


**InCites**

Stirring up interest in 3D integration

# State-of-the-3D Industry Future Opportunities and Challenges

# Outline

- ▶ Building the Case for 3D
  - ▶ 3D Vs. Scaling
  - ▶ Technology Roadmap
  - ▶ Technology Hurdles
  - ▶ Psycho-political Hurdles
  - ▶ Evolutionary vs. Revolutionary
  - ▶ The Players
  - ▶ Enabling Next Gen Products
  - ▶ Future Developments
  - ▶ Summary/Conclusion
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# Performance Needs Are Increasing

## Top Smart Phone Activities



Web 3.0  
"Always On,  
Always  
Connected"

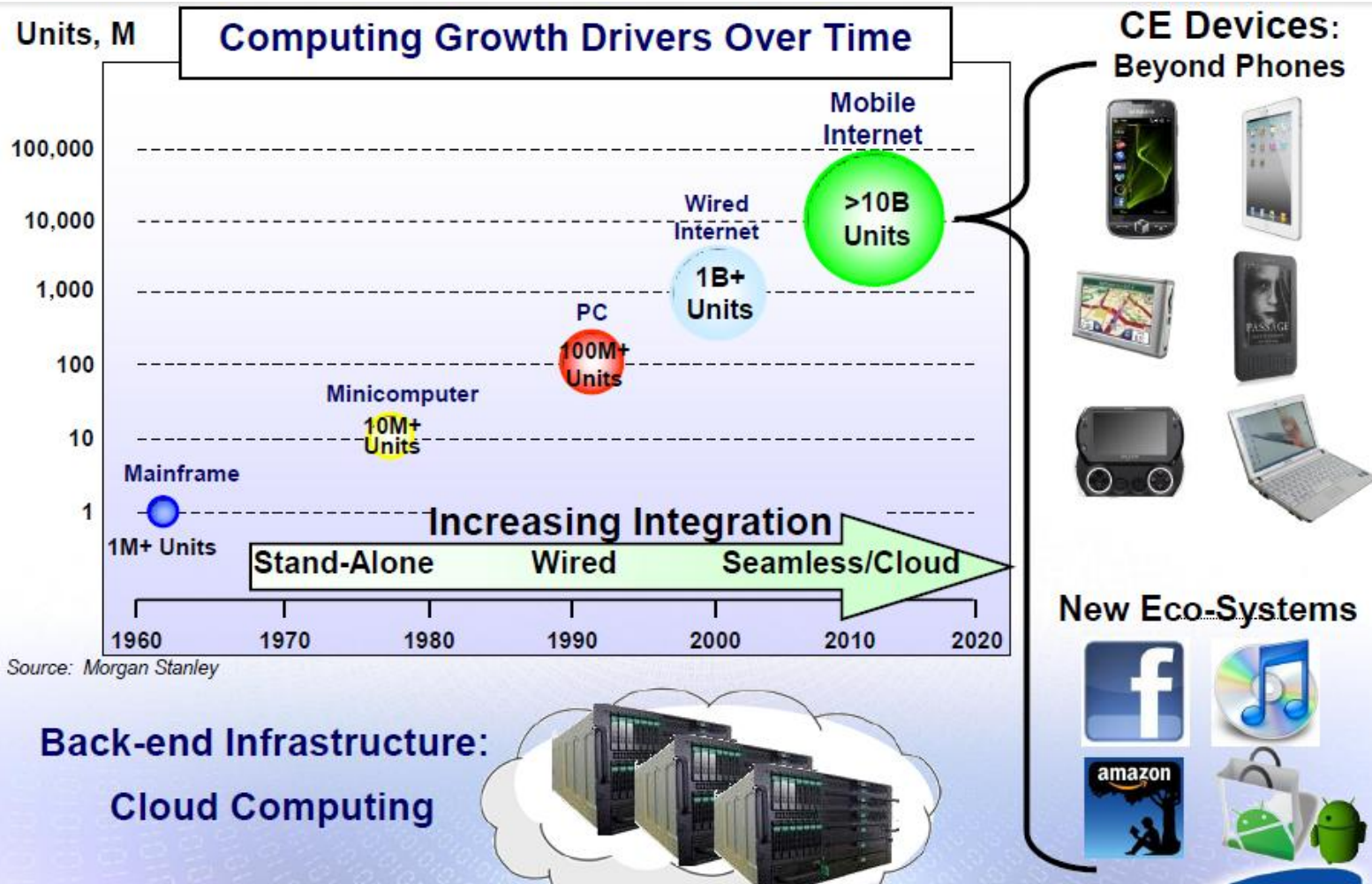
Comscore

"For the Class of 2014, Email is Already Dead..."

SAMSUNG

Courtesy of Jim Elliott, Samsung,  
GSA Memory Conference

# Beyond the mobile device



Courtesy of Jim Elliott, Samsung,  
GSA Memory Conference

# Mobile Computing Platform



Memory Bandwidth (GB/s)



Courtesy of Jim Elliott, Samsung,  
GSA Memory Conference

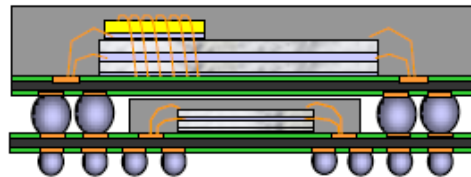
# So Why 3D?

3D Architecture's Power Alley...

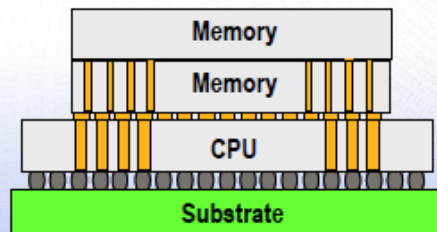
Memory + Logic TSV To Reduce Size, Decrease Power & Improve Speed

