HGST
a Western Digital company

Innovations in Non-volatile Technologies

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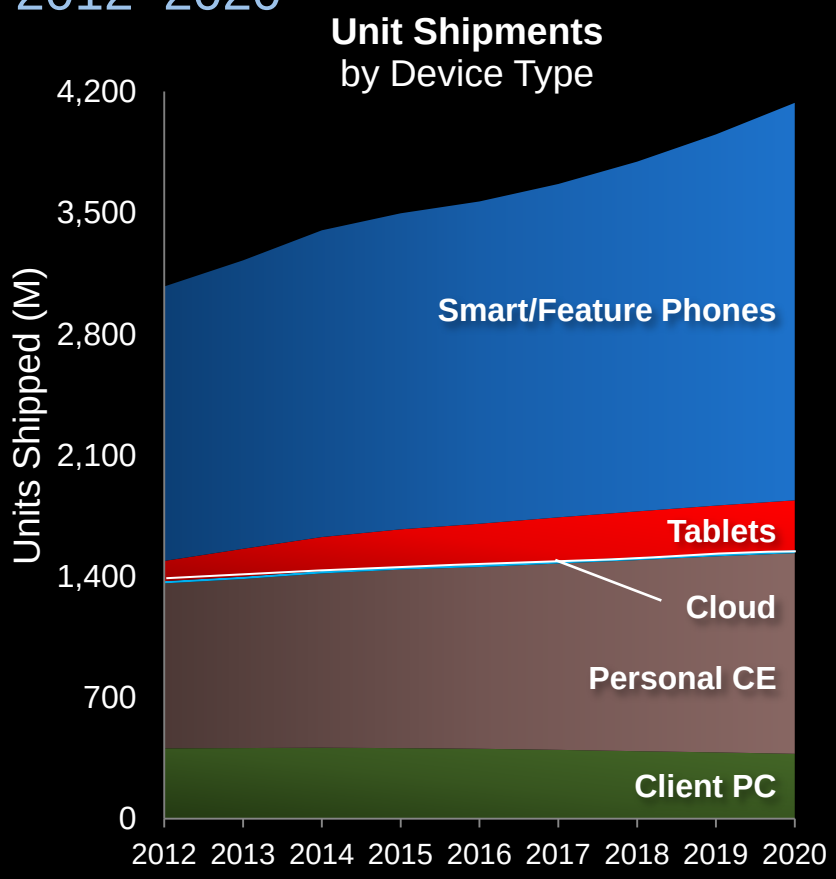
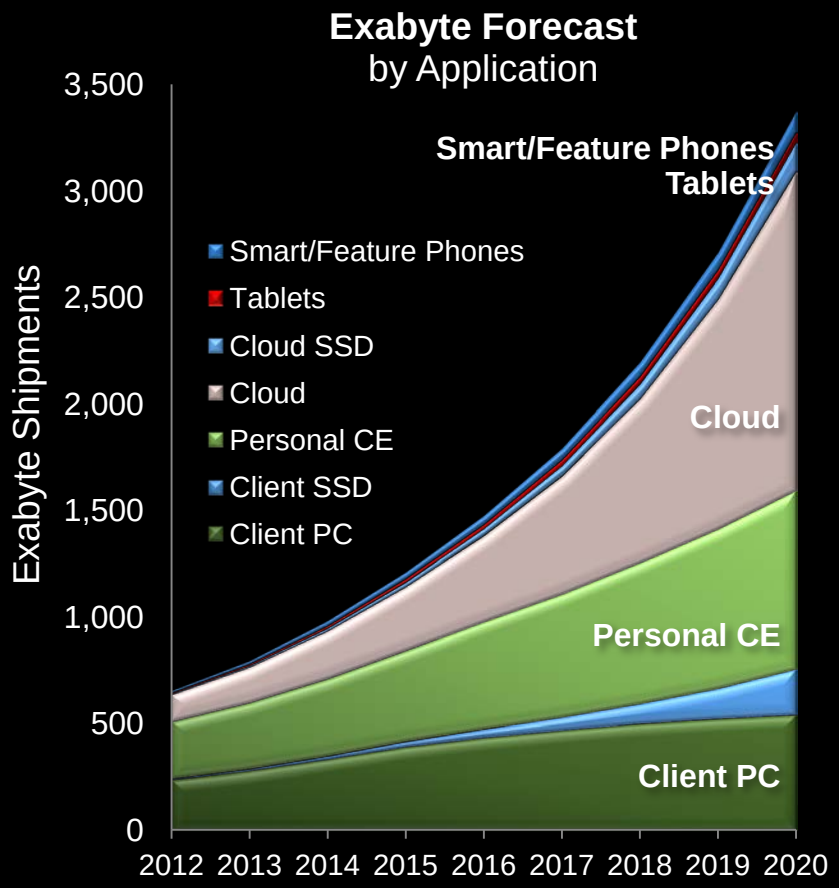
Storage Trends

