



Flash Market Update, 2018

Jim Handy

**OBJECTIVE
ANALYSIS**

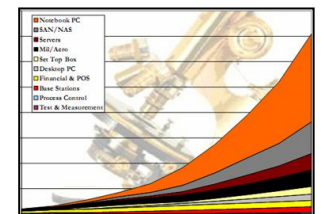
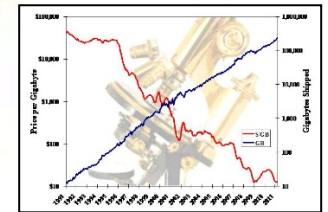
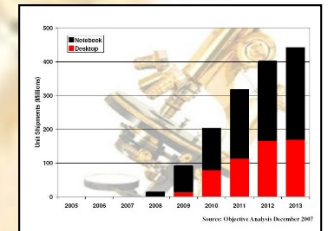
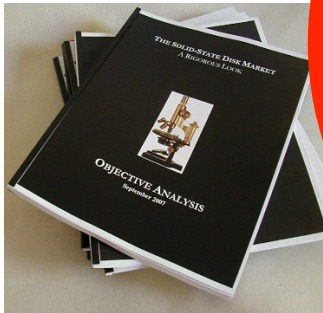
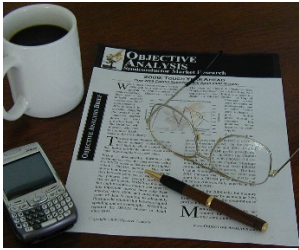
OBJECTIVE ANALYSIS



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OBJECTIVE ANALYSIS – www.OBJECTIVE-ANALYSIS.com

Objective Analysis

Semiconductor Forecast Accuracy

Year	Forecast	Actual
<u>2008</u>	Zero growth at best.	-3%
<u>2009</u>	Growth in the mid teens	-9%
<u>2010</u>	Should approach 30%	32%
<u>2011</u>	Muted revenue growth: 5%	0%
<u>2012</u>	Revenues drop as much as -5%	-2.7%
<u>2013</u>	Revenues increase nearly 10%	4.9%
<u>2014</u>	Revenues up 20%+	9.9%
<u>2015</u>	Revenues up ~10%	-0.2%
<u>2016</u>	Revenues up ~10%	1.1%
<u>2017</u>	Revenues up ~20%	22%
<u>2018</u>	Strong start supports 10+% growth	TBD

Agenda



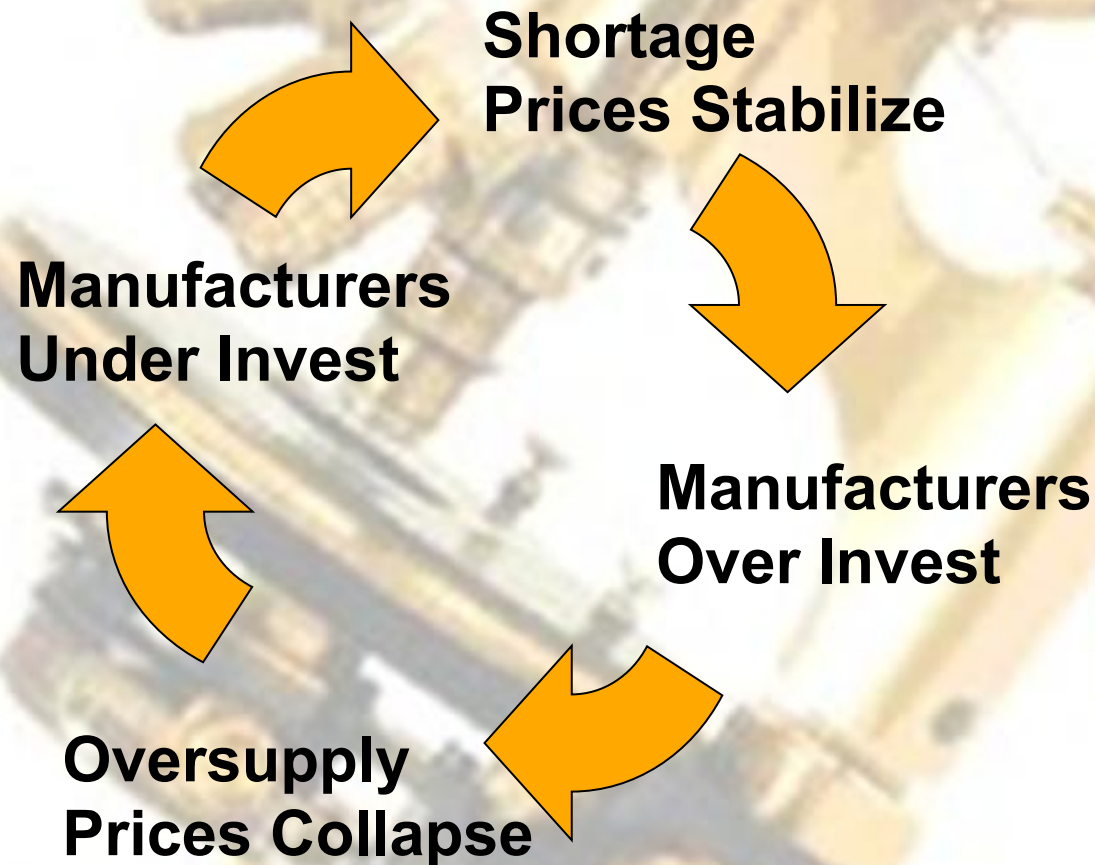
- NAND Flash Outlook
- Emerging Memories
- 3D XPoint
- China's Memory Plans
- Summary

A blurred background image of a brass microscope, showing the eyepiece, objective lenses, and the main body of the instrument. The text "NAND Flash" is overlaid in the center.

