Flash Market Current & Future

Jim Handy

OBJECTIVE ANALYSIS

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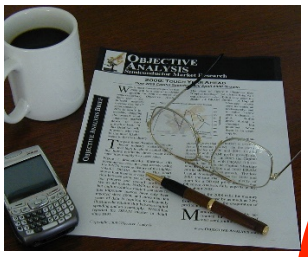
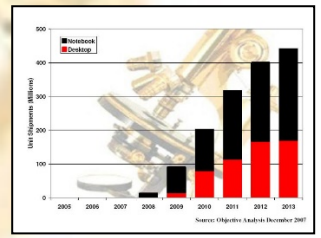
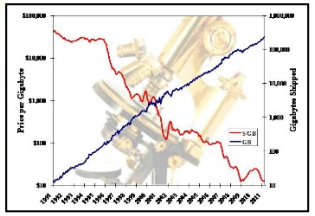
Profound Analysts

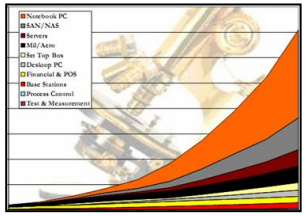


Reports & Services

Custom Consulting







OBJECTIVE ANALYSIS – www.OBJECTIVE-ANALYSIS.com

Objective Analysis

Semiconductor Forecast Accuracy

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

Outline

- Today's Shortages
  - 3D NAND
- How Long Will 3D NAND Last?
- What About China?
- Mergers Etc.
- 3D XPoint

