# Generalized Concatenated Codes for Flash Memories

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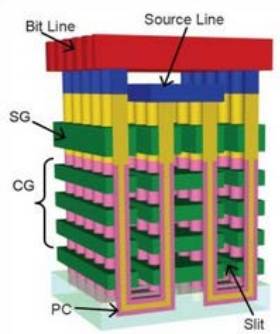
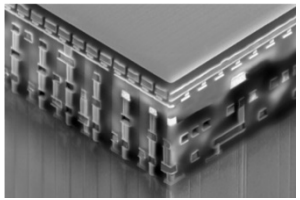
# Outline

- Standard ECC Options for Flash
  - BCH
  - LDPC
- Generalized Concatenated (GC) Codes
  - Introduction
  - GC codes based on LDPC for Flash
  - Simulation results
- Summary

# Storage Technology is Improving

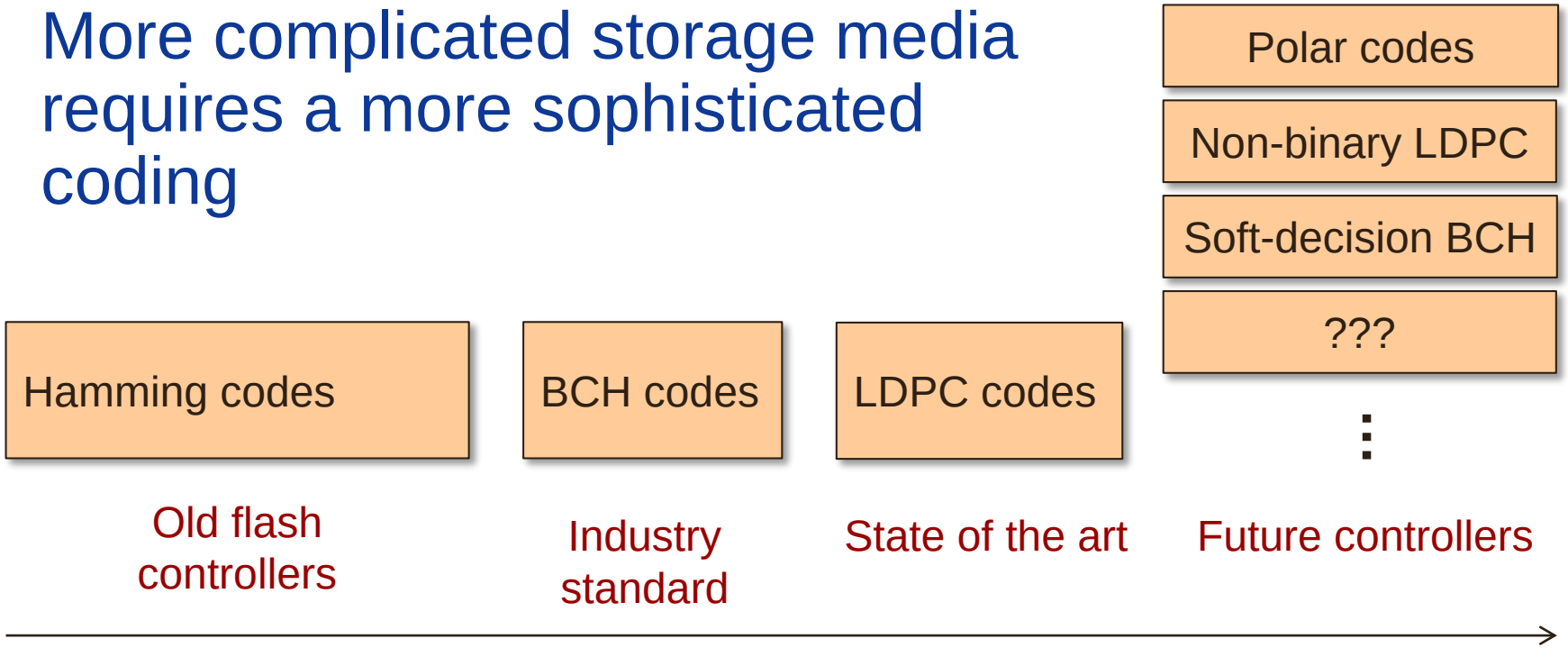
- New types of storage media:
  - 3D NAND, RRAM, MRAM, PCM, …




