From Microchips to Nanochips

how we got here . . . and . . . where do we go from here

G. Dan Hutcheson

VLSI RESEARCH INC

Where the Chip Making Industry Clicks to Find its Weather

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- Read papers, releases, Lammers
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- Rate them, comment, ask ?s, meet them
- Raise your visibility • Broadcast your ability
- Post your papers, learn, attract an honorarium

My Goal is to Help You See Today's World from a Bigger Perspective

So, sit back, relax, uncross your legs/arms, and open your minds

The storage and processing of information is an innate human need .

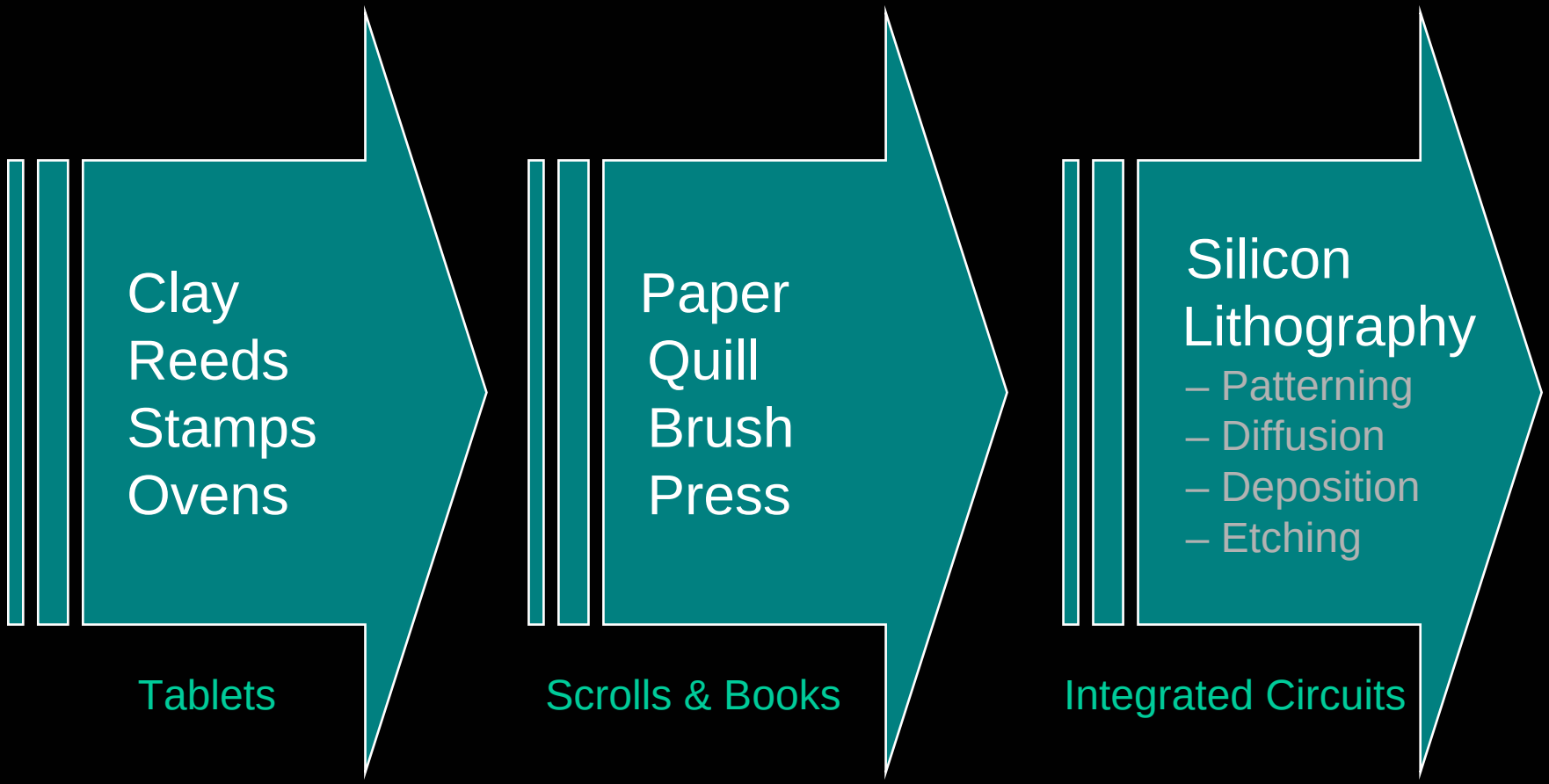
- This ability is how humans evolved to become the dominant species on the planet.
  - Other species learn & teach
  - But no known examples of ones that store information in libraries.
- It's how Europe & China came to dominate their worlds – Jared Diamond