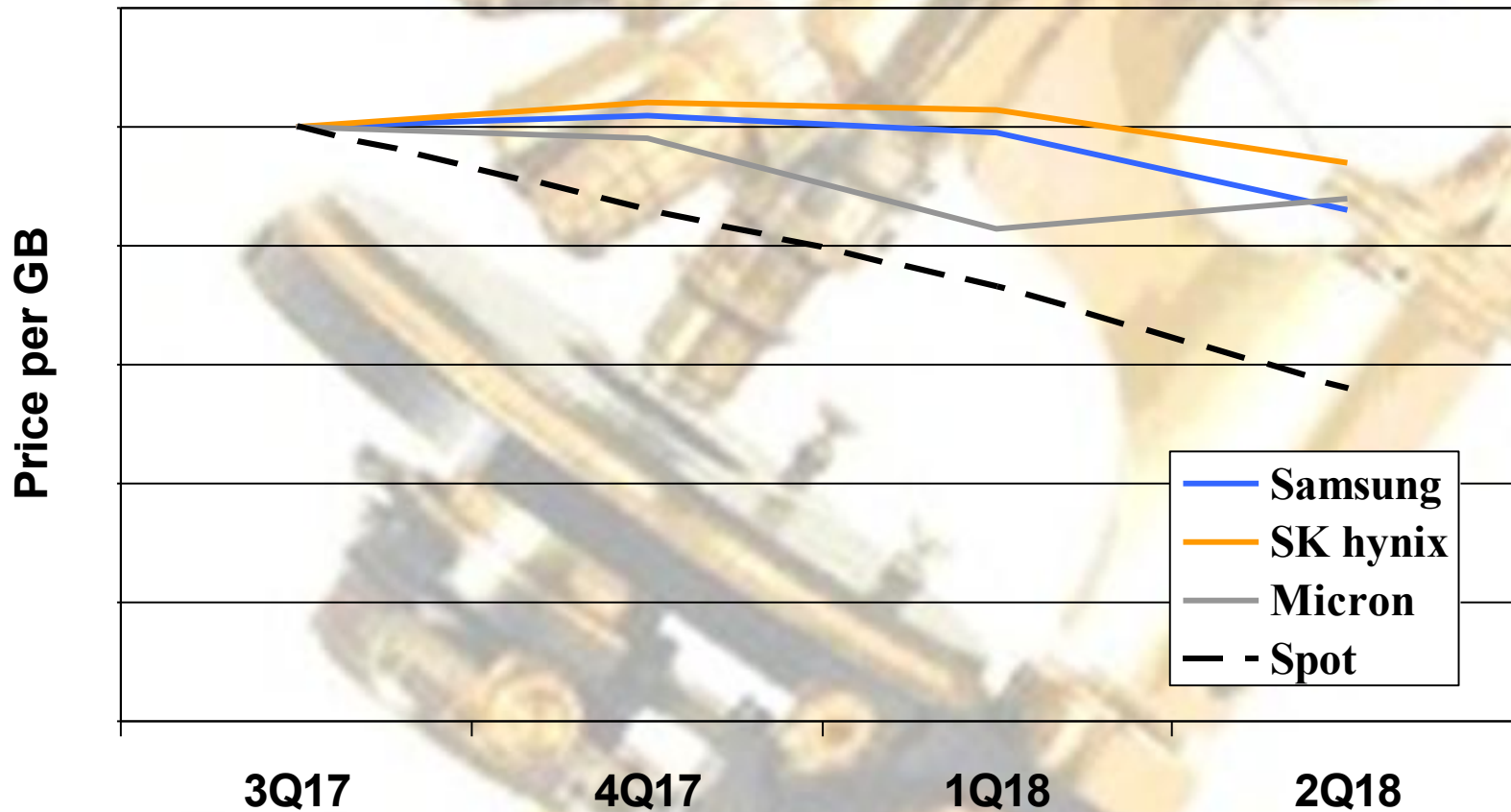
NAND Flash

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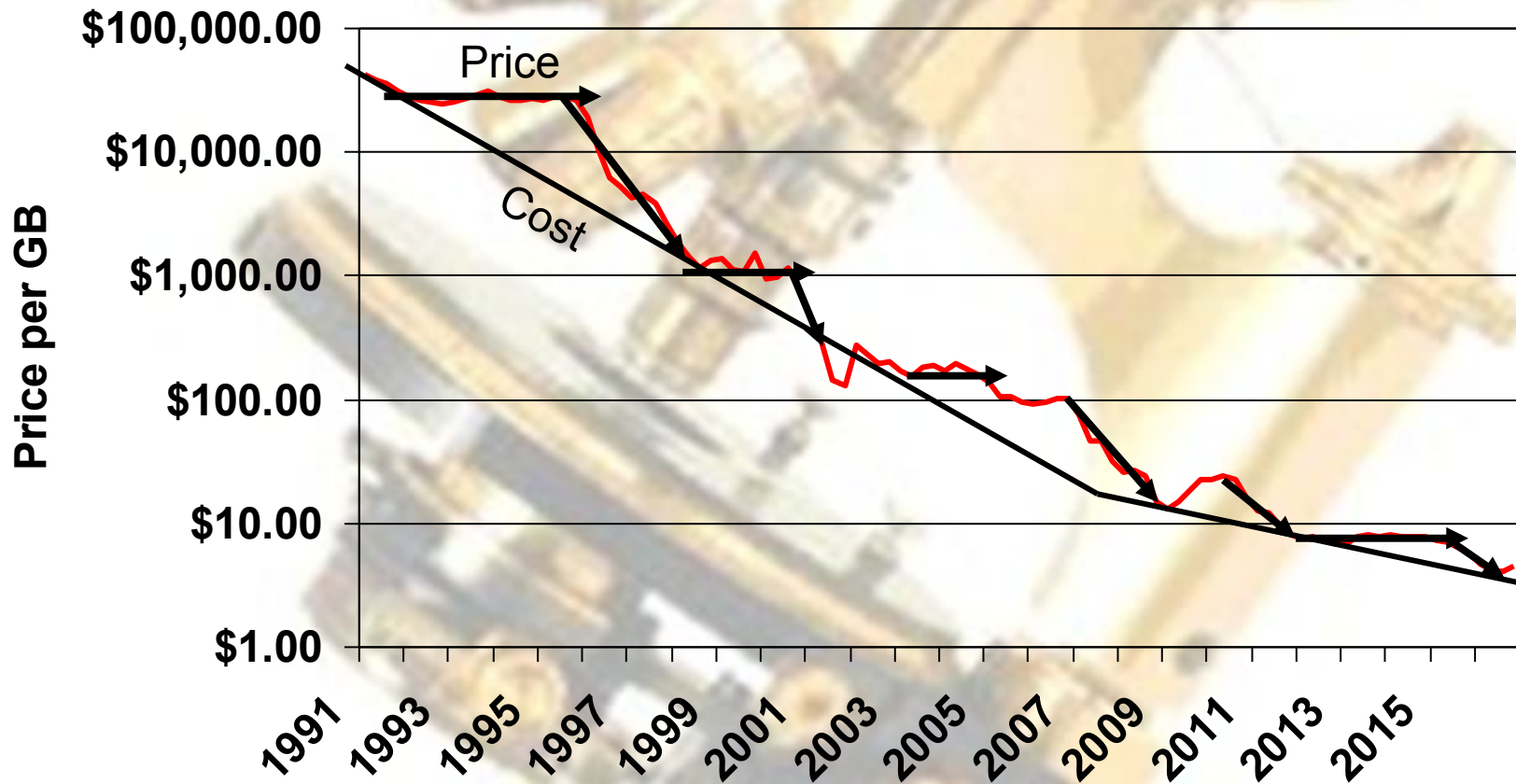
Vicious Cycle of a Price Collapse