2012–2020

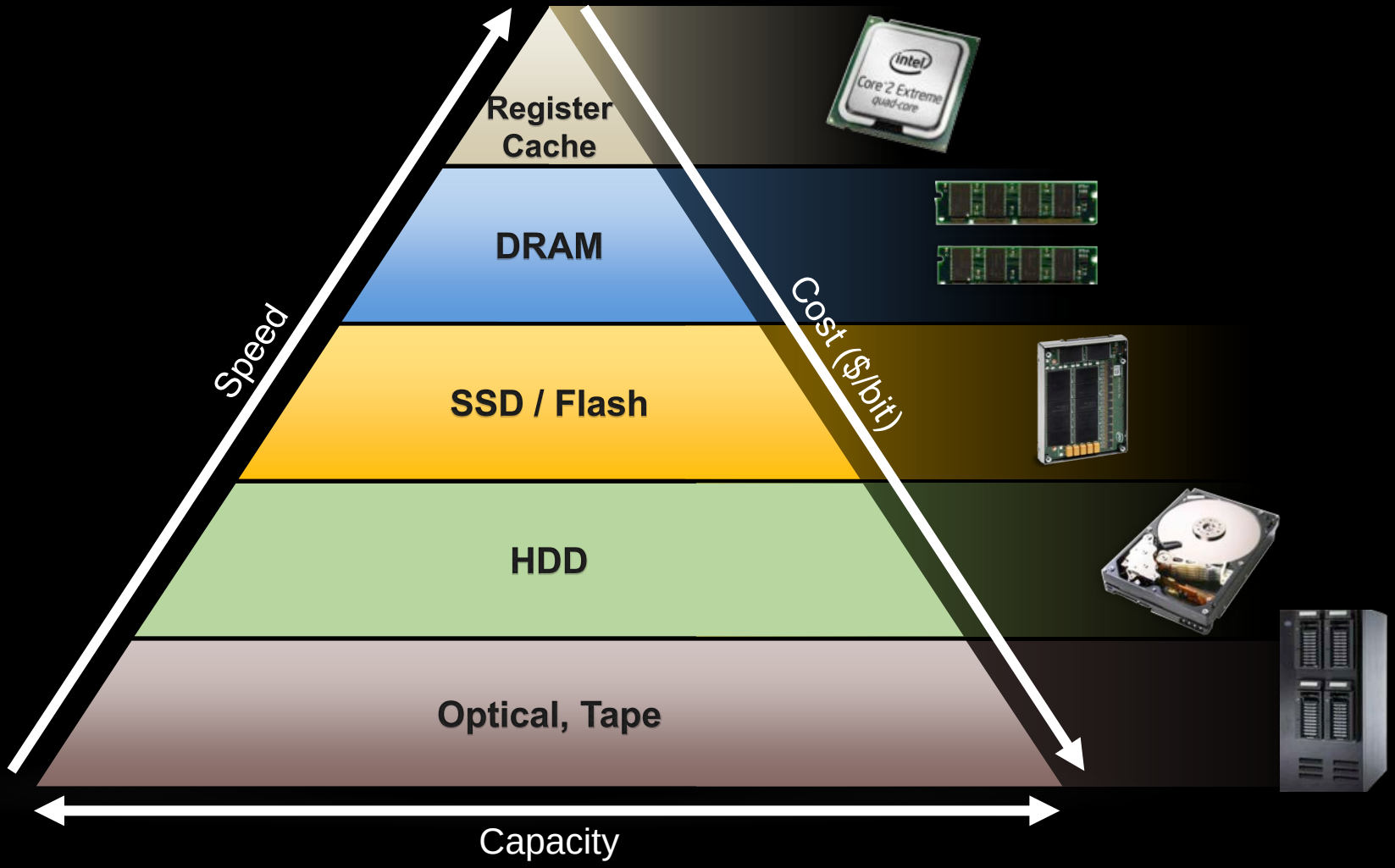




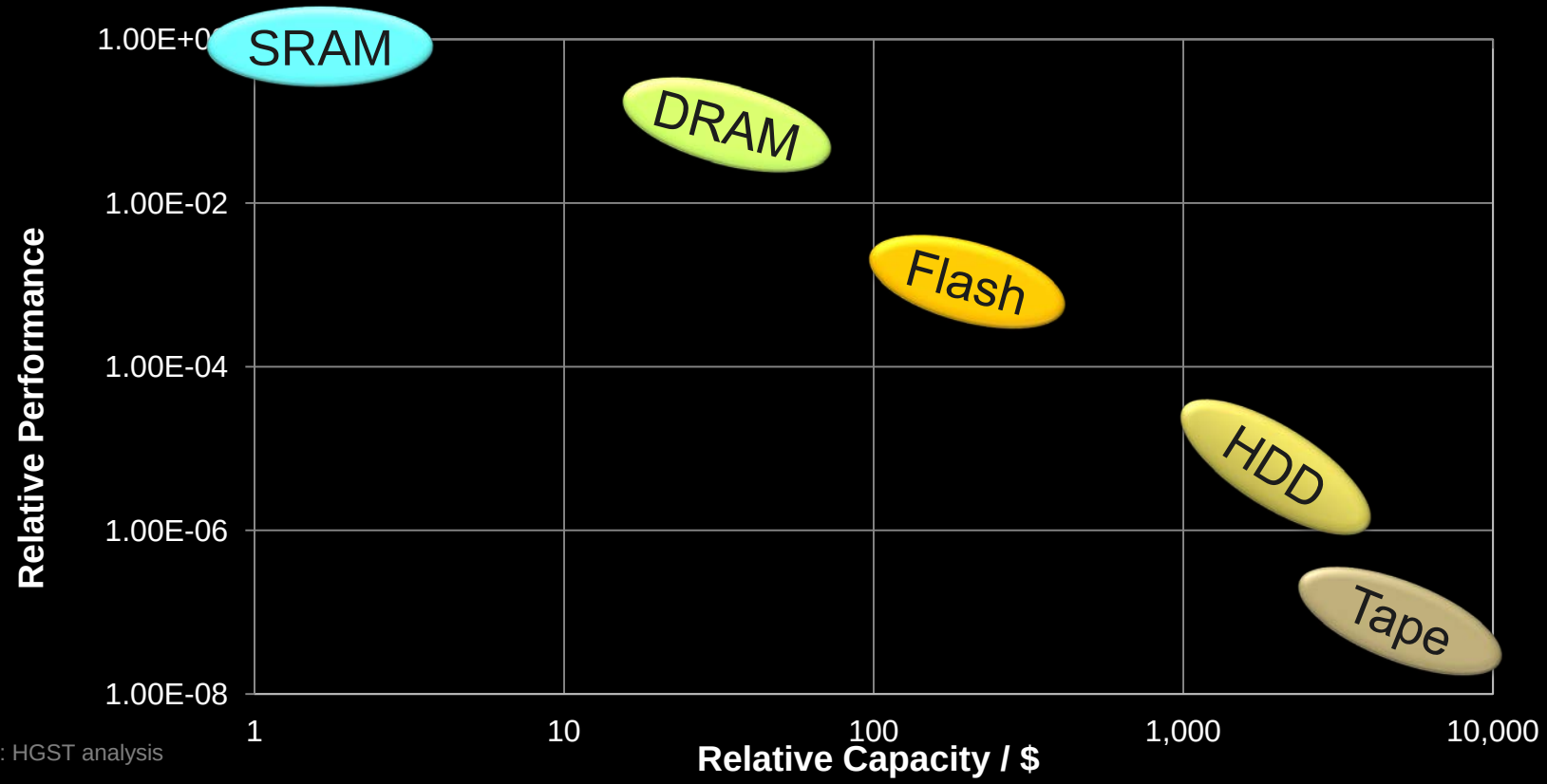
Source: HGST analysis

HDDs are the primary storage solution and will continue to adapt to the evolving ecosystem

