The Information Network

The Dynamics of the HDD Industry and its Impact on CMP

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The Information Network – What We Do

- Off-The Shelf Technical-Marketing Reports on High-Tech Sectors including HDDs, CMP, Semiconductors, Alternative Energy, LEDs, LCDs, MEMs, Processing Equipment, Processing Materials
- Custom Studies in the above areas
- Proprietary Leading Indicators correlating macroeconomic trends with projections of semiconductor and semiconductor equipment growth

- Formed in 1985
- First report on the market analysis of CMP in the 90s

"The Rumors of My Death Have Been Greatly Exaggerated" – Mark Twain

Disk Drive Industry 1960's

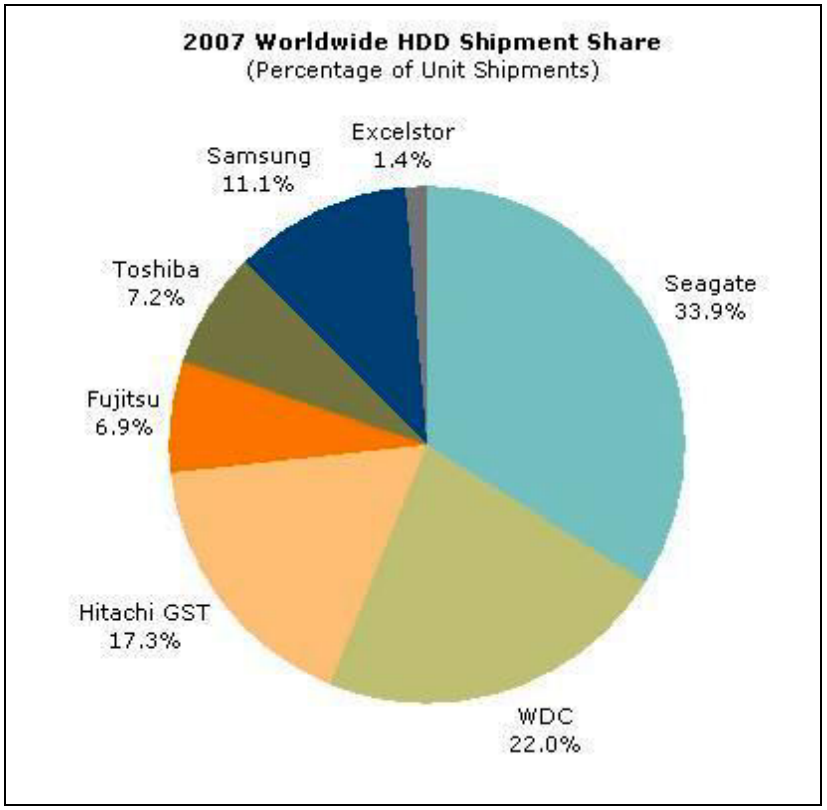
- Bryant Computer
- Burroughs
- Caelus Memories
- Century Data Systems
- Control Data
- Fujitsu
- Hitachi
- IBM
- ISS/Univac
- Marshall
- Memorex
- NCR
- NEC
- Potter Instruments
- Toshiba

Disk Drive Industry 1980's

3M
Advanced Storage Tech.
Alpha Data
Alps Electric
Amcodyne
Ampex
Applied Information Memories
Applied Peripheral Systems
Areal Technology
Atasi Corporation
Athenaeum
Ball Computer Preduct»
BASF
Brand Technologies
Burroughs
Cardiff Peripherals
Century Data Systems
CII-Honeywell Bull
Cipher Data Products
Cogito Systems
Comport
Computer Memories
Computer Peripheral Technik
Conner Peripherals
Control Data
Cybernex
Dastek
Data General
Data Peripherals
Data Recording Equipment
Datapoint
Data-Tech Memories
DDC Pertec
Digital Equipment Corporation
Disctron
Disk Memory Technology
Disk Tech One
DMA Technologies
DZU (ISOT)
Epson
Evotek
Fuji Electric
Fujitsu
Goldstar Telecommunication
Hawker Siddley
Hewlett-Packard
Hightrack Computer
Technik
Hitachi
Hokushin
Hyosung Computer
Ibis Systems
IBM
International Memories
Irwin International
ISS/Univac
Josephine County Technology
Kalok
Kennedy Company
Kovo
Kyocera
LaPine Technology
Lexitron
Magnum Technology
Magtron
Matsushita Corn. Ind.
Maxtor
Megavault
Memorex
Memory Systems
MFM Technology
Micro Peripherals
Micro Storage
Microcomputer Systems
Microdata
Micropolis
Microscience
International
Miltope
Miniscribe
Mitsubishi Electric
Mitsumi Electric
NEC
New World Computer
Newbury Data
Nippon Electric Industry
Nippon Peripherals, Ltd.
Nippon Systemhouse
Nipponcoinco
Nixdorf Computer
Northern Telecom
Ohio Scientific
Okidata
Olivetti
Otari Electric
ParSci
Peripheral Technology
Perkin Elmer
Pertec Computer
Philips Data Systems
Plus Development
PrairieTek
Priam
Quantum
Qume
Ricoh
Rodime
ROM-CD
Rotating Memory Systems
Sagem
Samsung Electronics
Seagate Technology
Seiko Epson
Shinwa Digital Industry
Shugart Associates
Siemens
SLI Industries
Sony
Sord Computer
Sperry
Storage Technology
SyQuest Technology
Tandon
Teac
Tecstor
Texas Instruments
Tokico
Tokyo Electric
Toshiba
ToyoSoda
Tulin
Unisys
Vermont Research
Vertex
Victor Company of Japan
Western Dynex
Xebec Corporation
YE Data