# Coding is More Important

More complicated storage media requires a more sophisticated coding

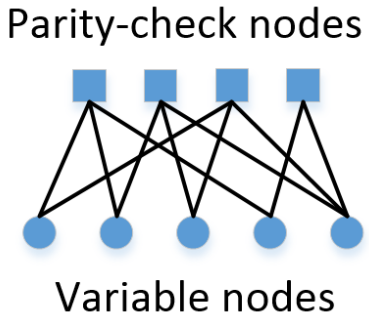


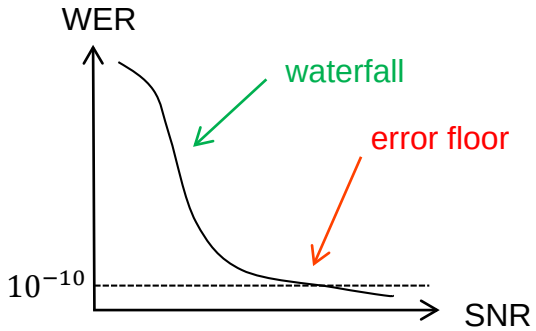
# BCH Codes

- Introduced more than 50 years ago
- Very well studied
  - Analytically predictable performance
  - Efficient algebraic encoder/decoder
- Wide range of rates and code word lengths
- Guaranteed error correction capability

# LDPC Codes

- Almost the same age as BCH
- Gained a significant attention only recently
- Efficient soft-decision decoding
- Small guaranteed error correction capability



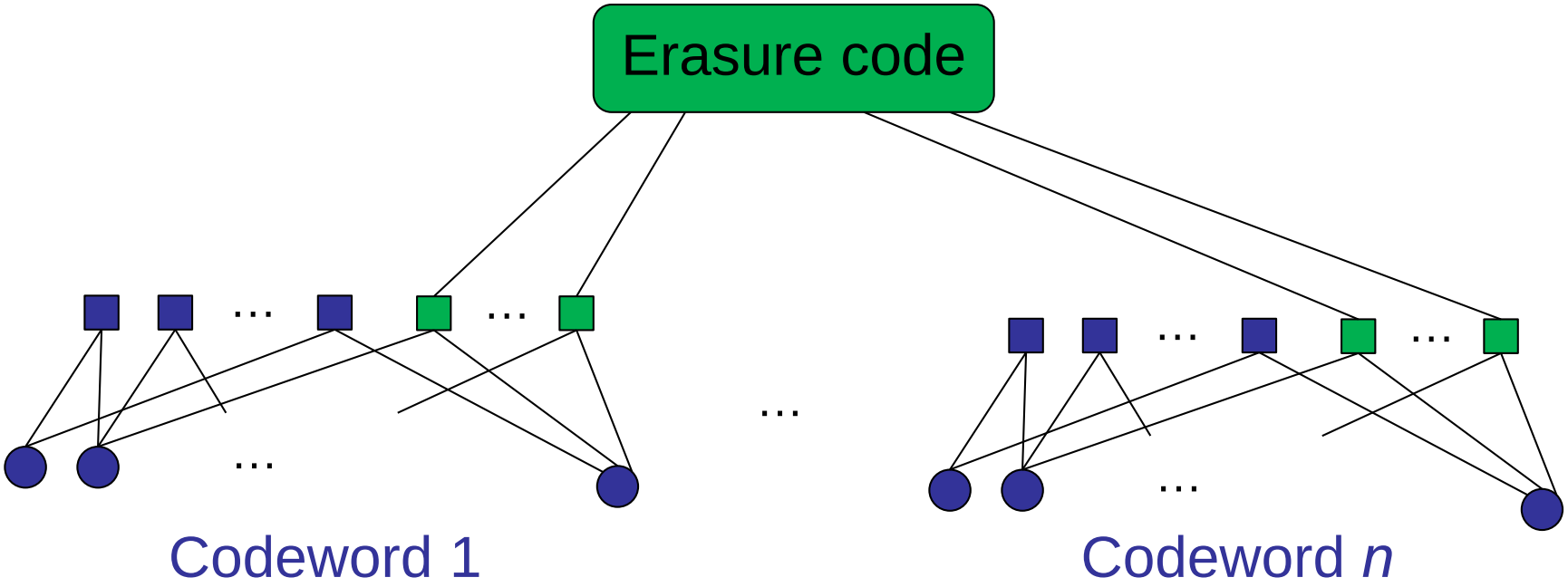
# BCH vs LDPC for Flash

| BCH | LDPC |
| --- | --- |
| **Pros:**<br>▪ Easy to support a wide range of rates & length (no ROM)<br>▪ Beat high rate LDPC in the error floor region for BSC | **Pros:**<br>▪ Large family of codes (need to find the good ones)<br>▪ Excellent waterfall performance<br>▪ Soft-decision friendly |
| **Cons:**<br>▪ Hard-decisions<br>▪ Waterfall performance | **Cons:**<br>▪ Error floors<br>▪ Large memory |

