Where Are We in the Current Flash Cycle?

Jim Handy

OBJECTIVE ANALYSIS
## Objective Analysis

### Semiconductor Forecast Accuracy

<table>
<thead>
<tr>
<th>Year</th>
<th>Forecast</th>
<th>Actual</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008</td>
<td>Zero growth at best</td>
<td>-3%</td>
</tr>
<tr>
<td>2009</td>
<td>Growth in the mid teens</td>
<td>-9%</td>
</tr>
<tr>
<td>2010</td>
<td>Should approach 30%</td>
<td>32%</td>
</tr>
<tr>
<td>2011</td>
<td>Muted revenue growth: 5%</td>
<td>0%</td>
</tr>
<tr>
<td>2012</td>
<td>Revenues drop as much as -5%</td>
<td>-2.7%</td>
</tr>
<tr>
<td>2013</td>
<td>Revenues increase nearly 10%</td>
<td>4.9%</td>
</tr>
<tr>
<td>2014</td>
<td>Revenues up 20%+</td>
<td>9.9%</td>
</tr>
<tr>
<td>2015</td>
<td>Revenues up ~10%</td>
<td>-0.2%</td>
</tr>
<tr>
<td>2016</td>
<td>Revenues up ~10%</td>
<td>1.1%</td>
</tr>
<tr>
<td>2017</td>
<td>Revenues up ~20%</td>
<td>22%</td>
</tr>
<tr>
<td>2018</td>
<td>Strong start supports 10+% growth</td>
<td>14%</td>
</tr>
<tr>
<td>2019</td>
<td>Semiconductors down -5%</td>
<td>TBD</td>
</tr>
</tbody>
</table>
Agenda

- Status of Current Cycle
- Emerging Memories
- 3D XPoint/Optane
- China & Trade Wars
- Summary
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Where Are We in the Current Flash Cycle?
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
Learning from Toshiba

• June 15: 13-minute power outage
• Slight spot price impact
• Supplier inventories huge
  – 9-13 weeks
  – Up from 4-6 weeks
• Material loss <10%
NAND Flash Prices Near Bottom

Normalized Price per GB

- Samsung
- SK hynix
- Micron
- WDC
- Spot

Source: Objective Analysis, 2019
Memory’s Price Dynamic

Price per GB


Source: Objective Analysis, 2018
Commodity Price Cycle

- **Oversupply**
  - Prices Collapse
  - Manufacturers Under Invest
  - Manufacturers Over Invest

- **Shortage**
  - Prices Stabilize
  - Manufacturers Under Invest

Source: Objective Analysis, 2019

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Boom-Bust Cycle

Source: Objective Analysis, 2018
2017 CapEx Drives 2019 Downturn

Quarterly CapEx ($Billions)

Samsung
Micron

Source: Objective Analysis, 2019
Outlook

• Prices are approaching cost
  – Prices will follow cost until next shortage
• 2019 CapEx cuts imply 2021 shortage
  – Oversupply unlikely to end before then
• China’s participation may extend down cycle
  – More on this shortly
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Emerging Memory Technologies

- MRAM: Magnetic RAM
- ReRAM: Resistive RAM
- PCM: Phase-Change Memory (i.e. 3D XPoint)
- FRAM: Ferroelectric RAM
- Etc.

All are nonvolatile memories: “NVM”
Scaling Limits Help New Memories

Relative Cost

- Flash
- New Tech

Process Geometry

- 500nm
- 250nm
- 130nm
- 65nm
- 32nm
- 16nm
- 8nm
- 4nm
- 2nm
Neural Networks for AI

\[ V_1 \frac{1}{R_1} + V_2 \frac{1}{R_2} + V_3 \frac{1}{R_3} + V_4 \frac{1}{R_4} \]

64Kb Array = 256 sums of 256 Multiplies EACH!
All in a single cycle.
Emerging Memories Report

- Emerging Memories Begin to Ramp
  - In-depth coverage emerging memory market
  - 171 pages, 125 figures, 30 tables
  - Can be purchased on-line for immediate download

https://Objective-Analysis.com/reports/#Emerging
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What is a Storage Class Memory?

Storage-class memory (SCM) combines the benefits of a solid-state memory, such as high performance and robustness, with the archival capabilities and low cost of conventional hard-disk magnetic storage.

IBM Almaden Research Labs
SCM 1960
3D XPoint/Optane

• Sole-sourced part with commodity pricing
• Whole new way to store data
• High-impact architectural change
3D XPoint Reduces DRAM Needs

Source: A Close Look at the Intel/Micron 3D XPoint Memory, Objective Analysis 2015
Intel’s Ongoing XPoint Losses

Operating Margin

Source: Objective Analysis, 2019
There’s a Report on That!

Intel/Micron 3D XPoint/Optane Update

https://Objective-Analysis.com/reports/#XPoint
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$100 Billion+ of Chip Imports/Year!

Share of Semiconductor Consumption

Source: Objective Analysis, 2018
“Made In China 2025” Initiative

• Strategy: Achieve self-reliance
• Become a leading manufacturer in
  – Semiconductors
    • 2015: <20% of consumption
    • 2020: 40%
    • 2025: 70%
  – Autonomous vehicles
  – Artificial intelligence
  – Robotics
China Has Abundant Cash

[Graph showing China's foreign exchange reserves from 2008 to 2018]
“Big Fund” Coordinates Financing

• Over $20 billion in first phase
  – Subsequent investments could reach $100B
  – A leading-edge fab is only ~$10B
• Big difference from western approach
  – Centrally controlled vs. competing interests
  – Pooled fund vs. independent efforts
Two-Element Market Entry

1. Invest heavily
   - Wafer fab cost $8-10 billion
   - Hire talent at inflated salaries

2. Go after a commodity
   - OEMs buy from the cheapest vendor
   - Penetration is immediate
   - NAND & DRAM fill the bill

All it takes is money!
What About IP?

• Home-grown route is slow
• Partnering is faster
  – Path taken by Japan in the late ‘70s, Korea in the late ‘80s, and Taiwan in the middle ‘90s
  – Offer very cheap wafers in return for know-how
• Solutions rarely remain confidential
• Patents seldom used to block competition
China Fabs Moving Ahead

YMTC

JHICC

CXMT

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Current Status

• Tooling incomplete
• YMTC sampling
• Others behind

• Trade war!
Trade War!

• Proving to be a 2-edged sword
  – US companies suffering consequences
  – SIA working to get this straightened out
• World economy makes trade wars difficult
  – All semi & tool makers are multinationals
• It’s worrisome
There’s a Report on That!

China’s Memory Ambitions

https://Objective-Analysis.com/reports/#China
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## Year-By-Year Outlook

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<th>Year</th>
<th>Outlook</th>
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<tbody>
<tr>
<td>2018</td>
<td>Mid-year NAND flash oversupply/collapse</td>
</tr>
<tr>
<td>2019</td>
<td>DRAM, then overall semiconductor collapse</td>
</tr>
<tr>
<td>2020</td>
<td>Second “Down” year</td>
</tr>
<tr>
<td>2021</td>
<td>China’s participation extends oversupply</td>
</tr>
<tr>
<td>2022</td>
<td>Demand catches up with supply. New shortage creates profits</td>
</tr>
</tbody>
</table>
Moving to New Memories

Logic

NAND

DRAM

2015 2020 2025 2030 2035

DRAM
MRAM?

NAND
ReRAM?

Logic

???

Source: Objective Analysis, 2018

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QUESTIONS?