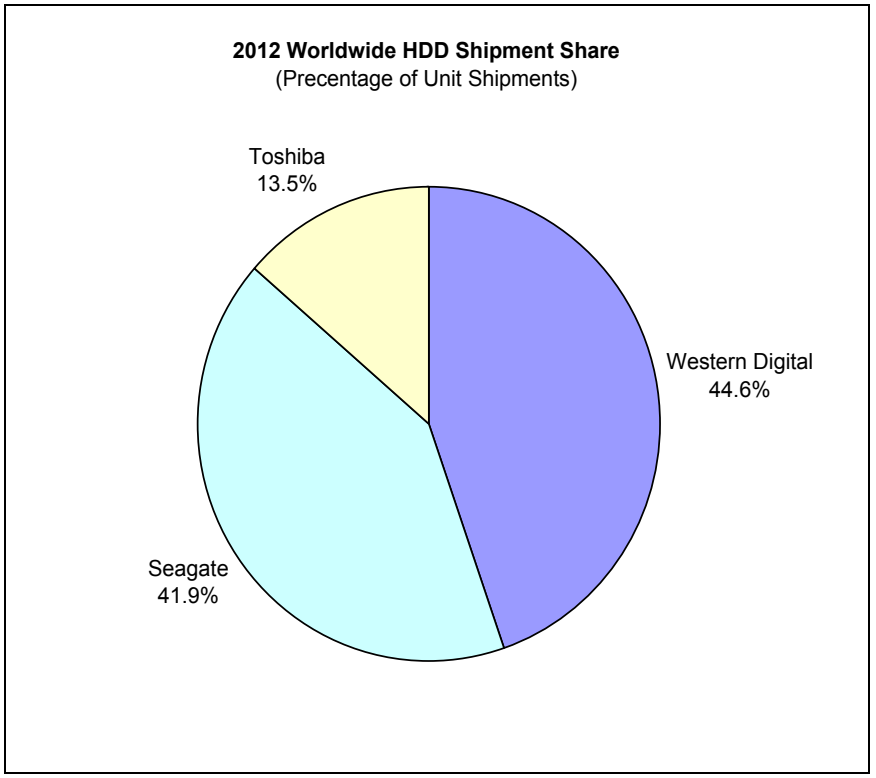
Disk Drive Industry 2007

Cornice
Excelsior
Fujitsu
Hitachi GST
Samsung
Seagate
Toshiba
Western Digital



Disk Drive Industry 2012

Seagate
Toshiba
Western Digital



A Complex Head Market

Changes taking place in the supply chain for WD with consolidations of the HDD industry

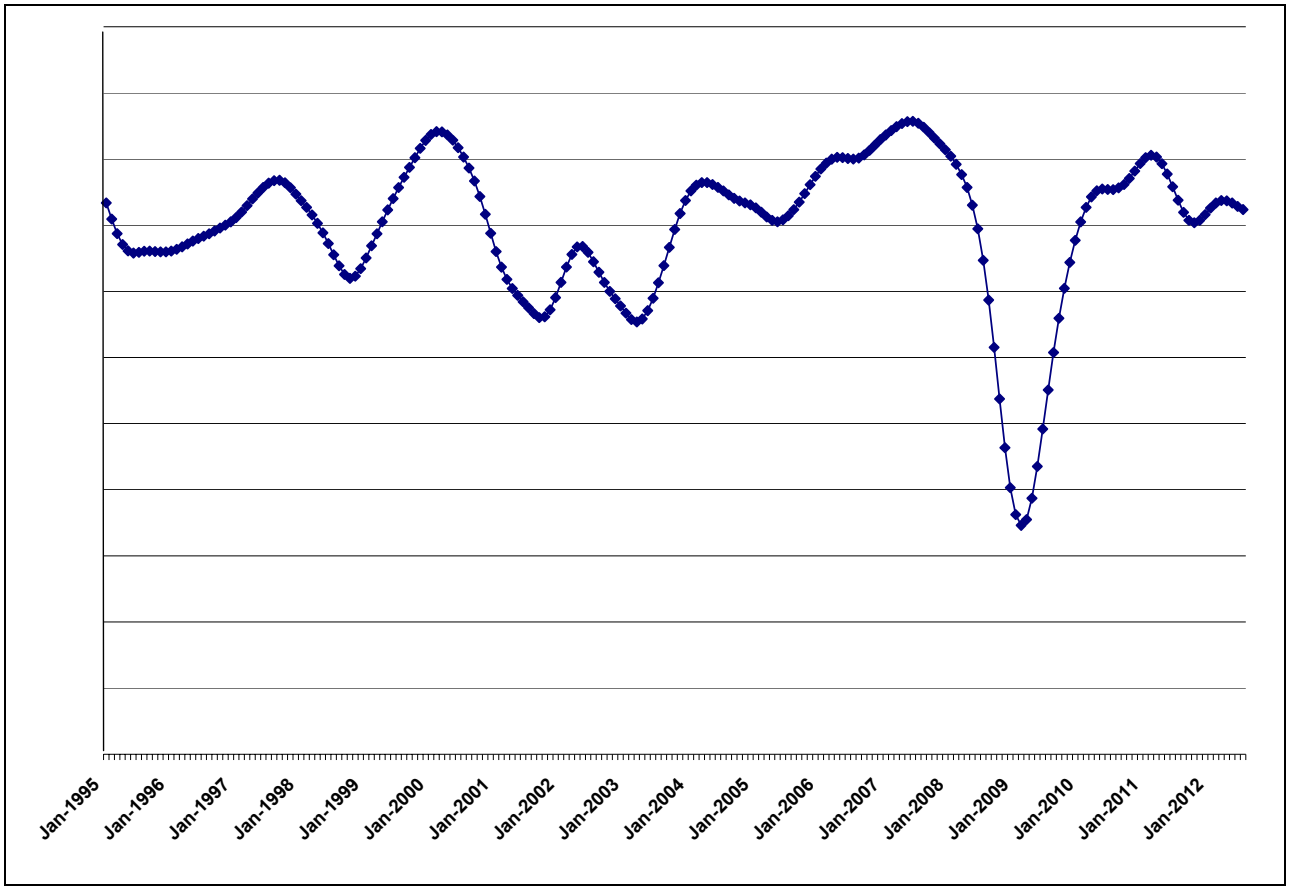
	Heads Sold	% made	Heads Made
Seagate	635	0.88	559
TDK			858
WDC	561	0.82	262
HGST	319	0.97	262
Toshiba/ Fujitsu	270	0	0
Samsung	155	0	0
Total	1941		1941

