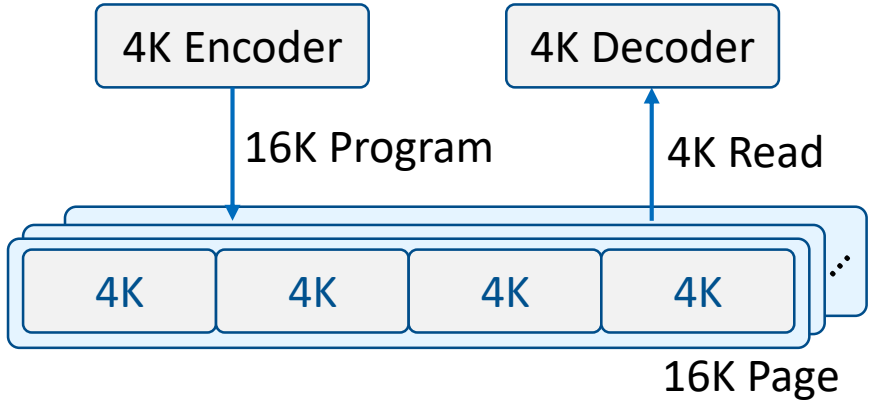
- LDPC: longer codelength greater decoding performance
- Is a 16K LDPC worth adopting in SSD system?
- 16K LDPC Challenge:

Challenges of 16K LDPC

- LDPC: longer codelength greater decoding performance
- Is a 16K LDPC worth adopting in SSD system?
- 16K LDPC Challenge:
  - ✓ Common situation: 4K read/ write with a 16K page size



