

# Tech Talk on HDD Areal Density

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СТО

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#### **Safe Harbor Statement**

This document contains forward-looking statements within the meaning of Section 27A of the Securities Act of 1933, and Section 21E of the Securities Exchange Act of 1934, each as amended, including, in particular, statements about our plans, strategies and prospects and estimates of industry growth for the fiscal guarter ending October 2, 2015 and the fiscal year ending July 1, 2016 and beyond. These statements identify prospective information and may include words such as "expects," "intends," "anticipates," "believes," "estimates," "predicts," "projects" and similar expressions. These forward-looking statements are based on information available to the Company as of the date of this document and are based on management's current views and assumptions. These forward-looking statements are conditioned upon and also involve a number of known and unknown risks, uncertainties, and other factors that could cause actual results, performance or events to differ materially from those anticipated by these forward-looking statements. Such risks, uncertainties, and other factors may be beyond the Company's control and may pose a risk to the Company's operating and financial condition. Such risks and uncertainties include, but are not limited to: the uncertainty in global economic conditions, as consumers and businesses may defer purchases in response to tighter credit and financial news; the impact of the variable demand and adverse pricing environment for disk drives, particularly in view of current business and economic conditions; the Company's ability to successfully qualify, manufacture and sell its disk drive products in increasing volumes on a cost-effective basis and with acceptable quality, particularly the new disk drive products with lower cost structures; the impact of competitive product announcements; currency fluctuations that may impact our margins and international sales; possible excess industry supply with respect to particular disk drive products; and disruptions to our supply chain or production capabilities. Information concerning risks, uncertainties and other factors that could cause results to differ materially from the expectations described in this document is contained in the Company's Annual Report on Form 10-K filed with the U.S. Securities and Exchange Commission on August 11, 2015, the "Risk Factors" section of which is incorporated into this document by reference and other documents filed with or furnished to the Securities and Exchange Commission. These forward-looking statements should not be relied upon as representing the Company's views as of any subsequent date and the Company undertakes no obligation to update forward-looking statements to reflect events or circumstances after the date they were made.

### Seagate: Storage Leader

Seagate is a 35 year High Tech manufacturing provider of data storage solutions Provide storage for enterprise, desktop, mobile computing, surveillance, consumer electronics and retail markets Vertically integrated storage technology

Leadership in Heads, Media, ASICs

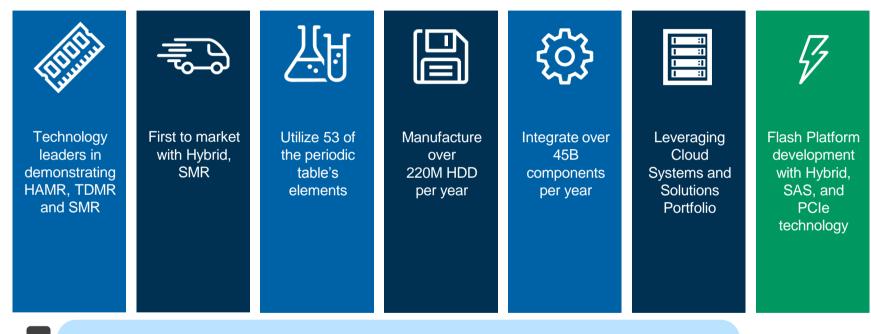
~9,000 Patents

~52,000 employees worldwide

Global manufacturing footprint

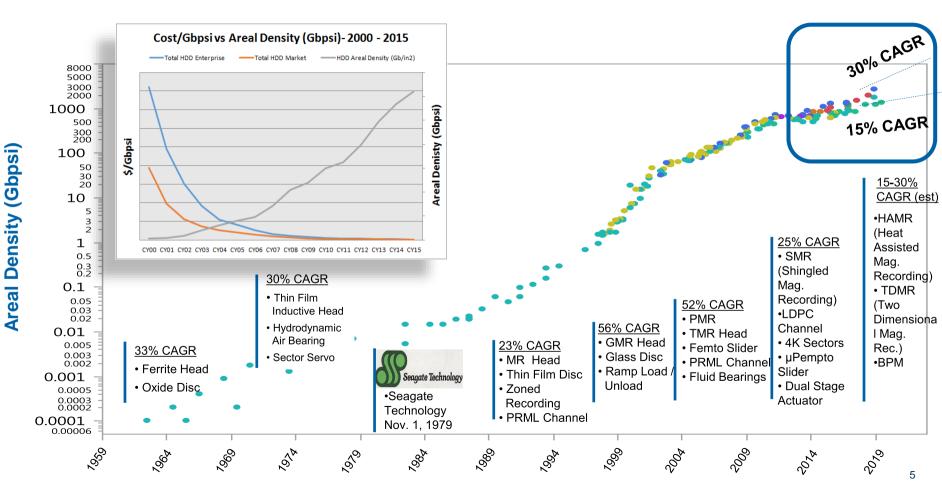
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### Seagate's Technology Leadership