## DRAM + Logic Stack

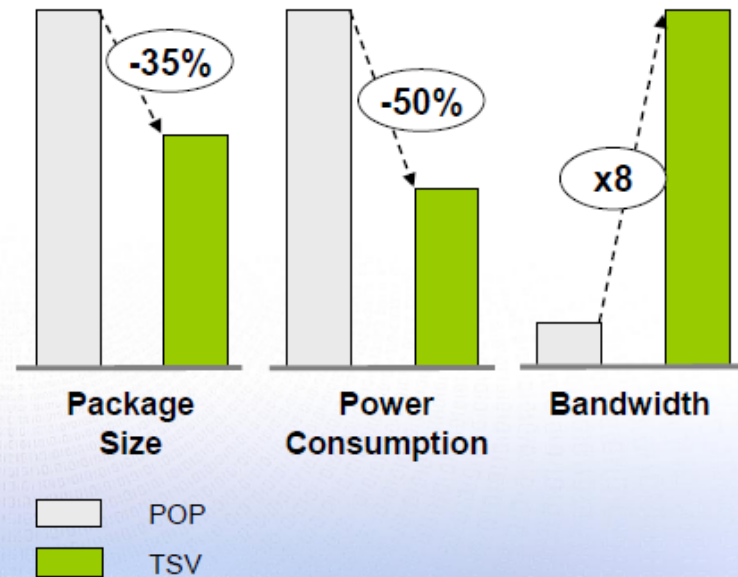
POP



TSV

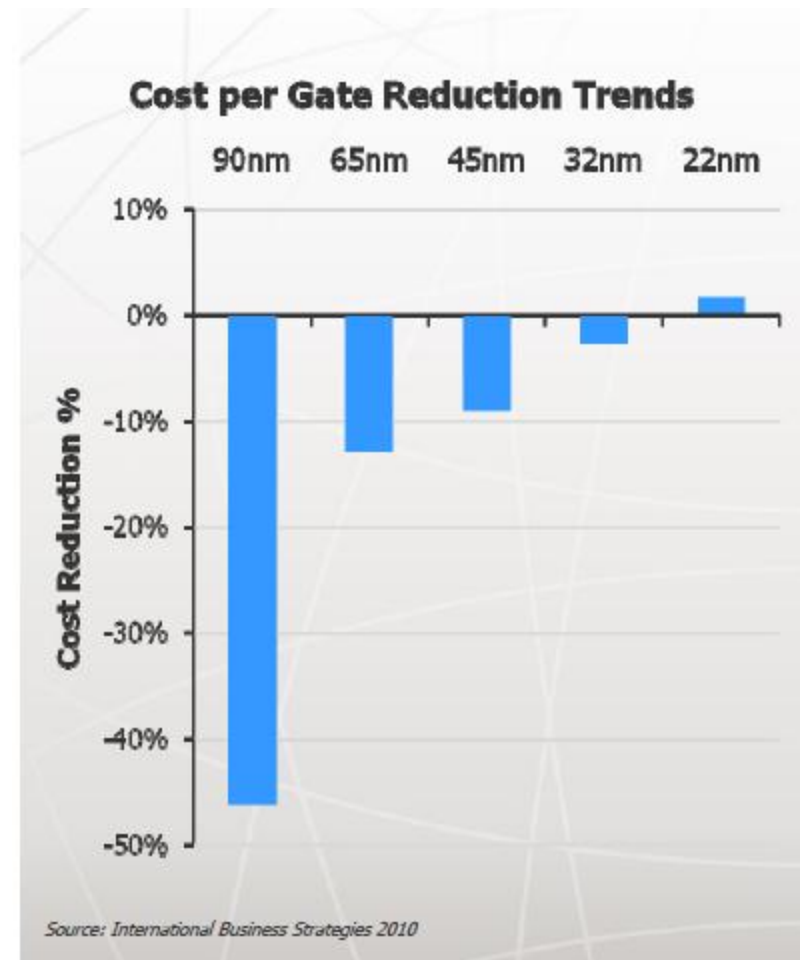


## Size, Power & Speed

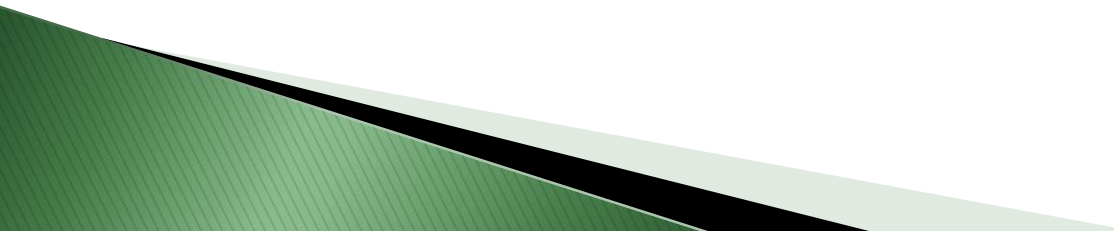


# Why Not just keep Scaling?

- ▶ Cost increases in scaling
  - At 22nm, per wafer cost increase is 15%, and is expected to be more at 20nm and 15 due to double patterning.
  - Next generation lithography will not solve the problem.
- ▶ Fewer players with capabilities for nodes past 22nm.
- ▶ Leakage current

