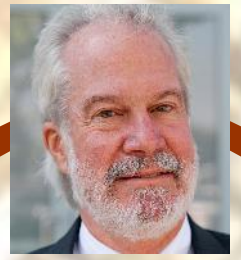
Moving DRAM to 3D

Jim Handy

Objective Analysis

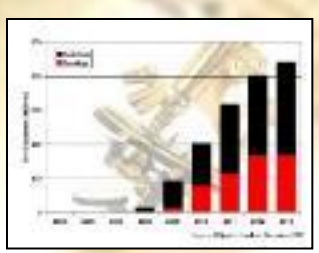
OBJECTIVE ANALYSIS

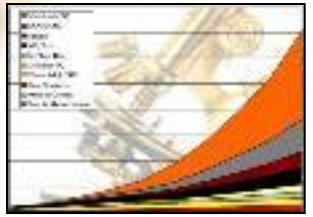


Profound Analysts

Reports & Services

Custom Consulting





Objective Analysis

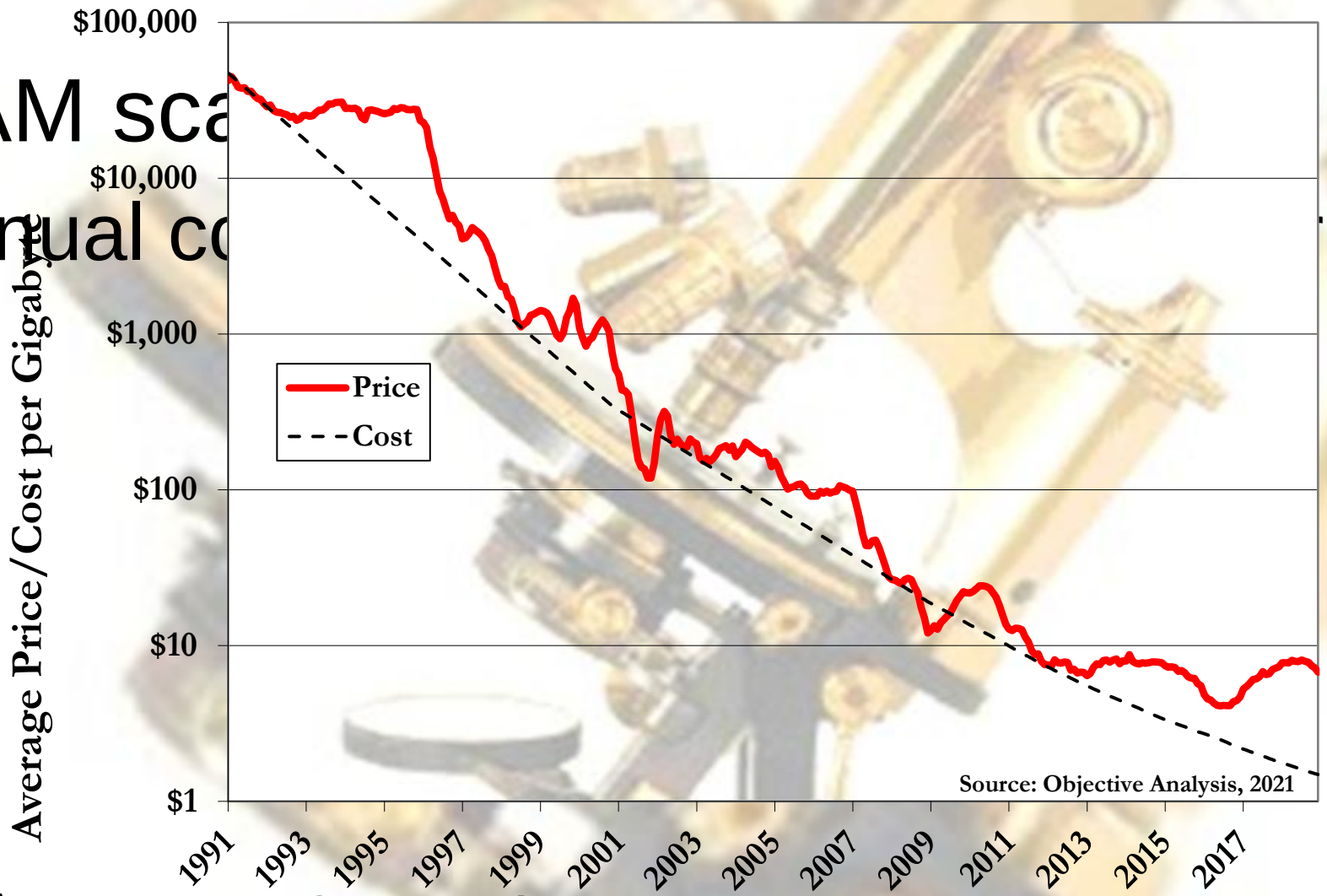
Semiconductor Forecast Accuracy

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%	22%
2018	Strong start supports 10+% growth	14%
2019	Semiconductors down -5%	-12.5%
2020	Zero growth at best	6.8%
2021	Revenues grow 6% by remaining flat	26.2%
2022	Total semi still grows 6%	TBD

Let's Talk About DRAM!