NAND Flash Prices Falling



Memory Price Cycles

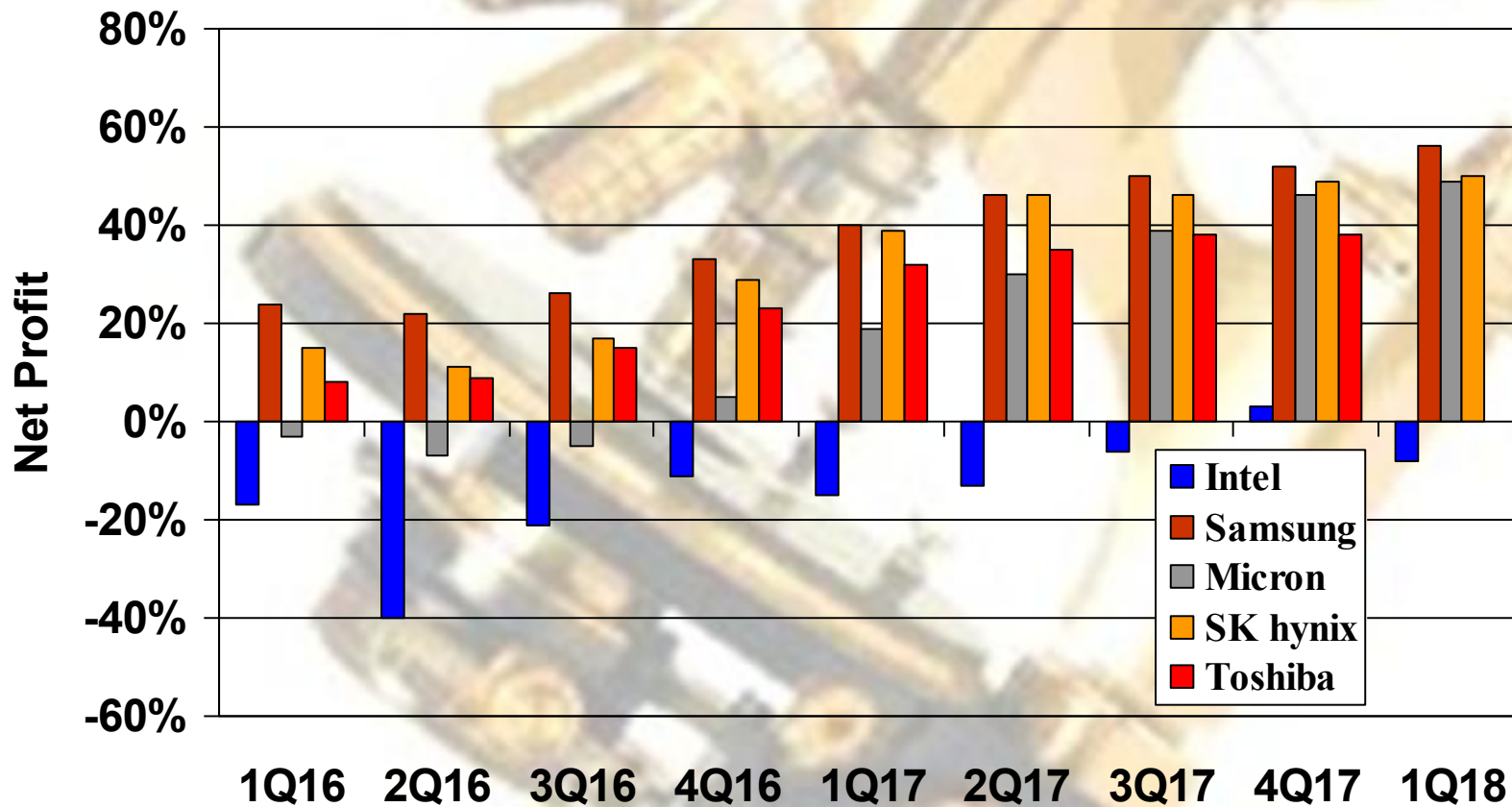




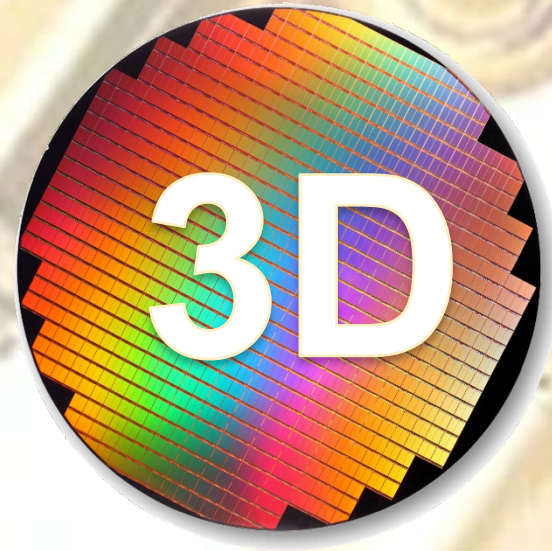
Collapse to Cost

What /S Cost?