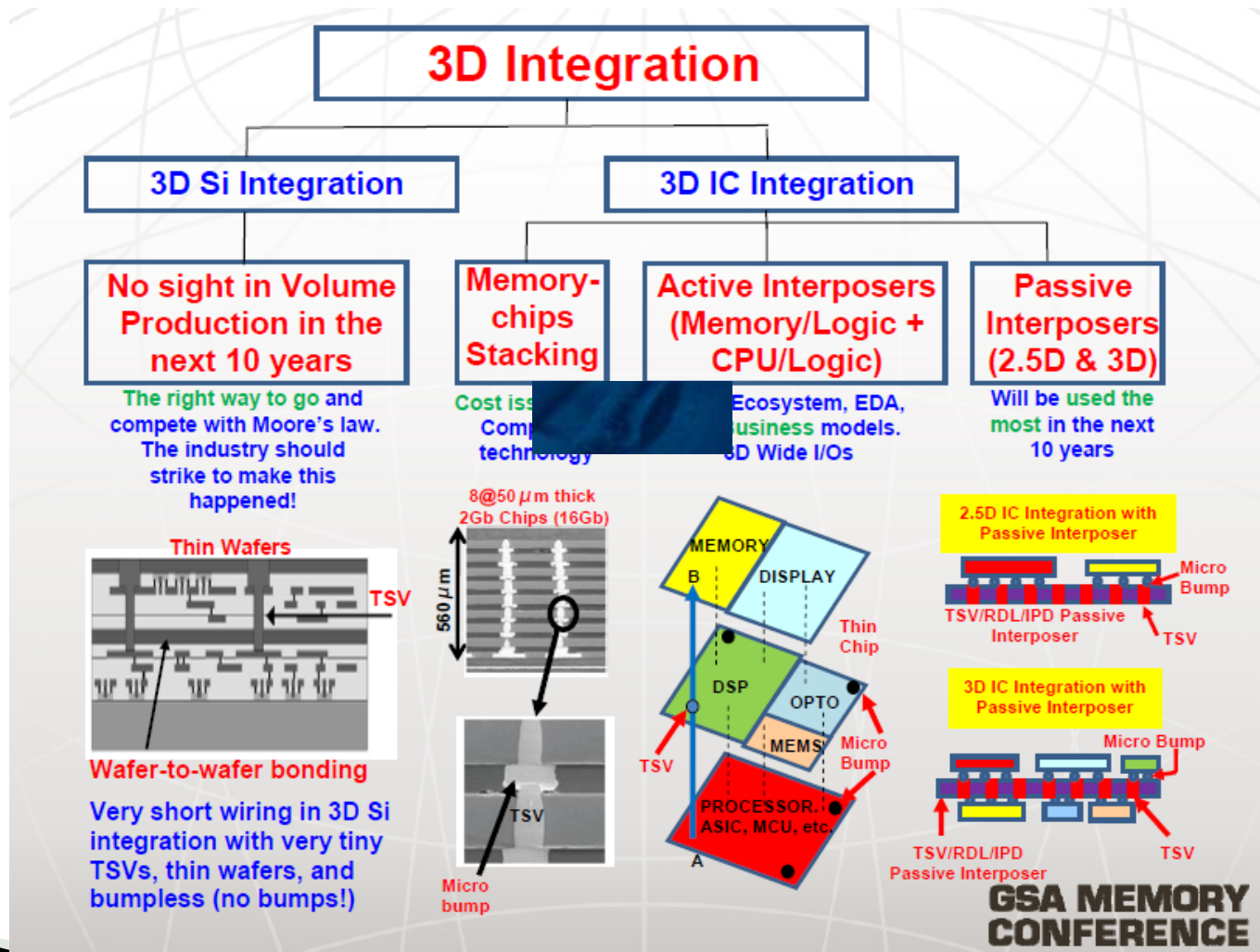


# IS 3D The “New Scaling”?

- ▶ Experts Agree – traditional scaling is “running out of steam”.
  - ▶ Memory Applications are particularly affected by this.
    - “3D integration is logical extension of the holistic embedded memory roadmap and is a big deal for heterogeneous integration.” Subramanian Iyer, IBM Fellow, Microelectronics, IBM
    - “We Believe 3D Read/Write Memory Will Likely Be the Successor to Floating Gate NAND Flash Over The Long Term” Yoram Cedar, Sandisk
    - “3D integration will provide a long-term solution to the industry’s expanding computational power and memory requirements” Dan Baldwin, Engent
- 