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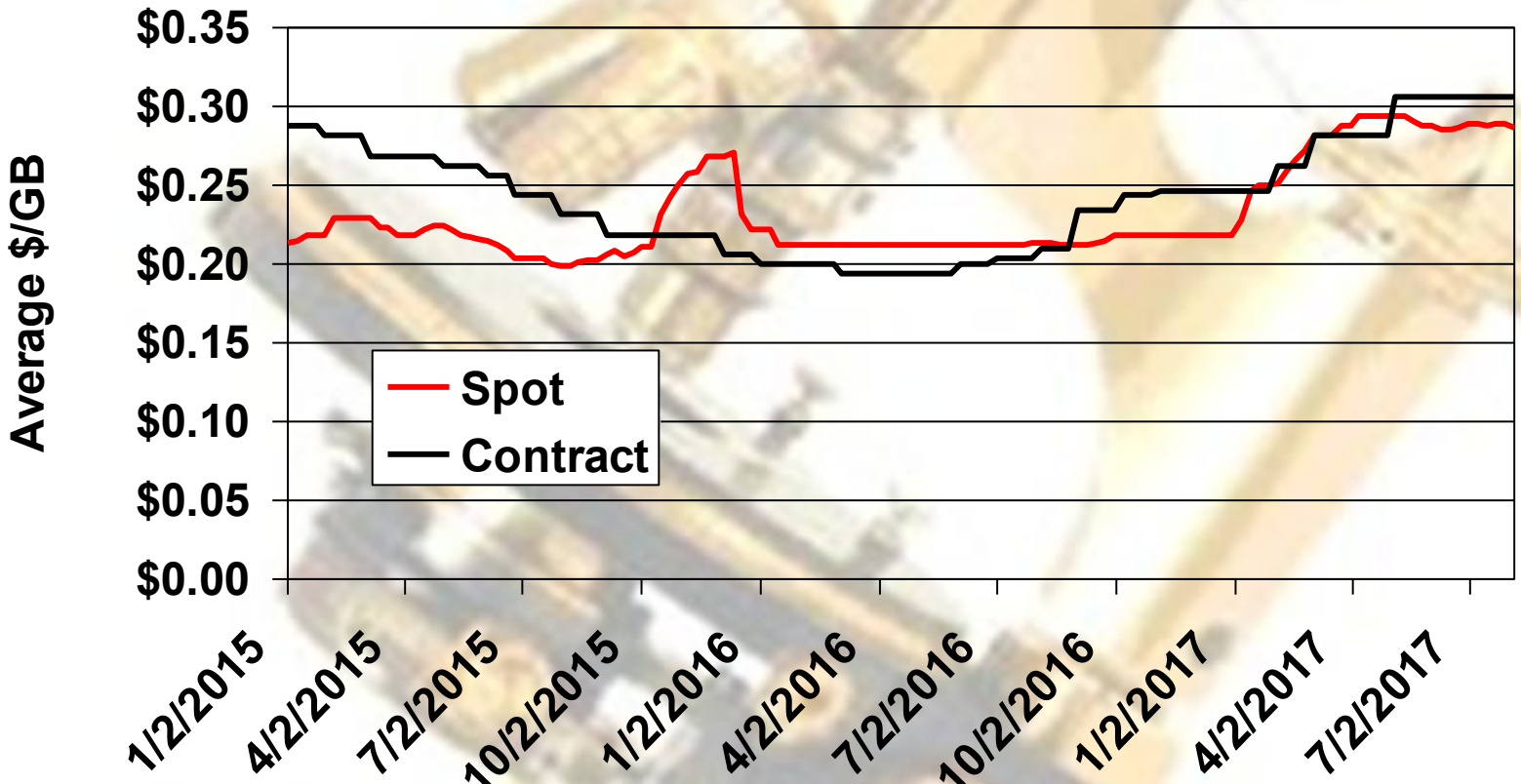
