



Flash Memory Summit



# Is 3D NAND the Right Technology for Removable Devices?

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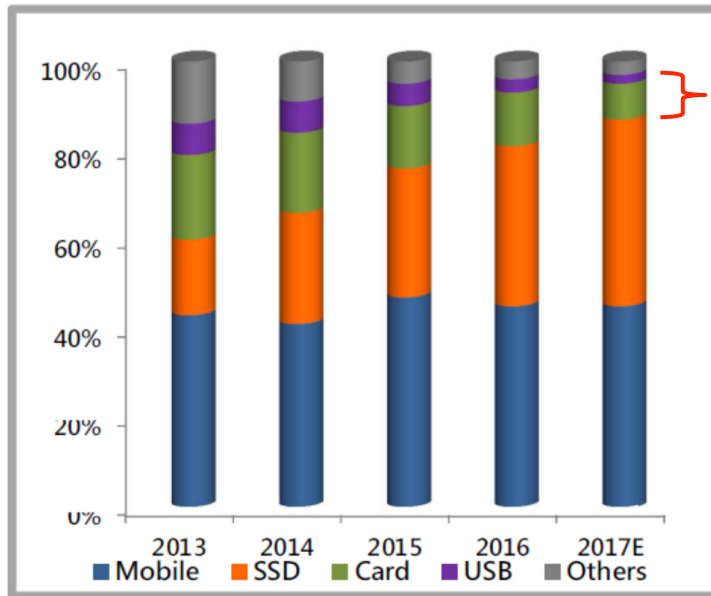
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# Agenda

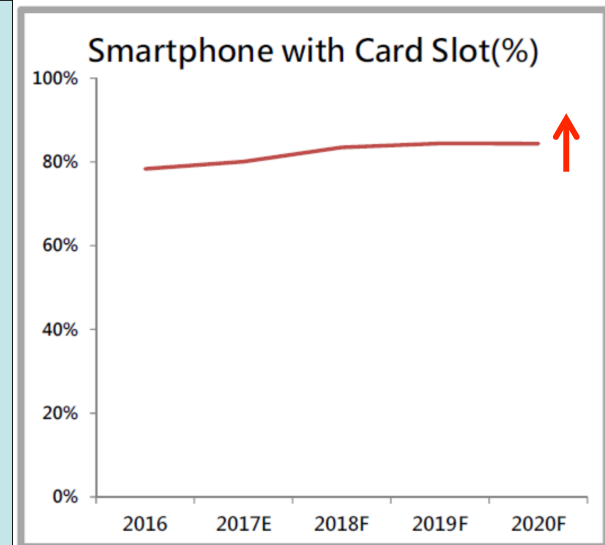


- Global NAND memory demands by products
- Removable V.S Other devices
- Consumer V.S Industrial products
- Challenges of adopting 3-D NAND in Removable devices
  - Endurance and ECC requirements
- Technology Migration and Consistency in Reliability
- Operation mode & Corresponding Test
- WHEN? 3-D NAND Adoption
- Take away

# Global NAND Memory Demands by Products



USB Drive ↓  
 Memory card ↓  
 Smartphone with Card Slot % ↑  
 Memory card: removable & extended memory: Android Marshmallow (or higher) allows Saving and running apps on a card





## Removable V.S. Other Devices

|                         | Removable Devices    | Others         |
|-------------------------|----------------------|----------------|
| Dimensions              | <b>Smaller</b>       | Larger         |
| External DRAM           | <b>No</b>            | Yes (Optional) |
| Capacitors              | <b>Limited Space</b> | More space     |
| Required capacity       | <b>Smaller</b>       | Larger         |
| Performance             | <b>Slower</b>        | Faster         |
| Power consumption       | <b>Lower</b>         | Higher         |
| Cost (price)            | <b>Lower</b>         | Higher         |
| Controller FW Algorithm | <b>BCH ECC</b>       | LDPC (new)     |
| Replacement/Rework cost | <b>Lower</b>         | Higher         |



