Innovation in Nonvolatile Memory

SNIA

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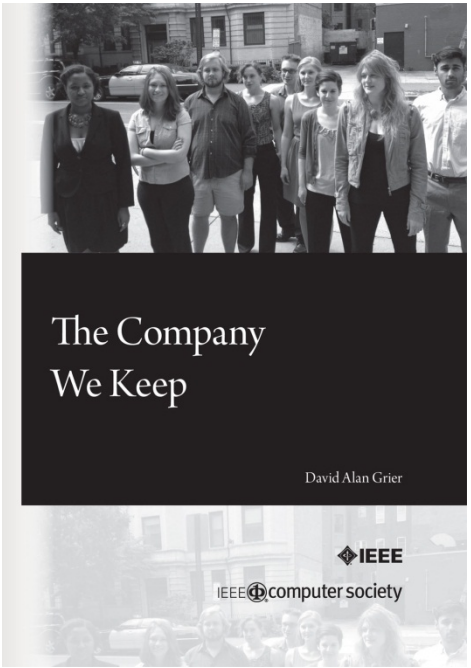
What I can Tell you About Non-Volatile Memory?

- Nothing that you don't know better than I

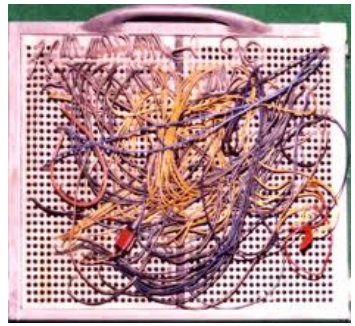


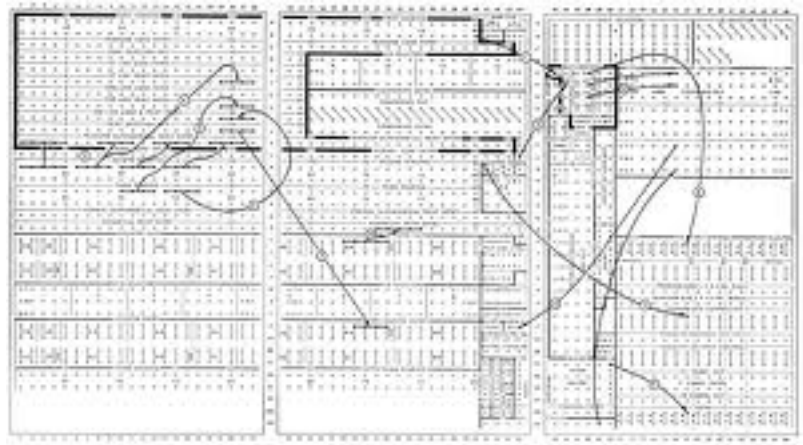
I could look up History

- Often Contentious
- Occasionally Silly
- Many times uninformative

Occasional Insight

- Punched Card
- Microprogramming
- Read Only Memory





Patterns That We Complete

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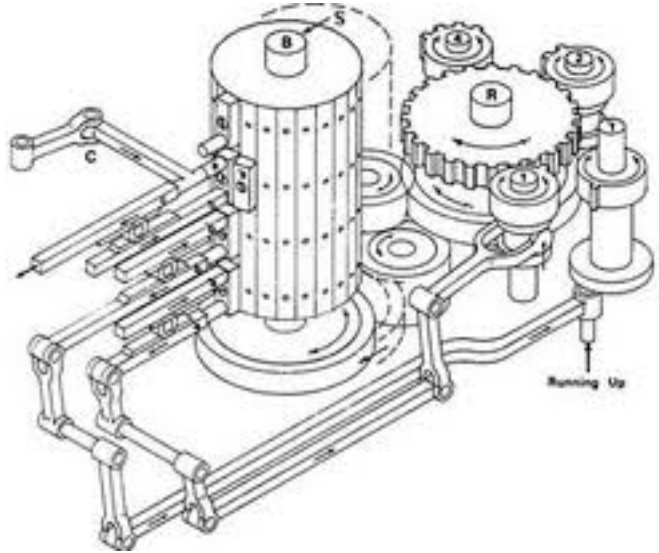
Or Perhaps All things in Balance