A Convoluted Suspension Market

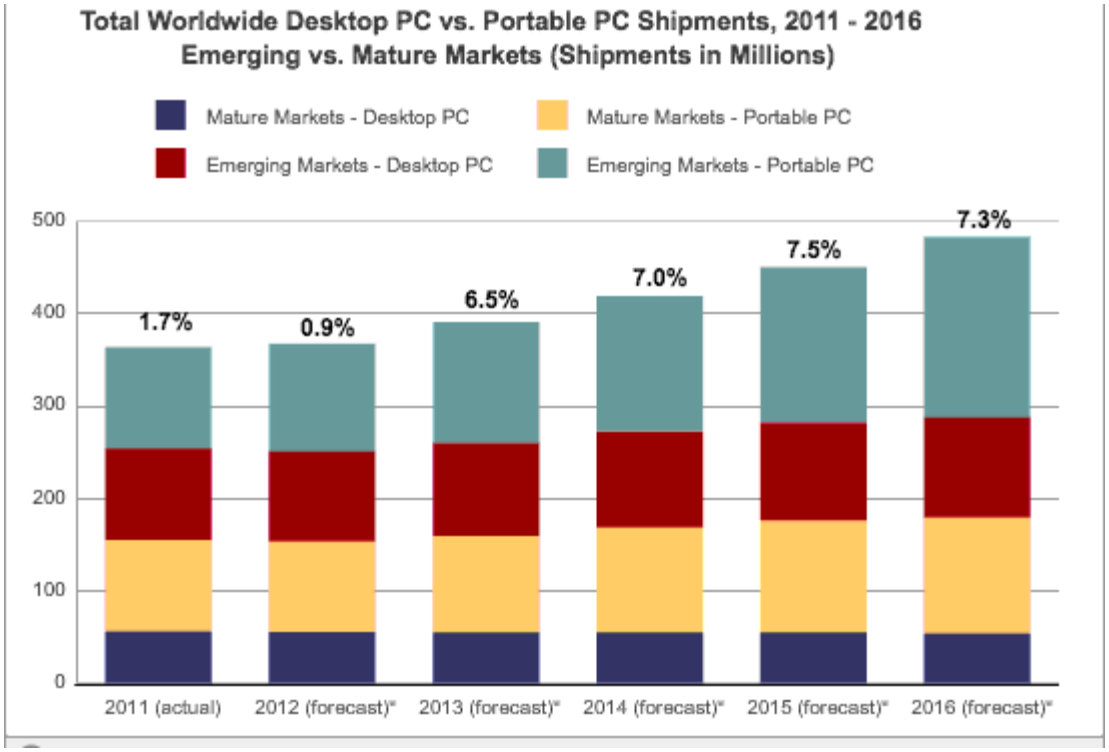
- Hutchinson Technology's customers include Western Digital Corporation, SAE Magnetics, Ltd/TDK Corporation, Seagate Technology, HGST, and Toshiba.
- MPT's customers include Western Digital Corporation , SAE Magnetics, Ltd/TDK Corporation, and Seagate Technology. SAE Magnetics sells further to Toshiba and Samsung
- NAT Peripheral's customers include SAE Magnetics, which sells further to Samsung. The NAT Peripheral joint venture has provided SAE Magnetics, Ltd./TDK Corporation the capability to produce suspension assemblies since calendar 2005.
- NHK's customers include Western Digital Corporation, Seagate Technology, and Hitachi.
- SunCall's Customer is HGST

	Millions of units	Share
Hutchinson Technology	454	23.4%
NHK	763	39.3%
MPT	645	33.2%
SunCall	79	4.1%
Total	1941	100.0%

Weak Economy Is the Number One Issue



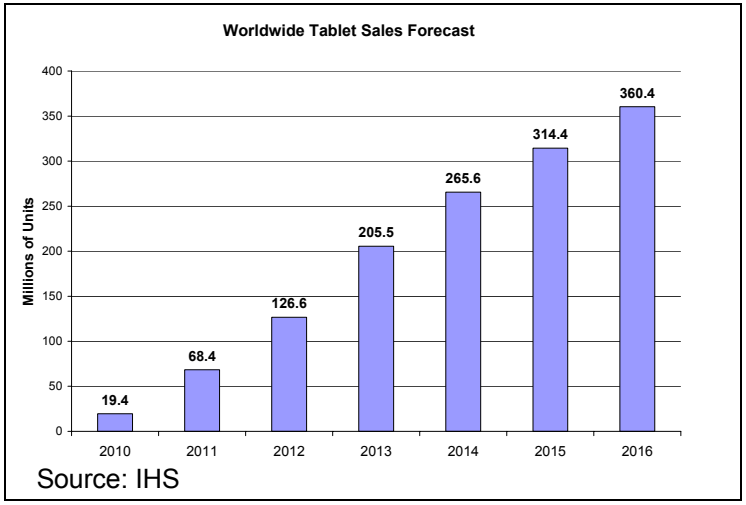
Weak Economy Is Culprit for Slow PC Growth

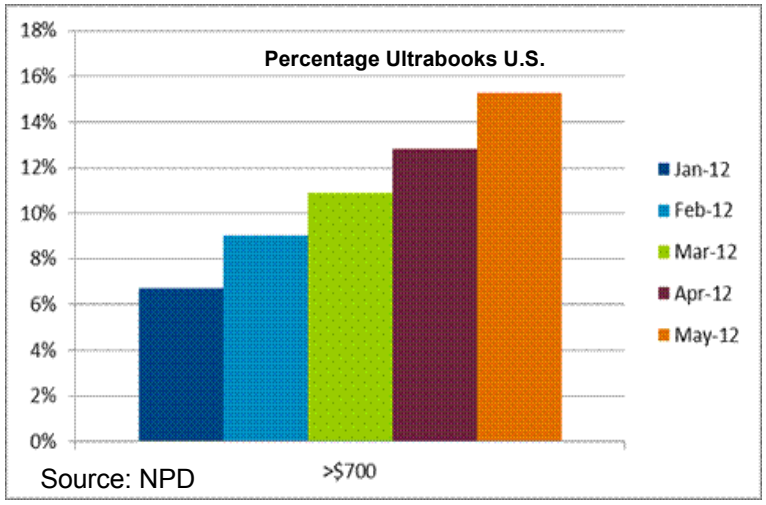


Source: IDC

Great WOW Factor – HDDs?

Great WOW Factor = Great Growth





Old Approach at the Enterprise

Old Approach:
More HDDs = Performance

HDD-ONLY CONFIGURATION

- Slower Mechanical Drives
- Inefficient I/O Transfer Rates
- Smaller Form Factor Drives
- Over-provisioning of HDDs
- Lower Capacity HDDs
- Latency and Bandwidth Issues

