



Flash Memory Summit

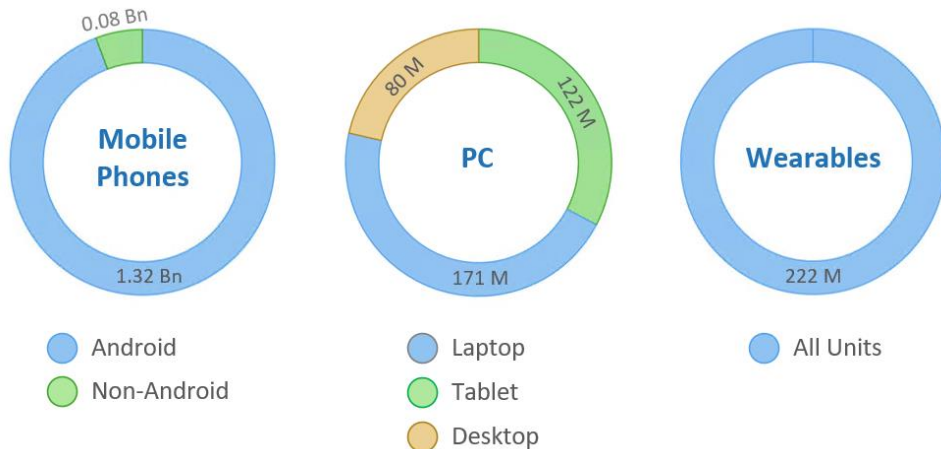
# Applying NVMe in Embedded and Mobile Applications

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# BGA Storage Opportunity

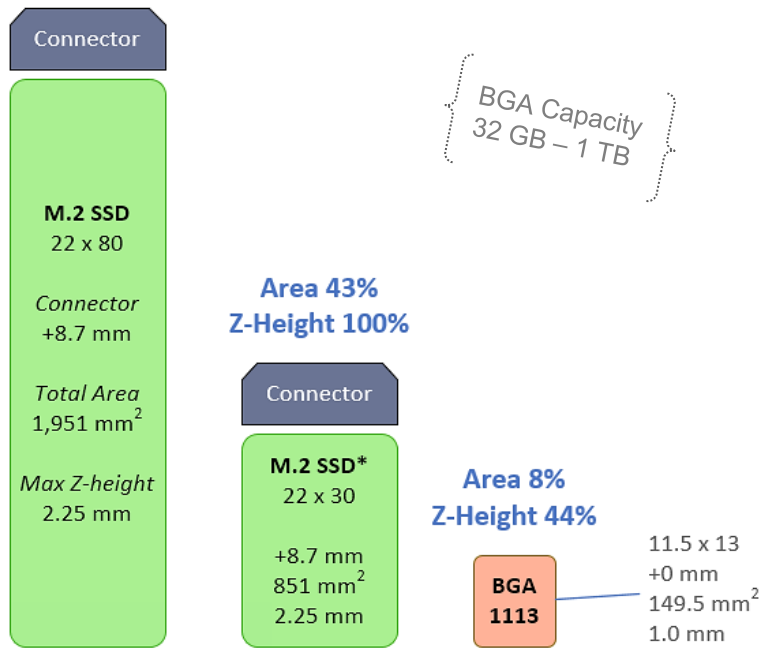
- Problem
  - By 2023, annual shipments for mobile phones are projected at 2.4 Billion and wearables will outnumber laptops
  - Global demand for small formfactor storage is enormous
- Solution
  - NVMe BGA is aligned with the rapid evolution of PCIe Gen-4 and Gen-5
  - Very small formfactor, low power, excellent performance





# BGA Area Reduction

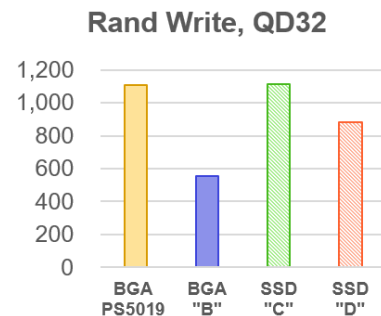
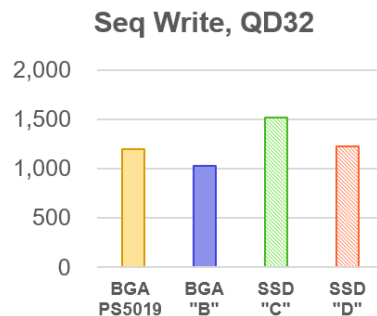
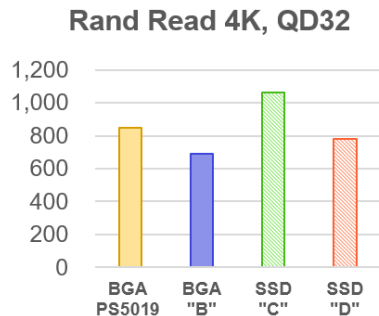
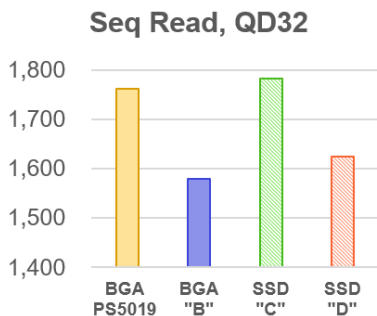
- The M.2 2280 formfactor is the most common module size today.
- On the next slide we will show that a properly designed DRAMless solution, with HMB enabled, can provide equivalent performance
- The BGA 1113 is thinner and smaller, allowing more room for sensors or a larger battery
- Only need to qualify one solution. The BGA can be mounted on a 2230 PCB for enterprise environments that want removable storage
- BGA supports co-layout with eMMC and UFS for added design flexibility