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# Consumer V.S Industrial Applications





# Consumer V.S. Industrial applications

| Requirements   | Industrial Application  | Consumer Electronics  |
|--|-------------------------|-----------------------|
| Density  | Smaller (<32GB)         | Larger                |
| Project longevity                                    | Long (3~5 years)        | Short (1~2 years)     |
| Validation period                                    | Longer                  | shorter               |
| Data Integrity<br>(Data retention / read disturb...) | Important               | Less concerned        |
| Power failure protection                             | Important               | Less concerned        |
| Performance  | Consistence             | Faster                |
| Price  | Total cost of ownership | Unit price is the key |
| Endurance TBW  | Normal                  | Depends...            |

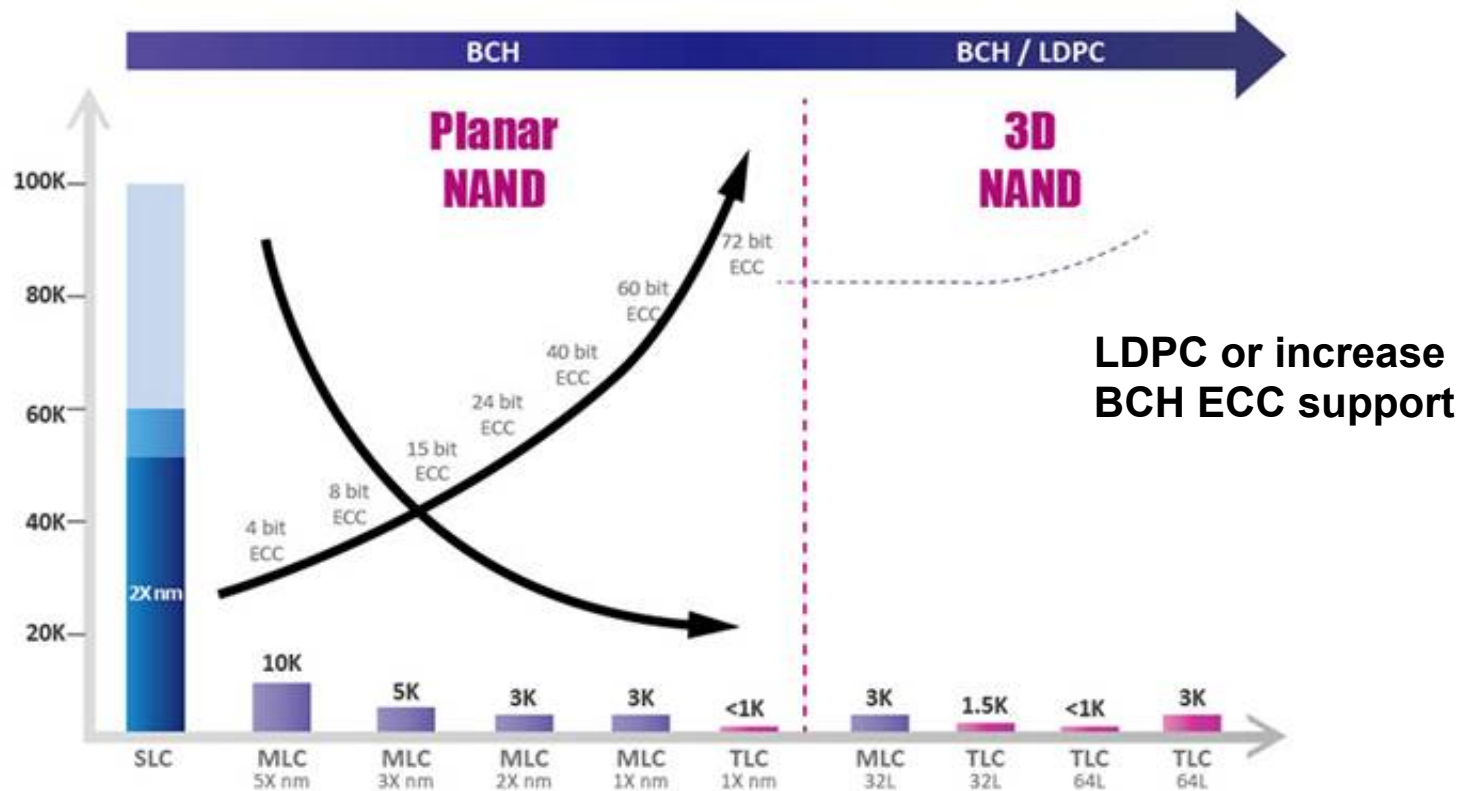
# Challenges of adopting 3-D NAND in Removable devices