NAND Flash Maker Profits

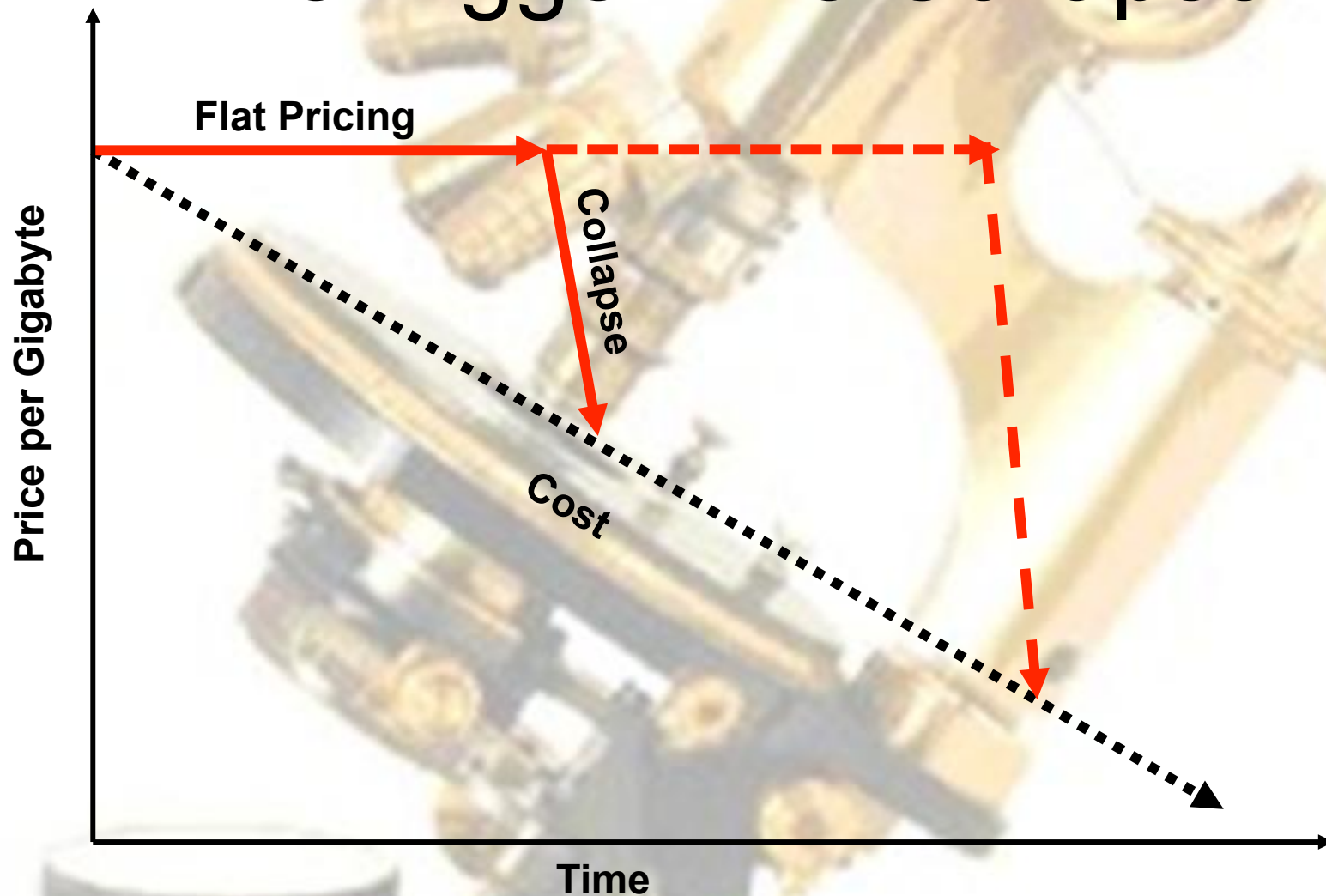


Planar vs. 3D NAND Mfg. Cost

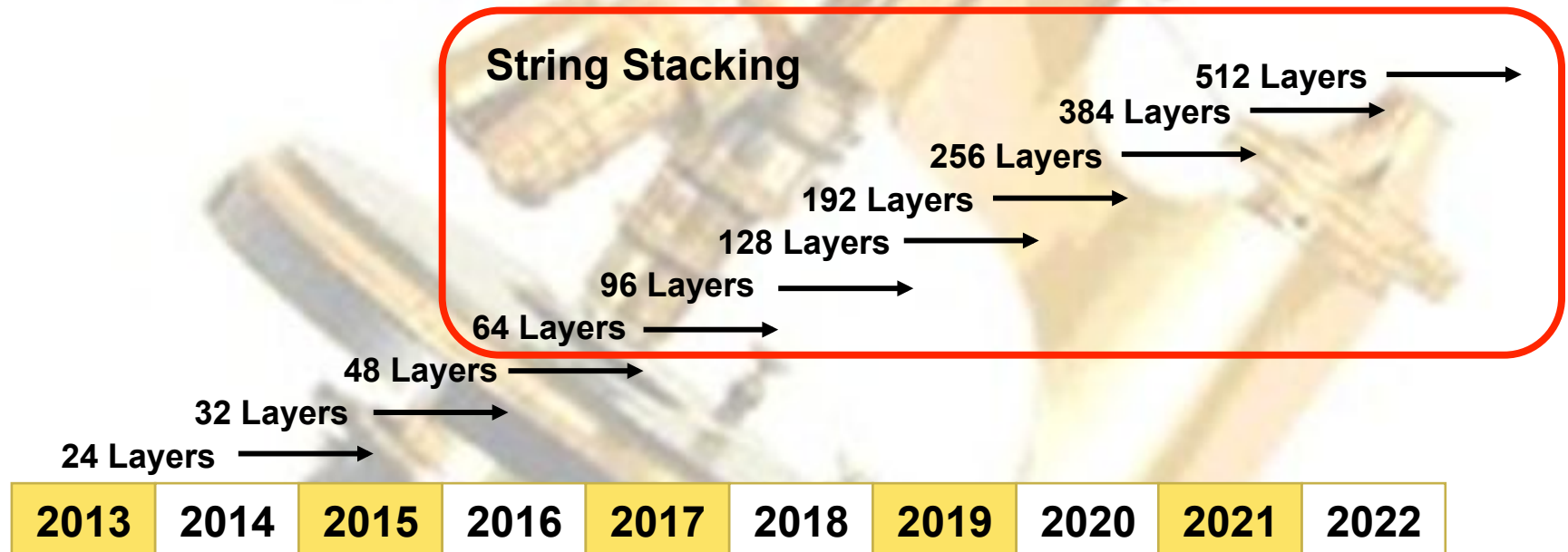


	16nm Planar	3D-32
Terabytes/Wafer	5.6	17.2
Wafer Cost	\$1,200	\$2,000
Cost/GB	\$0.21	\$0.12

The Longer Shortage, The Bigger The Collapse!



3D NAND Roadmap



Key DRAM & NAND Makers

Company	DRAM	NAND	Comments
Samsung	46%	33%	Focus: large customers & internal SSDs
SK hynix	26%	11%	Finally shipping 3D NAND in volume
Toshiba	--	19%	Spun off and ready to grow
WDC/SanDisk	--	18%	Rarely supplies chips
Micron	21%	12%	Breaking ties with Intel
Intel	--	7%	Only producing for Intel SSDs