- Elements Support Each Other
- Nothing in Place until all in place
- Complex Series of Market Decisions

Five Steps (1)

- Preliminary Test of Concept
  - Applications Identified
  - Ad Hoc Technology



Five Steps (2)

- Preliminary Test of Technology
  - Often not connected with application
  - Rarely Cost Effective

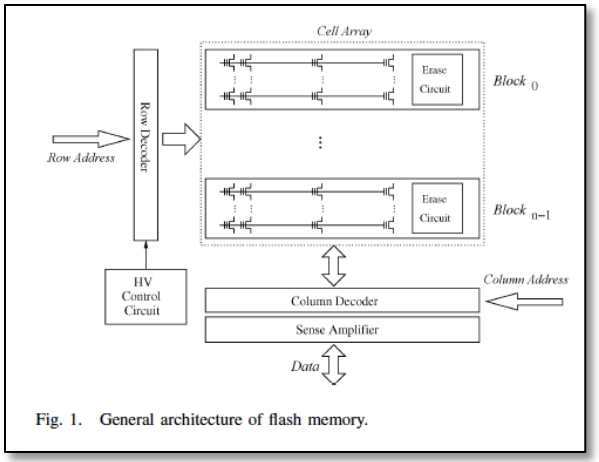


Fig. 1. General architecture of flash memory.

Five Steps (3)

- Cost Effective Application
  - Pulls Pieces together
    - Mature Problem
    - Straightforward Design
    - Revenue/Costs

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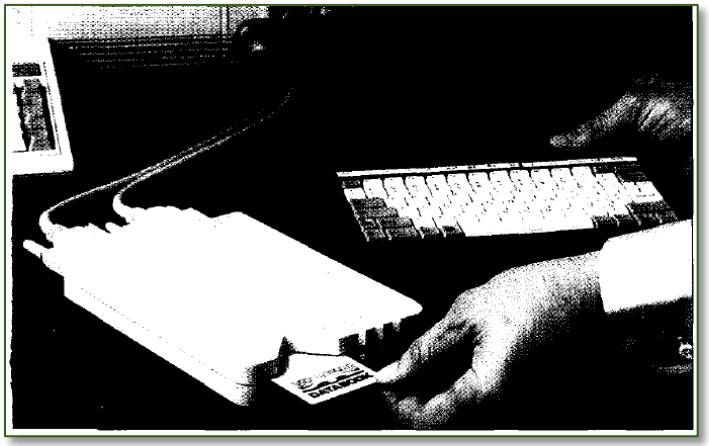
- Cost Effective Application
  - Pulls Pieces together
    - Mature Problem
    - Straightforward Design
    - Revenue/Costs
- Not the Killer App
  - The KEY EFFECTIVE APP

Five Steps (4)

- Expansion
  - Related Applications
  - Expand Market
  - Disseminate Skill



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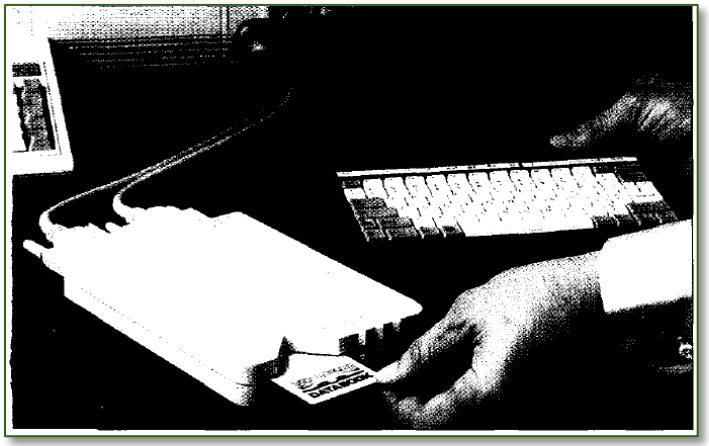
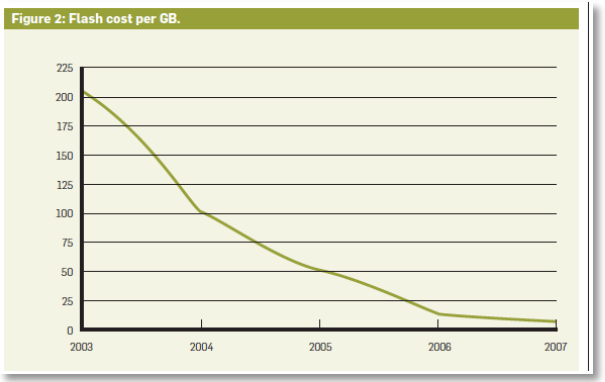