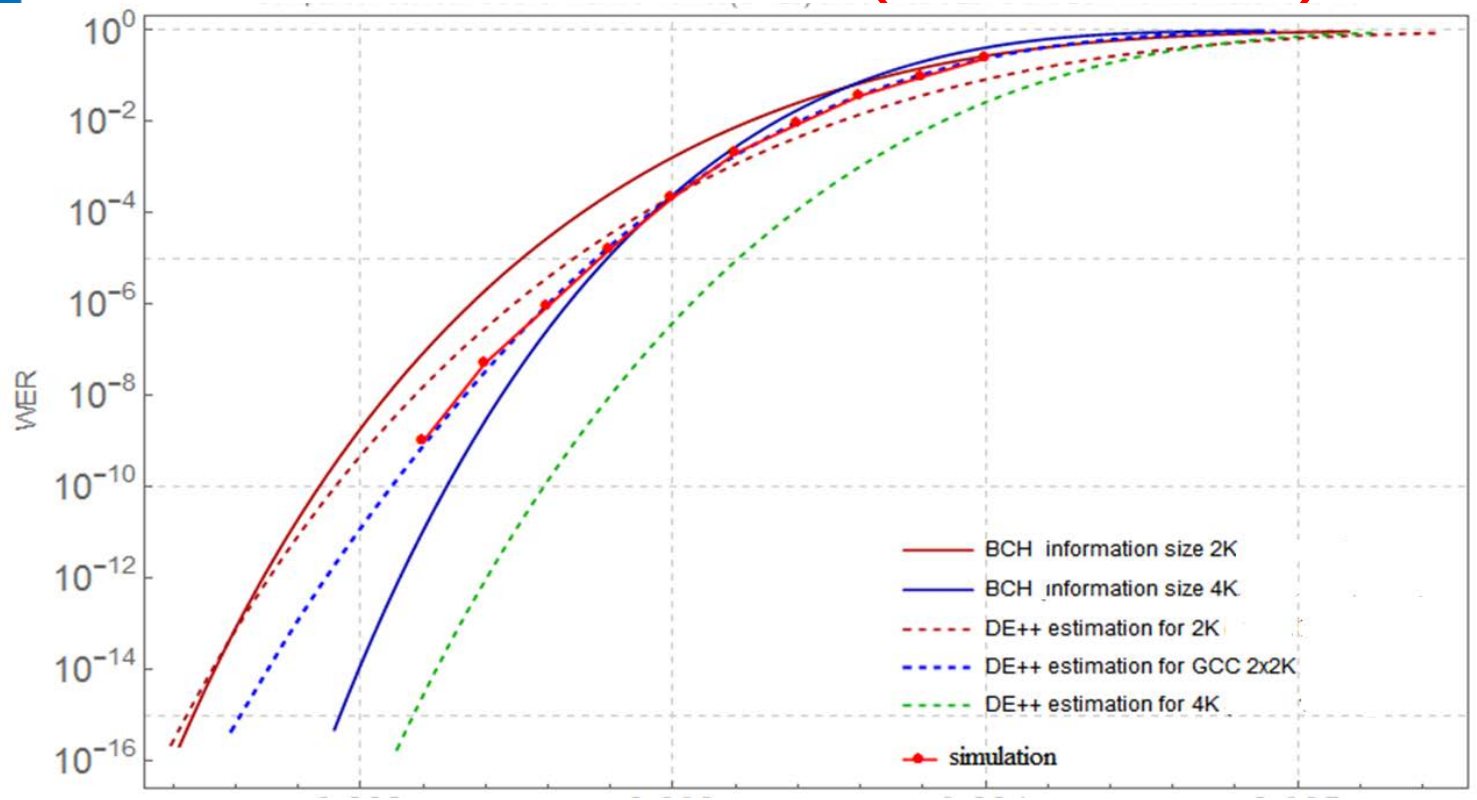
# Generalized Concatenated Codes

- Concatenated codes (Forney, 1966)
- Generalized concatenated (GC) codes (Blokh and Zyablov, 1974)
- Error location (EL) codes (Wolf, 1965)
- Generalized error location (GEL) codes (Zyablov, 1972)