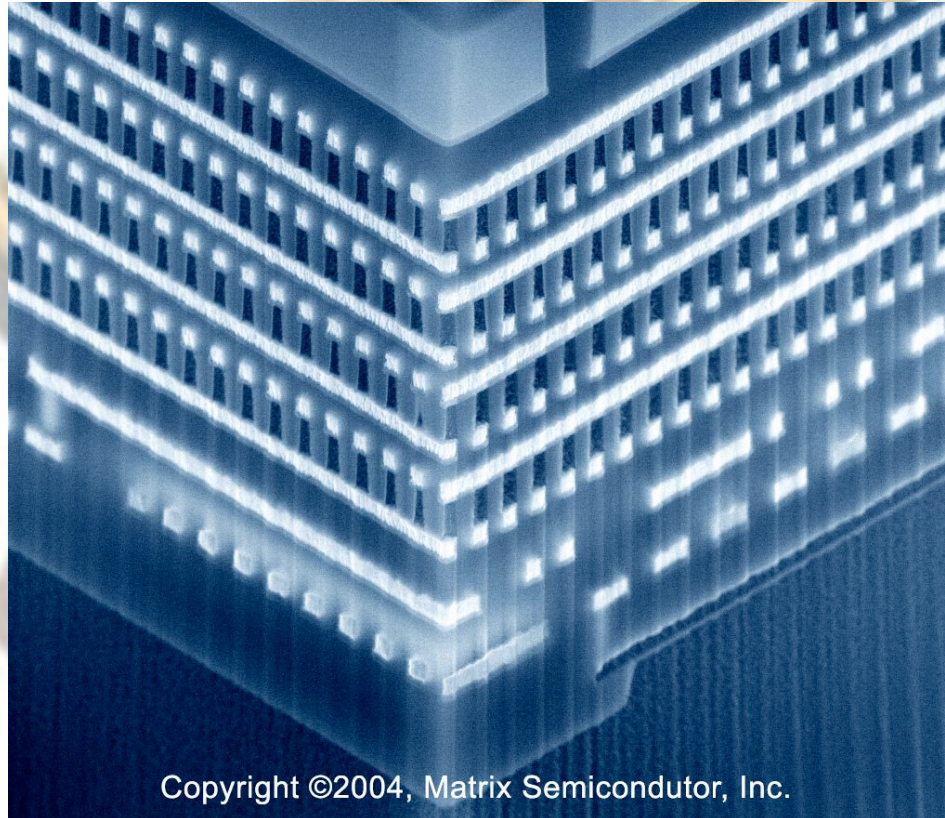
How Collapse Will Evolve

- NAND oversupply
 - Prices plunge to 3D-64 cost: <\$0.08/GB
 - Planar capacity no longer viable
 - Closed or converted to DRAM
- Subsequent DRAM oversupply
 - Some facilities no longer viable
 - Closed or converted to SRAM/NOR/Foundry
- Subsequent other oversupplies

2018 Revenue Growth Slows

- Great first half but mid-year collapse
 - Memory cycle is still alive!
- Strong start supports revenue growth
 - DRAM +12%, down from ~80%
 - NAND +9%, down from ~50%
- Downturn commences in 2H18
 - 2019 will be a down year

Emerging Memories



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Today's Memories Are Limited

	SRAM	DRAM	ROM	EEPROM	NOR	NAND
Nonvolatile	No	No	Yes	Yes	Yes	Yes
Erasable	Yes	Yes	No	Yes	Yes	Yes
Programmable	Yes	Yes	Factory	Yes	Yes	Yes
Smallest Write	Byte	Byte	N/A	Byte	Byte	Page
Smallest Read	Byte	Page	Byte	Byte	Byte	Page
Read Speed	V Fast	Fast	Fast	Fast	Fast	Slow
Write Speed	V Fast	Fast	N/A	Slow	Slow	Slow
Active Power	High	Med	Med	Med	Med	Med
Sleep Power	V Low	High	Zero	Zero	Zero	Zero
Price/GB	High	Low	Low	High	Med	V Low
Applications	Small Fast	Main Memory	Stable Code Volume	Serial #, Trim	Code	Data

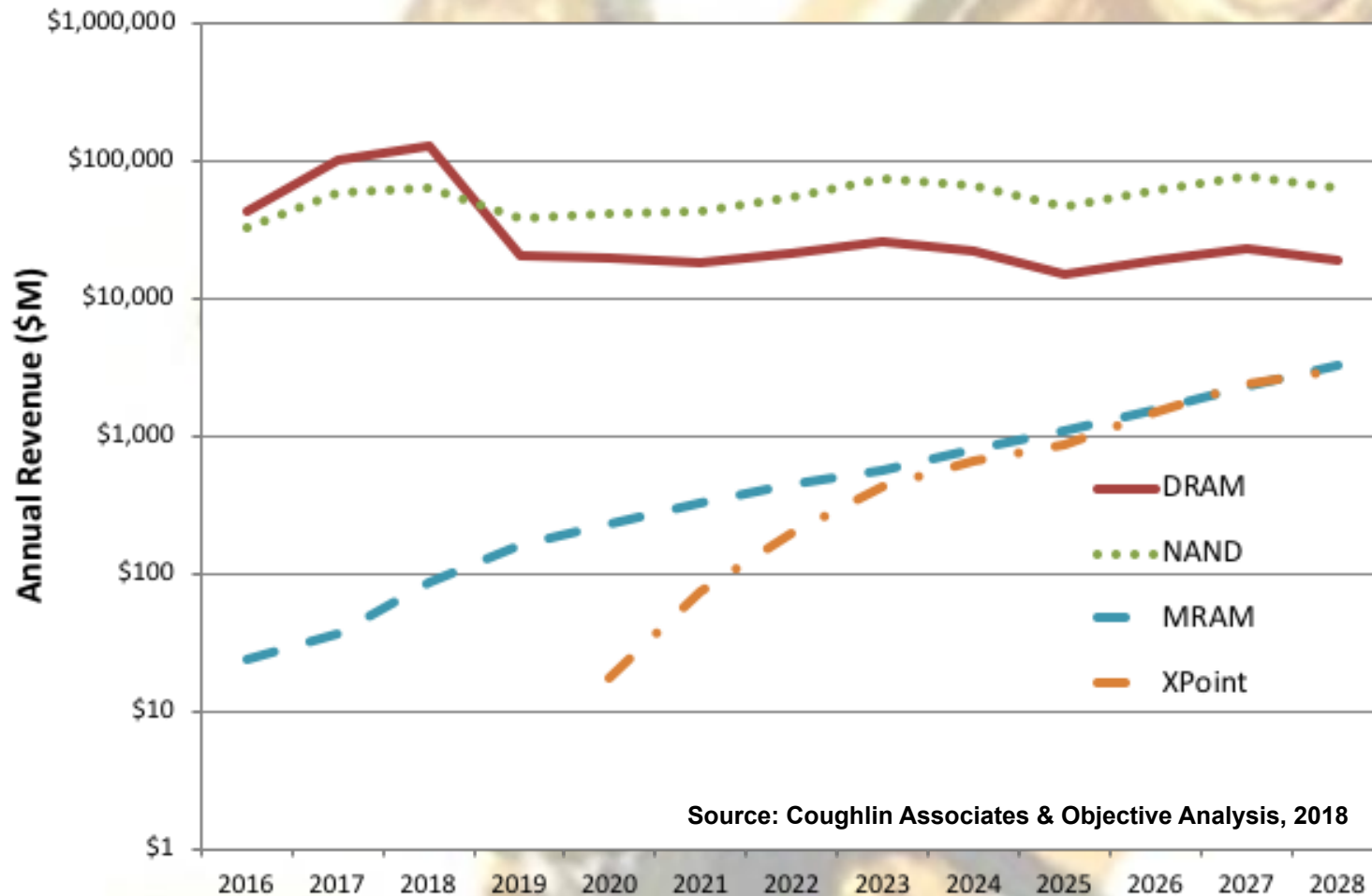
Emerging Memories Perform Better

	MRAM	ReRAM	FRAM	PCM	XPoint
Nonvolatile	Yes	Yes	Yes	Yes	Yes
Erasable	Yes	Yes	Yes	Yes	Yes
Programmable	Yes	Yes	Yes	Yes	Yes
Smallest Write	Byte	Byte	Byte	Byte	Byte
Smallest Read	Byte	Byte	Byte	Byte	Byte
Read Speed	Fast	Fast	Fast	Fast	Fast
Write Speed	Fast	Fast	Fast	Fast	Fast
Active Power	Low	Med	Low	High	High?
Sleep Power	Low	Low	Low	Low	Low
Price/GB	High	High	High	High	High?
Applications	Niche	TBD	Low Power	Obsolete	Main Memory