- Cost
  - Smaller density product with lower unit price don't need LDPC controller which accounts higher % of BOM cost.
  - 3-D NAND 128Gbit and below don't have cost advantages
- Technology
  - \*Based on BCH ECC, 3-D TLC 10% of 2-D MLC Endurance
  - \*Read disturb: 3-D TLC 15% of 2-D MLC read cycles
  - \*Data retention: 100% P/E cycles 1 year @ low temp.
  - SPOR is at higher risk when programming larger data size and there is limited space to add external DRAM or capacitors in removable devices



# Endurance and ECC requirement







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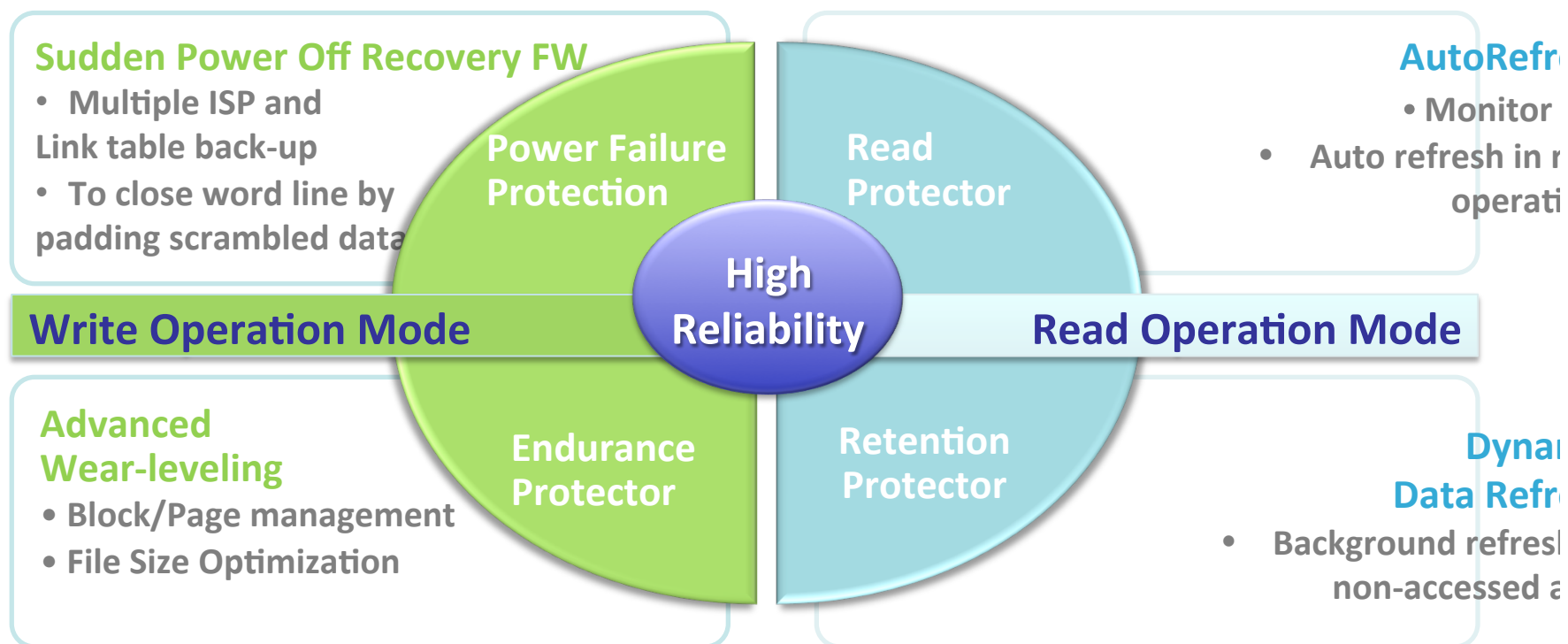
# Technology Migration and Consistency in Reliability