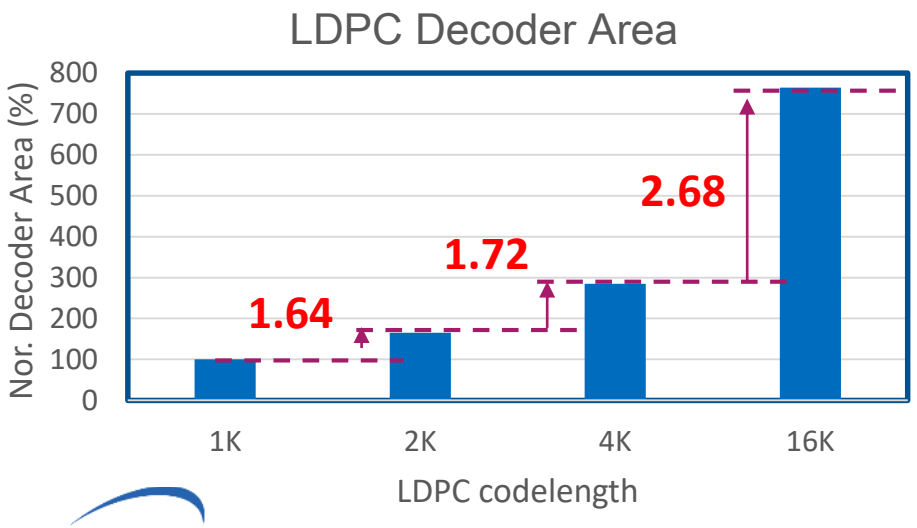


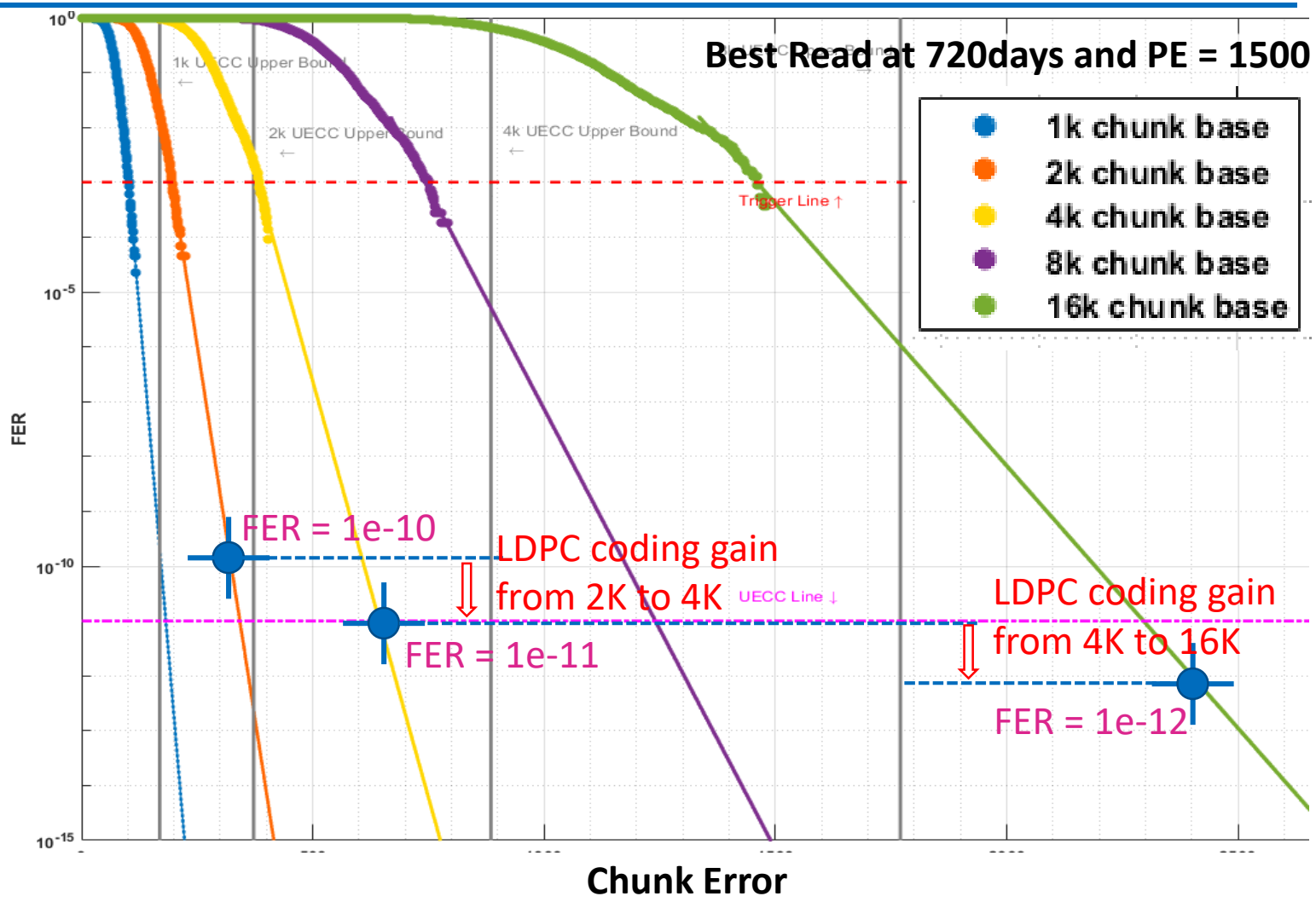


4K random read performance ↓

Challenges of 16K LDPC

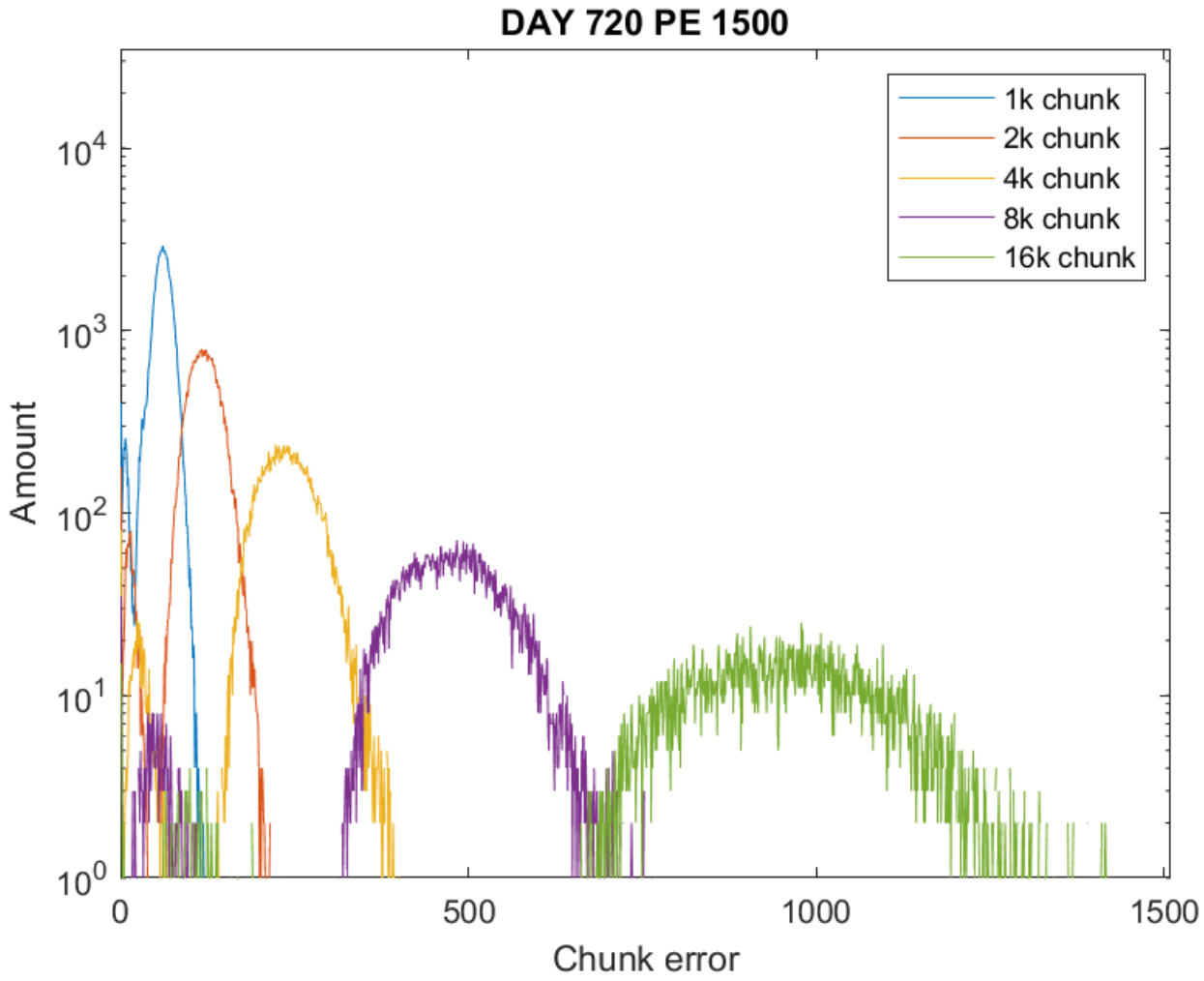
- 16K LDPC Challenge:
  - ✓ Common situation: 4K read/ write
  - ✓ Limited benefit for 16K LDPC compared to 4K LDPC
    - ➢ coding gain vs area