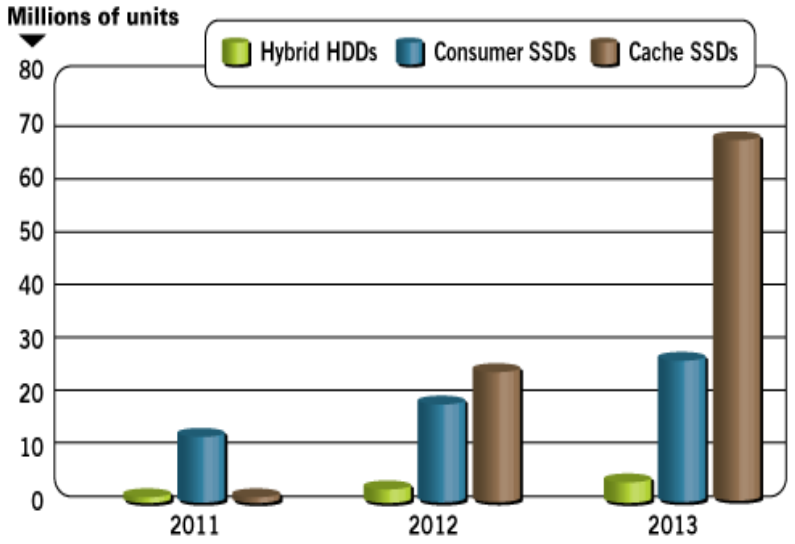
New Approach at the Enterprise

New Approach:
SSD + HDD = Cost Savings

HDD-ONLY CONFIGURATION	HYBRID CONFIGURATION
▪ Slower Mechanical Drives ▪ Inefficient I/O Transfer Rates ▪ Smaller Form Factor Drives ▪ Over-provisioning of HDDs ▪ Lower Capacity HDDs ▪ Latency and Bandwidth Issues	▪ Faster I/O Performance ▪ Lower System Cost $/GB ▪ Tiered Data Storage – 'Hot' Data on SSDs ▪ Improved Reliability ▪ Increased Capacity with a Smaller Footprint

Cache SSDs in Ultrabooks will Help the HDD Industry

- Cache SSDs are a discrete, separate memory component alongside the device's HDD, with both elements housed separately
  - Discrete cache SSDs and HDDs are much more scalable and efficient for mainstream storage, with a broad selection of drive manufacturers.
- Cost concerns, longer design cycles, and tighter engineering tolerances in the case of hybrid HDDs add to their difficulty of use in ultrabooks.



Source: IHS

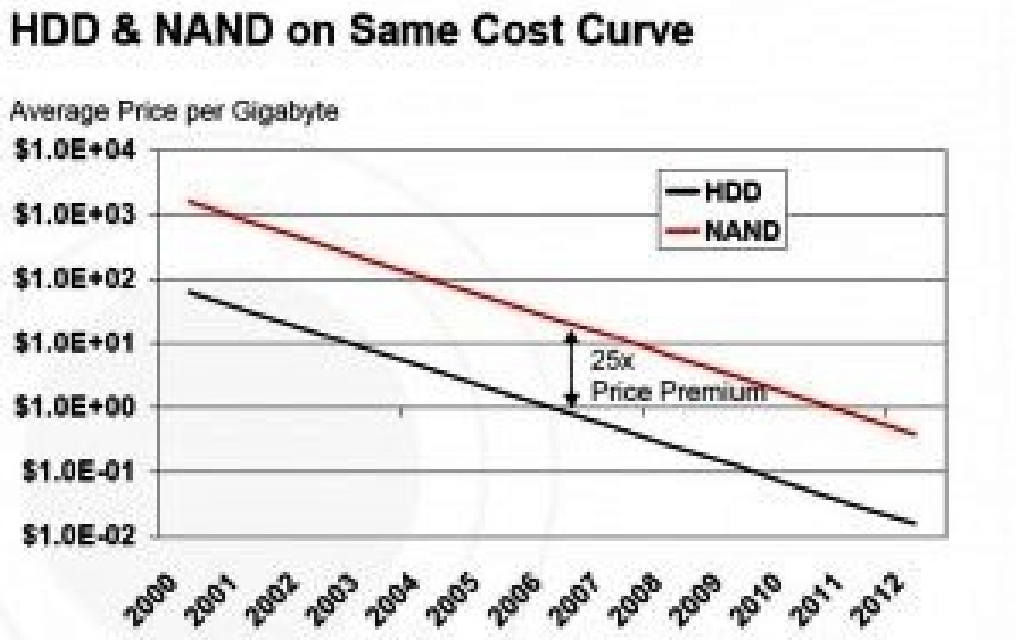
Social Media is Demanding Huge Amounts of Storage

Cloud Services: The Great Hard Drive in the Sky

Summary

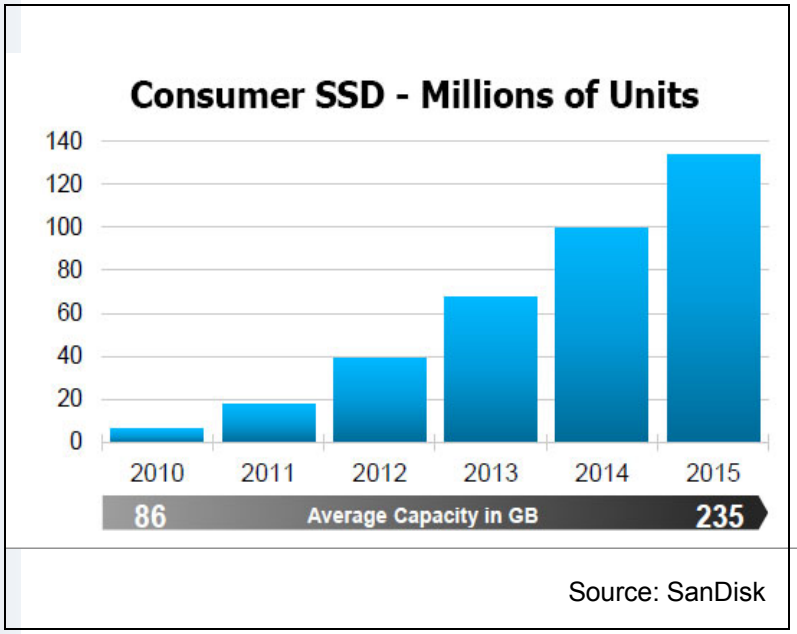
- Despite:
  - Consolidation
  - Floods
  - Poor Economy
  - Changes to Supply Chain
  - Rapid Advances of WOW Devices
- HDDs will continue to Trudge Along
  - Because of the Need for Massive Storage
- However….