The Problem

- DRAM sca
  - Annual co

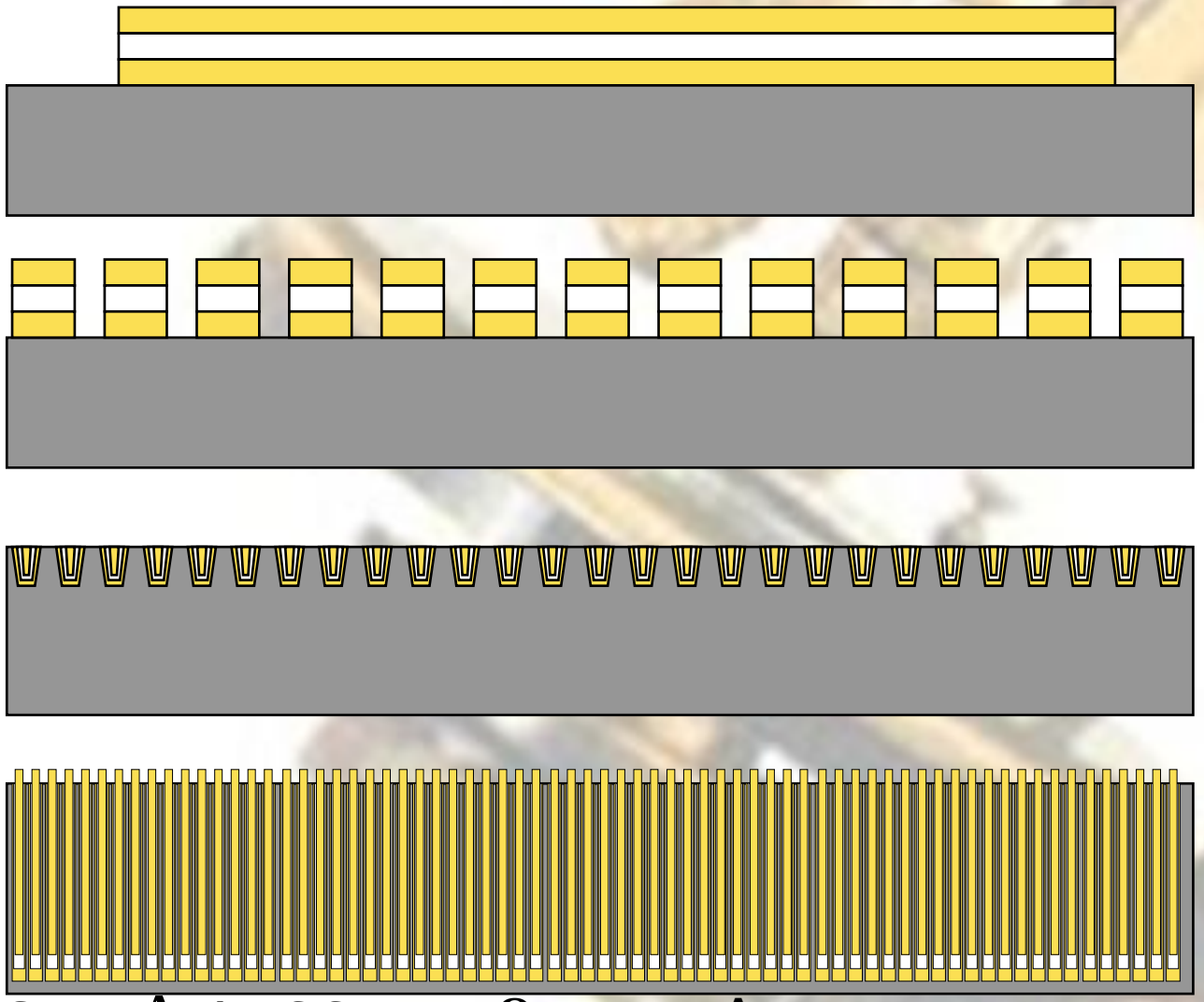


The Problem

- DRAM scaling is slowing down
  - Annual cost declines are getting smaller
- Industry is hitting physical limits
  - NAND successfully overcame this by going 3D

Can DRAM go 3D too?

