



Flash Memory Summit

Life Beyond Flash 2017

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How Long will Flash Last

- NAND flash has line of sight to at least 128L and QLC
- Scaling may get difficult but is possible
- This takes us to 2023 timeframe with a ~75% bit cost reduction
- After that, it is not clear what NAND can do.
 - Samsung and others claim it goes further



What is NEXT Technology

- Ideal Universal Memory
 - Fast as DRAM, Non-Volatile, Infinite cycles, Cheaper than NAND
 - Unicorn Memory ... It's a nice dream ... it doesn't exist
- Reality of what will happen
 - There is no FLASH replacement (ultracheap memory)
 - Combination of tradeoffs will need to be made
 - Compute architecture designed around what is available
 - Phone, PC, Server designed around DRAM+SCM or SCM+ cloud
 - There is no “new NAND” that is cheaper



New NVM Technologies

| | Latency | Density | Cost | HVM ready |
|-------|---------|---------|-------|-----------|
| DRAM | ***** | *** | *** | ***** |
| NAND | * | ***** | ***** | ***** |
| MRAM | ***** | * | * | *** |
| 3DXP | *** | **** | **** | ** 1/2 |
| ReRAM | *** | **** | **** | ** |
| NRAM* | *** | ** | ** | * |
| Other | *** | ** | ** | * |

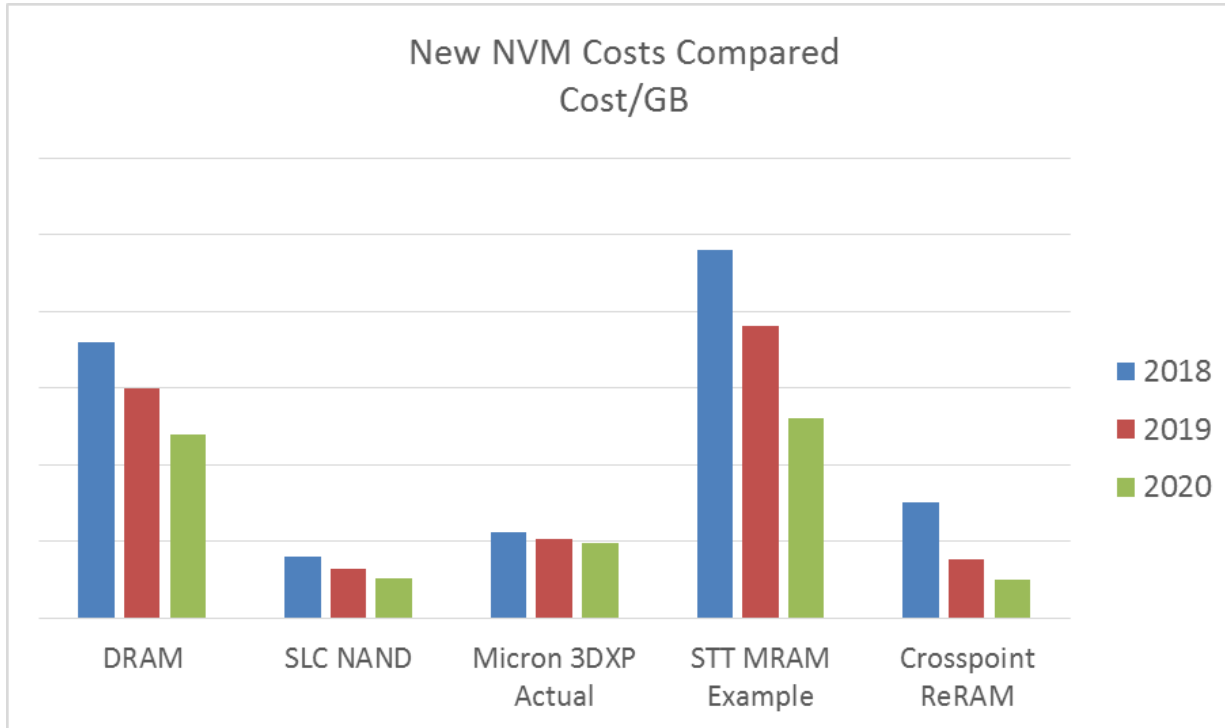


Summary of New NVM

- 3D Xpoint/Phase Change Memory
 - Pros: Fast SCM, in production, relatively high density
 - Cons: Can't be cycled like DRAM. Scaling is not clear
- MRAM
 - Pros: Fastest NVM... close to DRAM. Relatively mature
 - Cons: high cost, relatively low density
- ReRAM
 - Pros: potential for high density, low cost, Fast SCM
 - Cons: Need 64Gb+ parts out to show high density capability
- Other (NRAM, Molecular, Polymer, etc)
 - Pros: theoretical speed and density
 - Cons: 10+ years from products



Cost for Multi-Gbit Technologies





Future NVM Scenario

- NAND reaches end of scaling. It becomes financially unwise to scale cost/density
- Conferences/companies agree on this
- Compute architects find alternative memory/storage strategy.
- Products are piloted with this
 - Cell phone has 1GB MRAM + 16GB PCM/ReRAM + cloud storage
 - Performance and Cost are better than 2GB DRAM + 64GB NAND
 - PC has 4GB MRAM + 64GB PCM/ReRAM + Cloud
 - Performance and Cost are better than 12GB DRAM + 512GB SSD



Summary

- NAND has 5+ years and 2+ generations to go.
- There is no TLC NAND replacement... ultracheap memory
- Post FLASH will be an architecture based on what does exist
 - New Combination
 - With better performance
 - Lower Cost
 - Future scalability
 - Based on new NVM
- New solution, not a direct NAND replacement