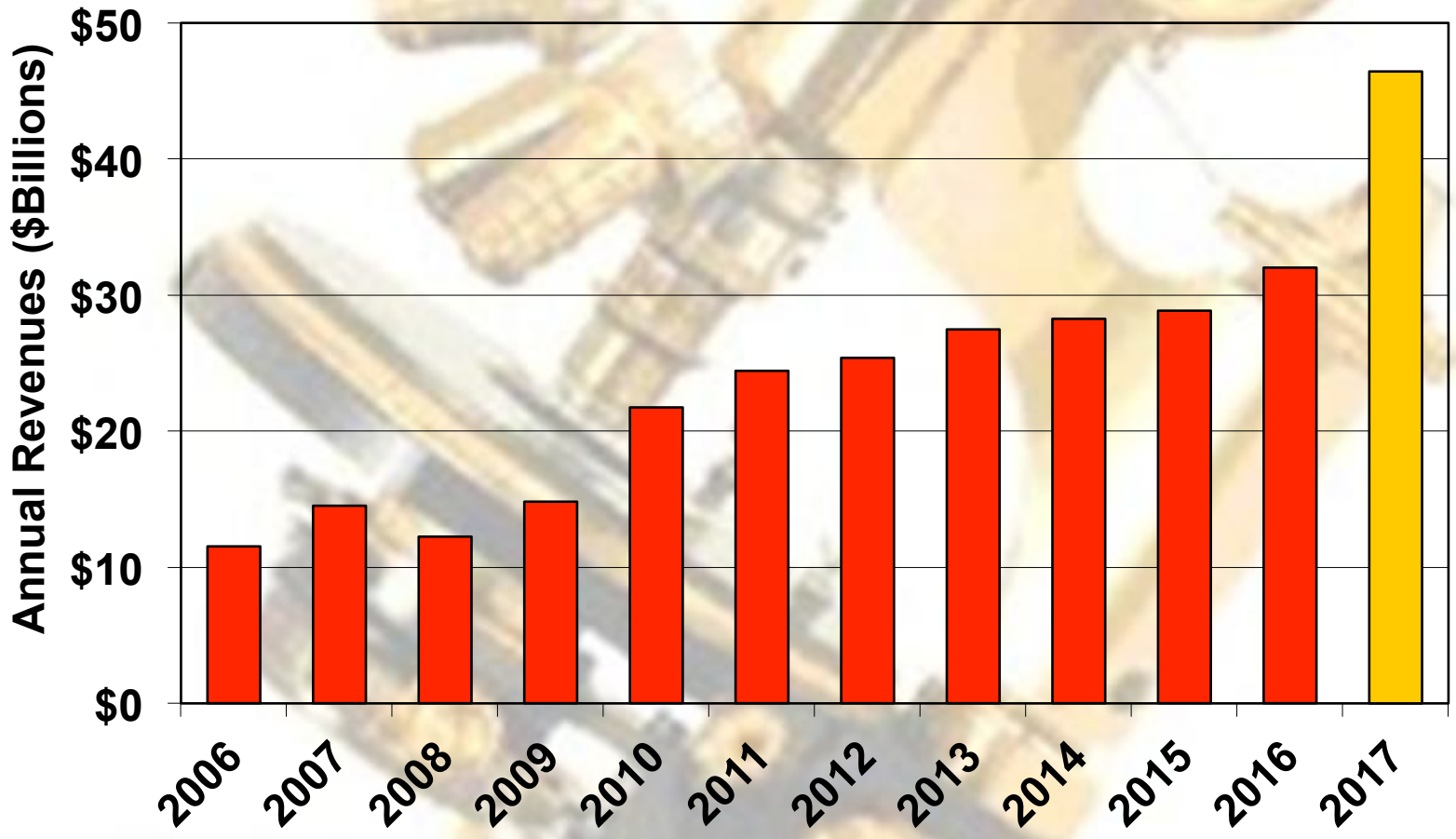
NAND Prices Are Up Today