The storage and processing of information is an innate human need .

- Never an abatement in the demand for more.
  - 30000 BC: Chauvet cave drawings
  - 9000 BC: Sumerian clay tokens
  - 3000 BC: Tokens replaced with tablets
  - 2000 BC: Egyptians develop papyrus paper
  - 105 AD: Ts'ai Lun invents wood based paper
  - 1436 AD: Johann Gutenberg invents printing press
  - 1456 AD: Gutenberg bible published
  - 1876 AD: Melville Dewey publishes classification system
  - 1936 AD: Alan Turing describes the "Turing Machine"
  - 1947 AD: Transistor Invented
  - 1958 AD: IC Invented – 1964 AD: IBM 360 Debuted
  - 1971 AD: Microprocessor invented.
  - 1976 AD: Apple founded to commercialize personal computing
  - 2001 AD: Apple introduces iPod

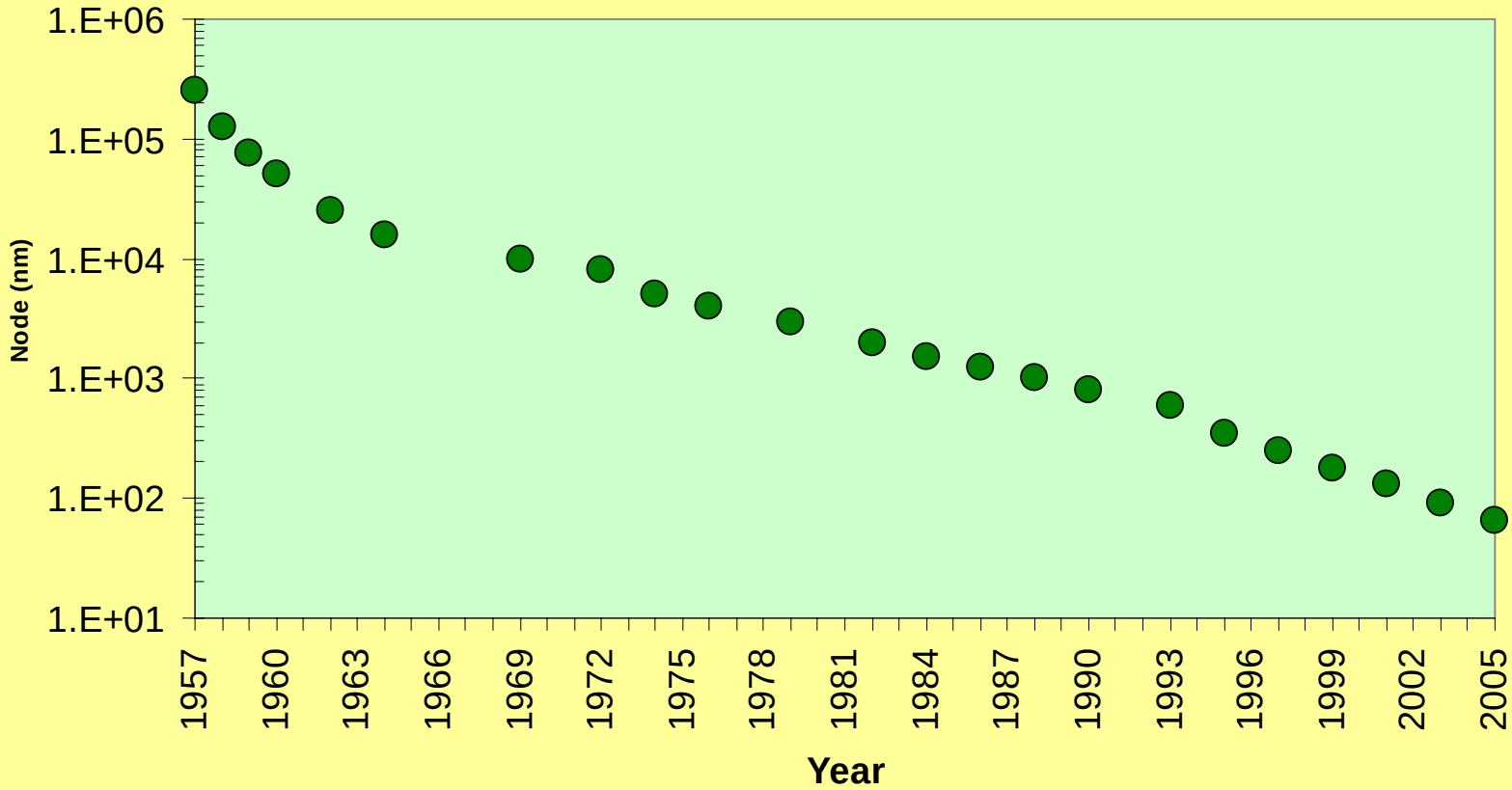
Lithography Applied to Semiconductor Manufacturing

