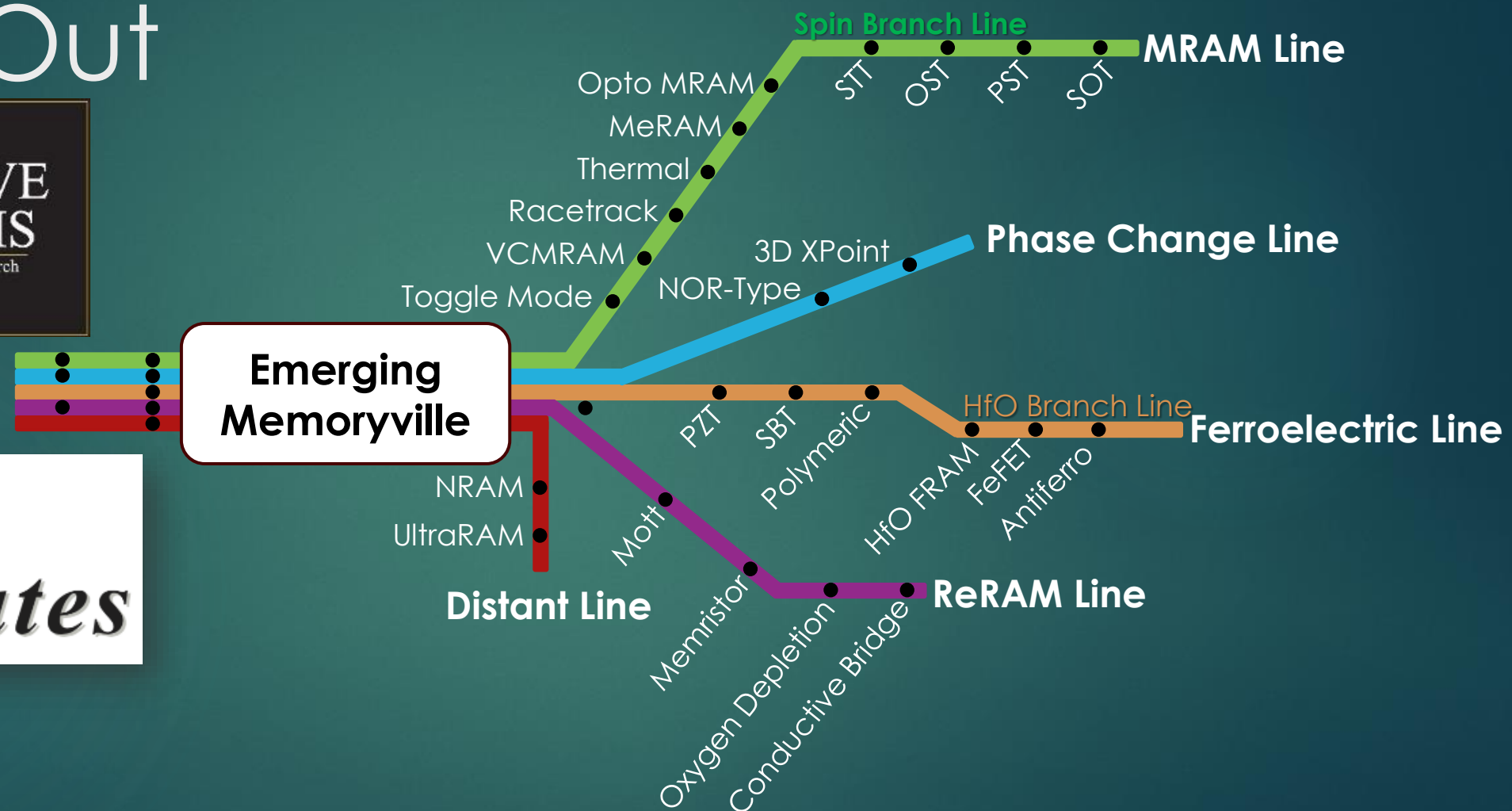


Life Beyond Flash: Will Emerging Memories Take Over?

JIM HANDY, OBJECTIVE ANALYSIS

TOM COUGHLIN, COUGHLIN ASSOCIATES

New Report: Emerging Memories Branch Out



Now Available!

<https://Objective-Analysis.com/reports/#Emerging>
<http://www.TomCoughlin.com/techpapers.htm>

What Are Emerging Memories?