# LDPC-based GC codes



# Simulation Results (2x2K GCC)



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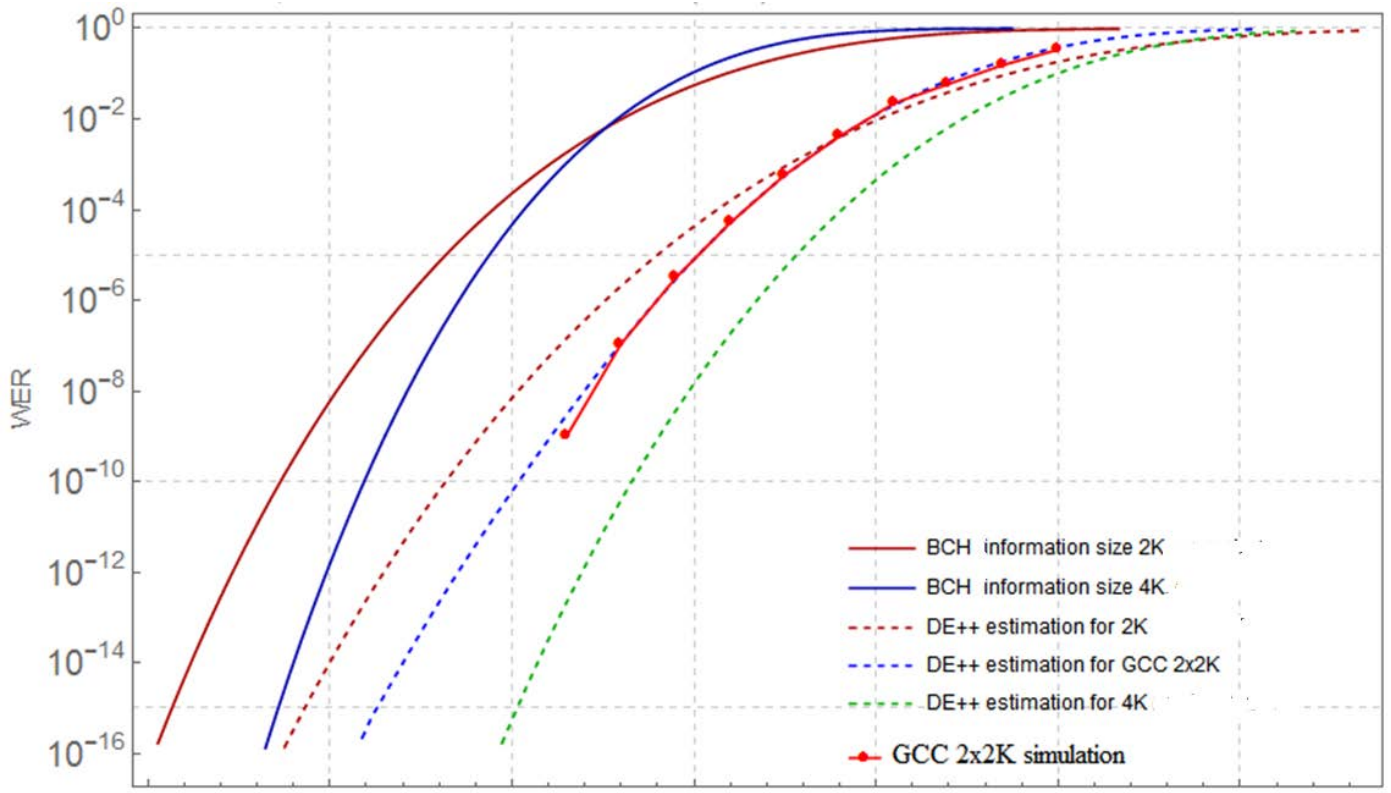

# Summary

- New GC code based on LDPC
- Better UBER with the same complexity
- Better error-floor
- Soft sensing support


# Thank you!