Challenges of 16K LDPC

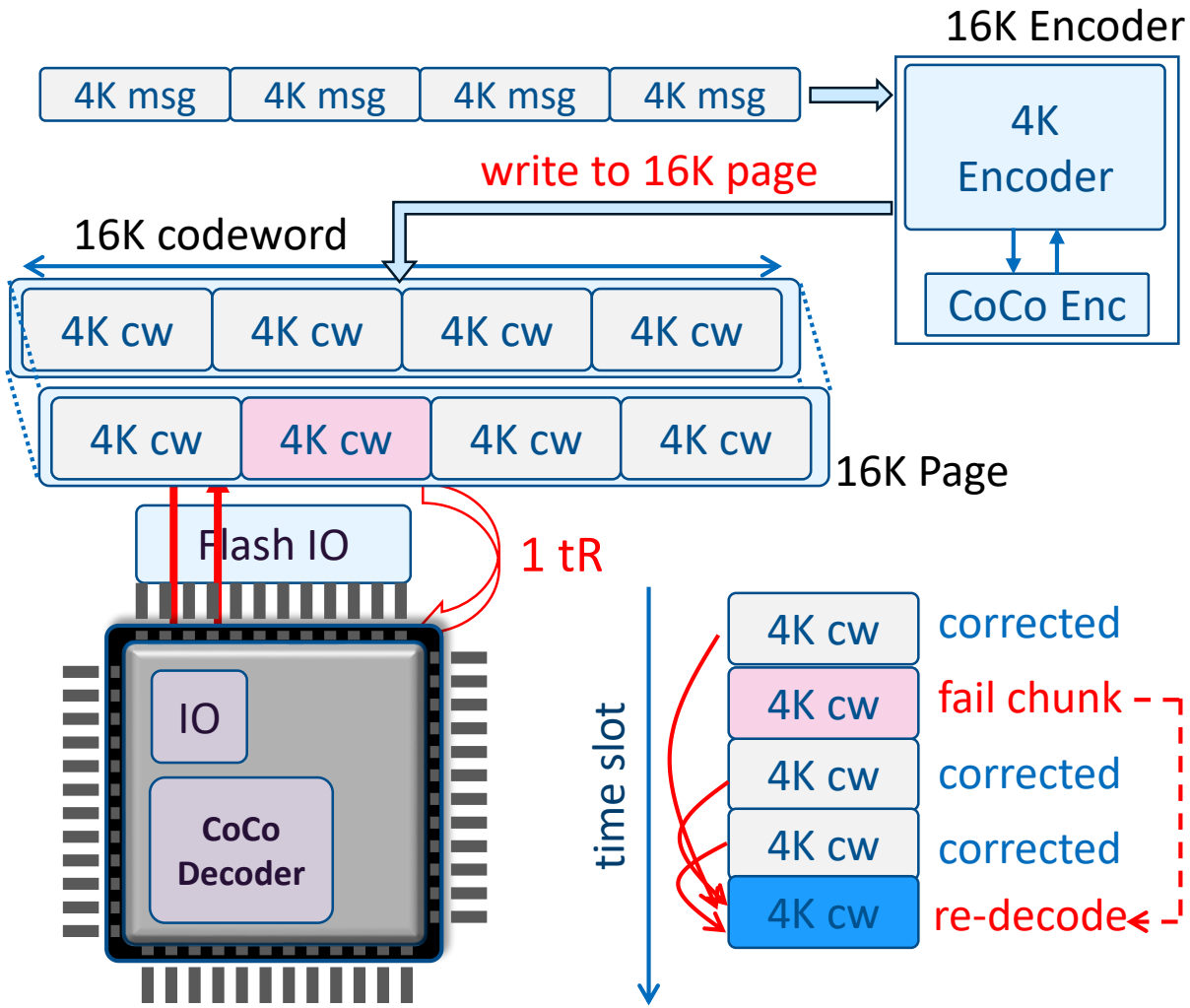
- 16K LDPC Challenge:
  - ✓ Common situation: 4K read/ write
  - ✓ Limited benefit for 16K LDPC compared to 4K LDPC
  - ✓ Ununiformed error distribution



CoCo
(Collaborative Codeword)

CoCo Technique Features

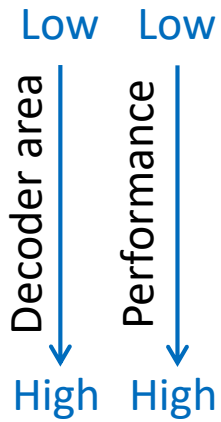
- **Concept:** The corrected chunks provide some information to help re-decode failed chunks
- **Code structure:** Four 4K codewords compose a 16K codeword
- Important features:
  - ✓ Good performance in random 4K read/write condition.
  - ✓ Decoding performance can approach that of a real 16K decoder
  - ✓ Complexity of the decoder is similar to that of a 4K decoder