Storage Tiering: Delivering Solutions

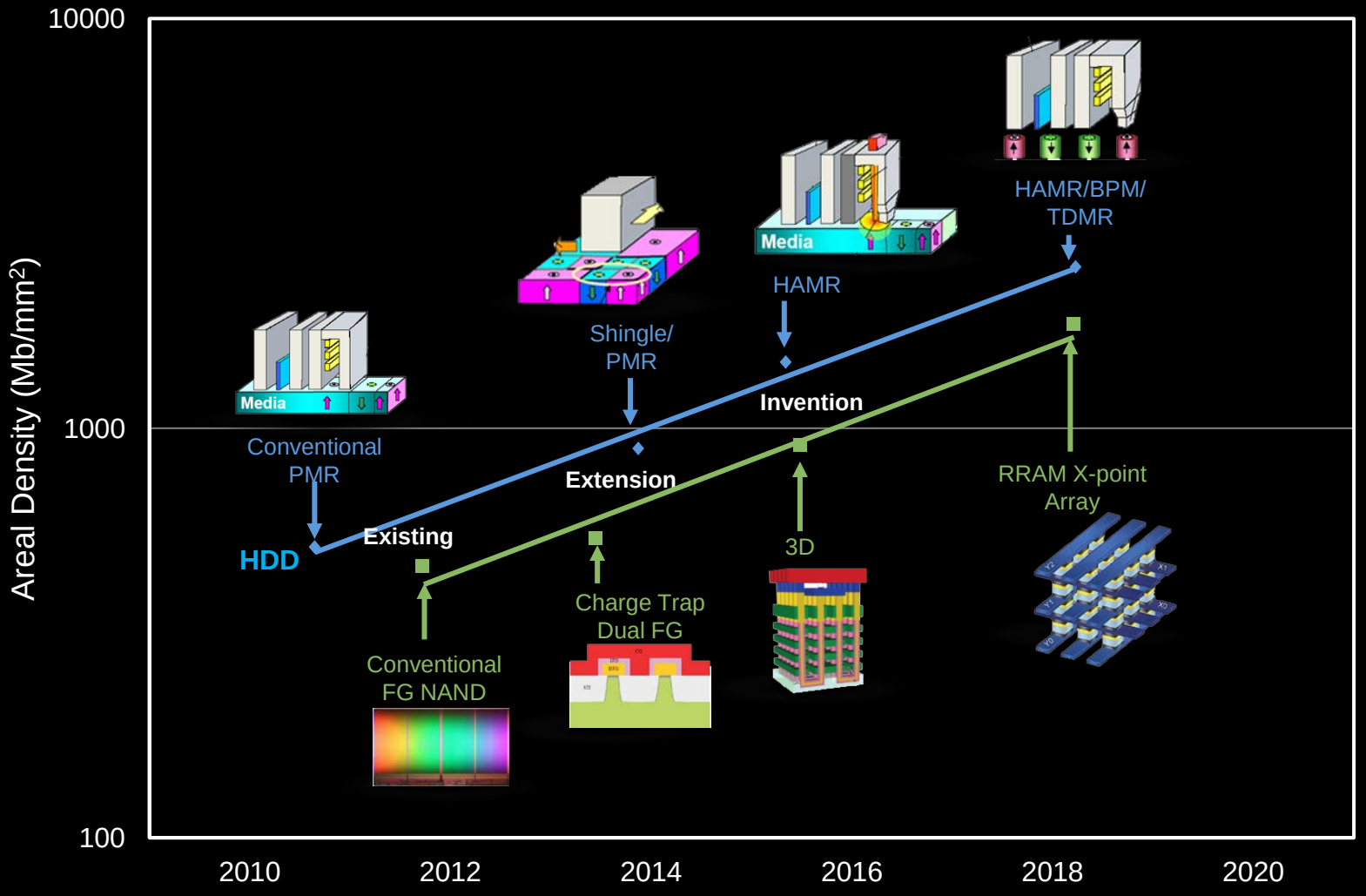


Performance vs. Cost – Today



Source: HGST analysis

Density Roadmap For HDD and NVM

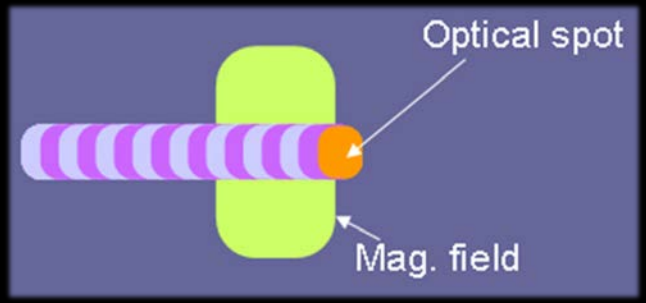


HDD and NAND Flash both facing similar challenges in scaling

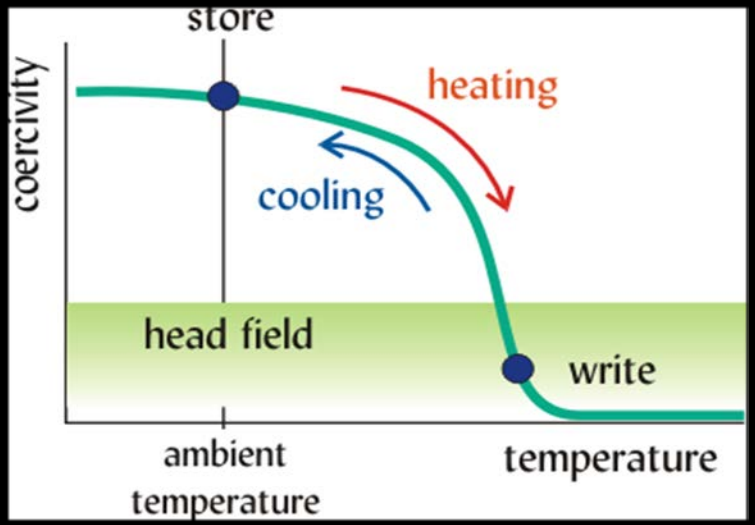
Heat Assisted Magnetic Recording (HAMR)