# BGA Performance is Competitive

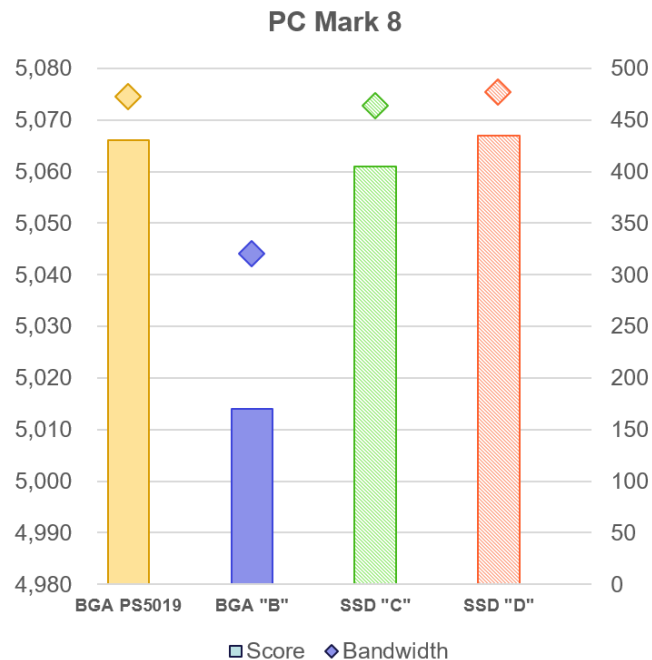
- BGA are DRAM-less + Host Memory Buffer (HMB)
- SSD have DRAM
- BGA 1113 limited to 2x PCIe Lanes
- Additional tuning and careful hardware design allows BGA to be competitive
  - Design with smart accelerators instead of CPU to save power and optimize simple lookup and DMA operations





# BGA Real World Applications

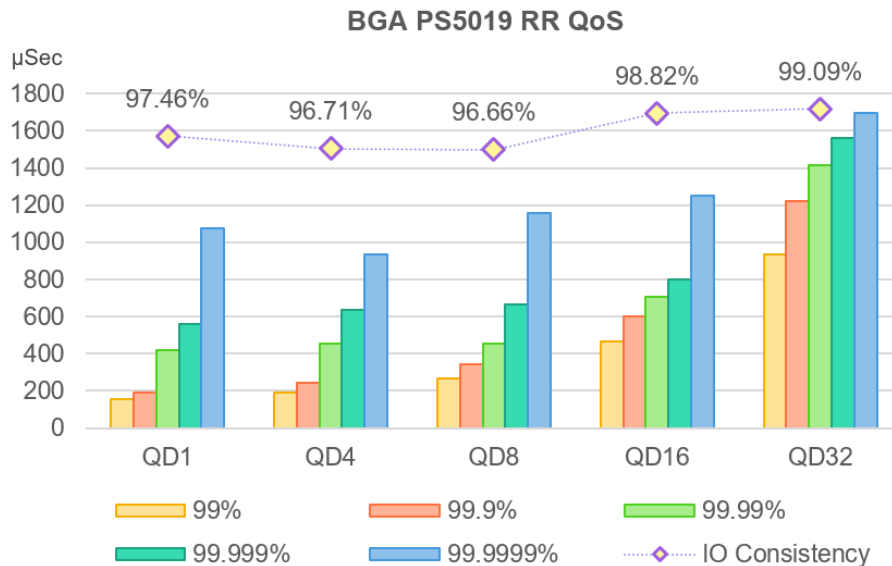
- No significant difference on properly tuned BGA solutions
- BGA supports additional embedded features
  - Replay Protected Memory Buffer (RPMB)
  - Boot Partition
  - Namespace (ie: Logical Unit)
  - Host Memory Buffer (up to 64MB on Windows host)
  - Deallocate (ie: Trim, Unmap)
  - TCG Opal, TCG Pyrite