Driving a NAND Revenue Jump

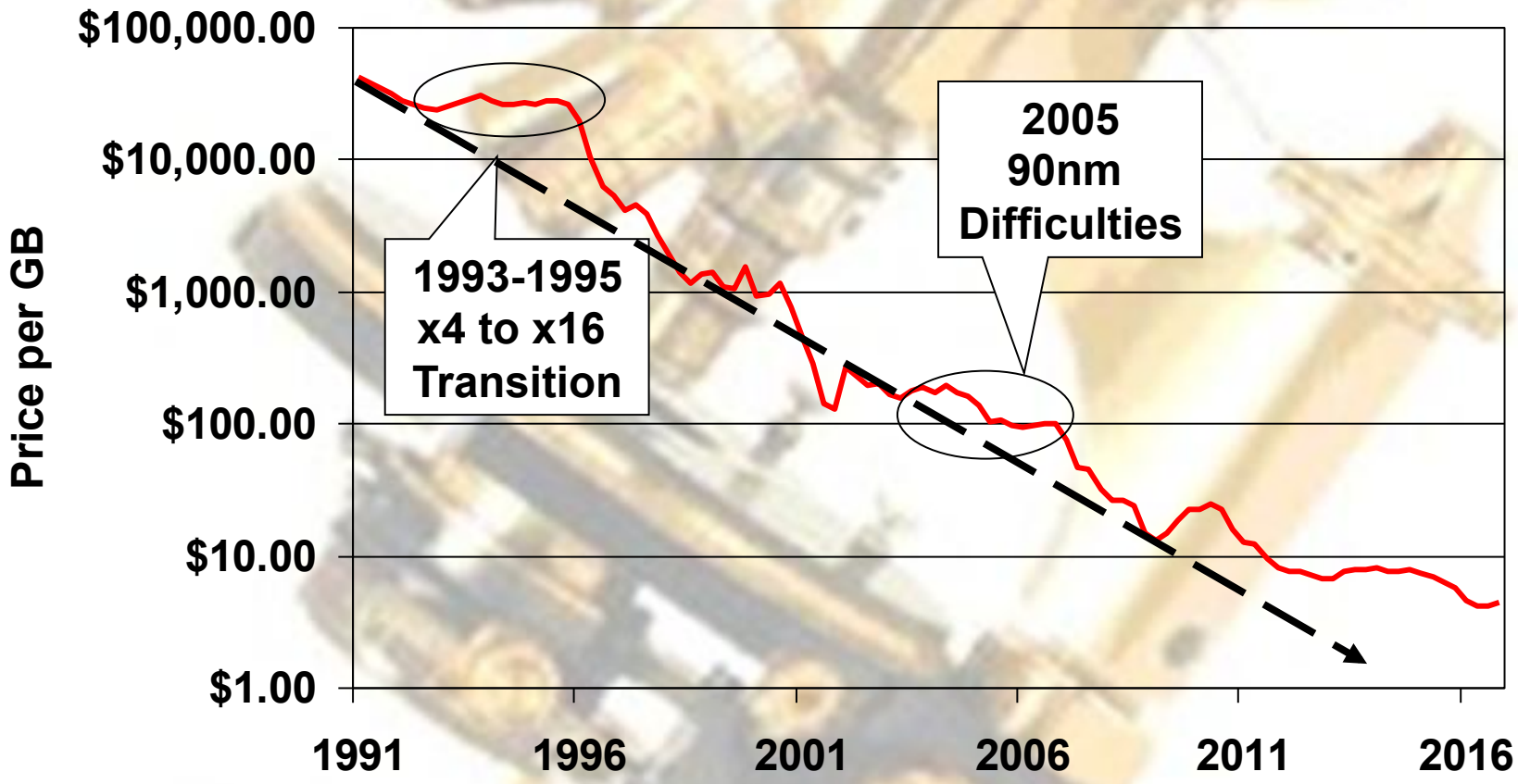


What Drives the NAND Market?