DRAM Is Already 3D



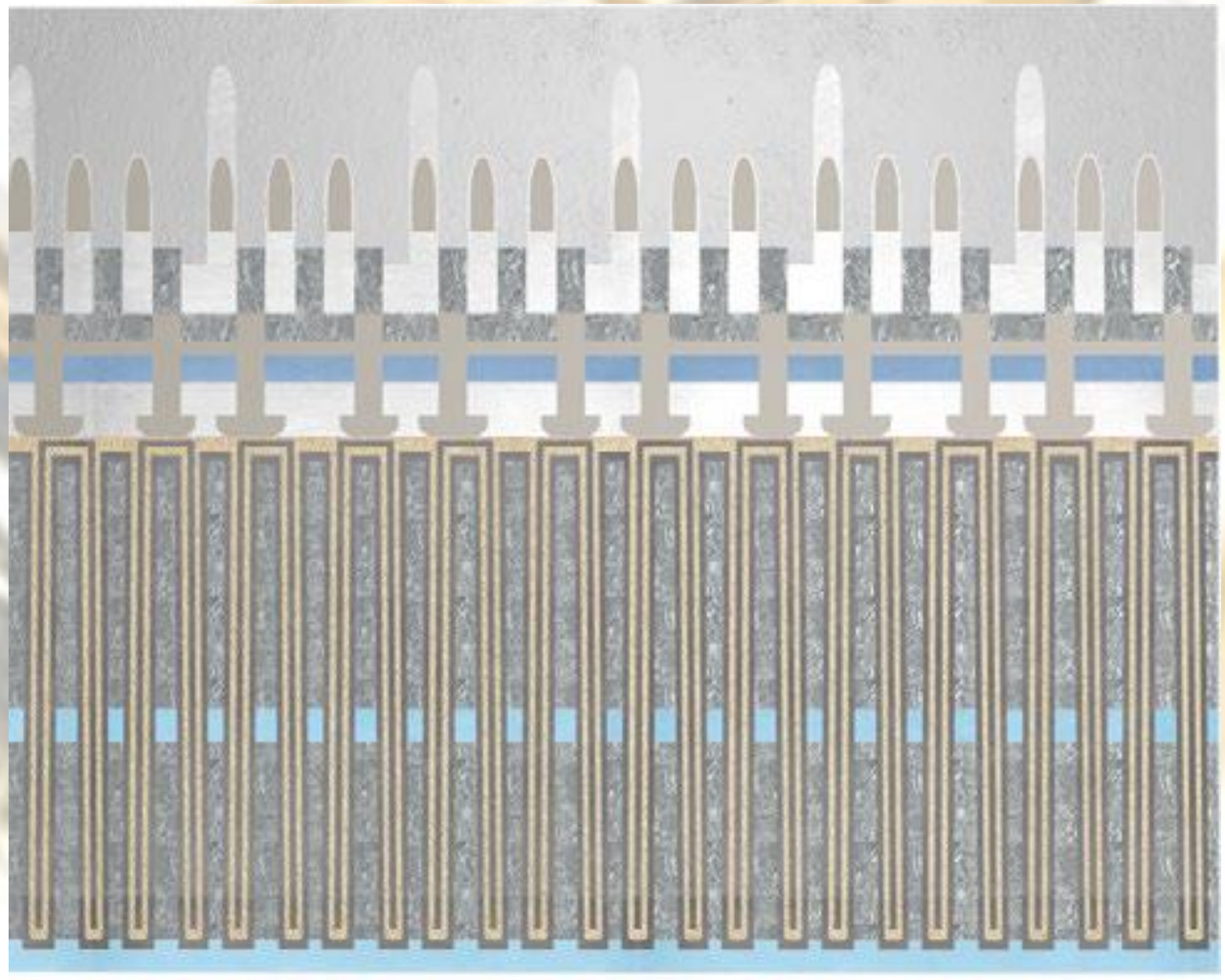
1970

1980

1990

2000

DRAM Is Already 3D

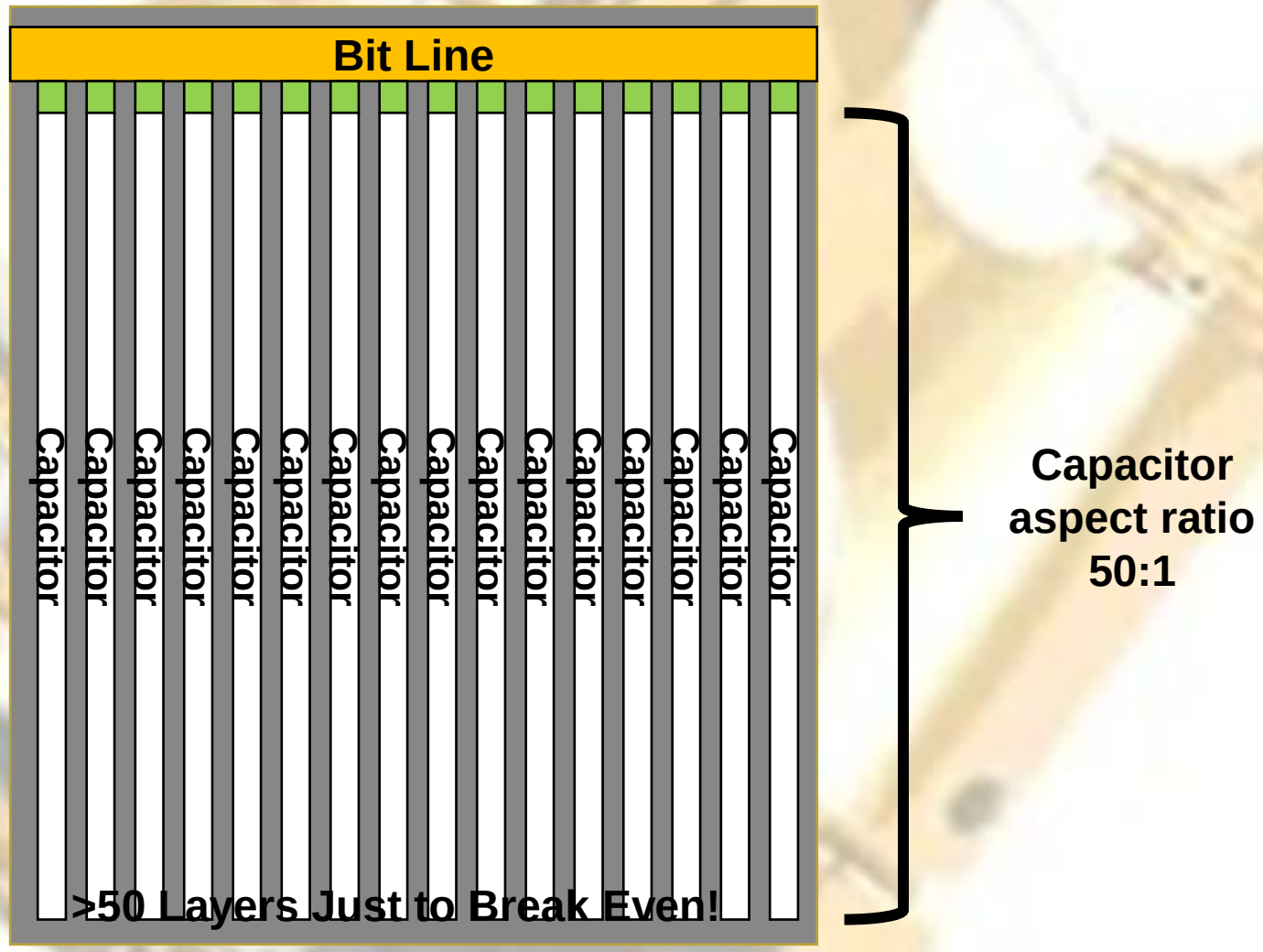


So What's The Problem?