# BGA Latency & IO Consistency

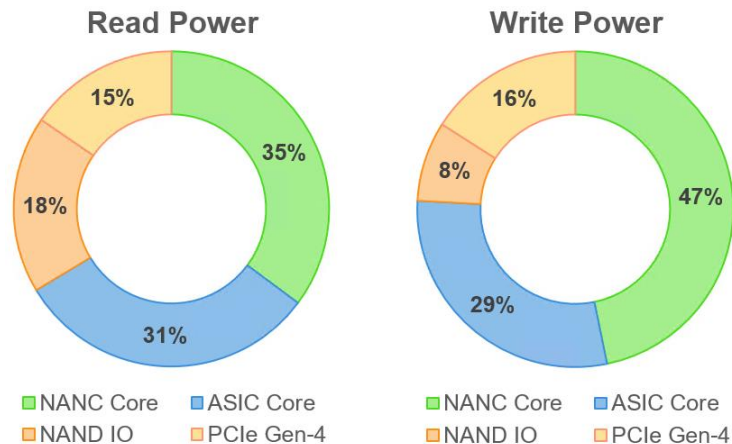
- With proper firmware tuning, a BGA solution can compete with desktop SSD
- Smooth progression from QD1 from QoS-1 to QoS-6
- Optimal performance is achieved at QD16 which takes advantage of NAND independent plane operations
- Latency jumps up at QD32 due to having more commands than points of parallelism, though it's still smooth
- Excellent IO Consistency





# BGA Configurable Power

- Uses 0.9, 1.2, 2.5V supply rail to reduce active power by 14% over same ASIC as M.2
- On DRAM-less BGA, power scales with read bandwidth ~1W / GB/s
- Power evenly split between IO, NAND and ASIC; approximately 0.3/0.3/0.3
- Silicon process node not a primary factor; can choose to optimize for cost
- BGA molding compound uses advanced heat transfer materials
- Platform should provide passive cooling through direct contact with metal chassis
- Using NVMe Power States, the BGA can be set to limit power 0.5W – Max, if performance is not a concern
  - One part can be used in many solutions ranging from wearables to gaming tablets and content creation laptops
  - One solution simplifies the supply chain



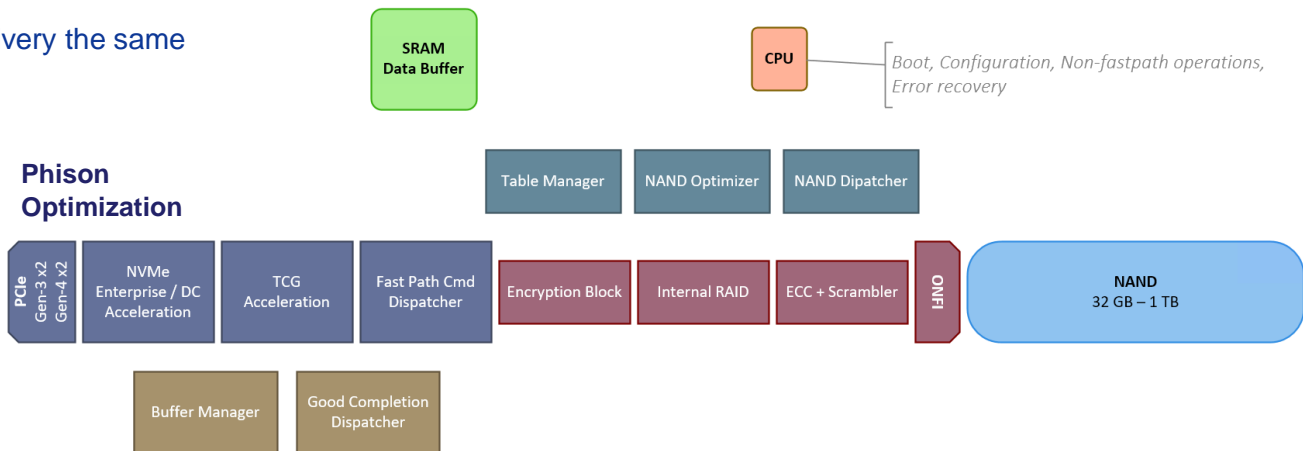
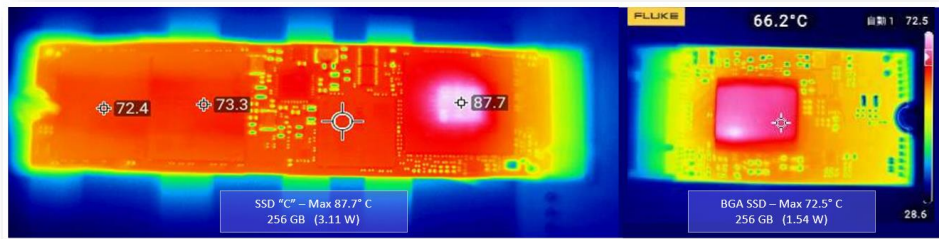
Current maximum BGA Gen-4 x2

- Read Speed = 3,500 MB/s
- Write Speed = 1,800 MB/s



# BGA Competitive Power

- PS5019 BGA and SSD “C” are both connecting as Gen-3 x2
- Both are running a sequential workload at the same throughput
- PS5019 BGA is on an M.2 carrier
- Advanced automation allows the design to run substantially cooler
- Uses less energy while delivery the same performance and latency







# Key Takeaway

1. NVMe BGA has excellent performance which means no more lag
2. Tightly aligned to the rapid evolution of PCIe Gen-4 and Gen-5
3. Small formfactor leaves more room for battery
4. Low thermal allows the device to drive cutting edge applications
5. Low power means the battery lasts longer



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