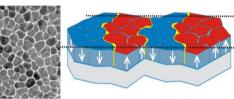
- Takeaways
- Continue investments in technology innovations
- Leverage technical innovations into product roadmap
- Enables low cost, high performance and reliable products

### **Innovations Driving Areal Density Growth**



# The Challenges to Increasing Drive Capacity

#### Thermal Stability

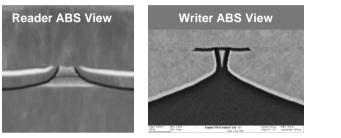


Media Top View Media Cross section

#### Increase AD / drive capacity:

- Reduce grain size
- Make grains harder to switch

#### Writer/Reader Scalability







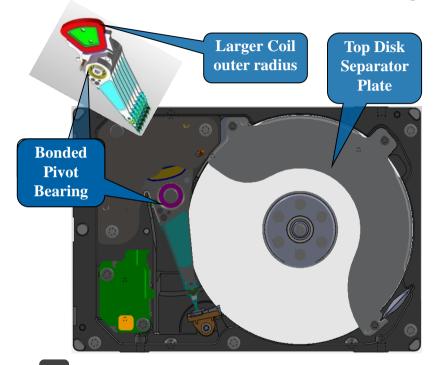
- Reduce bit width
- Reduce bit length

- Increase areal density
- Add heads and disk

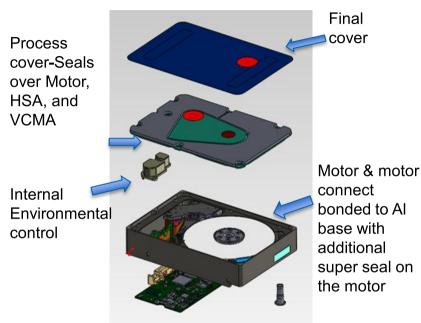
#### Solution:

- Heat Assisted Magnetic Recording (HAMR)
- Writer- Shingled Magnetic Recording (SMR) & HAMR
- Reader- Two-D Magnetic Recording (TDMR)
- Advanced Mechanical Designs
- Helium Drives
- Form factors optimized for racks

### **Advanced Mechanical Designs**



#### **Sealed HDA Features**



- Motivation- Increase drive capacities for enterprise & cloud applications
- Solution- Design to reduce turbulence

# **Emerging Technologies For Capacity Growth**

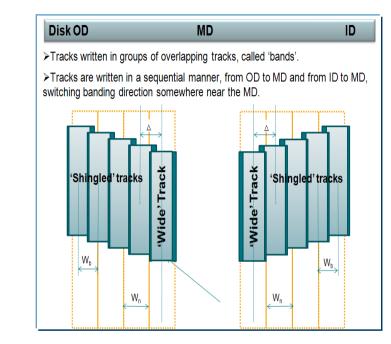
Perpendicular Magnetic Recording	Hybrid/ Enhanced Cache	Shingled Magnetic Recording	Two Dimensional Magnetic Recording	Heat Assisted Magnetic Recording	Heated Dot Magnetic Recording
AD Up to ~1.0 Tb/in <sup>2</sup> Current Mainstream Products	SSD-Like Performance	Shipping in Various Markets	Product Integration 2016 +	AD ~1.2 to 5.0 Tb/in <sup>2</sup> Product Integration 2016+	~5.0 to 10.0 Td/in <sup>2</sup> AD Initial Product Integration >2025

# Shingled Magnetic Recording



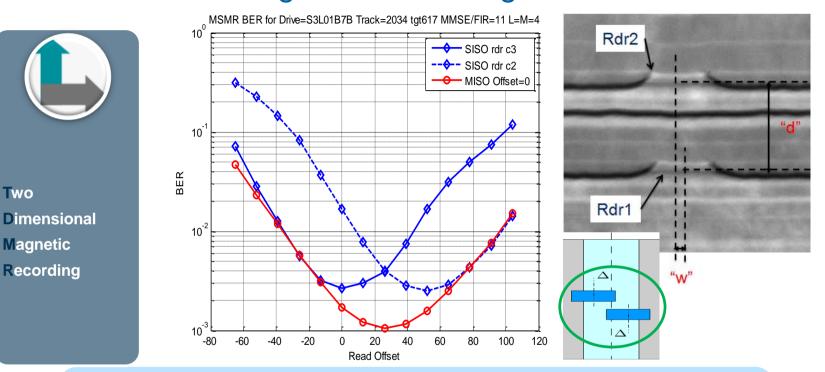
Shingled Magnetic Recording





- Takeaways
- SMR- increase capacity over conventional recording
- Allows more narrow tracks to be written
- Performance transparent in the vast majority of use cases