- ▶ Anything other than a charge-based cell
 - ▶ MRAM: Magnetism
 - ▶ ReRAM: Resistance
 - ▶ Either metal filament or oxygen vacancy
 - ▶ PCM: Resistance, too (crystalline or amorphous)
 - ▶ FRAM: Atom displacement

What Are Emerging Memories?

Part II

- ▶ Radiation-tolerant
- ▶ Nonvolatile
- ▶ Fast write compared to flash
- ▶ Byte writeable
- ▶ Scalable well past 28nm
- ▶ Based on innovative materials

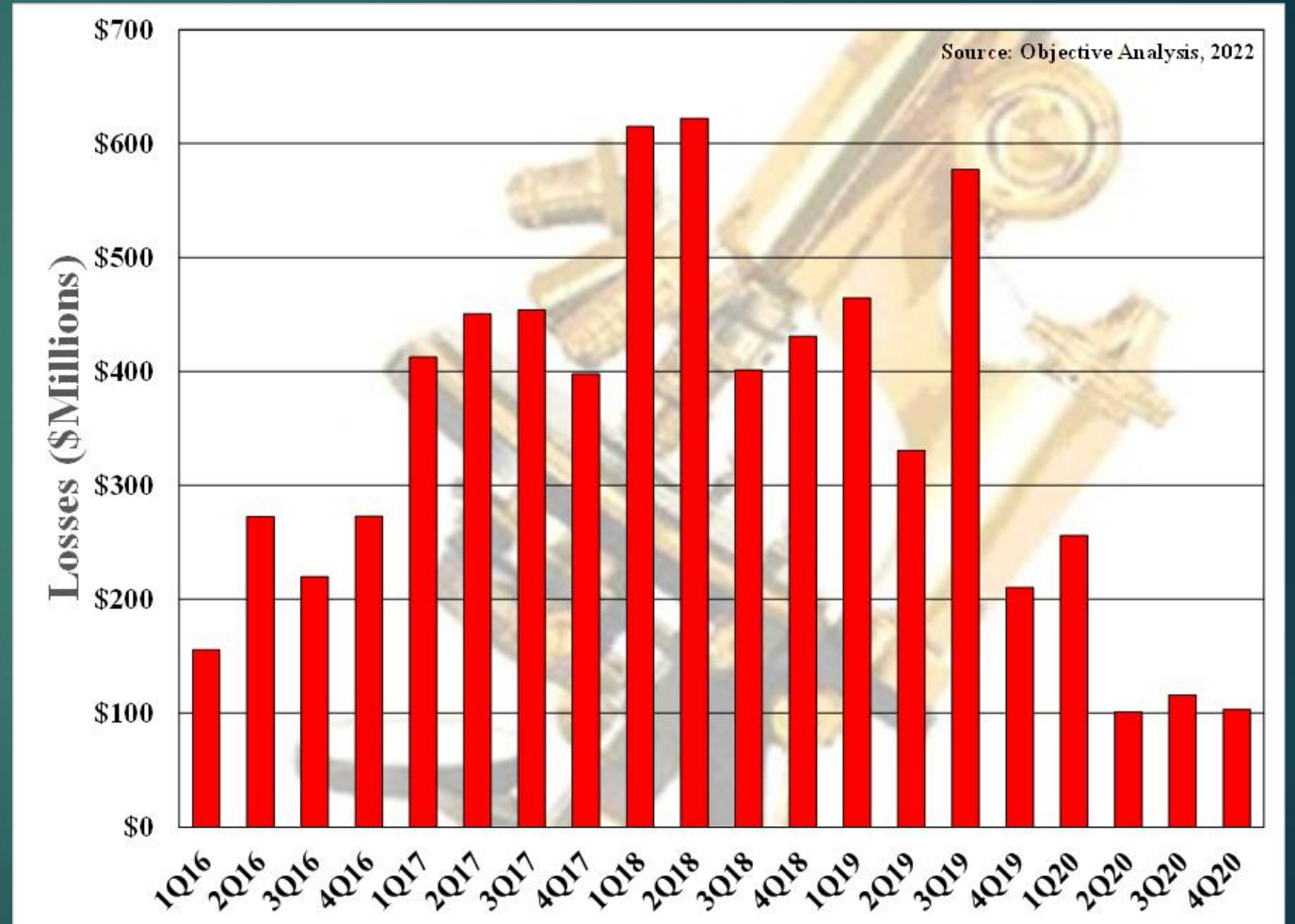


The Economics Are Challenging

- ▶ A small die size isn't enough
 - ▶ Manufacturing scale determines relative cost (economies of scale)
- ▶ Intel's Optane proved the difficulty
 - ▶ Volume never justified the cost