- KEY POINT
  - Cost does no longer matters

Five Steps (5)

- Optimization
  - Get the most from the least



Nonvolatile Memory

- Test of Concept (1)
  - Persistent, Non-Mechanical Storage
  - Identified by Early 1960s

Nonvolatile Memory

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  - Code Storage
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  - Data Recording
    - Disk Crashes

Non Volatile Memory (2)

- Preliminary Technology
  - By 1980
  - Static RAM
  - Flash Memory

Non Volatile Memory (2)

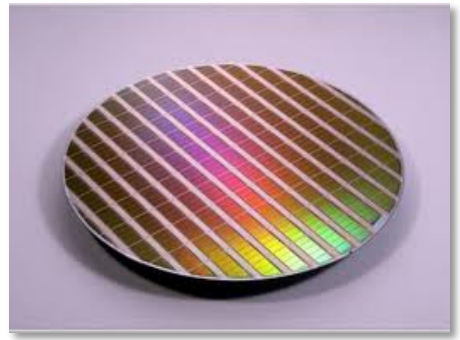
- Preliminary Technology
  - By 1980
  - Static RAM
  - Flash Memory
- Look at Magnetic Bubbles
  - 1970s

Non Volatile Memory (3)

- First Effective App
  - Data Recording on Shop Floor
  - Dirt/Vibration (oil)
  - Early-Mid 1980s

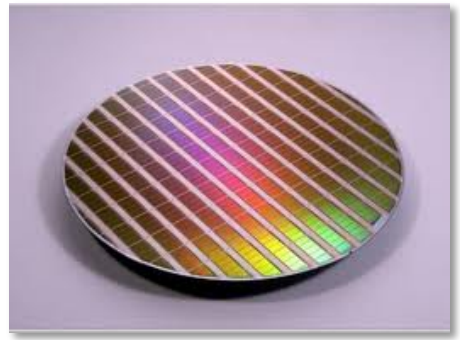
Nonvolatile memory (3)

- Key Effective App (1990s)
  - PC Memory Card (PCMCIA Standard)
  - Wide Application



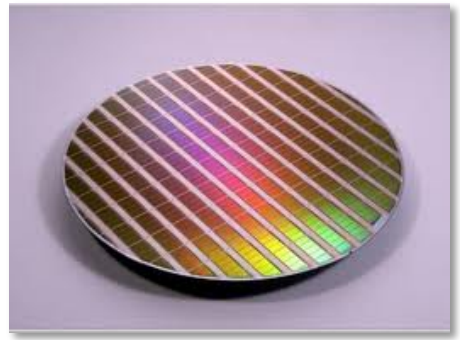
Nonvolatile memory (3)

- Second Effective App (1990s)
  - PC Memory Card (PCMCIA Standard)
  - Wide Application
  - Cost Drops
    - $70 per Mbyte in 1992
    - $30 per Mbyte in 1993



Nonvolatile memory (3)

- Second Effective App (1990s)
  - PC Memory Card (PCMCIA Standard)
  - Wide Application
  - Cost Drops
    - $70 per Mbyte in 1992
    - $30 per Mbyte in 1993
  - Technology to work existing drivers