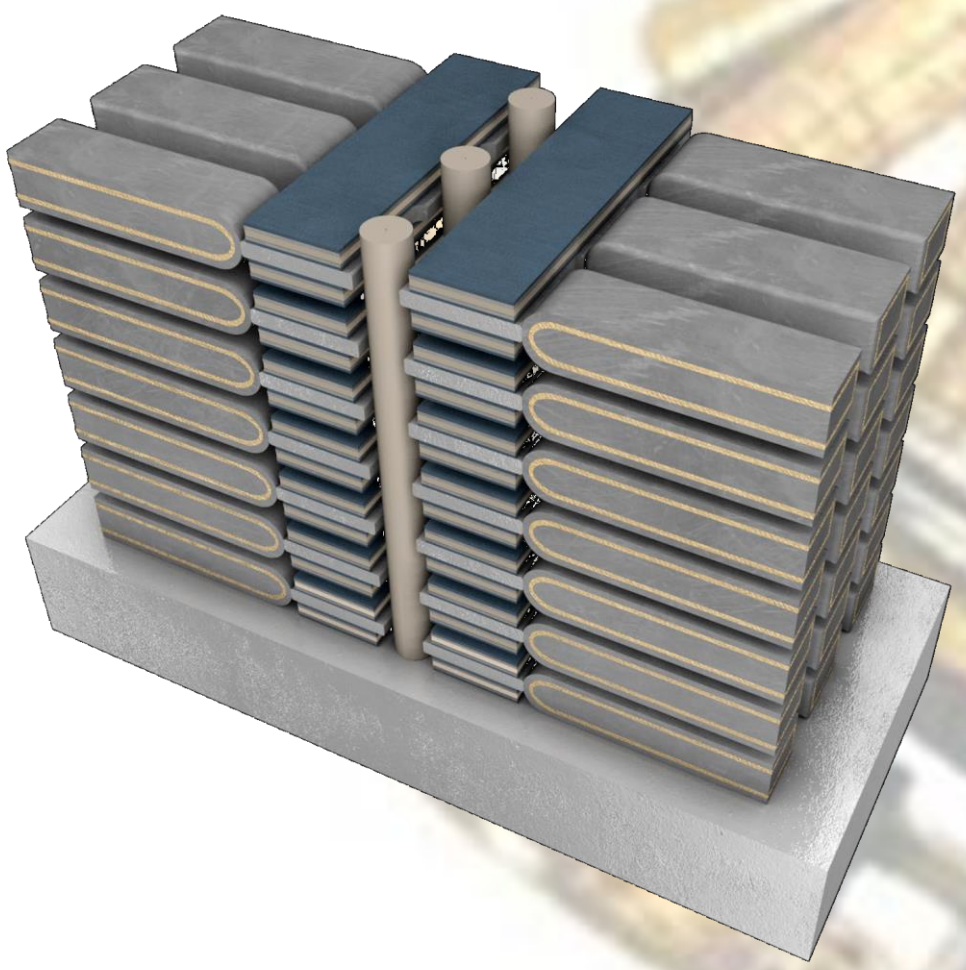
- Deep & Narrow trenches are hard to etch well
- The standard way to follow Moore's Law is to shrink the cell, which means:
  - Smaller width & length
  - Deeper trench
- The alternative is to use new dielectrics
  - Not well understood in a production environment

How NAND Flash Went 3D

The Problem with 3D DRAM



Applied Materials Approach



- Turn everything sideways
  - Simplifies capacitor etch
  - Complicates high-speed signals
- Should stack as high as NAND

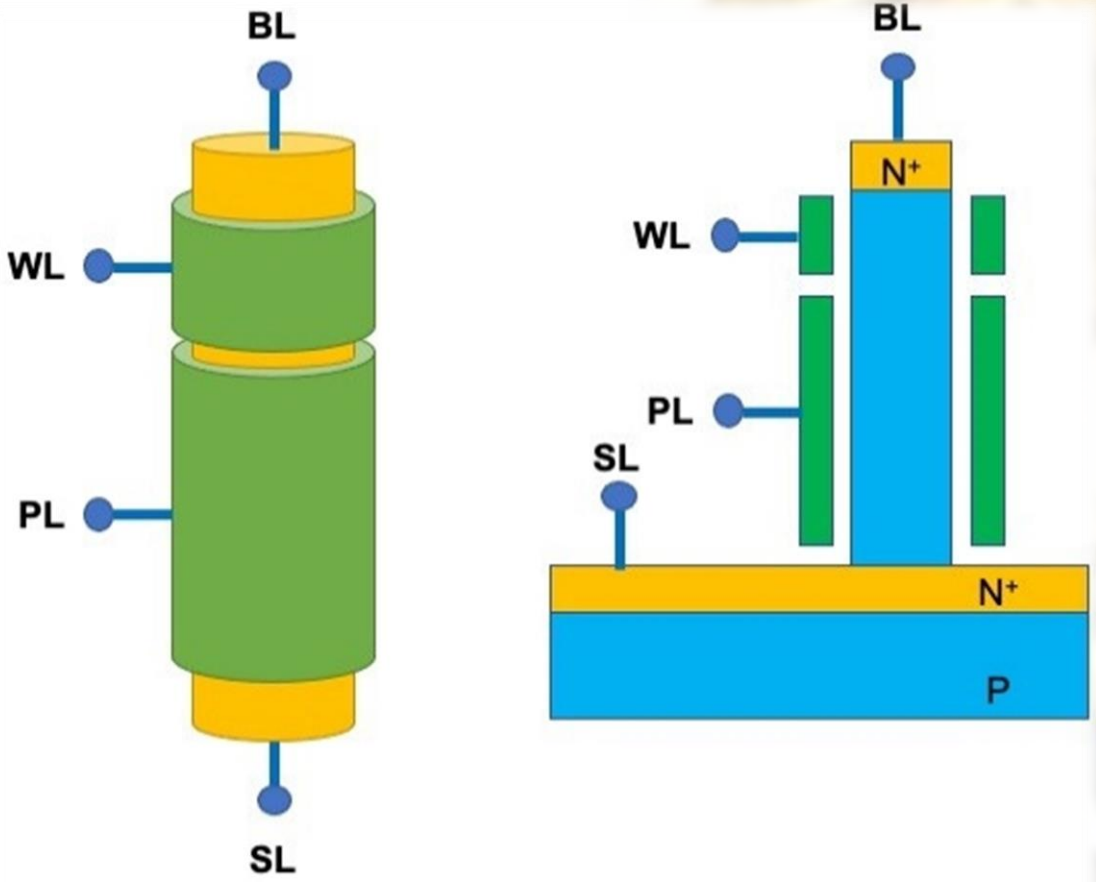
No Shortage of Alternatives

- Z-RAM
- Dynamic Flash Memory
- Short-retention flash
- Monolithic3D
- Vertical select transistor
- HfO dielectric on 3D NAND-like structure
- Gain cell
- IGZO
- Vertical Layered Thyristor (VLT)