HAMR : A Whole New Recording System

- Density growth limited by ability to make smaller bits thermally stable
- HAMR combines laser and magnetic field to write the media
- Allows for use of much higher coercivity media and hence enables higher densities



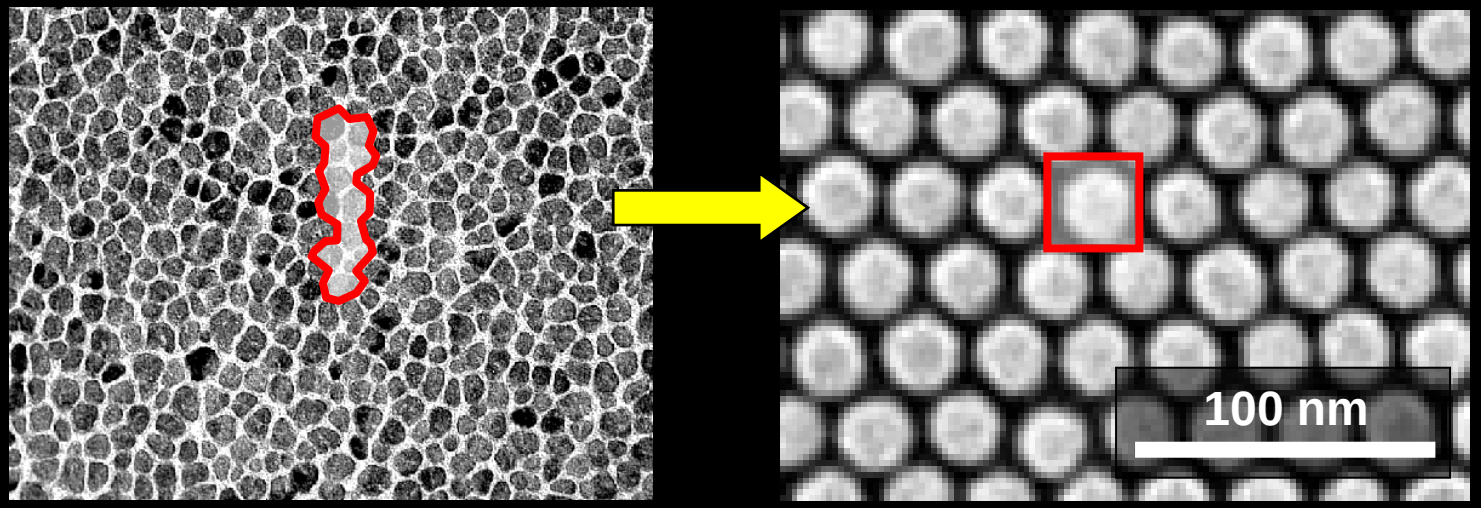
$$\frac{dH_{eff}}{dx} = \frac{dH_k}{dT} \cdot \frac{dT}{dx}$$