# What's Now, Next, and Beyond



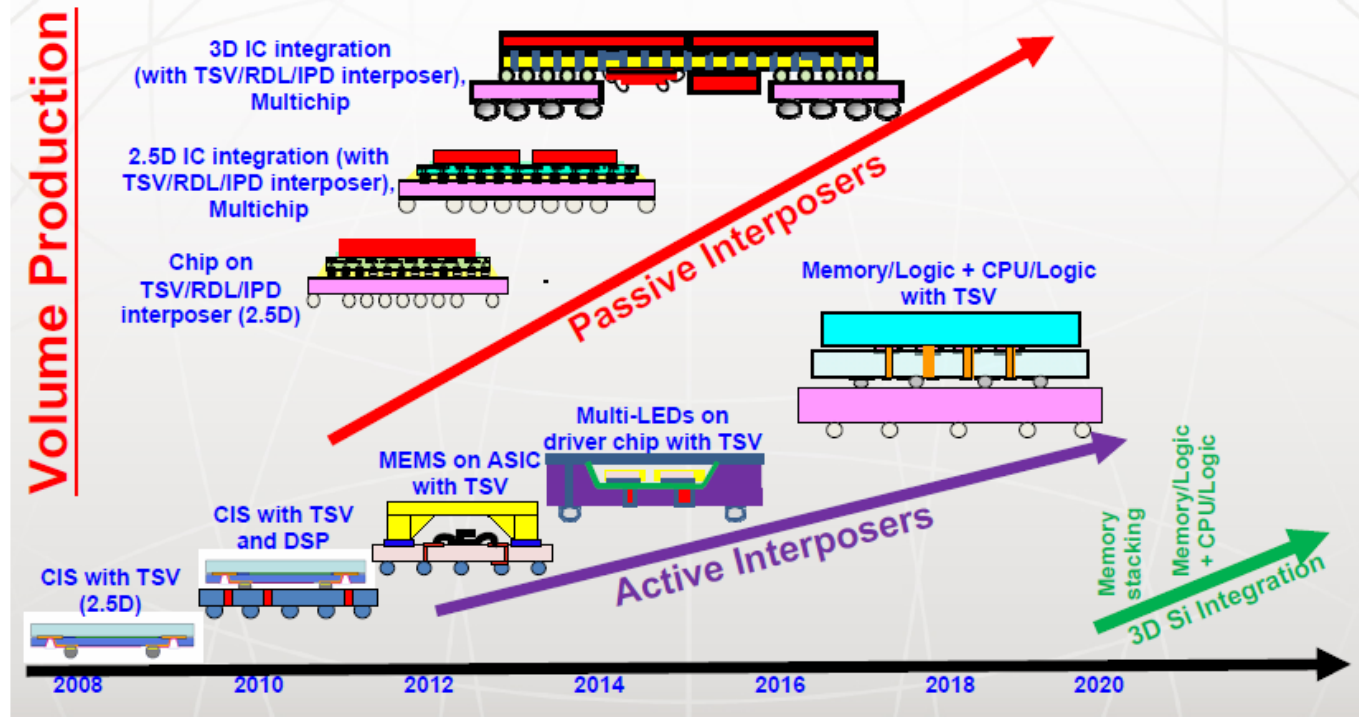
Courtesy of John Lau, ITRI, GSA Memory Conference

# 3D Technology Roadmap

- ▶ **Now**
  - Sensors on logic
  - Limited-volume stacked memory (wire bond)
  - Package-on-package and flip chip memories on processors
- ▶ **Next 2–3 years: 2.5D+**
  - Increased use of passive interposer technology with TSVs
  - Integration of logic and memory with flip chips and interposers
  - Mixed analog, RF, logic and memory in multi-die stacks
- ▶ **Future 5+ years: 3D**
  - TSVs in Active chip area
  - Embed TSVs in leading-edge logic chips
  - Mixed analog, RF, logic and memory in multi-die stacks