While Cost Differential of 25x May Hold

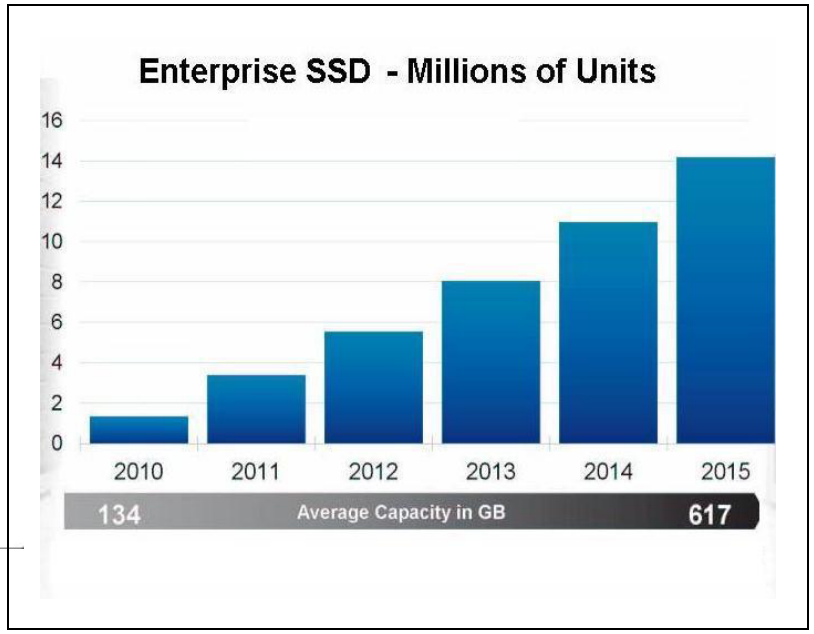


Source: Objective Design

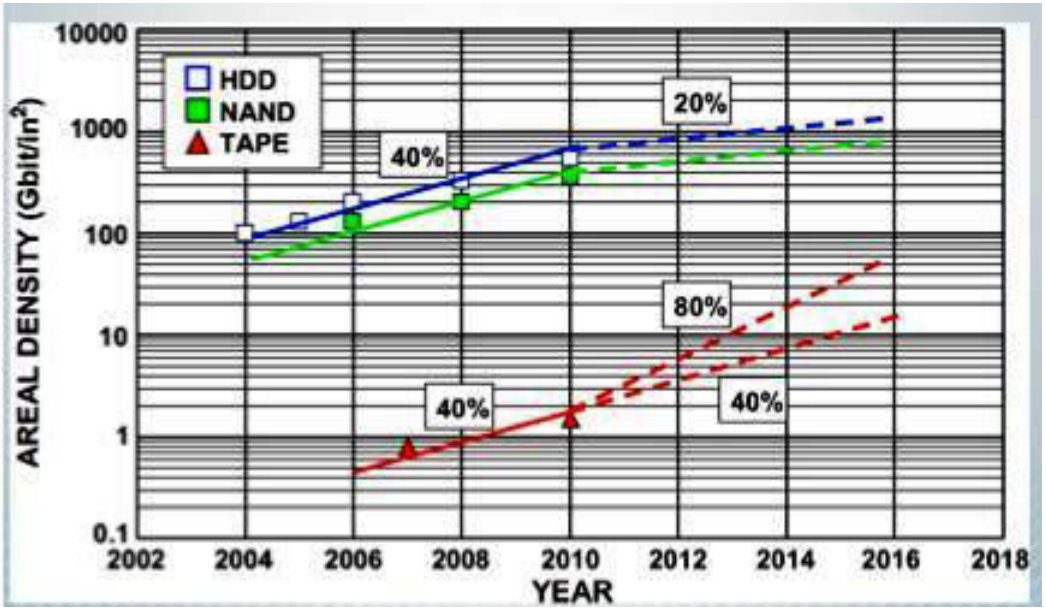
And Strong Growth is Forecast For SSDs



Source: SanDisk



Areal Density for HDD (and SSD) has Slowed to 20%/year



Source: Hitachi

And So HDDs As We Know Them May Hit a Brick Wall Soon

PROBLEM:

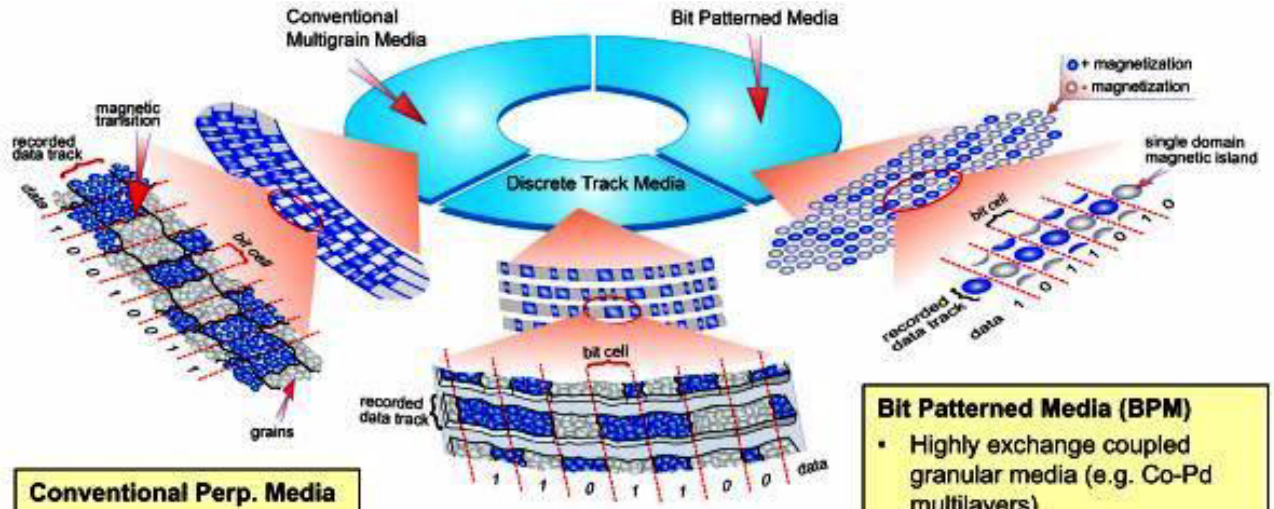
- To increase density, need smaller grains
- Smaller grains (~100 Angstroms) are thermally unstable
- To avoid thermal instability, increase grain anisotropy Ku
  - This increases the medium coercivity and makes the medium more difficult to write

SOLUTIONS:

- Work with higher anisotropy:
- Capped and exchange spring media
- Thermally assisted recording (TAR)
- **Work with larger 'grains': patterned media**

Courtesy: Thomas R. Albrecht, HGST

Replaced by Bit Patterned Media (BPM)



Conventional Perp. Media

- Continuous granular recording layer
- Multiple grains per bit
- Boundaries between bits determined by grains
- Thermal stability unit is 1 grain (~ 6 nm diam.)
- Reaching its limits

Discrete Track Media (DTM)

- Conventional perpendicular media, with patterned tracks
- Multiple grains per bit
- Eliminates track edge noise and reduces adjacent track interference
- Thermal stability unit is still 1 grain (~ 6 nm diam.)
- Modest areal density gain possible