PM Market Drivers

- Early adopters need unique features
 - Less sensitive to cost
- Foundry will drive process refinement
 - Ports to stand-alone memories later
- Volume depends on economies of scale
 - Economies of scale depend on volume
- Persistence requires software support
 - SNIA & others are making this happen

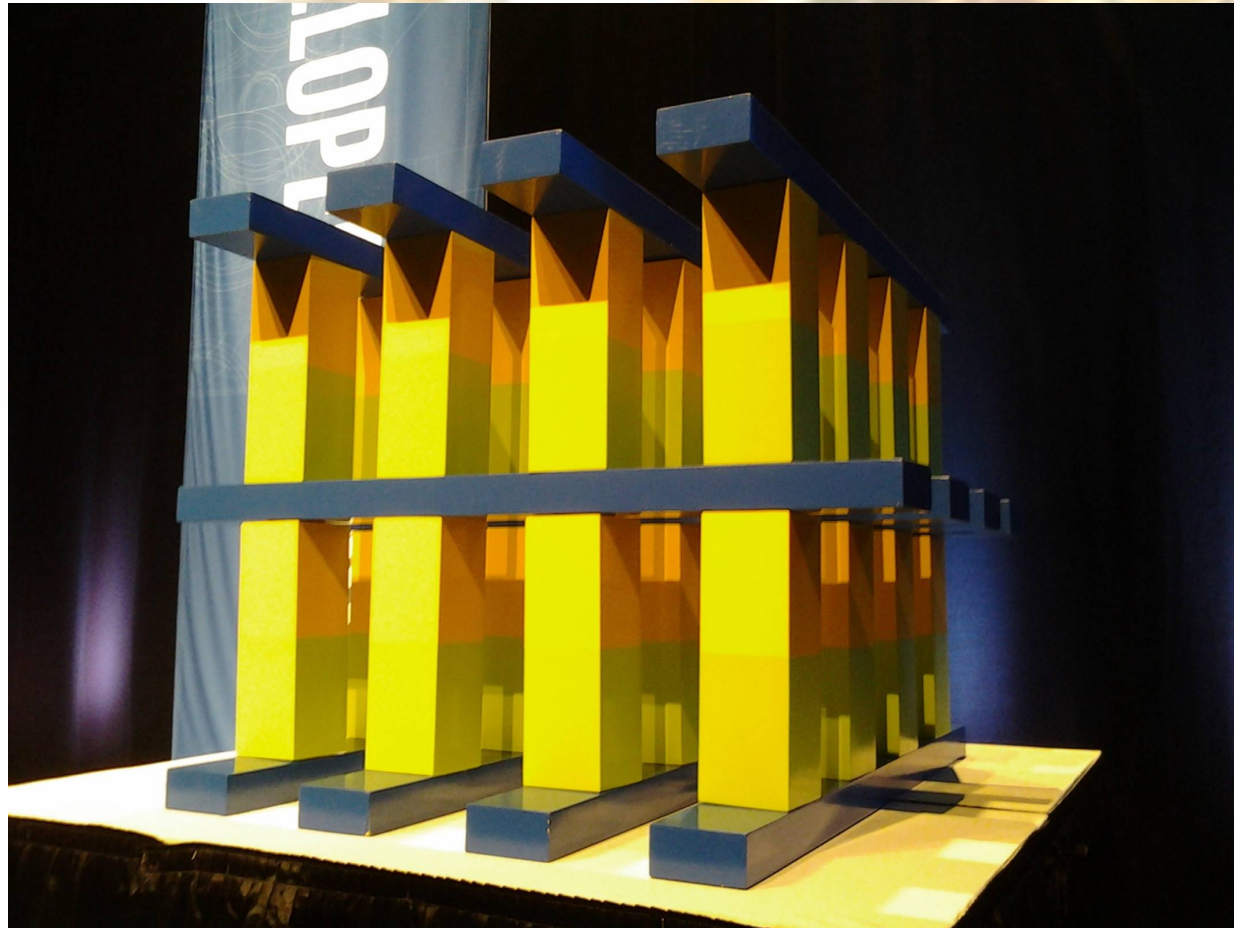
Emerging Memory Revenues



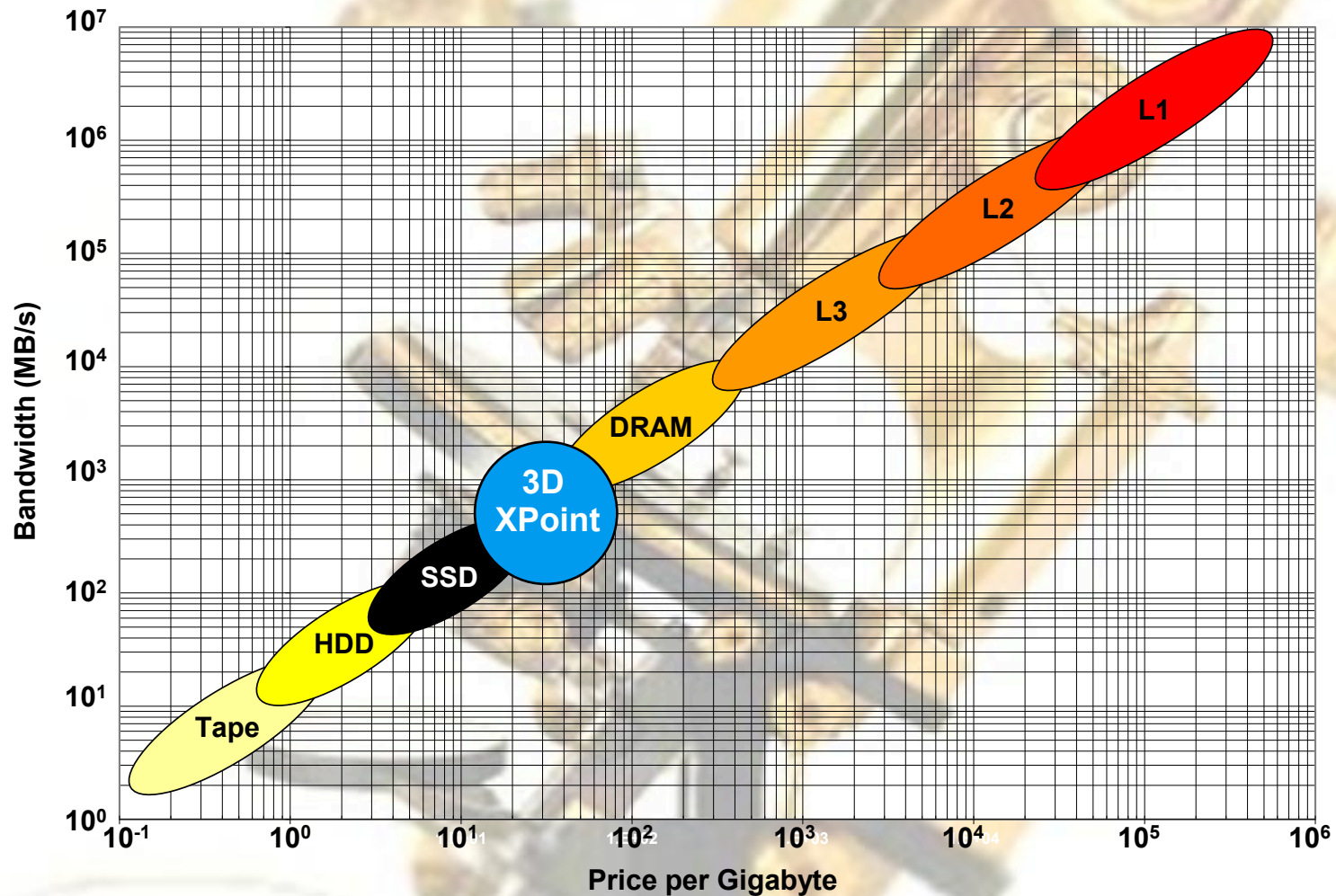
Emerging Memory Report

- Covers all major emerging memory technologies and companies
- Describes major driving applications