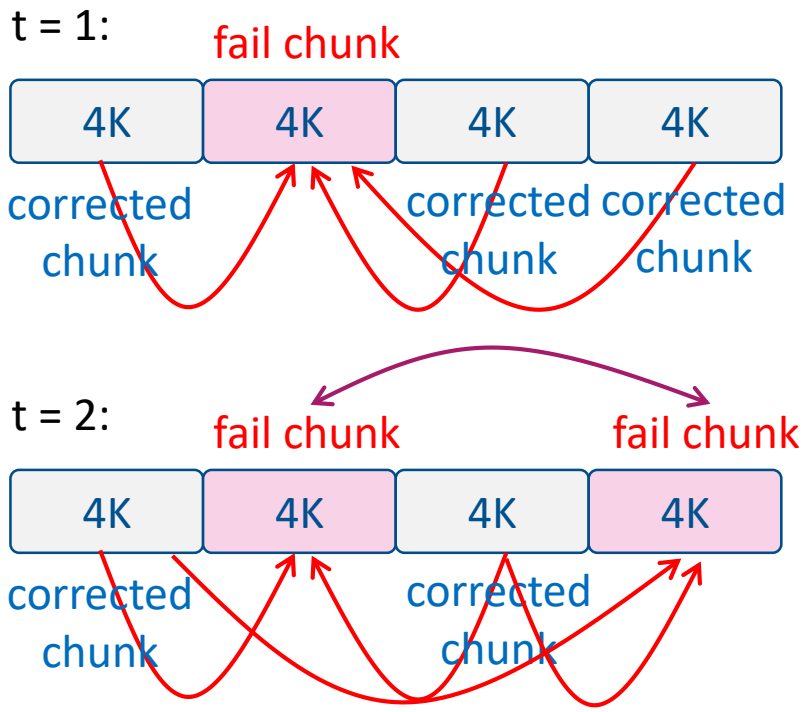


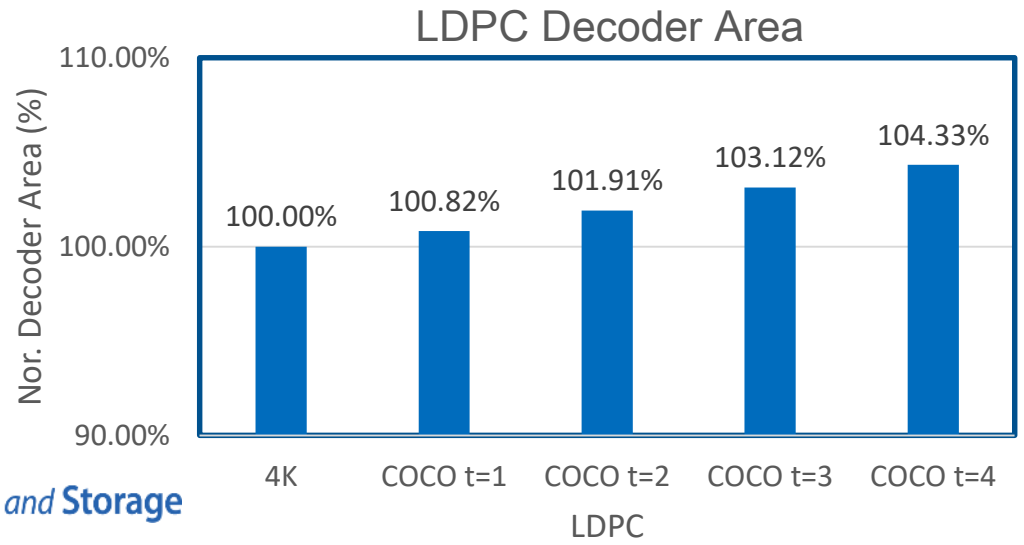
CoCo Technique

- 4 types in CoCo

Case	Description
t = 1	one chunk fail, and other are corrected
t = 2	two chunks fail, and other are corrected.
t = 3	three chucks fail and one chunk decode pass.
t = 4	four chunks can be failed.