- Gigabyte consumption
  - Usually grows pretty steadily
- Price/GB
  - A function of Moore's Law and Supply/ Demand balance
- Revenues = GB x $/GB

Market Cycles & Shortages

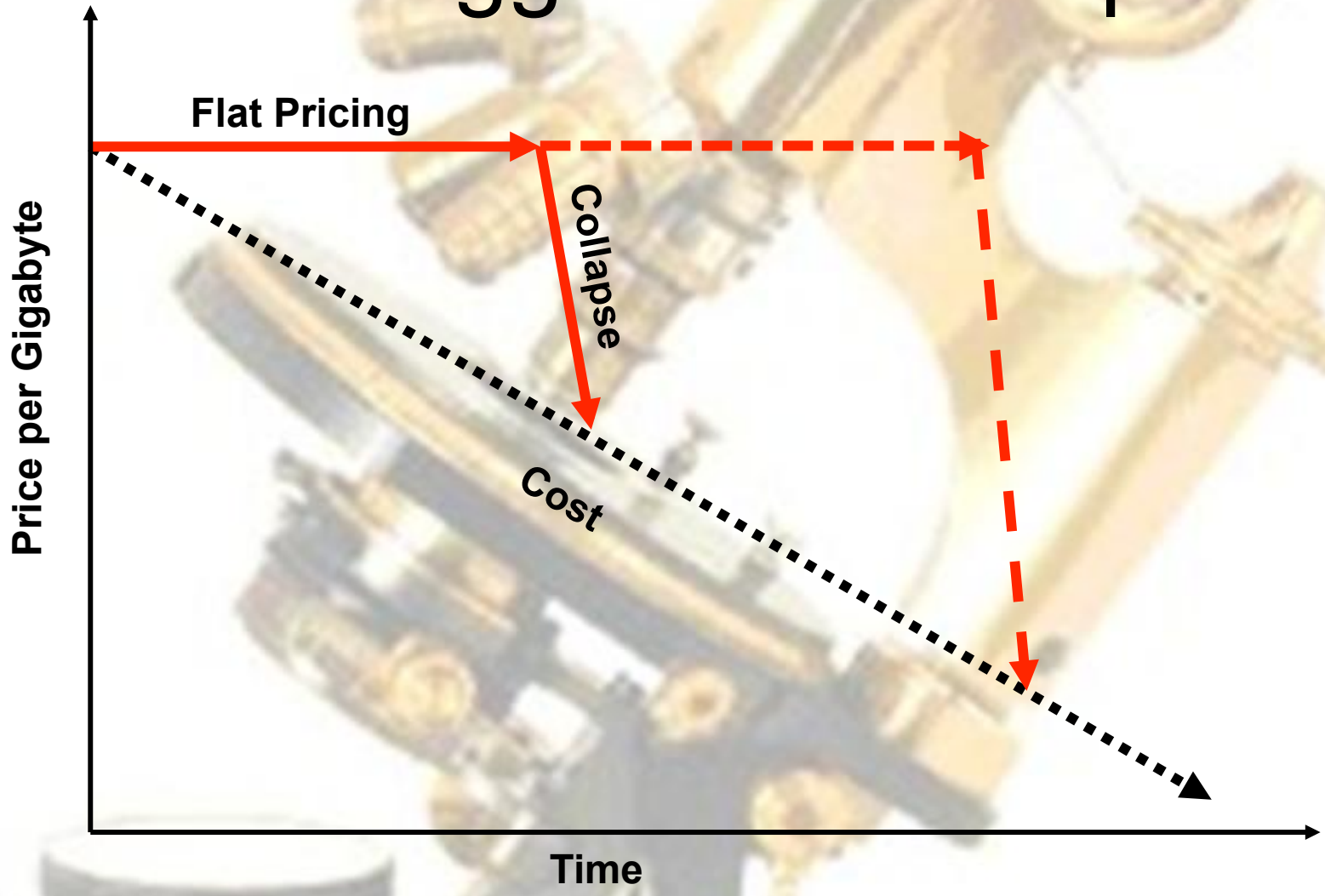
DRAM Examples



The Next Downturn: Why? How? When?