- Persistent memory forecasts (both embedded and stand-alone)
- Projections for capital investments
- **Now Available!**
- **<https://tomcoughlin.com/tech-papers/>**

3D XPoint



3D XPoint Helps Reduce DRAM Needs



Source: *A Close Look at the Intel/Micron 3D XPoint Memory*, Objective Analysis 2015

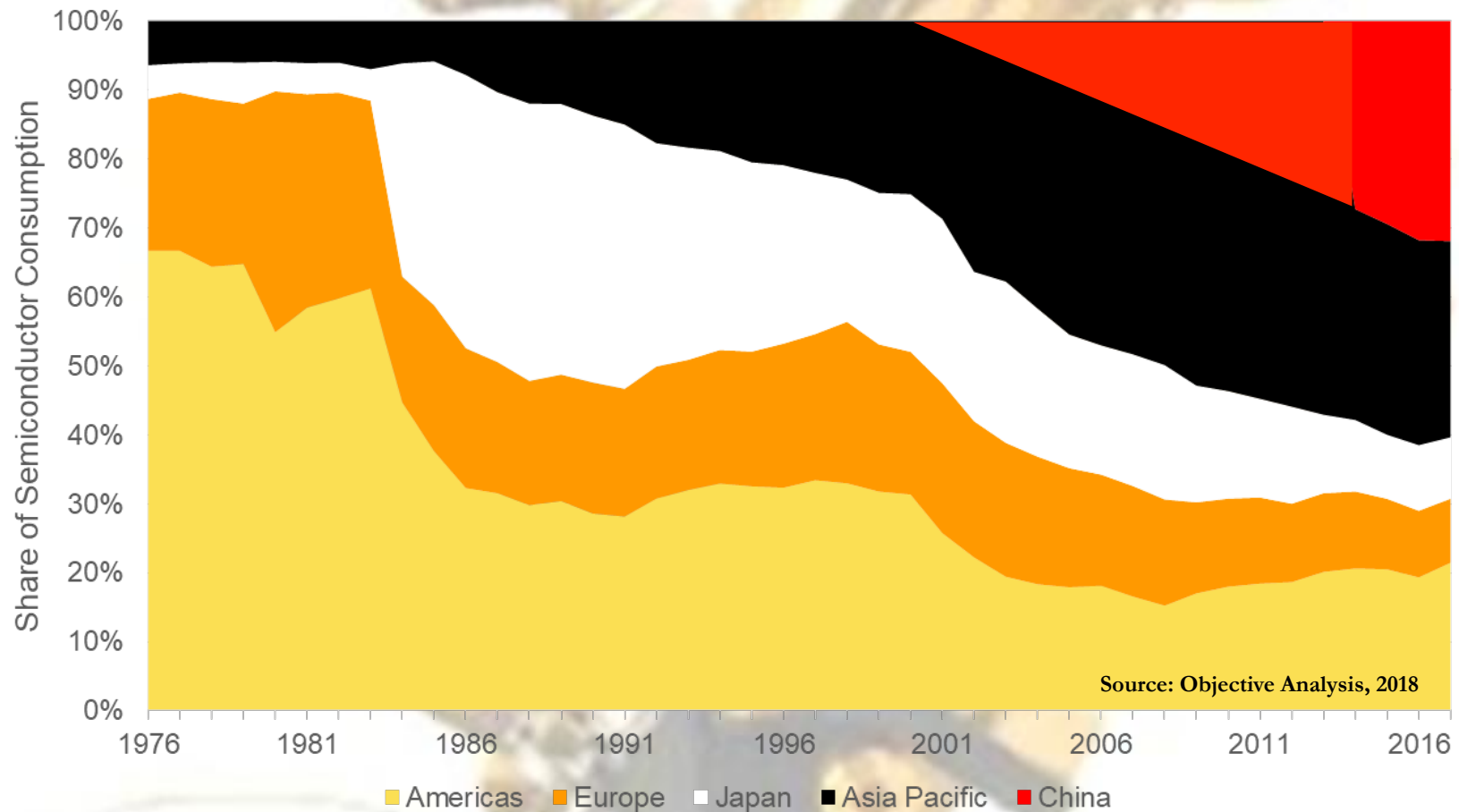
3D XPoint Status

- Continued delays
 - DIMMs now slated for 2019 production
- Issue is scale
 - Cost must be below DRAM
 - Volume must reach 10% of DRAM
 - Production currently stopped
 - Intel selling below cost to develop market