# 3D Technology Roadmap

## ITRI 3D IC/Si Integration Roadmap (Excluding Memory Stacking)

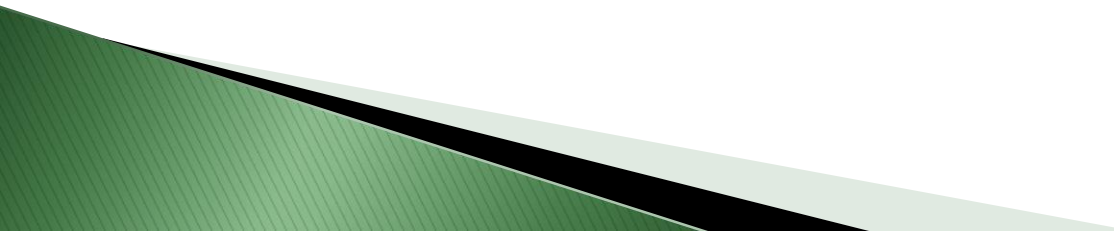


Courtesy of John Lau, ITRI, GSA  
Memory Conference

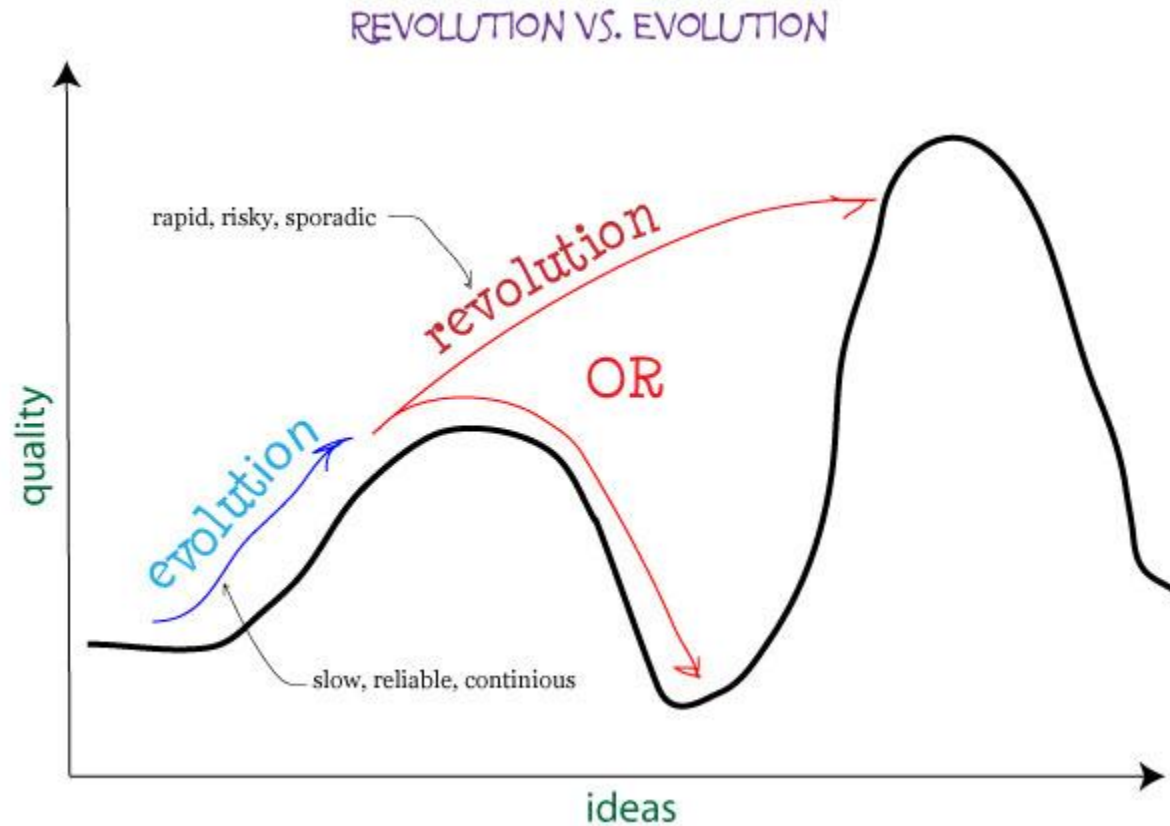
# Technology Hurdles

- ▶ What's been the hold-up?
  - Waiting for the “Killer APP” – Breaking down the Memory Wall
    - Wide I/O DRAM on Logic.
  - Standards
  - Thermal management
  - Design tools
  - Test methodologies – cost could stop the show
- ▶ What will drive it forward?
  - The realization that there is no other way to do it.

# Psycho–Political Hurdles

- ▶ If it Ain't Broke, Don't Fix It Mindset
  - ▶ Evolutionary vs. Revolutionary
  - ▶ Fear of Change vs. Resistance to Change
  - ▶ Disruptive Technology Syndrome – who will be displaced and what can they do to hold up progress.
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# Evolution vs. Revolution