- Stable prices to mid-2018
  - Stable prices drive profits
  - Largest-ever price-cost gap
- 2018 price collapse
  - 3D suddenly becomes cost-competitive
  - Instant overcapacity
    - Caused by 3D fabs becoming efficient
    - China investments will create trouble much later

The Longer Shortage, The Bigger The Collapse!



When Will Shortage End? That's Hard to Predict

- When will 3D NAND be mastered?
  - All vendors are now shipping
    - This does not imply that 3D costs less than planar
- 2017 is the year of the big ramp
  - Manufacturers hope that volume will improve costs
- Our guess: Mid-2018 cost parity for all
  - Capacity will be used efficiently
  - This drives an oversupply

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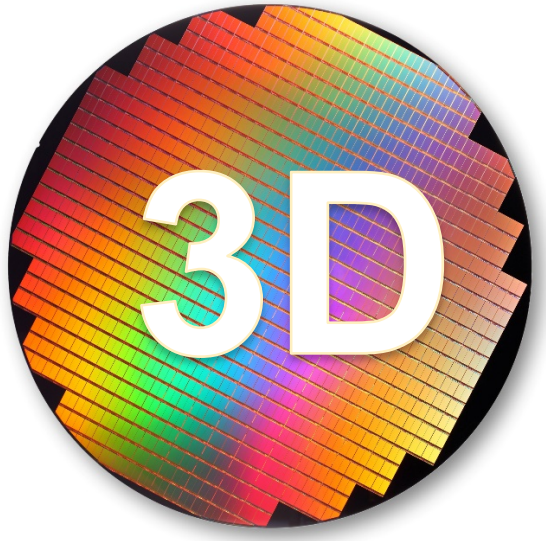
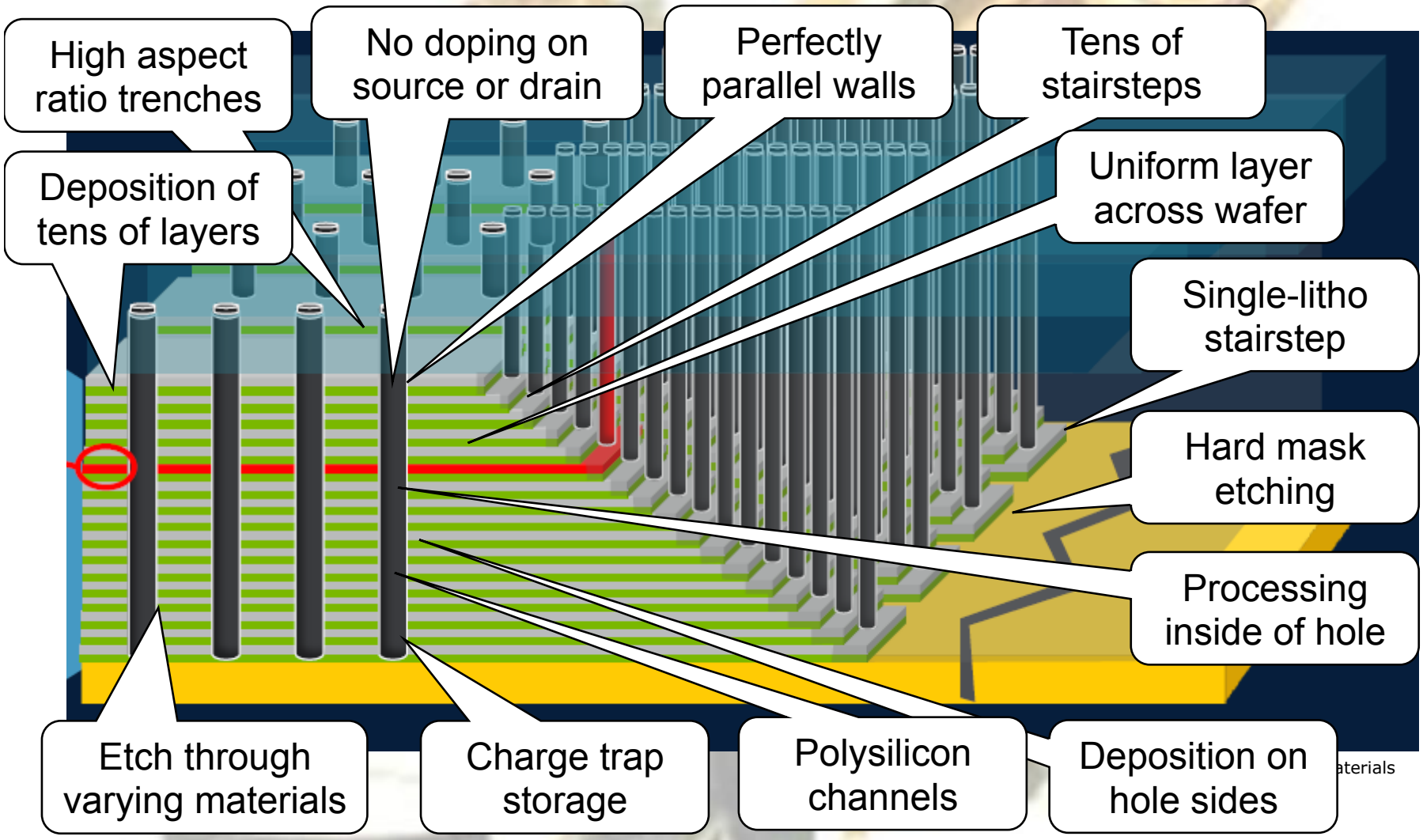
Planar vs. 3D NAND Mfg. Cost