Industry projecting the introduction of HAMR technology in 2016-2017

Bit Patterned Media

Granular Media versus Bit Patterned Media



- Extend density by replacing randomly sputtered grains with very uniform, lithographically-defined magnetic islands
- The challenge for bit patterned media is how to fabricate these very small islands precisely and cost-effectively
- Feature sizes will need to be smaller than semiconductor

Have already demonstrated all the steps necessary for 13 nm half pitch

Innovation for Capacity and Power

Cloud Storage Demands

- Lower cost/bit
- Higher capacities in same square footprint
- Lower power consumption

Mechanical Design

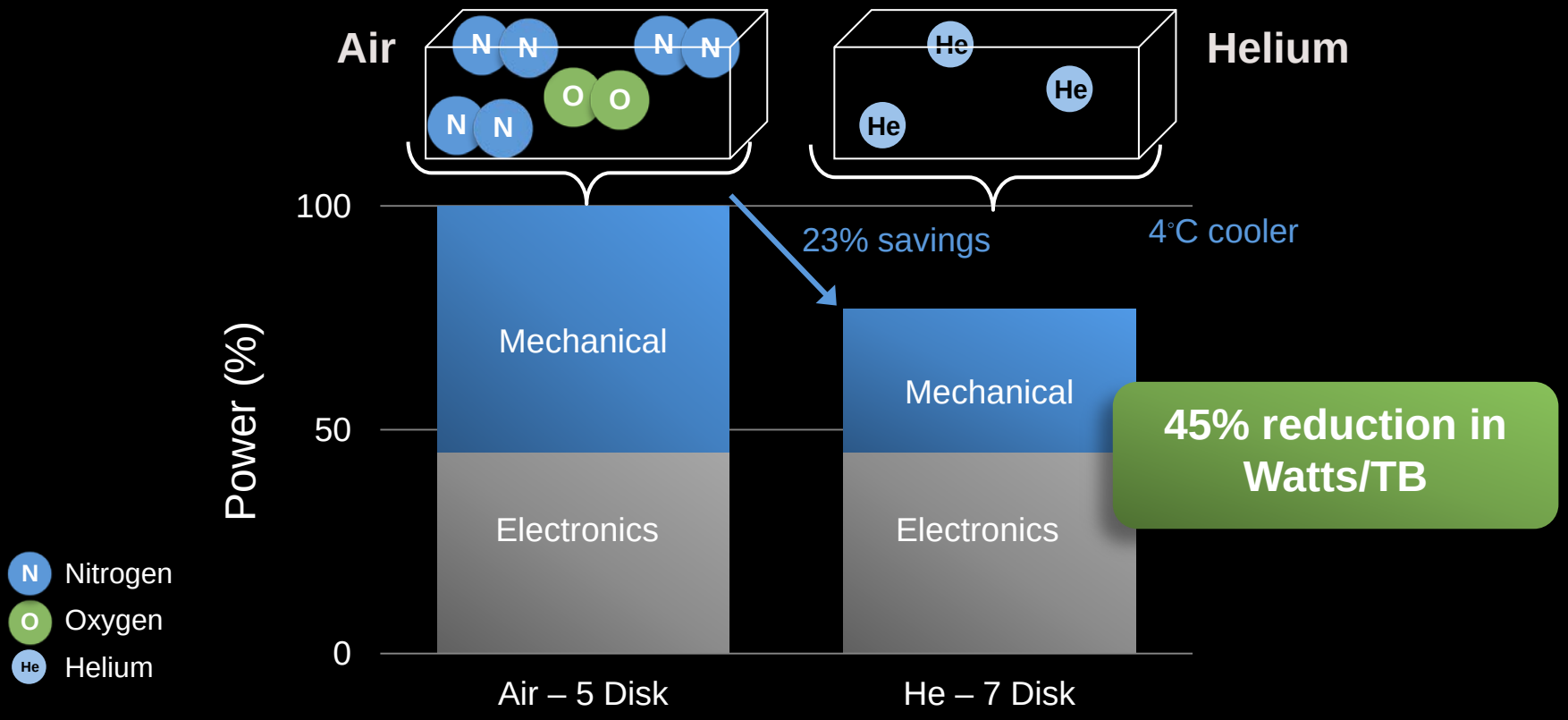
- Bigger diameter platter
- More platters
- Slower RPM

What are the opportunities for a disruptive new technology ?

