Power:

Where it matters,
when it matters,
and
when it does not

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Keynote for the Berkeley Symposium on Energy Efficient Electronic Systems
Semiconductor Analytics

• **IC Sales**: October crash ends
  – 3% growth for the last week of the month

• Semiconductor Sales Activity hits 10th week of + W/Q growth

• Electronics Sales Activity hits new high for 4th Week
  • 10th week of W/Q strength
• Holiday electronics buying cycle stays on track for growth.
• This data series does not look recessionary.
Power is the new Fall Fashion

Will it Last?
Power has New Chasms to Leap

• Server Farms
  – The most expensive server…

• Mobility Explosion

• Competitively
  – 3D transistors
  – Cost of producing
    • In the 10-20nm range

• But …
Koomey’s Law

- Computer power efficiency grows at a 54% CAGR
- Thus power-per-computation is declining at a 35% annual rate
Koomey’s Paradox

- **If** power efficiency has been declining at a 35% CAGR since the 1940’s
- **Then** why is power in vogue today?
  - Taken 6 decades
Koomey’s Law or Observation?

- What are the drivers?
- Isn’t it just a restatement of Moore’s Law and Dennard’s scaling rules?
Moore’s Law

Component density **doubles** every two years due to **geometry shrinks** for roughly the **same areal cost**

*Gordon Moore - 1975*
Dennard’s scaling rules

Transistor **shrinks** result in **proportional power** and/or **performance gains**.

*Robert Dennard - 1974*
mils to nm
\[ \sum_{i=5} \]

Moore's Law
+ Dennard Scaling

= Shrinkonomics
... and the Semiconductor Industry went in Nodal Leaps and Bounds
Now we did worry about power a bit back around 2000
Power Density Trends
(in Watts/cm²)

Source: Robert Dick, University of Michigan
There was no nuclear meltdown
Everybody pretty much forgot about the power part … until now

Even Koomey’s paper focused on performance efficiency, not power
Where did Koomey’s System Level Performance gains come from?

• The **result of improvements** in
  – *transistor* architectures and …
  – *processor* architectures

• Systems are assemblies of chips
  – Not ground-up designs
  – like mainframe era systems
System versus Transistor Power Improvements over Time

- What do you get if you take…
  - system power efficiency
    - and
  - divide it by transistor count
    - Or transistor equivalents
    - i.e. tubes, magnetic cores, or transistors
Koomey, Moore & Dennard

(Computations per kWh per Transistor Equivalent)
Mainframe versus PC eras

• Both eras distinctly different
• Computer industry went from
  – tubes to
  – bipolar transistors, to
  – bipolar ICs, then
  – NMOS ICs, and eventually
  – CMOS ICs
Improvements in switches led to

• Huge leaps forward in power reduction

• Resulted in greater computational power efficiency

• NOT reductions in power use
Power Efficiency Improvements in the PC Era

• 54% = Koomey’s Law Annual Growth Rate
• 39% = Transistors per system growth
• 16% = Transistor normalized annual growth
  – computations-per-kWh
Moore’s Law & Dennard’s scaling rules

• Increasing transistor density with lower power accounts for most of the computational efficiency gains since the eighties
What this means for market drivers

• Computational power more important
  • than power use

• Why CPUs are the most profitable sector of semiconductors

• But will this change?
Despite reports to the contrary, PCs are still alive and well.
Marketing Power
IC Marketing 101

Power is **NOT** a market

It’s an electrical parameter and a design constraint
Power’s 1st Order Design Constraints

Power Source > **Black Box** < Function

Mainframe >>> to >>> Mobile
Power’s Last Order Design

Constraint: Heat Dissipation

- You have to get the heat out of the box
- Reason why laptops are now called notebooks
- Datacenter Power Costs rising 6-8x spending on servers

Apple Power Mac G5 Dual 2.5GHz Processor
Source: Mac2MacOnline.com

Source: Dow Corning

Source: Deep Cool
... and the box can be a building

- Datacenter Power Costs have been rising 6-8x that of spending on servers
- Nuclear power plants don’t scale with Moore’s Law