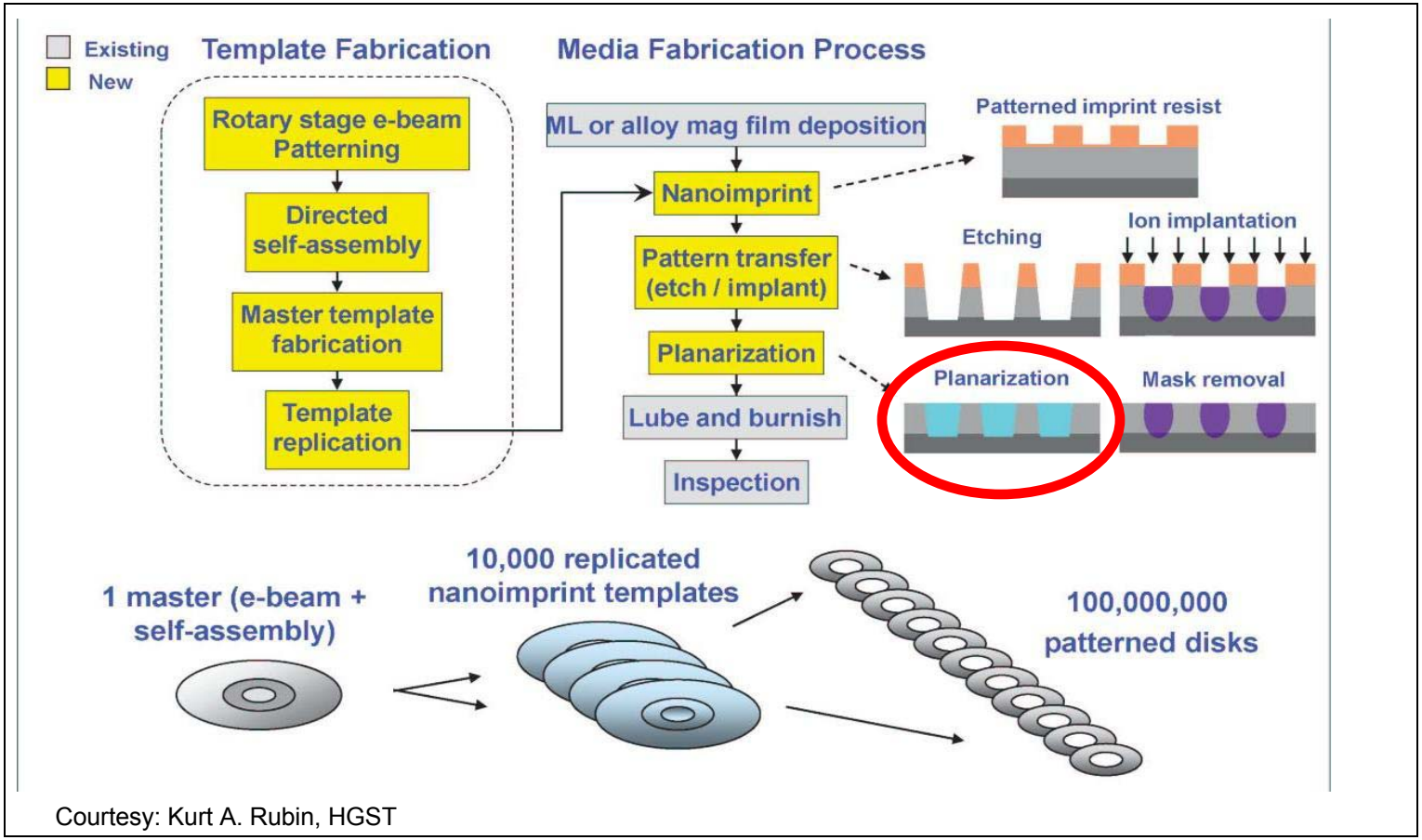
Bit Patterned Media (BPM)

- Highly exchange coupled granular media (e.g. Co-Pd multilayers)
- Multiple grains per island, but each island is a single domain particle
- Bit locations determined by lithography
- Therm. stab. unit is 1 island (~15 nm diam.)
- Substantial areal density gain should be feasible

3

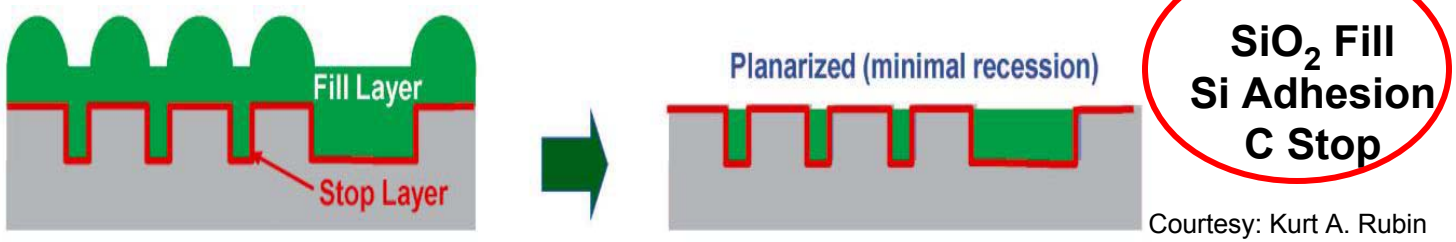
Courtesy: Thomas R. Albrecht, HGST

Bit Patterned Media: Fabrication Overview



Courtesy: Kurt A. Rubin, HGST

Challenges in TFH CMP

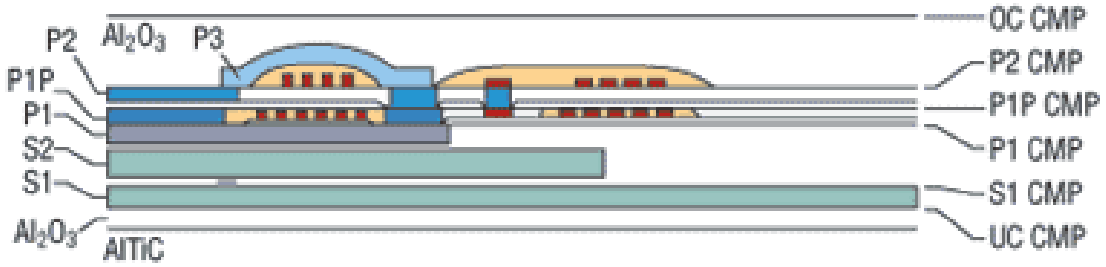


Courtesy: Kurt A. Rubin

- Total thickness variation (TTV) of AlTiC substrates
- CMP results are sensitive to pad surface
- Wafer flats
- Final thickness control
- Pre-CMP film non-uniformity
- Corrosion of exposed metal on the head device
- Most IC CMP advancements take place at 300mm while the bulk of GMR Head manufacturing is being done on 150 to 200mm wafers