Innovation for Capacity and Power

Replace the air with a gas, Helium, that has 1/7th the density

- Reduces mechanical power dissipated in air shear
- Allows platters to be placed closer together enabling more capacity



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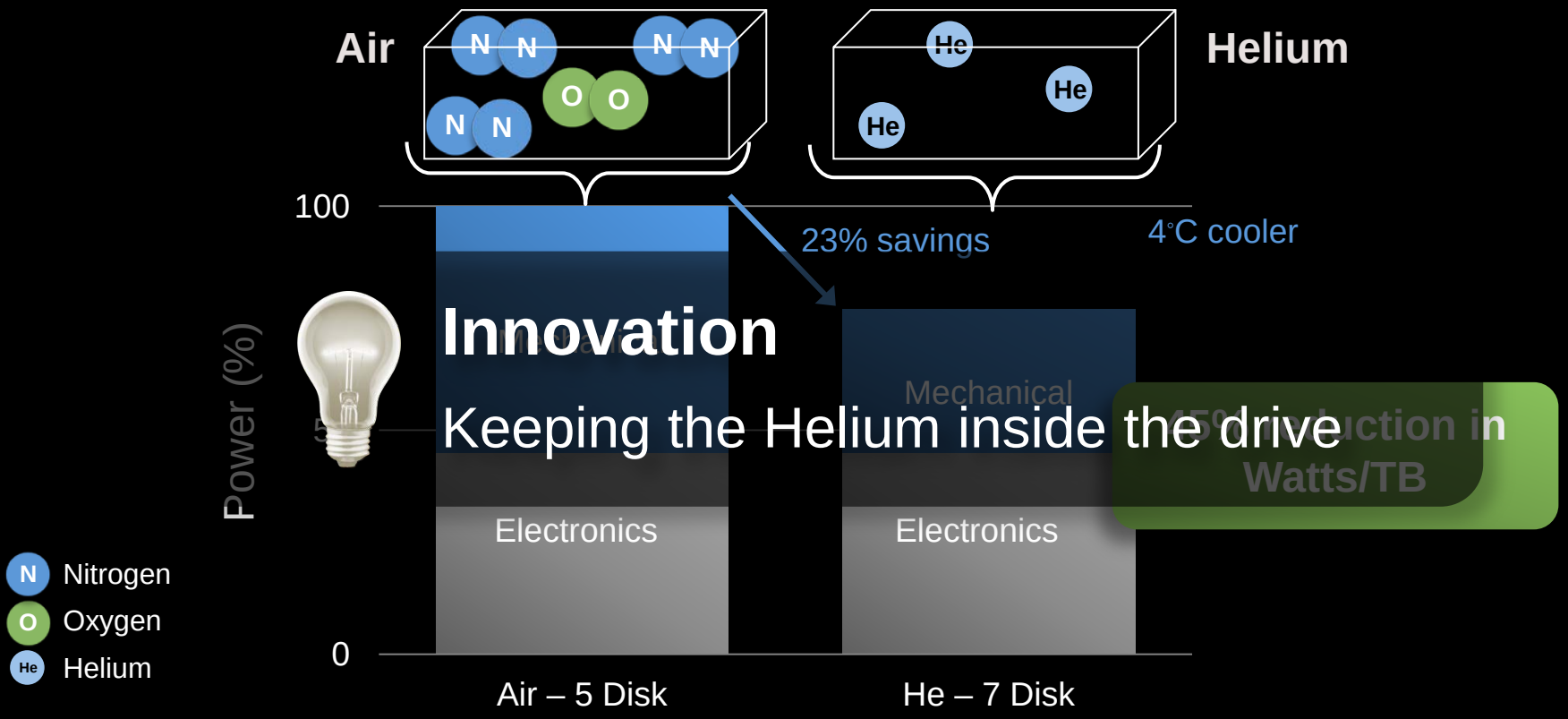

Summary

- Data will continued to be tiered among different technologies for the foreseeable future
- While SSD and new NVM will provide higher performance, HDD will continue to provide at least 10x lower bit cost
- Many innovations are coming for HDDs to allow continued progress on higher capacities, lower bit cost, and lower power dissipation