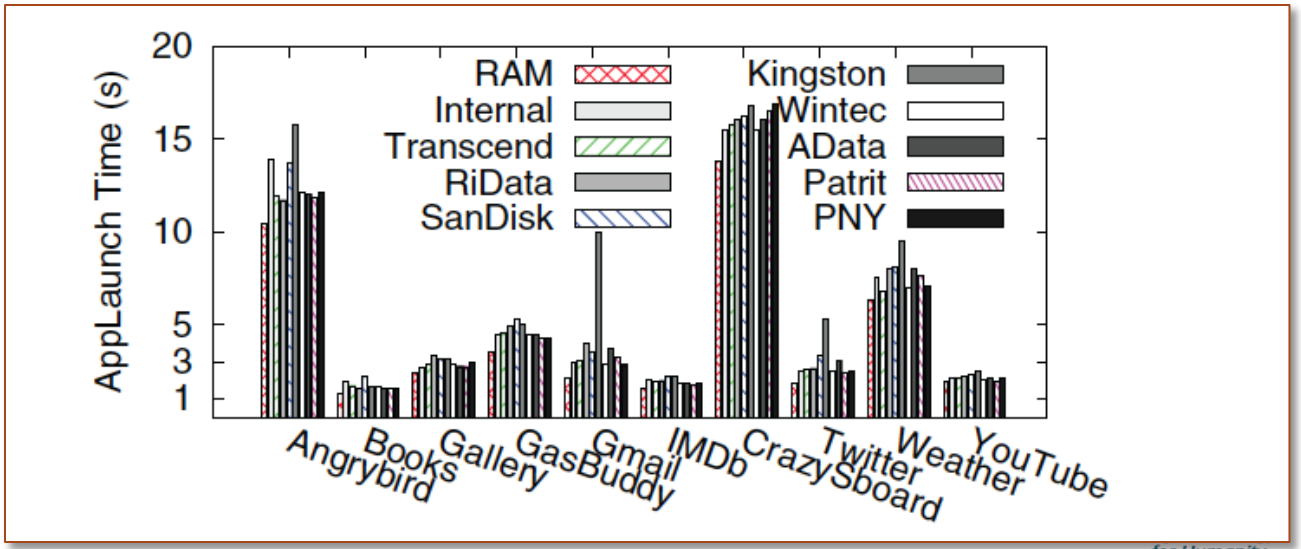


Non-Volatile Memory

- Expansion to new areas (4)
- Cost not longer Matters Point
  - Solid State iPod (2003)

Non Volatile memory

- Optimization (5)
  - Get Most of out Technology
  - Mathematical Modeling



Non Volatile memory

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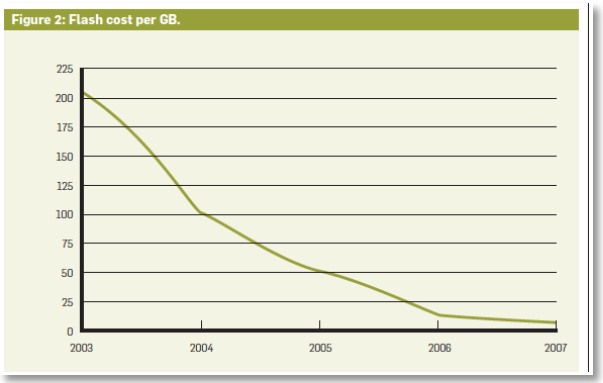

So what do we learn?

Lesson

- Invention is a Misleading Concept
  - Reward Technical Prowess Instead

Important Points in development

- Key Application
  - Shows technology workable
  - Big enough scale to be profitable
  - Disseminates ideas
  - Product stands on merit
  - 1992 for Non volatile Memory

Important Points in Development

- Price no Longer Matters
- Next you optimize

Why Should You Care?

- If Business, Affects Future Growth
- If Engineer, shows you where problems lie
  - And how rewards are bestowed

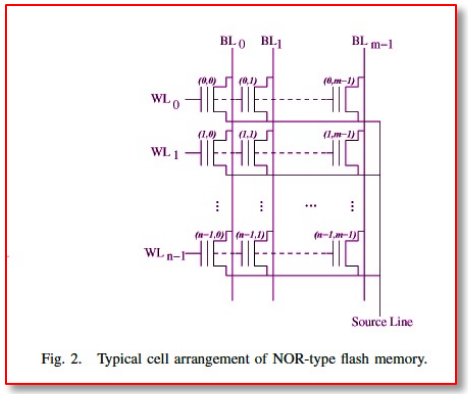

Fig. 2. Typical cell arrangement of NOR-type flash memory.