Z-RAM

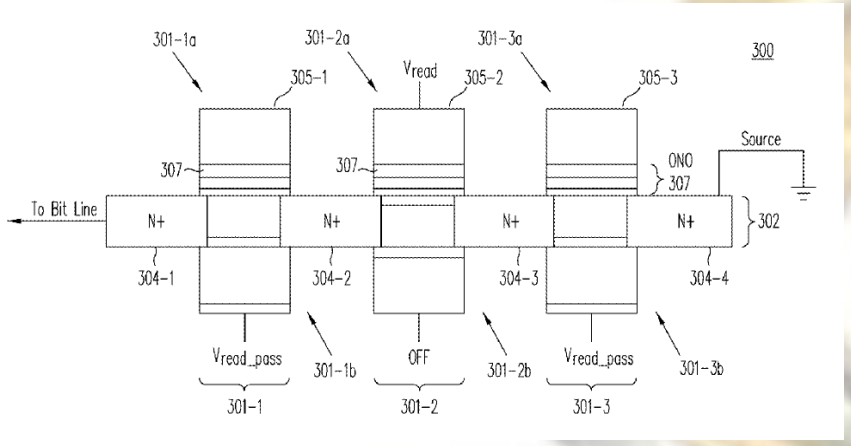
- The original floating body DRAM
  - No capacitor
- Made a big splash in 2007
  - Company still exists, but no website today

DFM: Dynamic Flash Memory



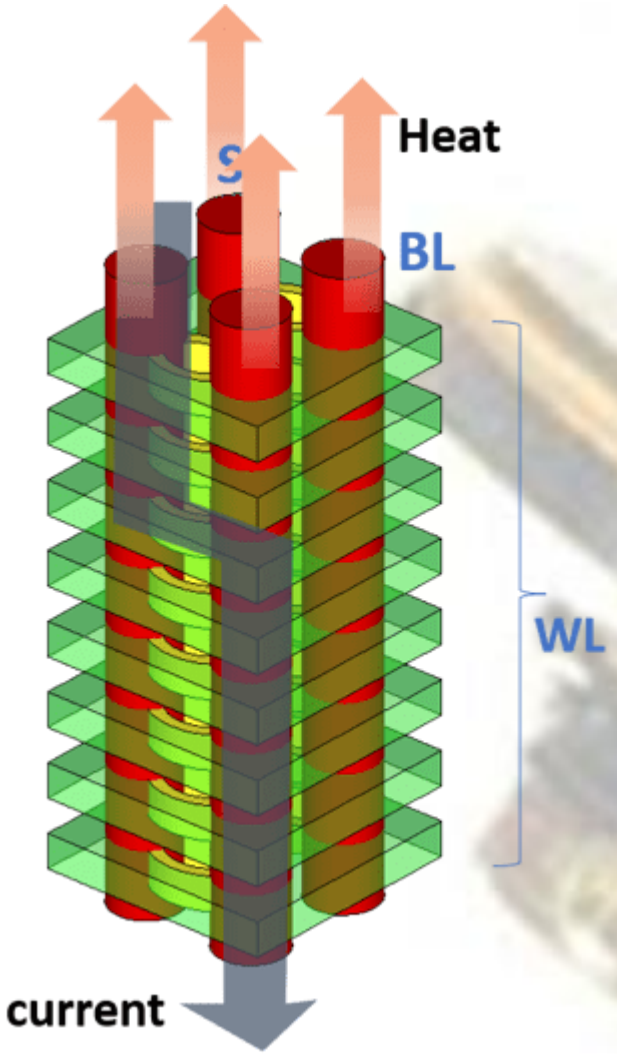
- Stabilized floating body concept
- Highly promoted
- Potentially stackable
- Not yet prototyped

Short-Retention NAND Flash



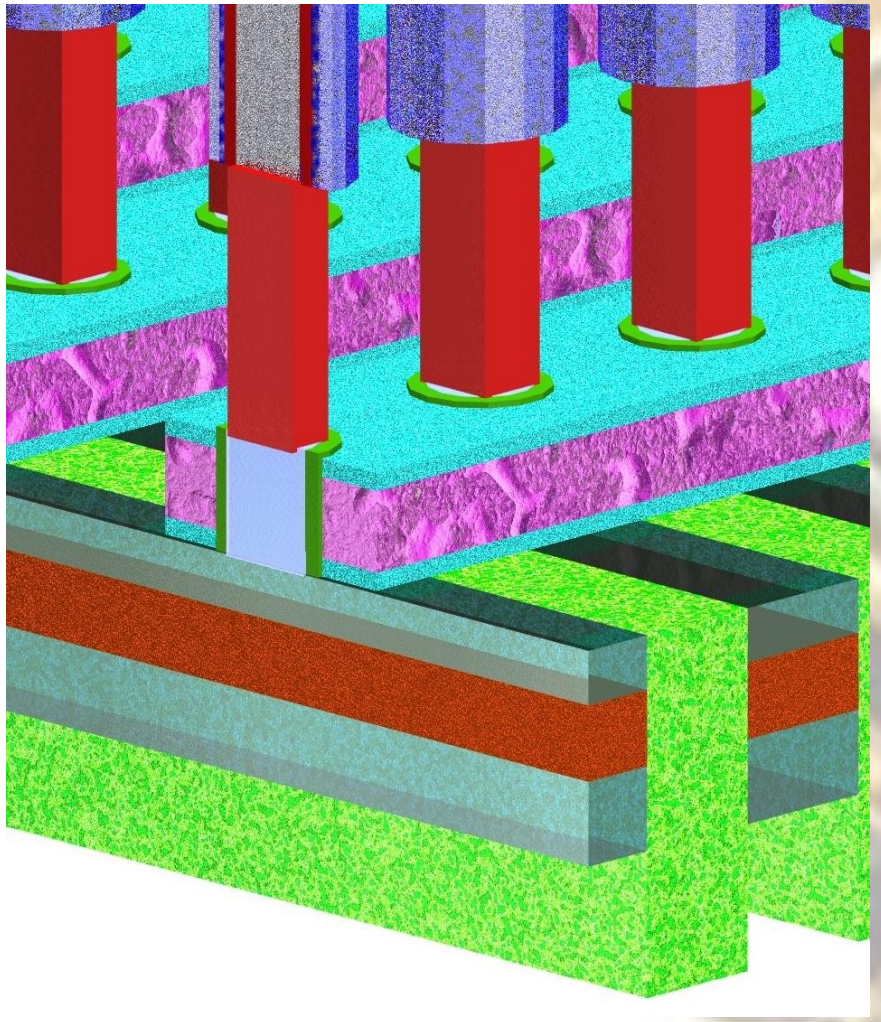
- It's a tweaked 3D NAND chip
  - Built using existing 3D NAND chip designs
- Trades off fast write against short retention
  - Like DRAM it needs refreshing
- Patent applied for, then abandoned