	Planar	3D
Terabytes/Wafer	5.6	17.2
Wafer Cost	$1,200	$2,000
Cost/GB	$0.21	$0.12

What's So Hard About 3D NAND?



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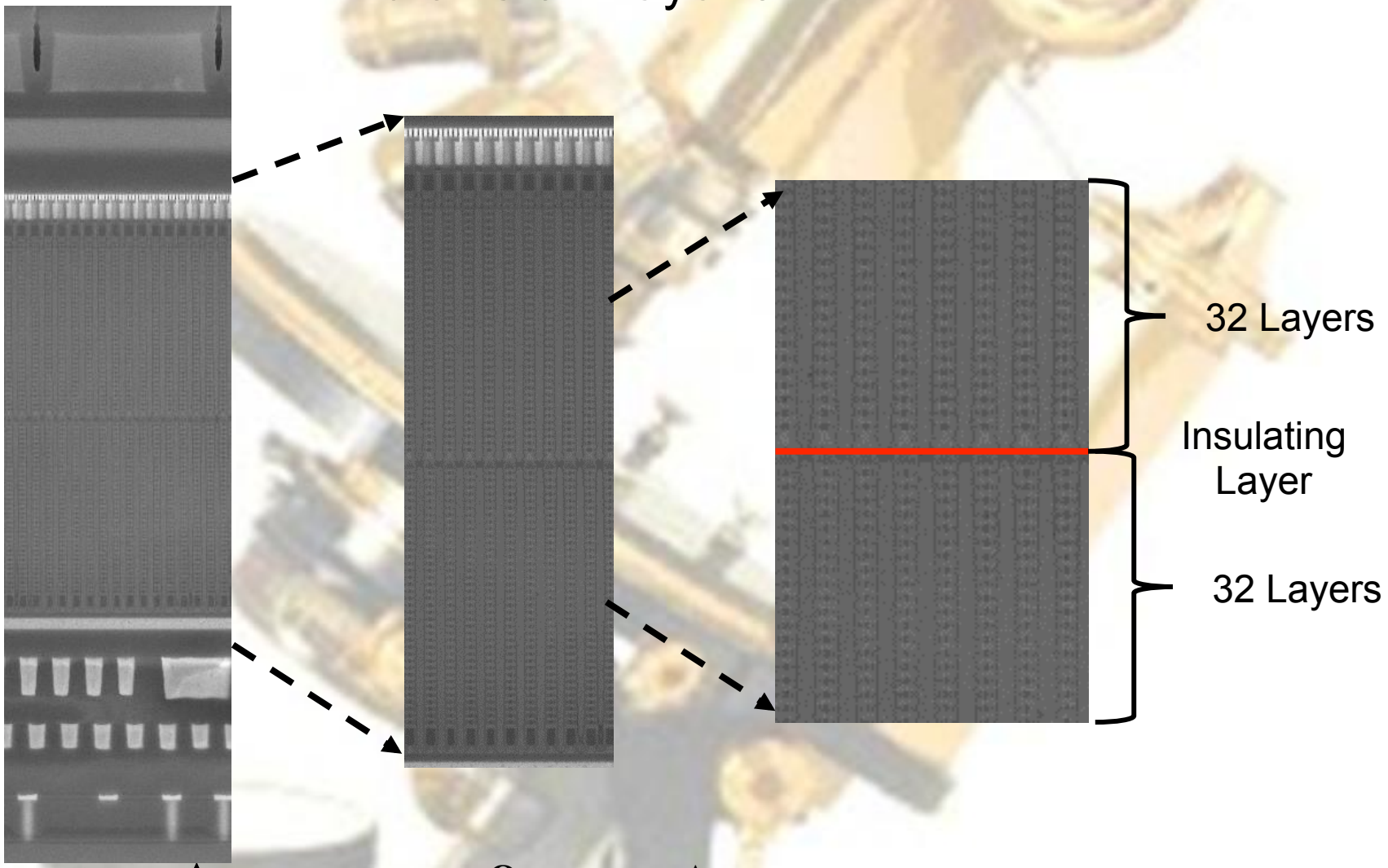
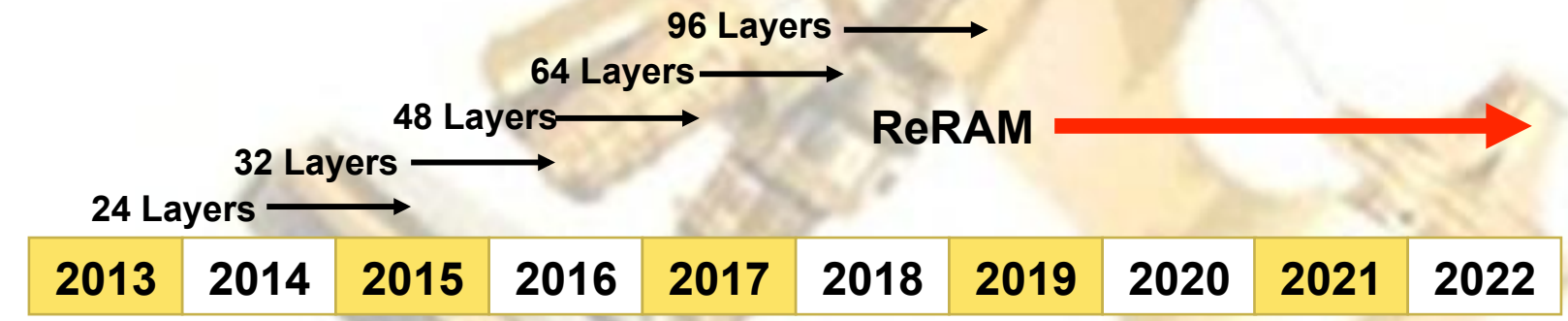
String Stacking