Principles of Manufacturing for Storage Devices



Five Decades of Critical Dimension Shrinks

(in nanometers)

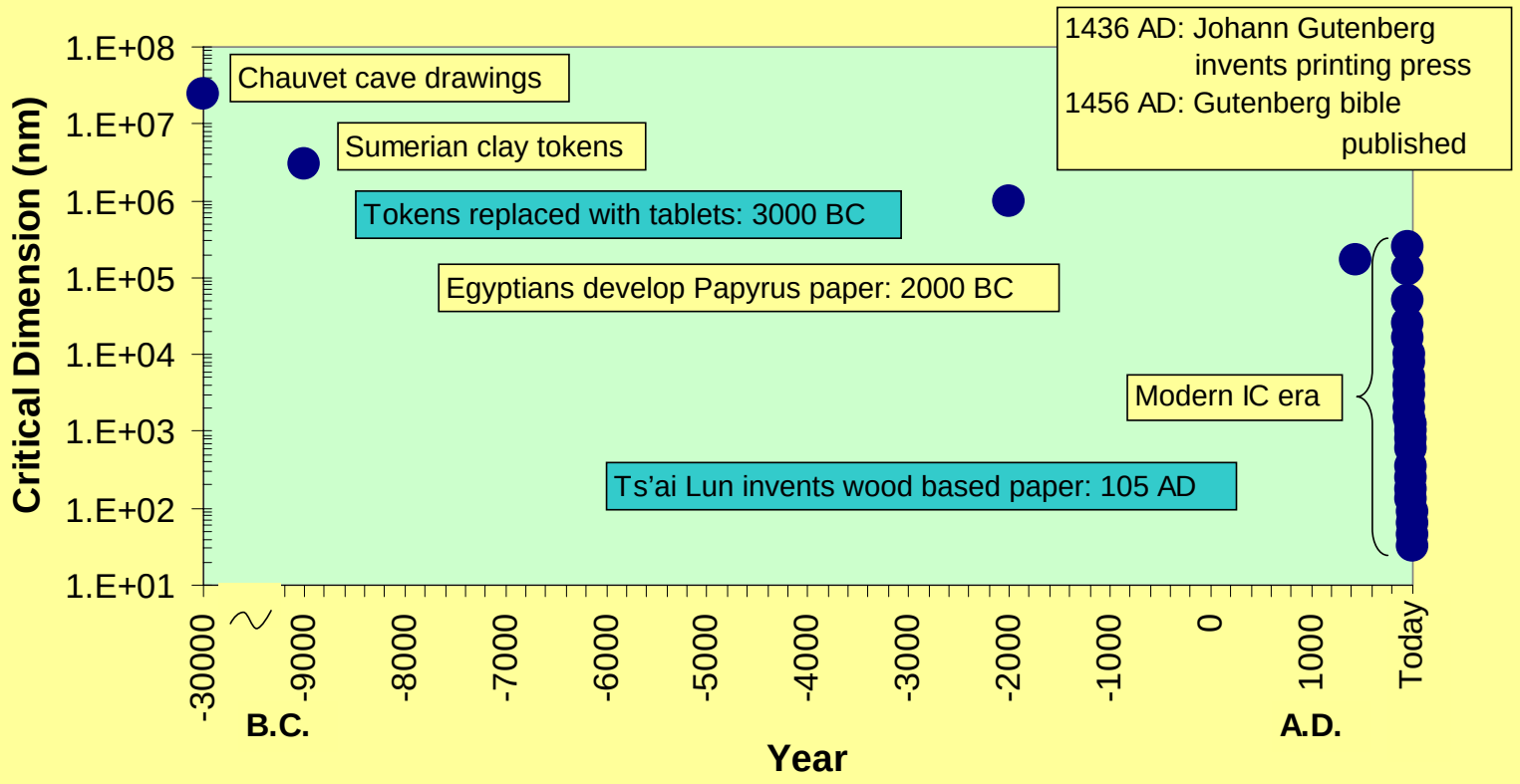


Moore's Law: How we got here

Year	CD (nm)	Lithography Technology
1957	254,000	Camel's Hair Brush
1958	127,000	Silk Screen Printer
1959	76,200	Contact Printer – Emulsion plates
1964	16,000	Contact Printer – Chrome plates
1972	8000	Proximity Aligner
1974	5000	Projection Aligner
1982	2000	g-line Stepper
1990	800	i-line Stepper
1997	250	248nm Scanner
2003	90	193nm Scanner
2008	45	193nm Immersion Scanner

- *We've gone from 10 cents to 25 Million Dollars and Moore's Law is still alive.*

Lithography is the miracle of modern times



30,000 YEARS IS PRETTY INCOMPREHENSIBLE.

SO, WHAT WOULD IT LOOK LIKE IF WE COMPRESSED IT INTO A SINGLE DAY?