- **Product Spec is not compromised?**
  - Identical Test Condition
- **Mission Profile**
  - Simulate user environment & application
    - e.g. Temperature profile, performance, product longevity, data retention, sudden power-off cycles...
- **Joint validation**
  - Test removable devices with host device
- **3-D pseudo MLC or pseudo SLC**
  - Considering supply (mainstream), reliability, performance, endurance..
  - This could be the option if there is cost advantage compared to 2-D NAND

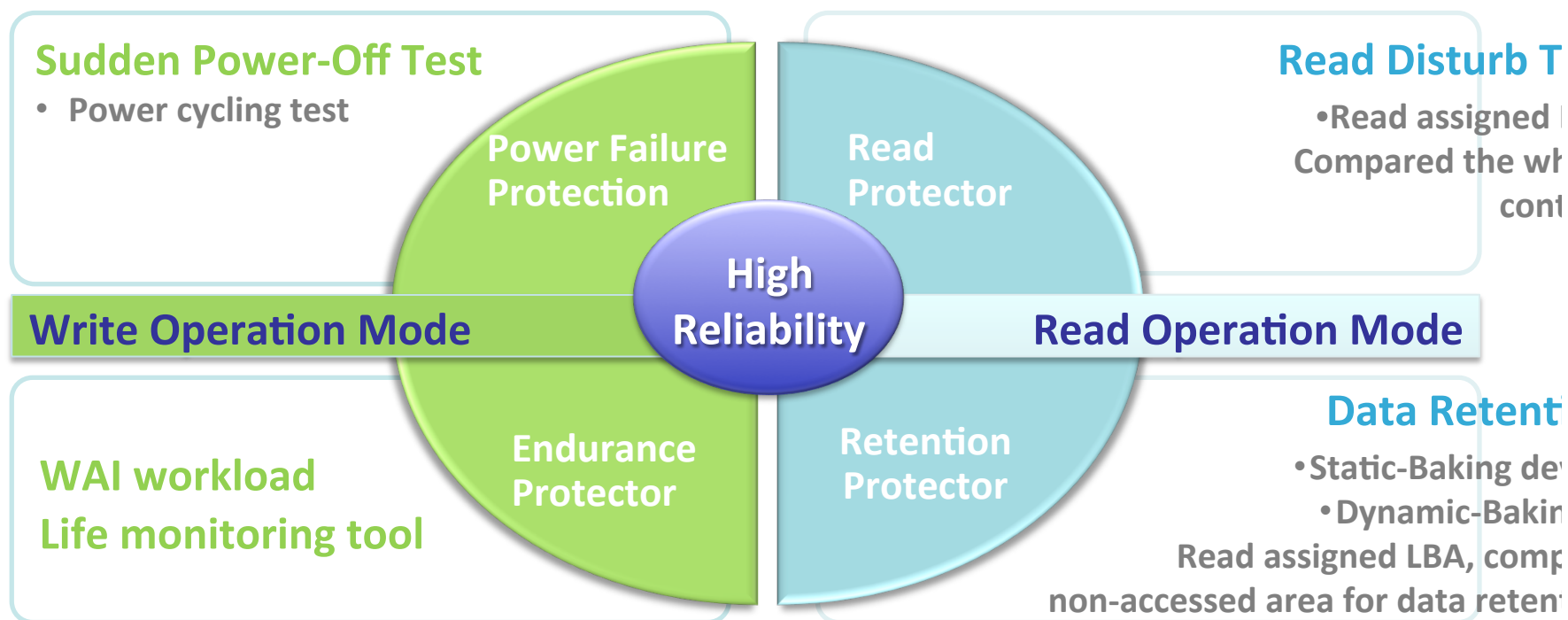


# Operations? Read or Write Centric





# Corresponding Test





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# Endurance: IC Level Test Example