Monolithic3D



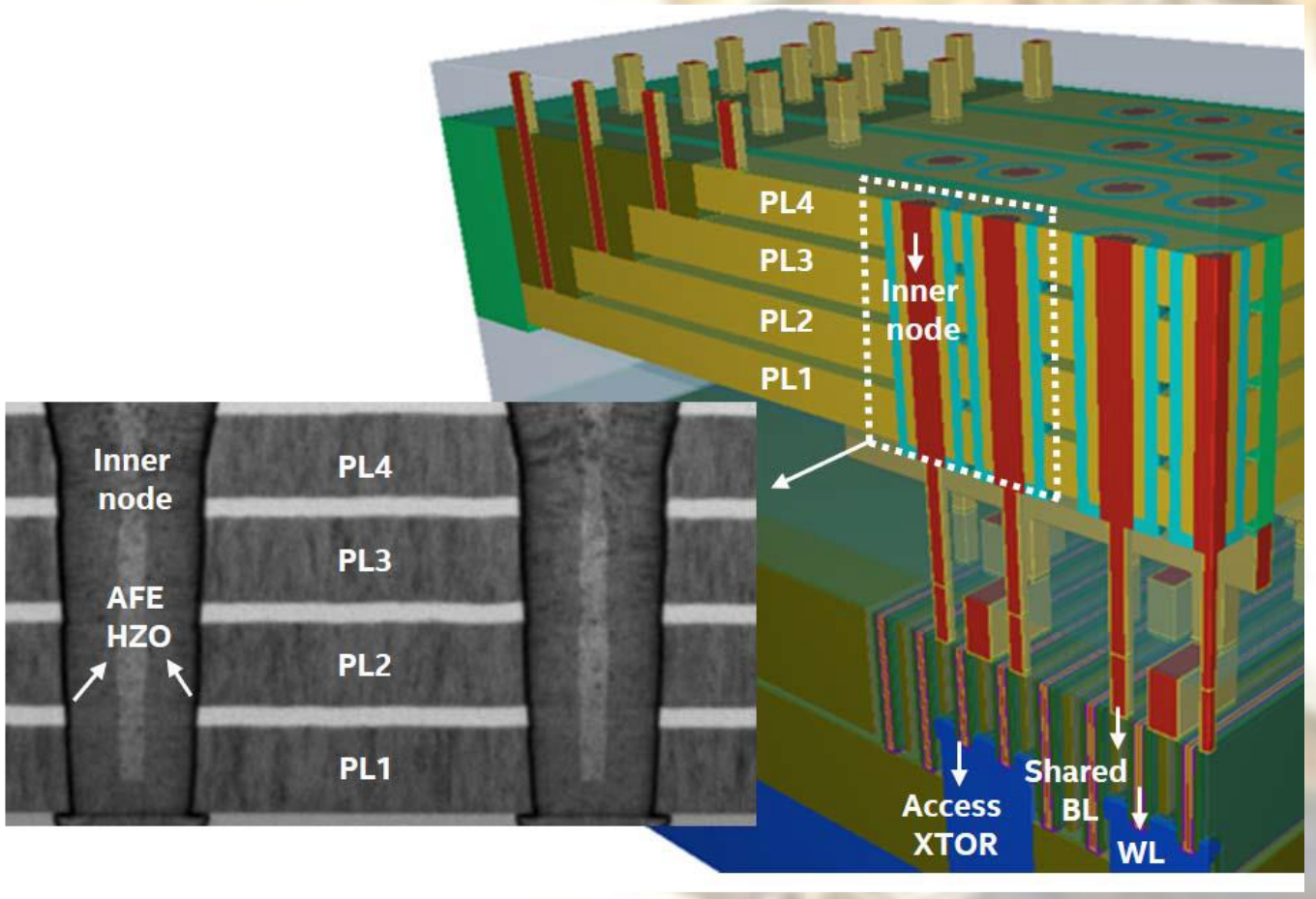
- Similar to 3D NAND topology
- Metal pillars instead of polysilicon
- 3 holes for every bit line
- Not yet prototyped

Spin Memory's Vertical Selector



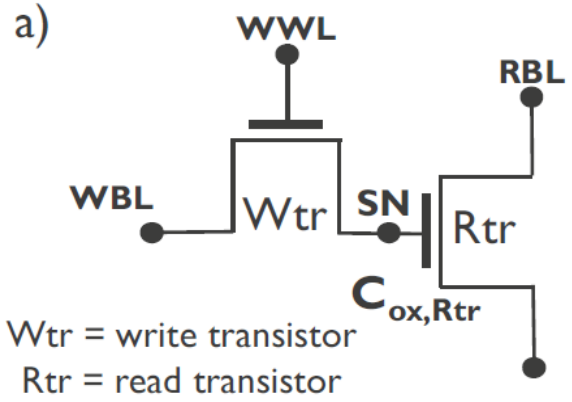
- Borrows 3D NAND techniques
- Supports smaller cells
  - Potentially stackable
- Company liquidated