The History of Shrinks on a 24 Hour Time Scale

9000 BC: Sumerian clay tokens

2000 BC: Egyptians develop papyrus paper

1436 AD:
Johann Gutenberg invents the printing press

1958 AD:
The IC is invented

1970 AD:
1st 10 Micron ICs

1988: 1 Micron
Barrier broken

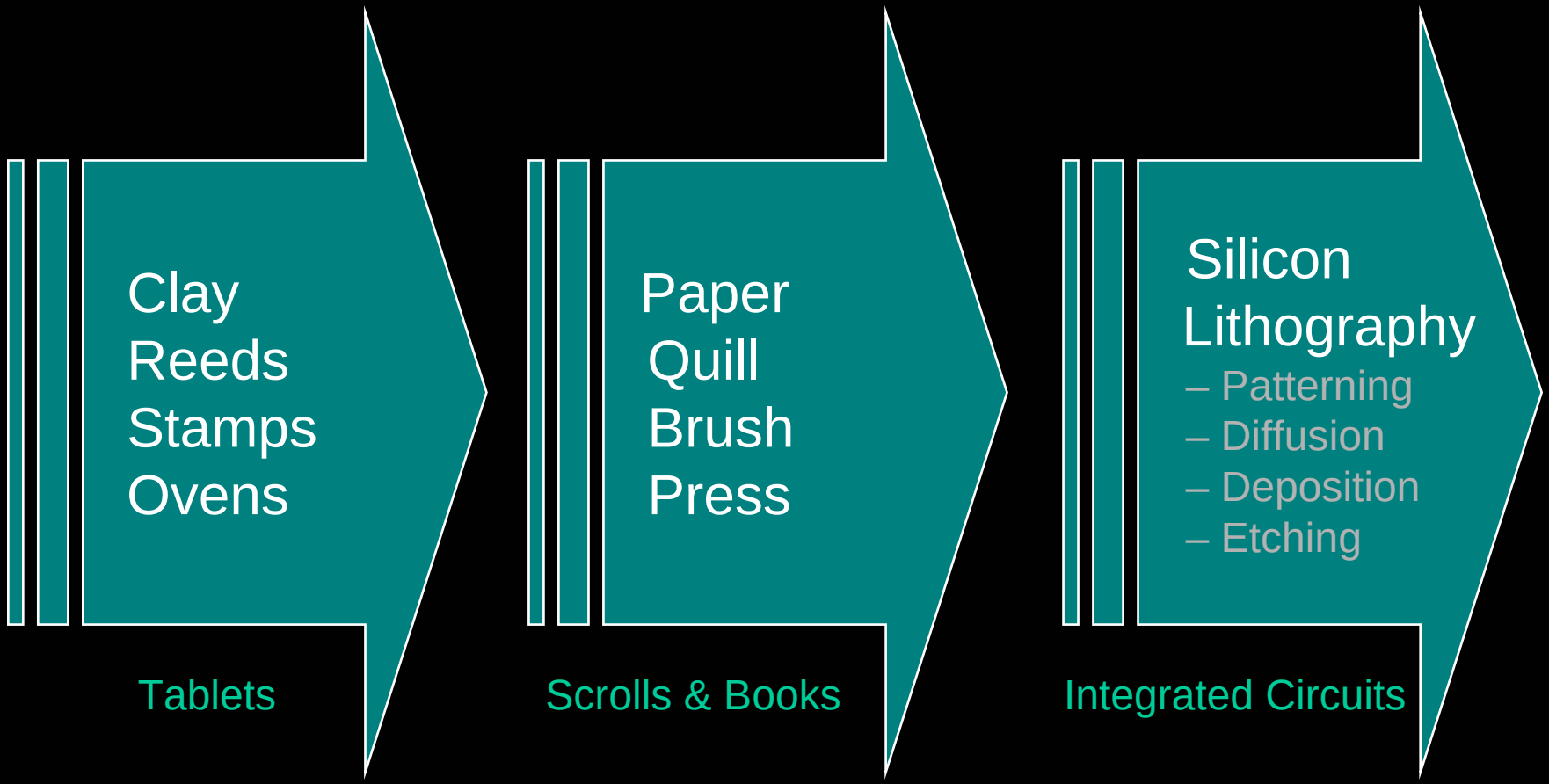
2001 AD: The industry reaches nanoscale dimensions

130nm reaches production a mere 16 seconds before midnight!