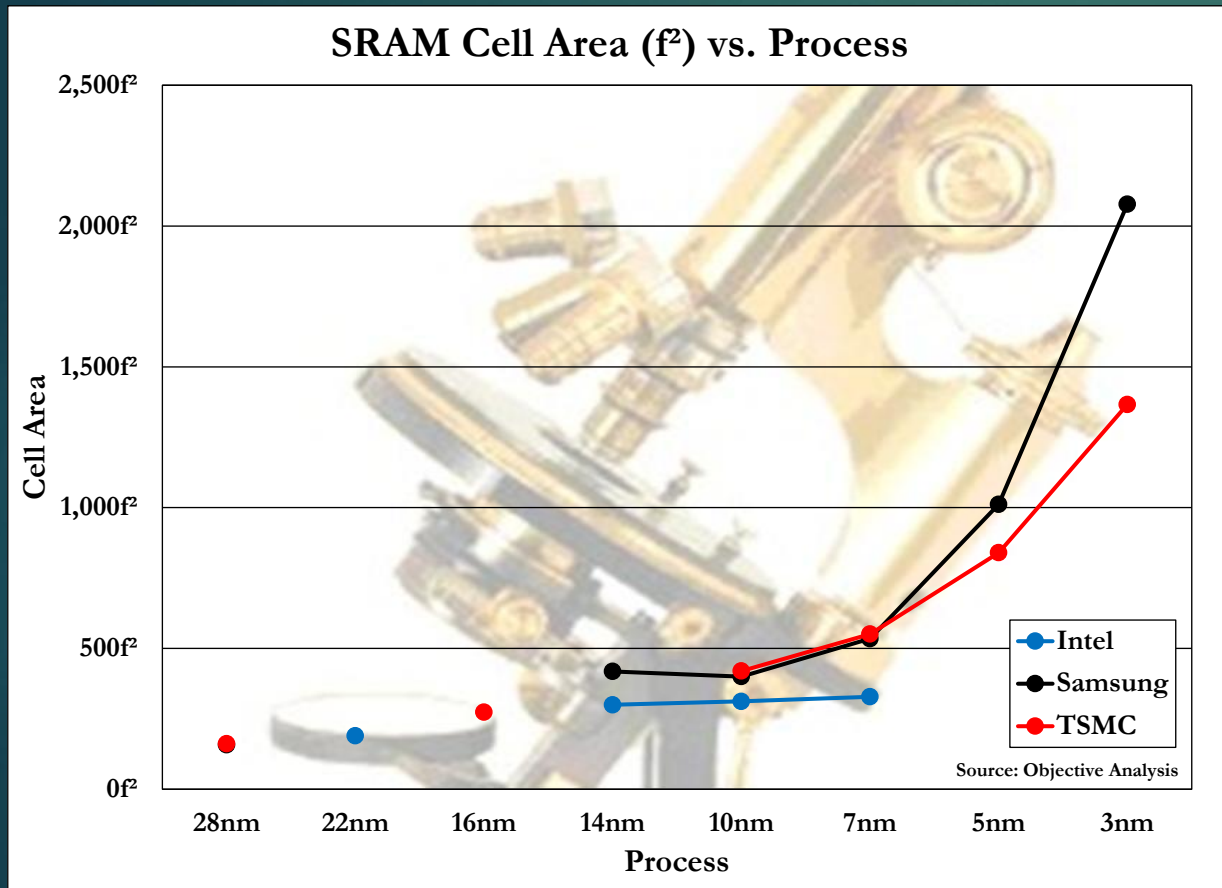
Intel's Optane Losses

- ▶ >\$7B in Intel losses
 - ▶ Micron losses ~\$400M/quarter
- ▶ Optane SSDs intended to drive early volume
 - ▶ Users disliked the price
 - ▶ Volume never really ramped
- ▶ Optane DIMM was delayed



Is There No GOOD News?