Source: Horst D. Simon “From Bits to Buildings: Energy Efficiency and the Path to Exaflops”
Fundamental IC Design-for-Market Boundary Conditions

- Energy to Function Conversion
  - Minimize Power Source
  - Maximize Function per $
- Minimize Heat out

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This is why processor power never went nuclear

You must pick your market and design to its constraints or you go out of business
Market Constraints are Why

• Laptops have typically burned up their battery power after 2-4 hours
  – 5 lb. laptops have brick power supplies
• Cell phones burn them up in less than a day

• Battery life promises are like politicians’ promises to reduce the deficit
Basic Business Model

Customer → Seller

Seller → Customer
Consumer’s view of power
Basic IC Business Model

Customer

ODM

IC Company
ODMs often don’t get it

- Apple presented with ability to lock-up a critical battery patent
  - It was between Steve Jobs’ tenures
- CTO’s response was:
  - “Batteries are not a core technology for us.”
- ODMs are often focused on doing more of the same better or cheaper
  - Look at Apple’s battery life today vs the average laptop
Basic Mobile IC Business Model

Customer

Carrier

IC Company

ODM
Carrier’s view of power

- Accessories extremely profitable – *instant cash*
- Phones are loss leaders
The Bottom Line

- There are a lot of sinkholes on the power landscape to step into
- Power tends to come free with every transistor generation

... or does it?
Fabs are not Free

- They are not even cheap
- $4-5B for the Fab + $3-5B in Development
Beyond Dennard … Less is Moore

• New alternatives for staying cool
• It’s *Back to the Transistor*
• For example:
  – Mears Technologies
  – SOITEC
  – Suvolta

• New life for old fabs
Questions?

... and about VLSI

This presentation will be available at

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- VLSI Research Inc is a leading provider of market research and economic analysis of high tech industries.

- Known for its sharply focused insight into the rapidly changing landscapes of the industries covered.

- VLSI has been the only market research firm to consistently gauge the direction of growth since the early eighties.

- VLSI Research was founded in 1976.
Appendix: Web sites

VLSIresearch.com
- VLSI’s market research page
- For research on the semiconductor supply chain

ChipHistory.org
- Education site on semiconductors
- Virtual history museum
- Based on industry donations

weSRCH.com
- Where Technology = Opportunity
- A virtual science & engineering conference
- >10M Page Views and >700K visitors per month
  - 15-20mins & 35 page views / visit, >1 visit / week
  - High signature authority and income viewership
  - High Yield on Targets for your business
Appendix: Product Offerings

- **Semiconductor Analytics**
  - *weekly market updates*

- **Chip Market Research Services**
  - *The Chip Insider®, ForecastPro, Semi & FPD*

- **PV Solar**: *The Database on PV Manufacturing Markets*

- **Critical Subsystems** *for Semiconductor, Flat Panel Display & Data Storage Manufacturing Equipment*

- **INDUSTRY PULSE PRO®** *entry level datapacket*

- **Customer Satisfaction** *Custom Internet surveys in multiple languages*
about Semiconductor Analytics

• This is a new offering
  – Addresses the semiconductor supply chain
  – End demand focus

• Single Stop for Industry Fundamentals
  ▪ All Industry Fundamentals readily available
    ▪ Weekly and Monthly
  ▪ Only source of
    ▪ Weekly IC Sales statistics
    ▪ Monthly capacity statistics
  ▪ Knowing what’s happening now with little latency
    ▪ 3 business days instead of a month or quarter
  ▪ Eliminate costly searching for “free data”— Dan
Semiconductor Analytics’ TOC

• This Week in the Supply Chain
  – IC Billings, Units, and ASP’s
  – Semiconductor Sales
  – Electronics Sales Activity
  – Electronics Price Trends

• This Month in the Supply Chain
  – Electronics Sales and Growth with 3/12 - 12/12 Charts
  – Personal Tools: PC’s, Tablets & Handsets
  – Consumer
  – IT Infrastructure
  – Automotive
  – Foundry capacity and production
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