# **Two Dimensional Magnetic Recording Works**

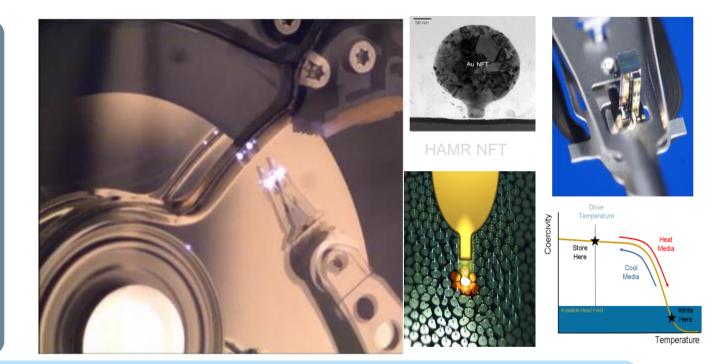


- Takeaways
- 2 or more readers on the same track or partially on adjacent tracks
- Current areal density gains in the 5-10% range
- Future work to get larger areal density gains

## Heat Assisted Magnetic Recording Making Significant Progress



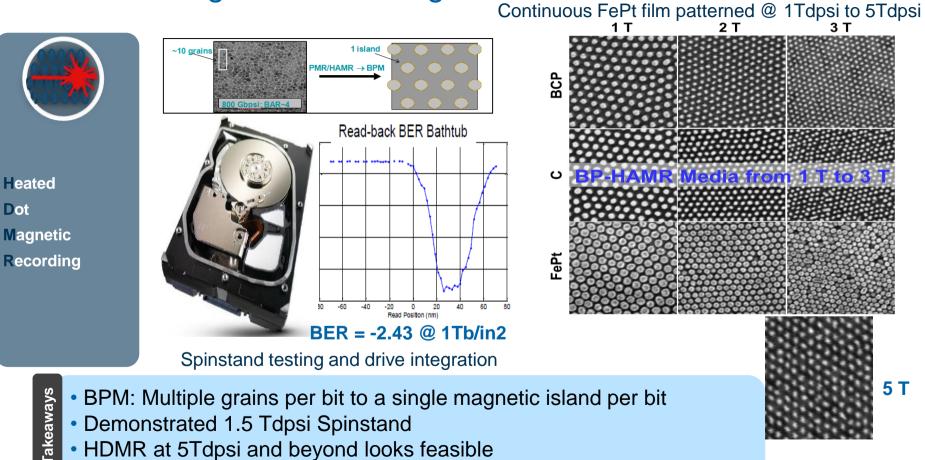
Heat Assisted Magnetic Recording



Takeaways

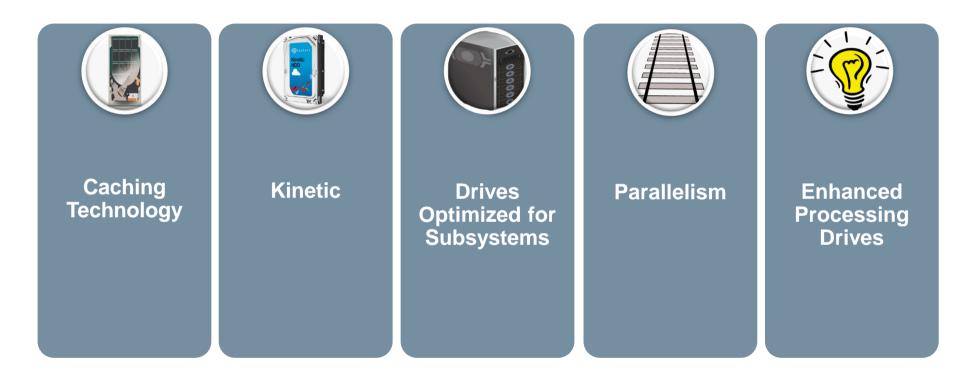
HAMR need for increase in areal density.
HAMR areal density attainment is 1.5 Tb/in<sup>2</sup>
Still focusing on reliability and area density

### Heated Dot Magnetic Recording= BPM + HAMR



HDMR at 5Tdpsi and beyond looks feasible

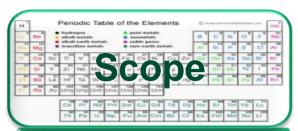
# **Emerging Technologies for Performance**



### Summary



- Technology most precise, complex, and dynamic in the world
- Design, develop and manufacture over 50 Million HDDs per quarter
- Ranked16<sup>th</sup> best supply chain in the world by Gartner in 2015



- Complex, spanning
   multiple disciplines
- Drives utilize 53 of the periodic table's elements
- Head flying at couple of angstroms over media
- Aligned to Product Roadmap



- Nominated by Thomson Reuters 3 straight years
- ~9000 patent/disclosures
- First to market –Hybrid and SMR drives
- HAMR maturing
- **Performance** boost-Enhanced cache
- Continued investment to deliver Flexible and Aggressive technologies