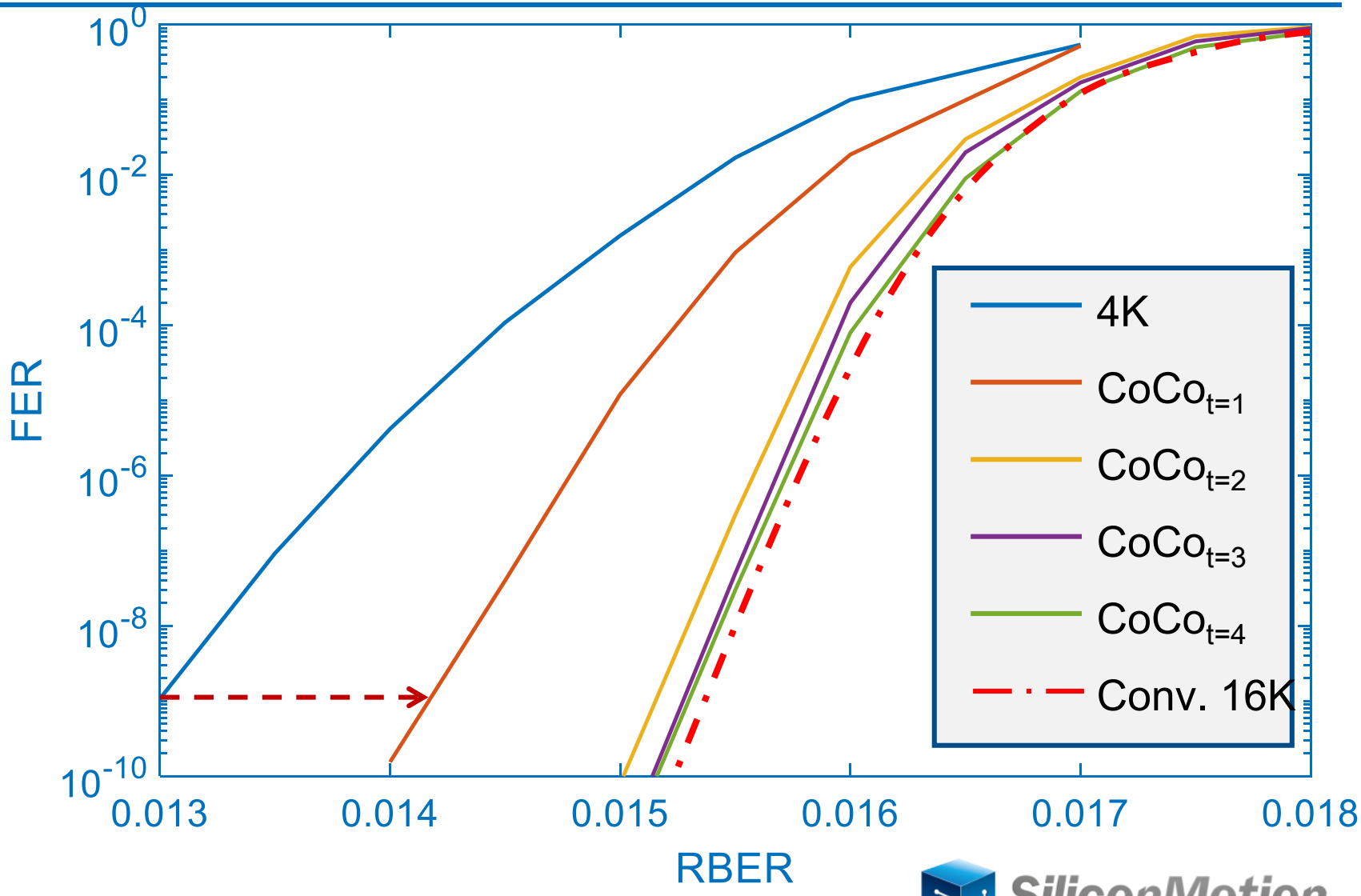






Decoding Performance Comparison

- Summarize CoCo:
  - ✓ Sweet spot @ $CoCo_{t=2}$
  - ✓ Best performance: $CoCo_{t=4}$
  - ✓ lowest complexity: $CoCo_{t=1}$



Summary

- 16K LDPC has a better decoding performance, but
  - ✓4K read performance may be decreased.
  - ✓it requires much more complex calculations.
- SMI develops the CoCo technique to balance LDPC performance and complexity.
  - ✓Support the fast 4K decoding
  - ✓Approaches to 16K decoding performance.
  - ✓The area complexity is similar to the 4K decoder.

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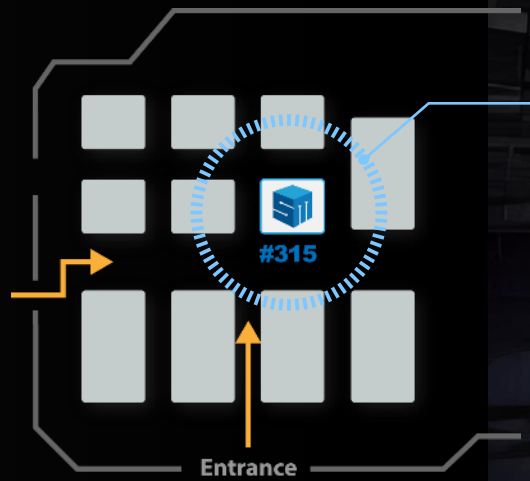

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