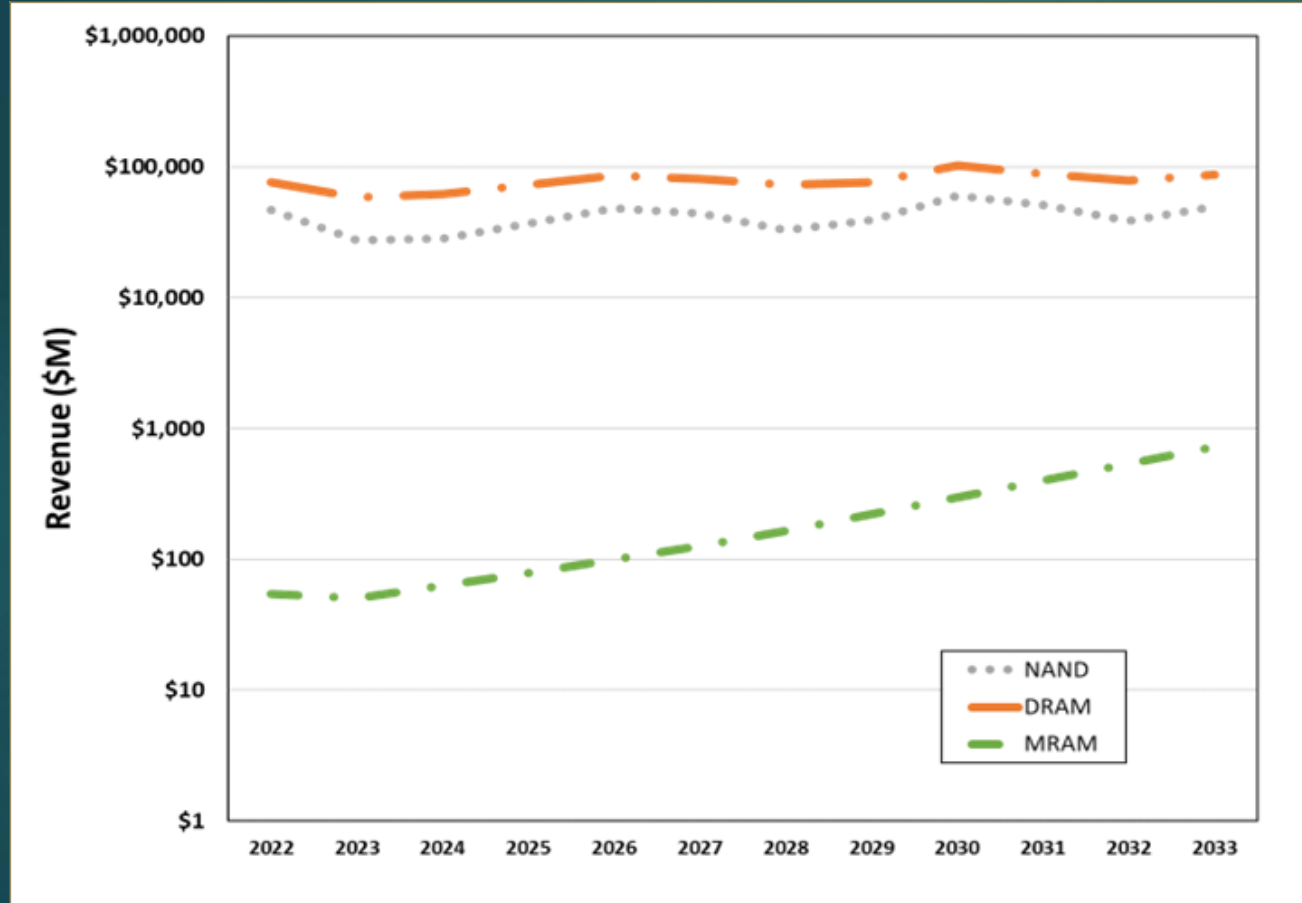
SRAM Won't Scale With Logic



From: [Emerging Memories Branch Out](#)

- ▶ SRAM doesn't scale with CMOS logic process
 - ▶ Cost increases with smaller geometries
- ▶ Emerging memories can solve this problem
- ▶ Future caches will use emerging memories
 - ▶ Larger capacities
 - ▶ Cheaper
 - ▶ Persistent

The Future of Emerging Memories



Emerging memory revenues to grow much faster than DRAM or NAND flash

From: [Emerging Memories Branch Out](#)

Success in Wearables



- ▶ Garmin Versa 4
- ▶ Google Fitbit Luxe
- ▶ Garmin Fenix 7 Solar



Where Will They Thrive?

- ▶ Embedded memories look like a win:
 - ▶ NOR flash can't scale past 28nm
 - ▶ SRAM scales badly below 7nm
- ▶ Wearables are already adopting it
 - ▶ Look for other IoT applications soon
- ▶ Volume wafer production will drive costs down

Thank You!