Source:;Strasbaugh

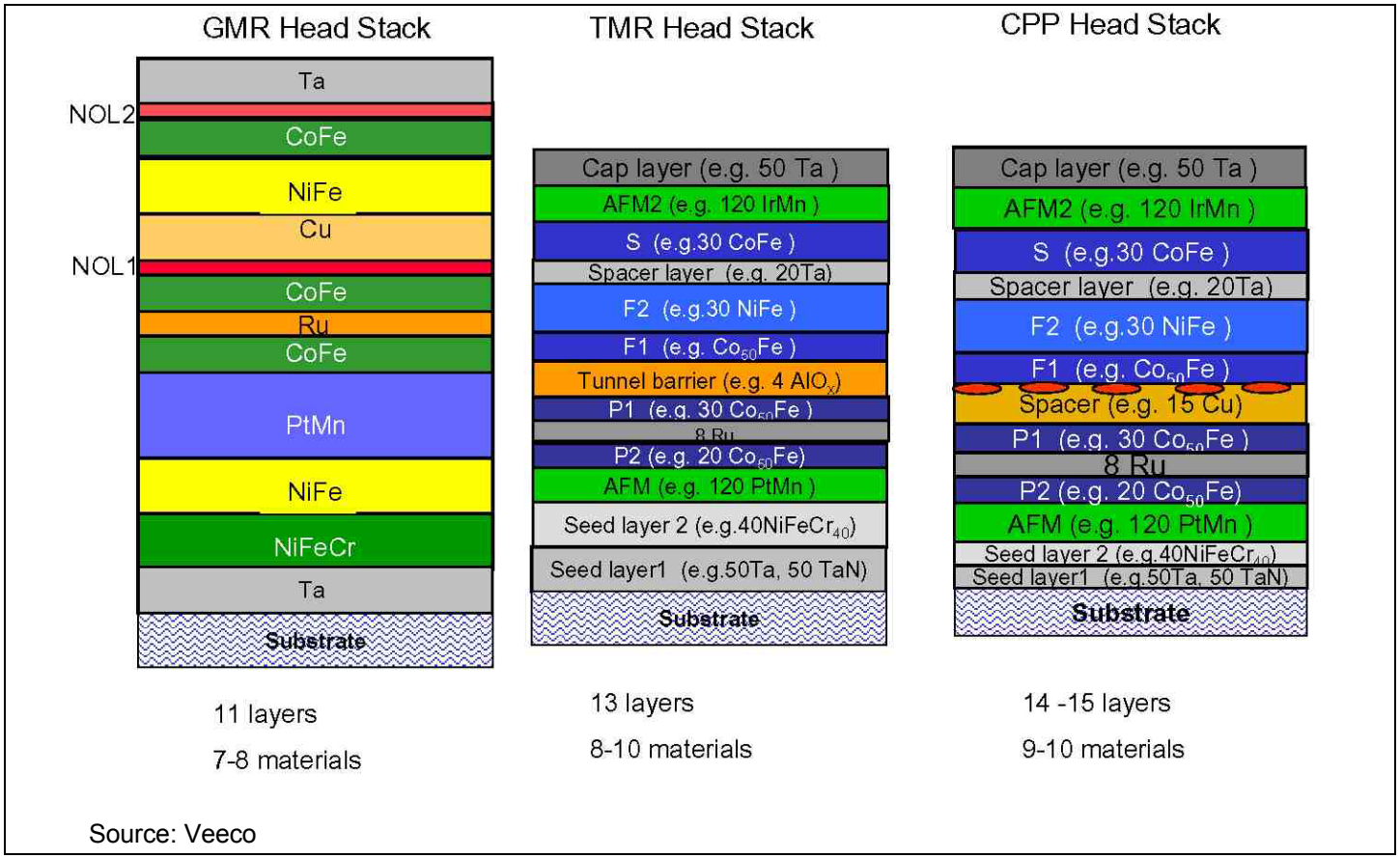
TFH: Fabrication Example



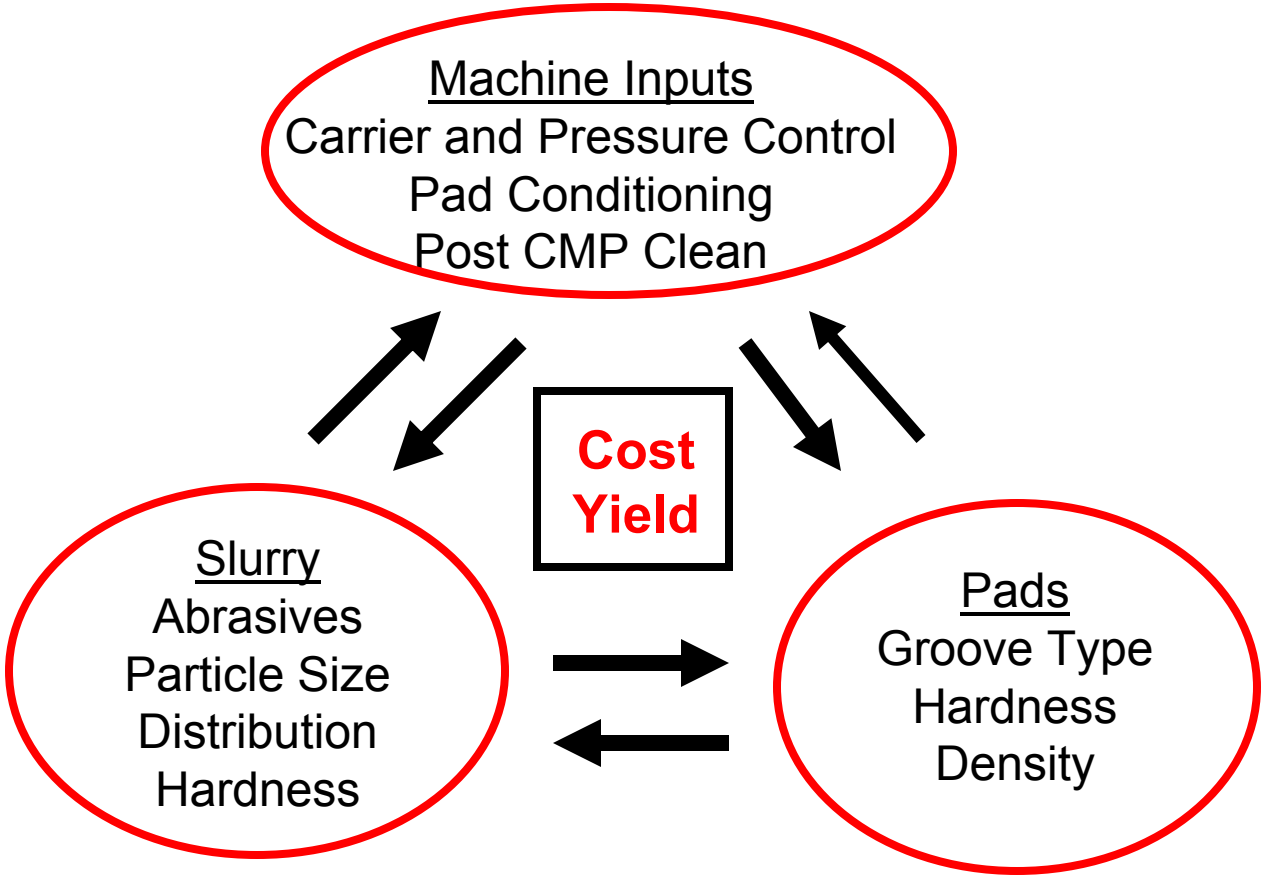
- AlTiC substrate;
- Undercoat (Al2O3) deposition and polishing (UC CMP);
- First shield (NiFe) pattern, deposition/plating, fill, and CMP (S1 CMP);
- First gap (Al2O3) deposition, GMR film deposition, GMR track-width definition/hard bias/leads, GMR stripe-height definition;
- Second gap (Al2O3) deposition;
- Second shield (NiFe) pattern and plating, separating gap deposition, first write pole (NiFe) pattern, plating, fill, and CMP (P1 CMP);
- First write pole extension P1P (NiFe, CoNiFe, or CoFe) and first layer write copper coil pattern, plating, fill, and CMP (P1P CMP);
- Write coil insulation and writer gap deposition, second write pole (CoNiFe, CoFe) pattern, plating, pattern of second pole width into first pole by ion milling, fill, and CMP (P2 CMP);
- Second layer write coil and P3 (NiFe) yoke plating, copper connections, overcoat (Al2O3) deposition and polishing (OC CMP);