Intel's HfO Dielectric 3D DRAM



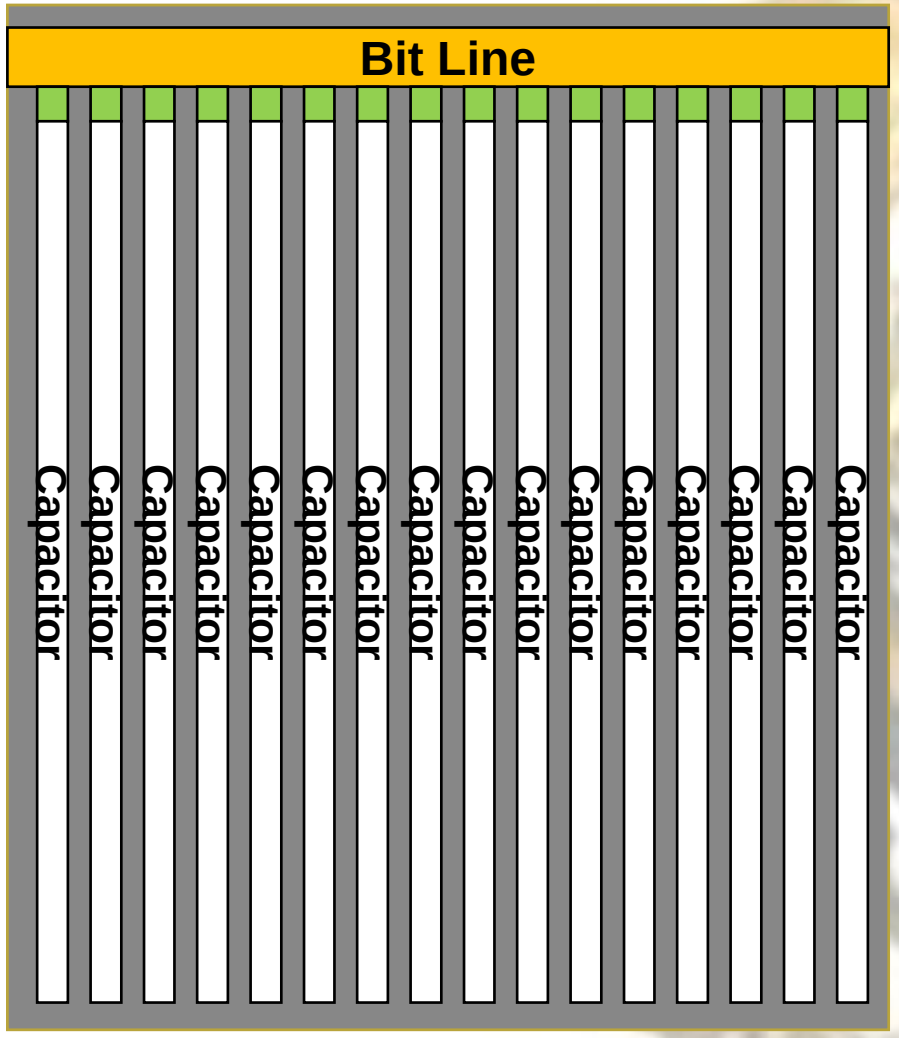
- Presented at IEDM '20
- Working prototypes
- 3D NAND topology
- Antiferroelectric HfO dielectric
  - Not well understood

Gain Cell



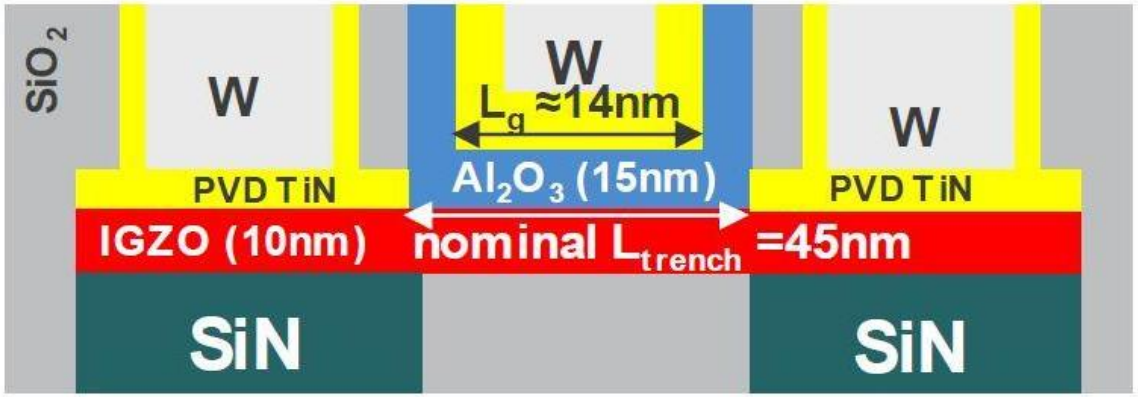
- 2-transistor-0-capacitor (2T0C) DRAM cell
- May not have economies of 3D NAND
  - Current designs use more costly topology