Pass

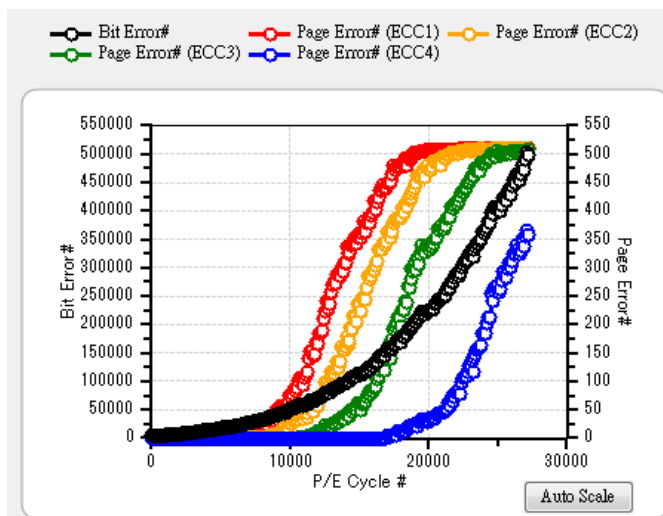
2-D 1xnm MLC

**Approx. 20,000** P/E cycles (BCH ECC 60bits/1KB)

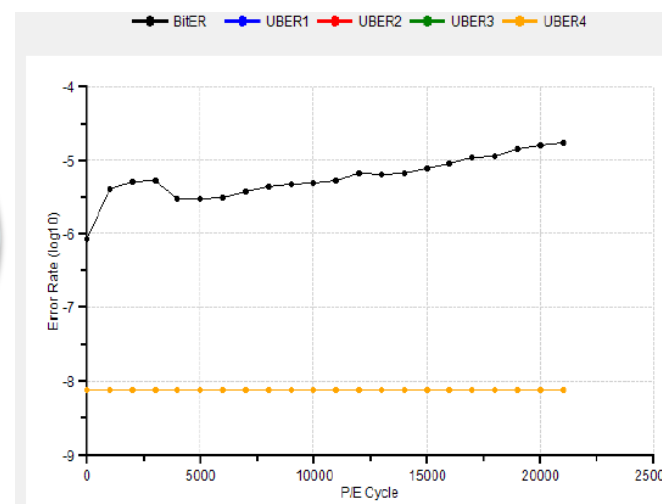
Pass

3-D first generation MLC

**Approx. 21,000** P/E cycles (BCH ECC 72bits/1KB)



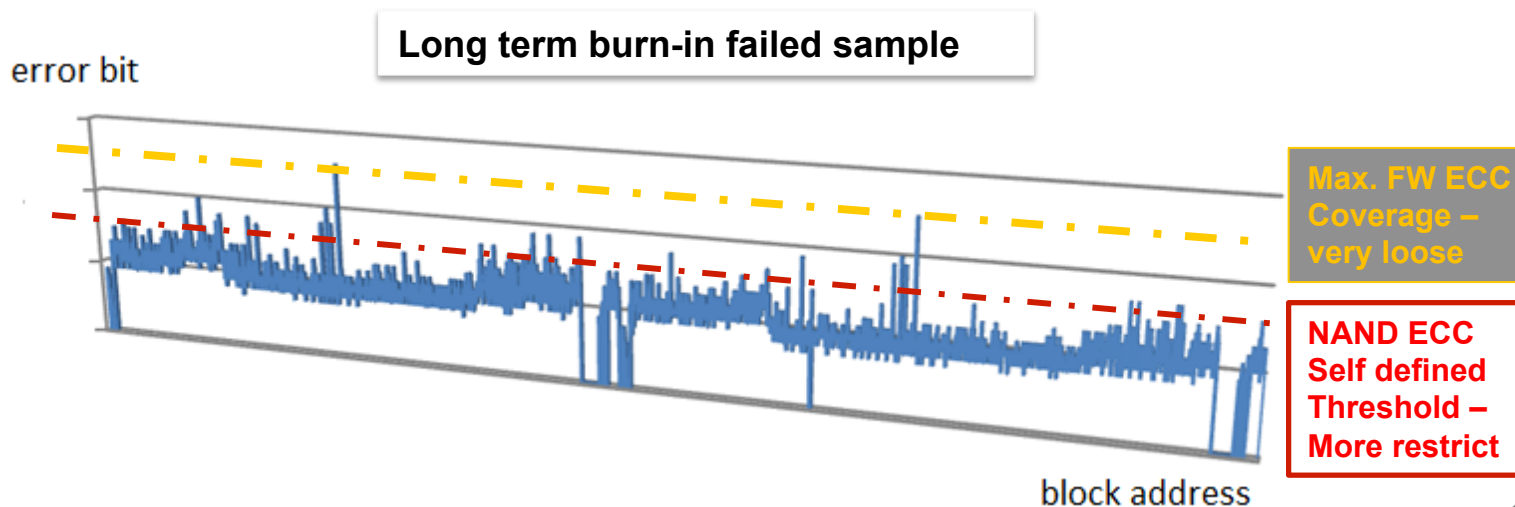
Both Meet 3K P/E Cycles





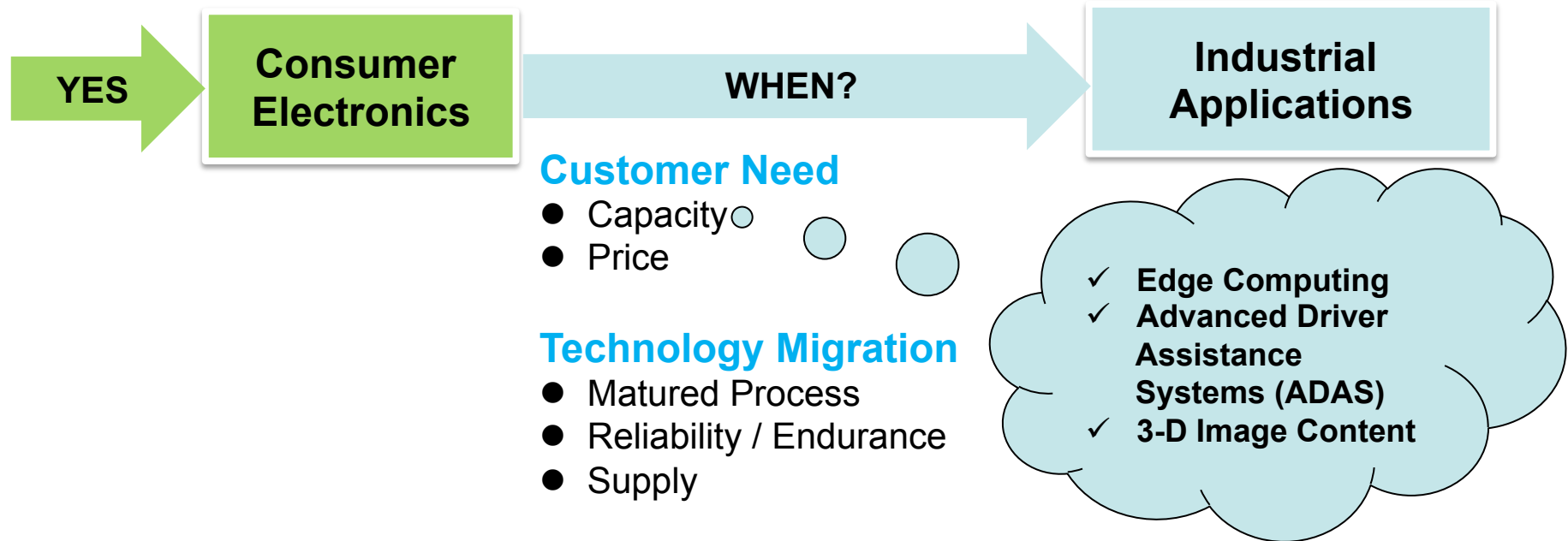
# Device Level NAND Screening Test

- To screen out weak NAND by checking error bits
- Still applicable for BCH ECC FW NAND devices (no matter 2-D or 3-D NAND)
- More restrict than traditional burn-in test, no need long term test period