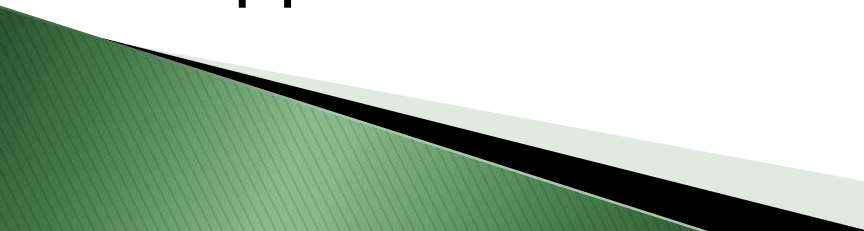


# Evolution vs. Revolution

*Incremental vs. revolutionary improvements...*



# Evolutionary vs. Revolutionary

- ▶ Traditional SEMI Manufacturers
  - ▶ Conservative approach
  - ▶ Makes decisions based on historical data.
  - ▶ Risk-averse
  - ▶ Incremental Steps approach
  - ▶ Start-ups with Disruptive Technologies to Exploit.
  - ▶ Risk takers
  - ▶ Decisions based on future vision
  - ▶ Innovative
  - ▶ R&D focused
- 



# What Just Happened?

“The Rapid Ramp of Mobile Internet Usage Will be a Boon to Consumers and Some Companies Will Likely Win Big (Potentially Very Big) While Many Will Wonder What Just Happened”... Mary Meeker, Kleiner Perkins

# Concept to Market Traditional Roles

## Academia

- Proof of Concept
- Government funding
- Continued research
- Far term technology