Micron's 64-Layer 3D NAND

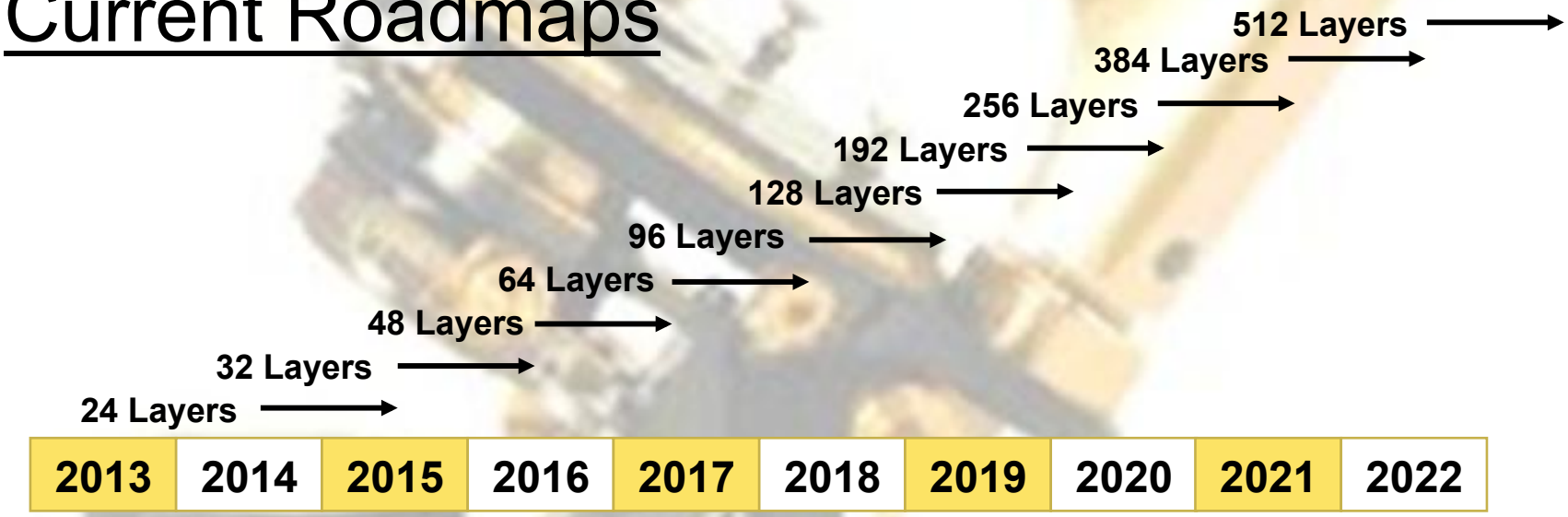


String Stacking Has Changed The 3D NAND Roadmap

Old Roadmaps:



Current Roadmaps



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China

China Spending is Just Starting

Impact of China Spend

- Production boost for its technology partner
- China will acquire a share of the market
- Timing not likely to create a collapse
  - This should already have occurred
- Will lengthen ongoing oversupply
  - Watch for a market exit

Speaking of Market Exits…

"What the heck is going on at Toshiba?"

Toshiba: How Did This Happen?

- Nuclear cost overruns
  - Westinghouse bankrupt
- Toshiba can't escape liabilities
- Semiconductor division's value matches liabilities

Everybody Wants Their Way!

- Toshiba
- Western Digital (SanDisk)
- Japan's government
- SK hynix
- Foxconn/Hon Hai
- US government
- Private investors

Expect a Lengthy Battle!

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3D XPoint Is Moving Ahead

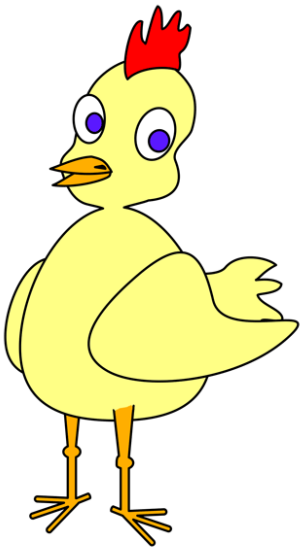
- NVMe “Optane” SSDs are shipping
  - Aimed at PC applications
  - Sever DIMMs are the natural application
- Good fit for the memory/storage hierarchy:
  - Faster than NAND, slower than DRAM
  - Costlier than NAND, cheaper than DRAM
- Opens door to in-memory storage – “SCM”
- Applications are being developed for it

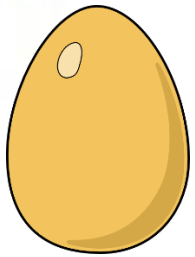
This Will Require a Huge Effort!

- DDR can support variable access times
  - Fancy arrangement of flags and software
- O/S, BIOS, & CPU support in development
  - Cache & memory management
  - Special CPU instructions for persistence
- Persistence will require application support
  - SNIA developed a PM Programming Standard
    - https://www.SNIA.org/PM
  - Linux "pmem" initiative: www.pmem.io

A Chicken & Egg Problem

- 3D XPoint will sell in volume once it's priced lower than DRAM
- 3D XPoint mfg. costs will fall below DRAM once the volume is high enough





Summary

- We're in a shortage
  - Prices high until 3D NAND is cost-effective
- A collapse will follow
- 3D NAND may last a very long time
- China will be important *after* the collapse
- Consolidation will continue
- 3D XPoint is real

Thank You!

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