# WHEN? 3-D NAND Adoption

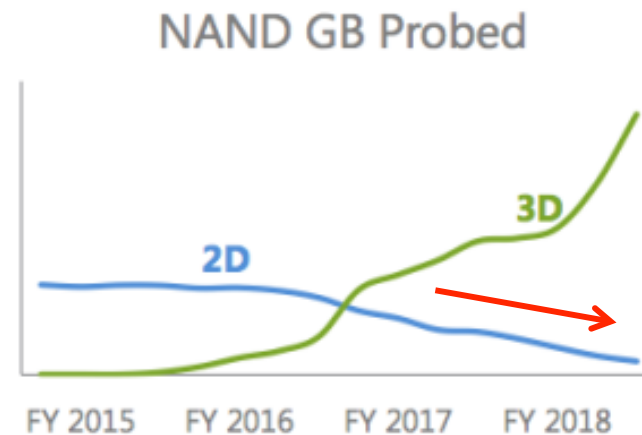
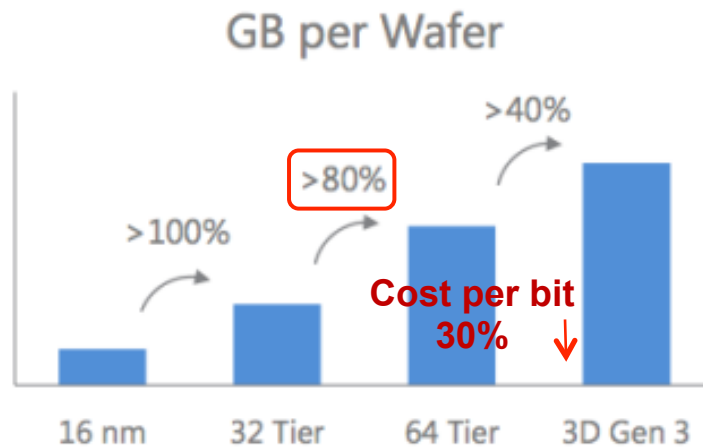


# 2D and 3D NAND Bit Crossover 64-layer 3D NAND



**Price:**  
Crossing the Threshold

**Supply:**  
Mainstream vs Legacy





## Take Away

- 2-D and 3-D NAND will coexist for a long period of time with lower densities continuing on in 2-D, higher densities migrating to 3-D.
- Industrial customers take longer time to embrace new technology, but it will be driven by customer needs (capacity, price) and technology migration (reliability, supply) eventually. The supply gap is increasing from 2017, 2019 will be a critical year.
- Current controller for removable NAND devices are still based on BCH ECC instead of LDPC.
- Future options under consideration include 3D TLC in SLC mode or MLC mode configure. Suitability for the running mode depends on the application requirements for endurance, retention, and other aspects of reliability.





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# Thank you !

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**Visit us @ Room 205**

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