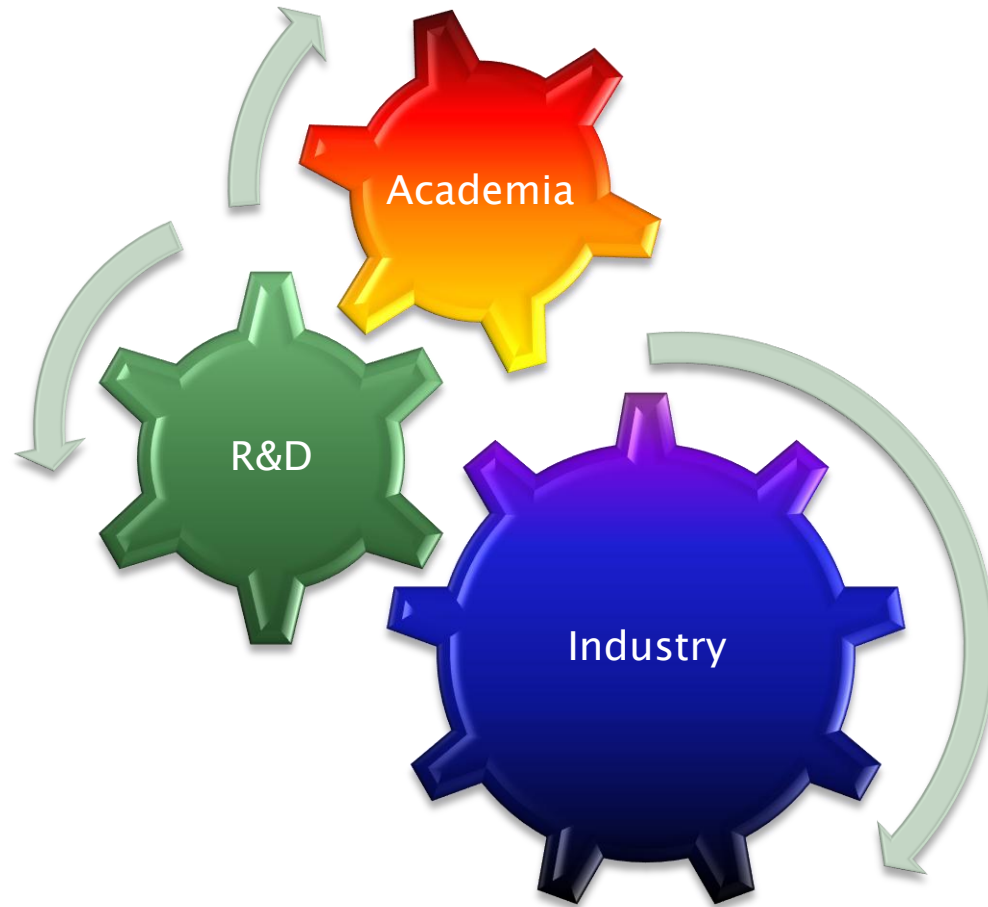
## R&D

- Emerging/near term Technology
- Marketability
- Technology Transfer
- Low Volume Production

## Industry

- Market adoption
- Value Proposition
- Cost of Ownership
- Market Adoption
- High Volume Production

# Adapting for 3D Ecosystem



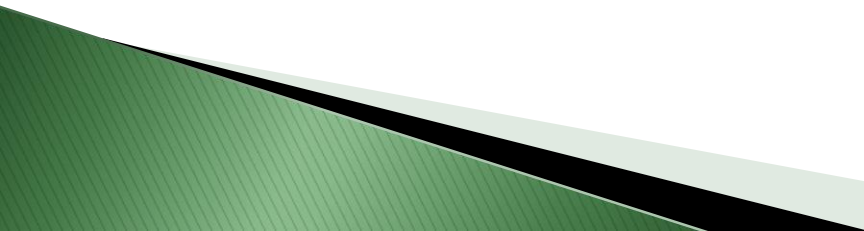
# Enabling Next-Gen Products

- ▶ 3D Memory stacking can provide fast access and high bandwidth
- ▶ Memory Bandwidth Challenges in Many-core processors
- ▶ Enables Exascale computing
- ▶ Technology benefits will outweigh cost (Wide I/O DRAM)
  - HPC and Graphics Purposes
  - Future Quad High-Definition TV (HDTV) application

# Future Developments

- ▶ 3D Systems: Where 2.5D and 3D IC Coexist
  - 3D Systems integrating heterogeneous devices will likely incorporate both passive interposer and 3D TSV stacks in the same package.
- ▶ 3D Silicon Integration
  - How it differs from 3D IC integration
  - What does it solve?

# Summary/Conclusions

- ▶ R&D would benefit from understanding the psycho-political hurdles.
  - ▶ Proof of Concept is not enough. Cost efficiency must be designed in
  - ▶ Infrastructure must be considered when developing disruptive technologies
  - ▶ Requires collaboration with ecosystem from the start.
  - ▶ Identify hurdles early and address them concurrent with technology development.
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# A Final Word....

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