China



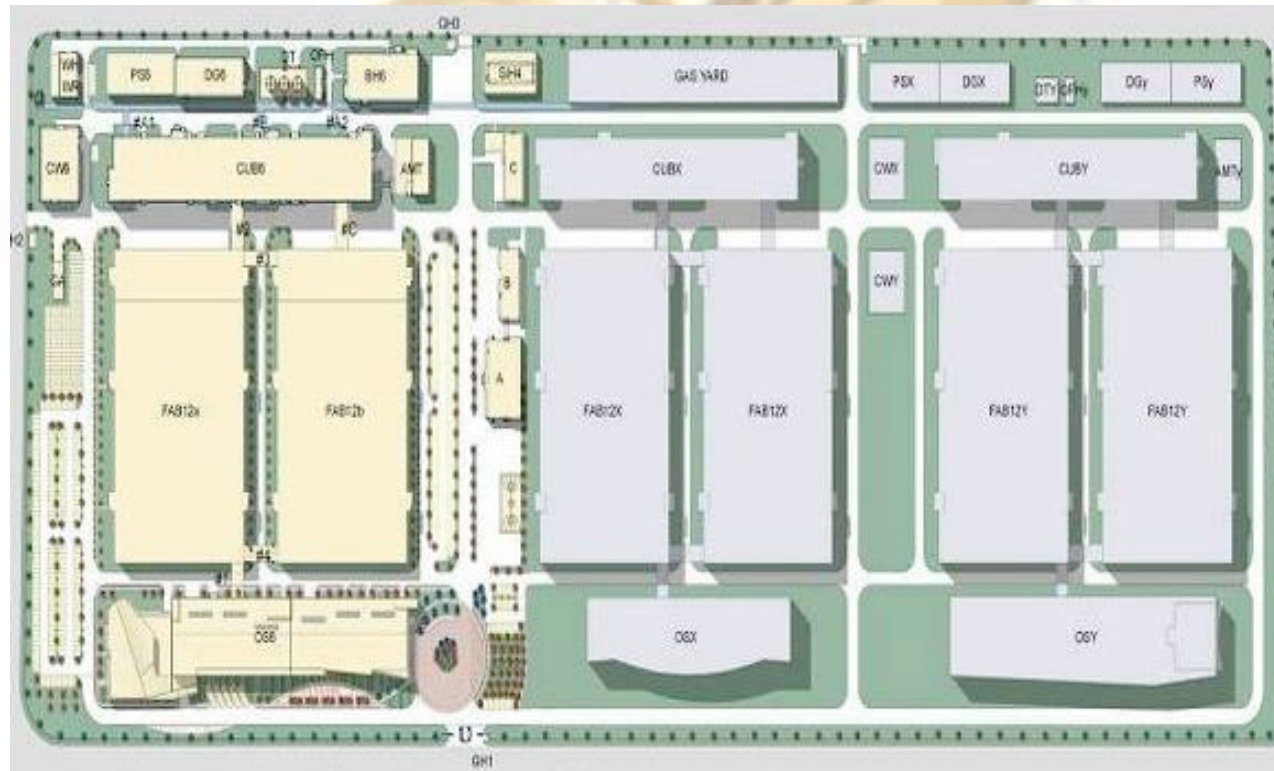
\$100 Billion+ of Chip Imports/Year!



China's Memory Aspirations

- 91% of China's chips sourced externally
 - China consumes 32% of world's ICs
- The country is wealthy today
 - Plenty of cash to fix this problem
- There is prestige in semiconductors
- Memory is a commodity
 - Easy market to penetrate if you have cash

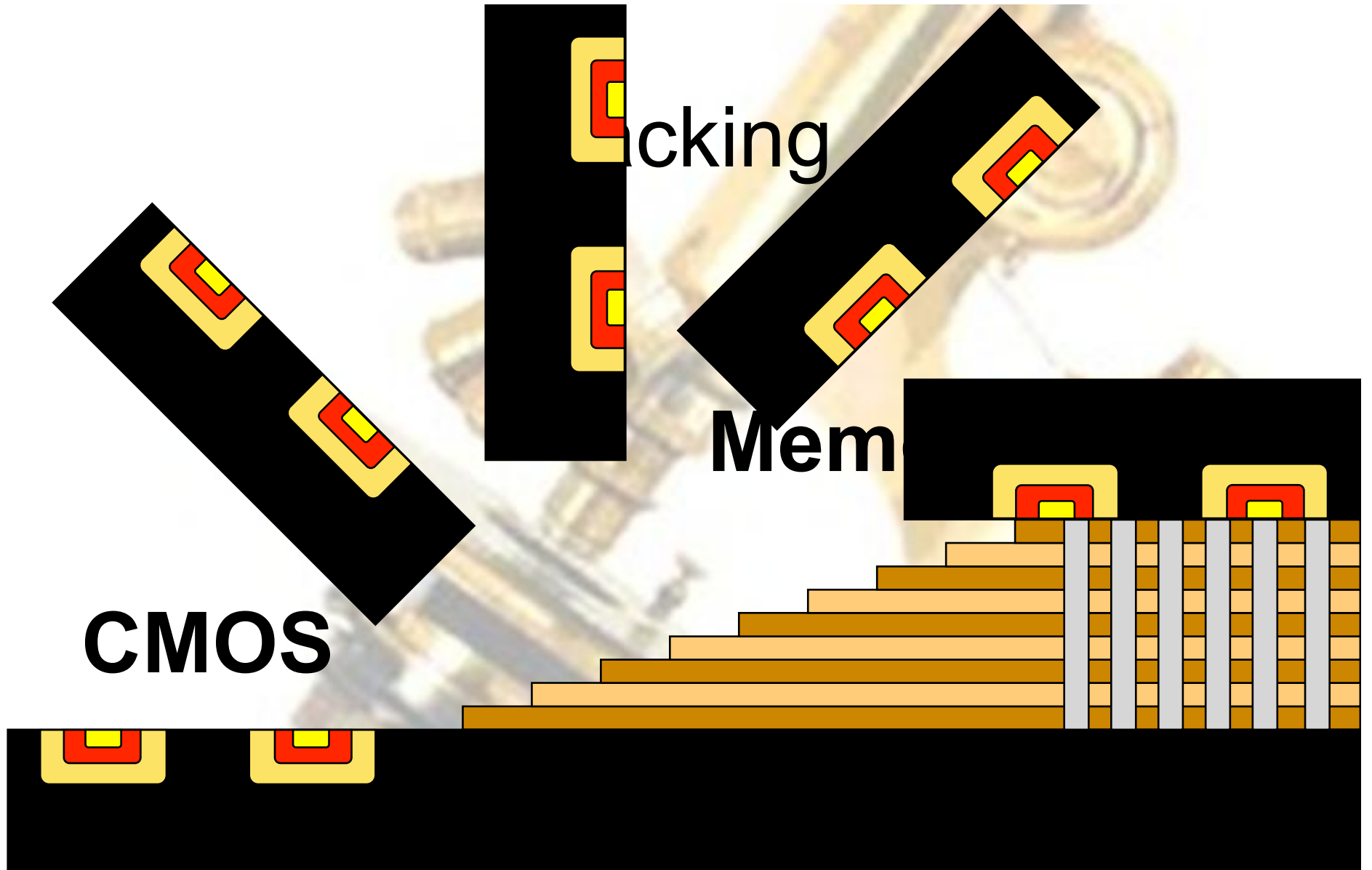
China Spending is Just Starting



YMTC's Plans

- Open 2H18
- 100K starts
- 32-Layer 3D
- YMTC's own technology





Impact of China Spend

- China will acquire a share of the market
- Timing unlikely to cause a collapse
 - This should already have occurred
- Will lengthen ongoing oversupply
 - Watch for a market exit
- Will probably use a technology partner
 - Partner will receive a production boost

China Report

- Details of China's approach & methods
- Compares China's effort to other countries' DRAM market entry (Japan, Korea,...)
- Compared to China's penetration of other markets: PV, LCD panels, LEDs, Steel...
- Explains likely outcome
 - Impact on others: Competitors, OEMs, investors

• **Coming this month (August 2018)**

Summary



- NAND flash collapse just starting
 - Other markets will follow
- Emerging memories show great promise
- 3D XPoint is still a challenge
- China will be important soon



Thank You!

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