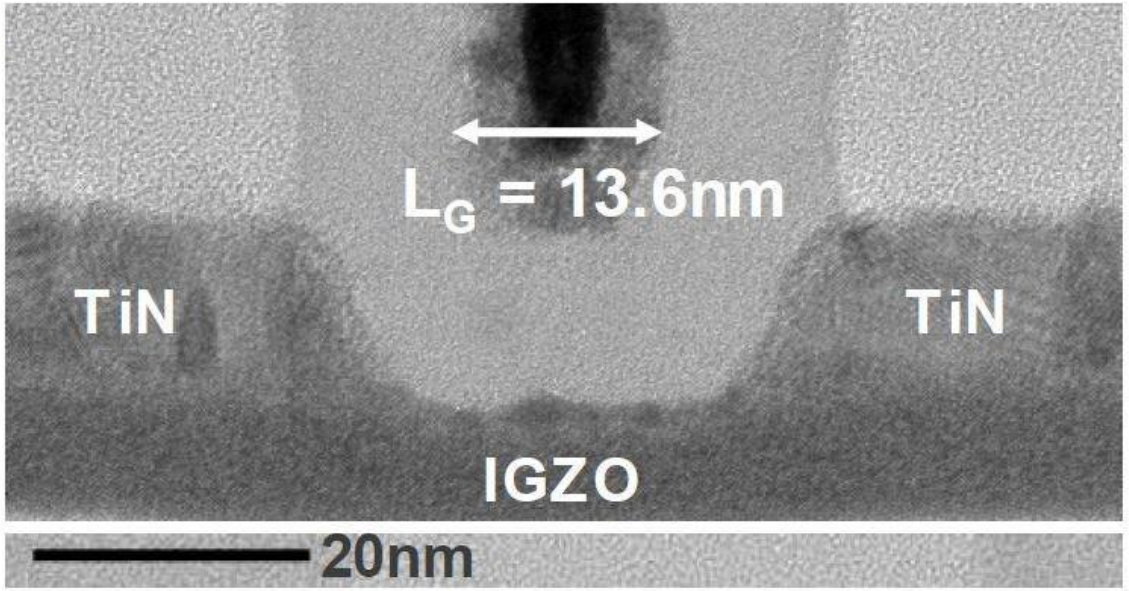
Gain Cell Pluses and Minuses



- Remove half of the capacitors
- Shrink the other half
- Suddenly it's like a NAND string!

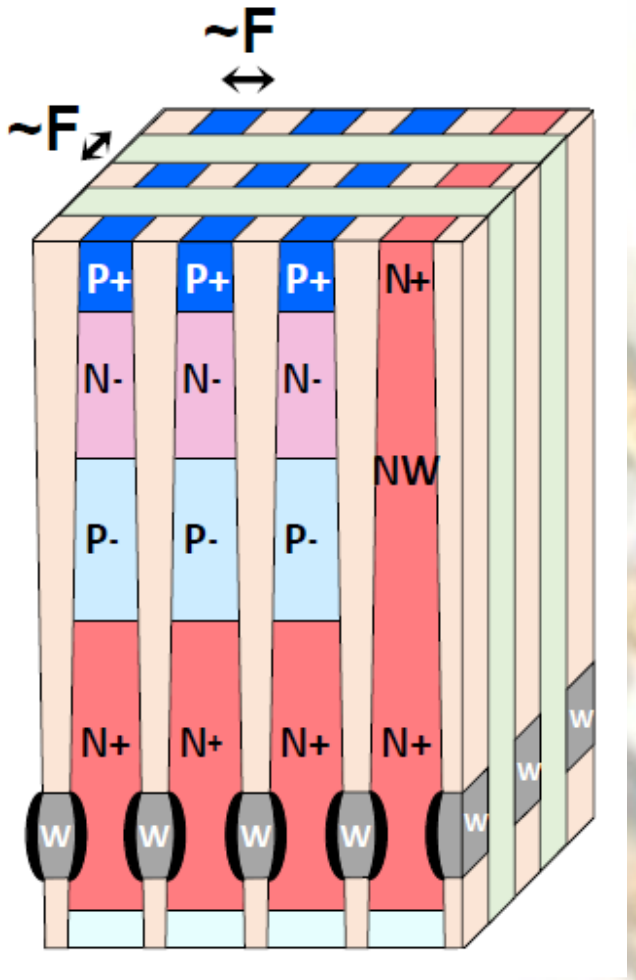
IGZO: Indium Gallium Zinc Oxide





- Gain cell with low-leakage read transistor
- Shown at IEDM 2020
- Lab prototypes at 45nm (imec)
- IGZO is not well understood

VLT: Vertical Layered Thyristor



- Announced in 2016
- Capacitor-less 4f² cell
  - Prototyped at 55nm
  - Scales <10nm
- Never got any traction

The Short Answer?

We're not even close yet!

Moving to 3D

Lessons Learned from NAND Flash

- Toolset changes are extremely expensive
- New processes are hard to master
  - Toshiba announced BiCS in 2007
  - First 3D NAND shipments 2013
  - Production stalled until 2016
  - Shortages in the interim
- All vendors must pull together

My Expectation?

It’s about a decade out.

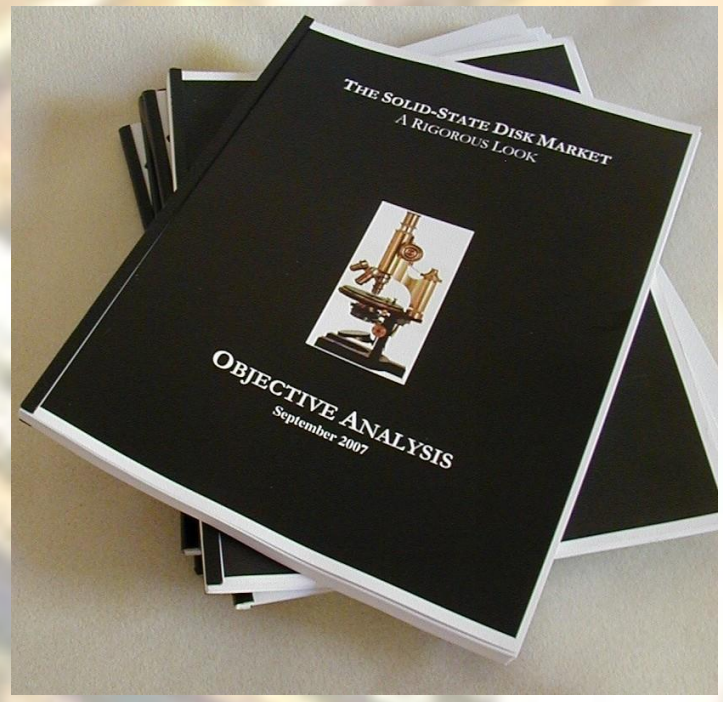
Where I Post Blogs About This

www.TheMemoryGuy.com

www.TheSSDguy.com

www.Smartkarma.com

Reports on Similar Subjects:



Emerging Memories Find Their Direction

https://Objective-Analysis.com/reports/#Emerging

Intel/Micron 3D XPoint Optane Update

https://Objective-Analysis.com/reports/#XPoint

Purchase online for immediate download


QUESTIONS?