Source: HGST

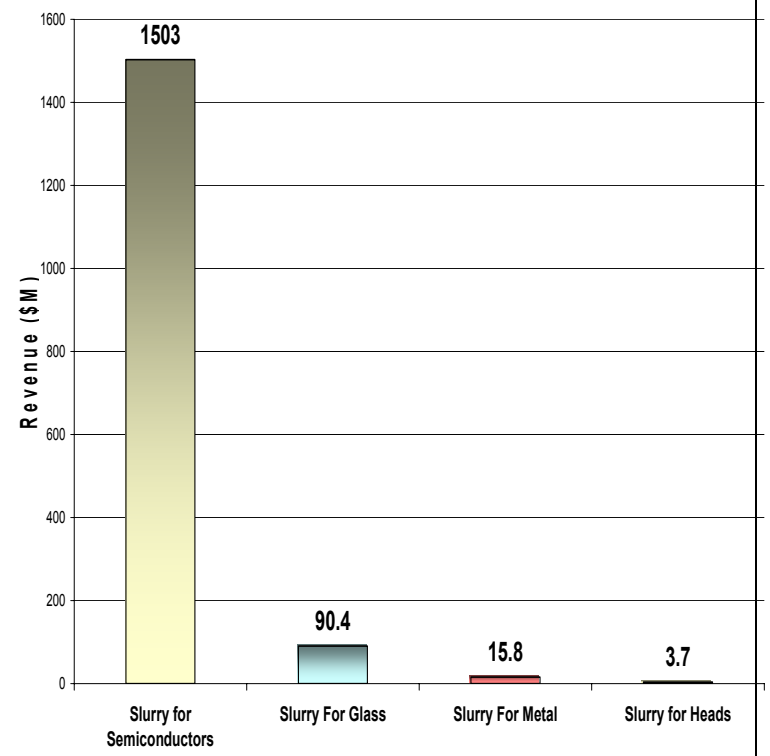
Vast Array of TFH Stacks With New Materials and Thinner Films



Huge R&D Costs in Supply Chain With Technology Advances



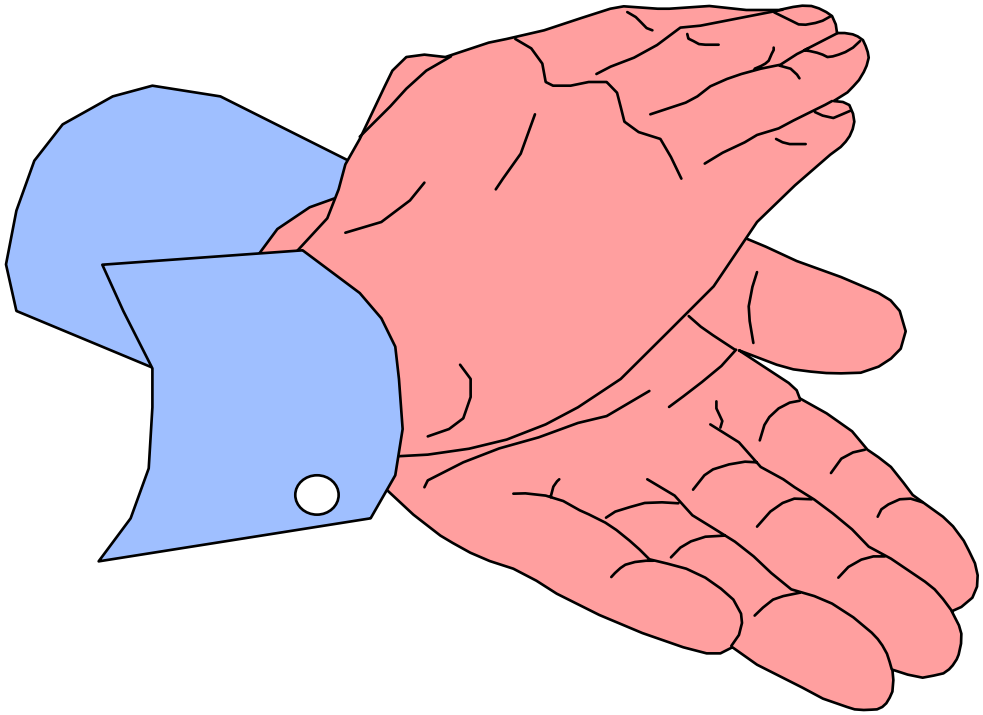
Small Market, Big Concerns



Source: The Information Network

- Only a handful of customers left after consolidation
- Market extremely small
  - Will Equipment, Slurry, and Pad manufacturers continue to emphasize R&D?
  - Will small customer base force suppliers to get out of the market?
  - Will HDD and platen manufacturers need to spend more internal R&D on planarization material customization to make up the difference?

Thank You



Source: The Information Network