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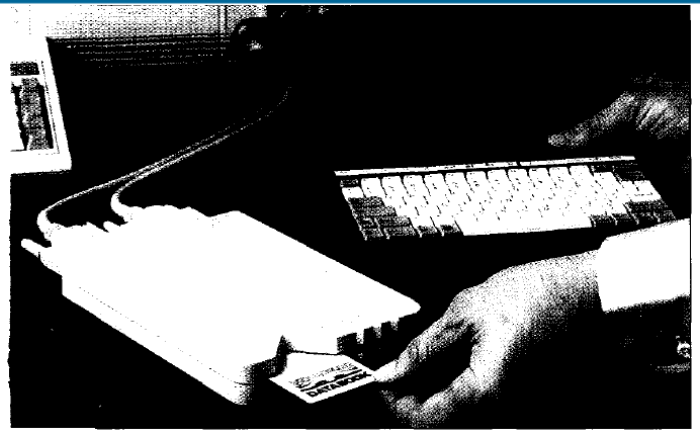
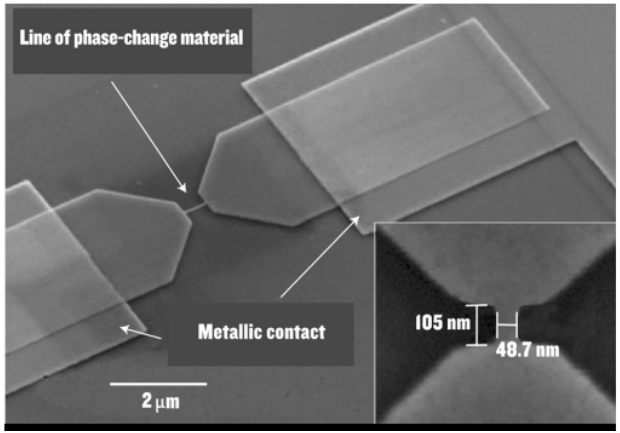
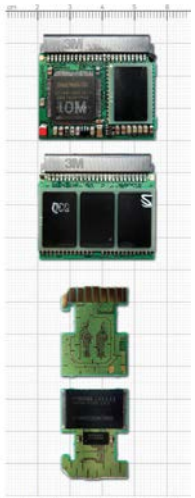
PC cards can serve as peripherals, like modems, as well as mass-storage devices

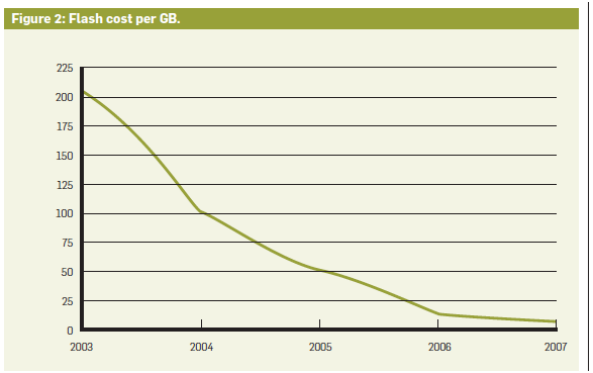


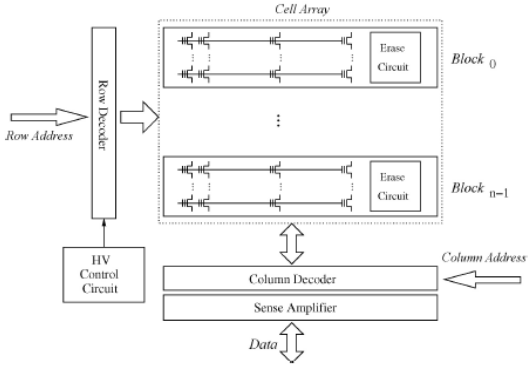




Top: A 10MB compact flash card from 1996.
Bottom: A 2GB SD flash card from 2008.

Figure 2: Flash cost per GB.





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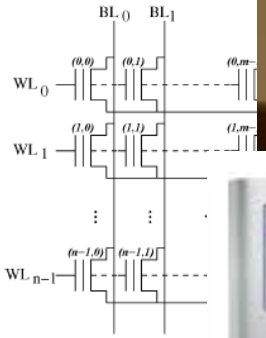

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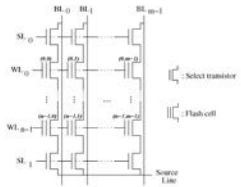

Fig. 3. Typical cell arrangement of NAND-type flash memory.