People make it all Possible

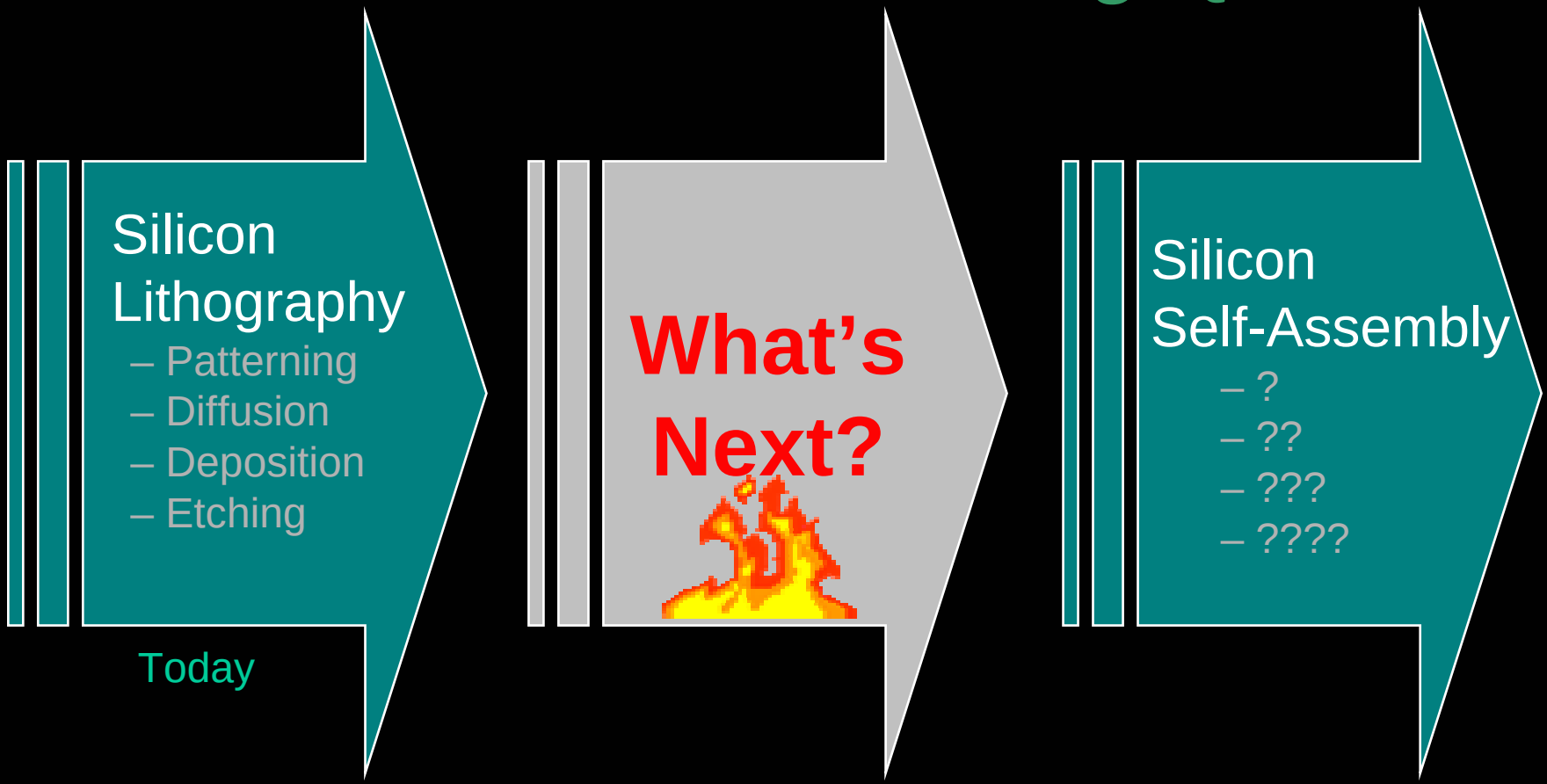
- Ideas only come from people, which is the result of the viral effects of. . .
  - **Community**
  - **Collaboration**
  - **Conferences**
  - **Consortia**
  - **Universities**

Principles of Manufacturing for Storage Devices



Principles of Manufacturing for Storage Devices:

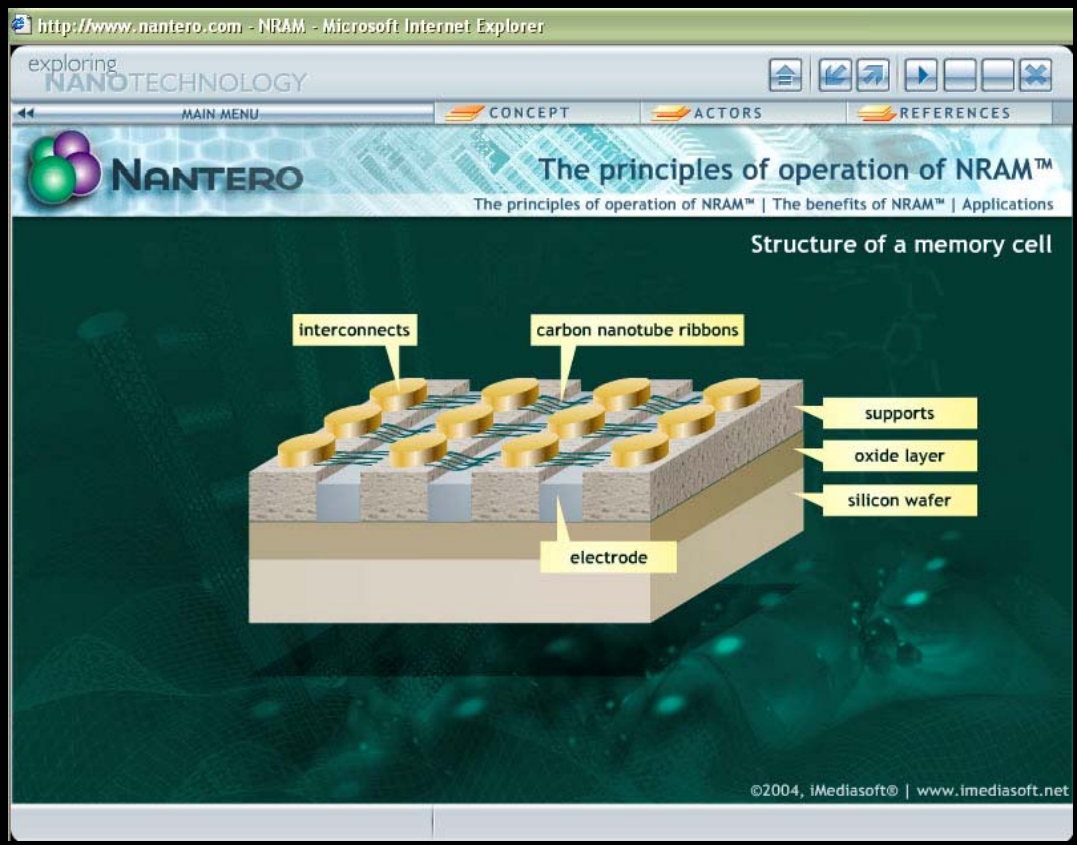
The Burning Question



What We Think We Know

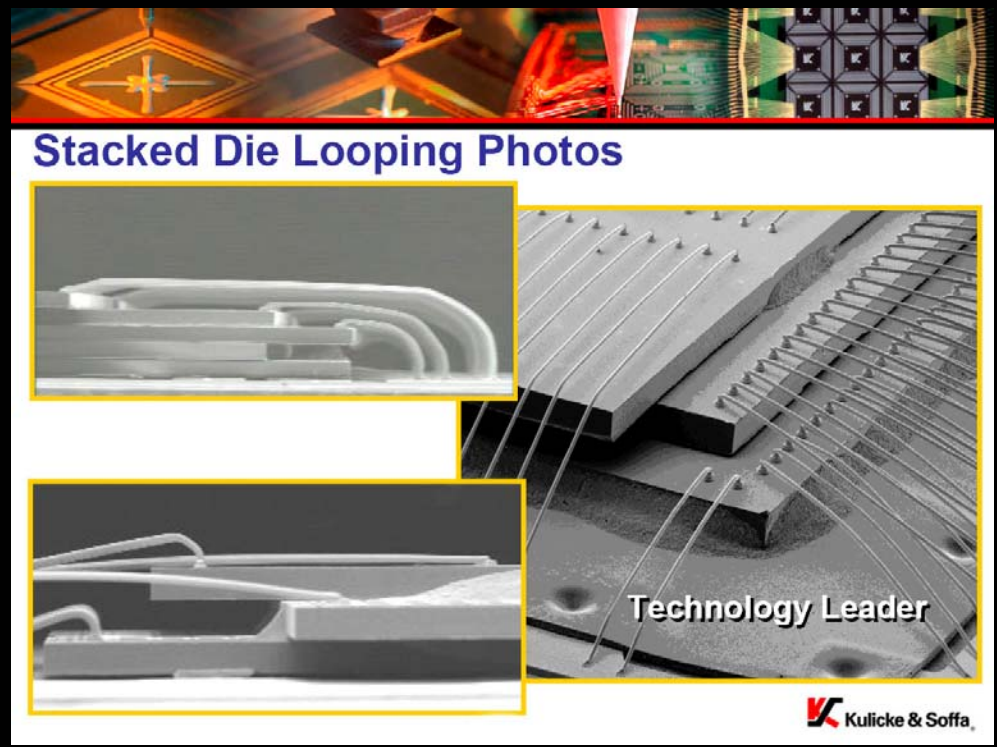
- Will Likely be
  - on Silicon
  - Some form of Spintronics
  - Carbon nanotubes will play a role
- The biggest unknown is how to manufacture in volume **without** lithography.
  - *EUV is most likely the end of the road.*

Nantero's NanoRAM

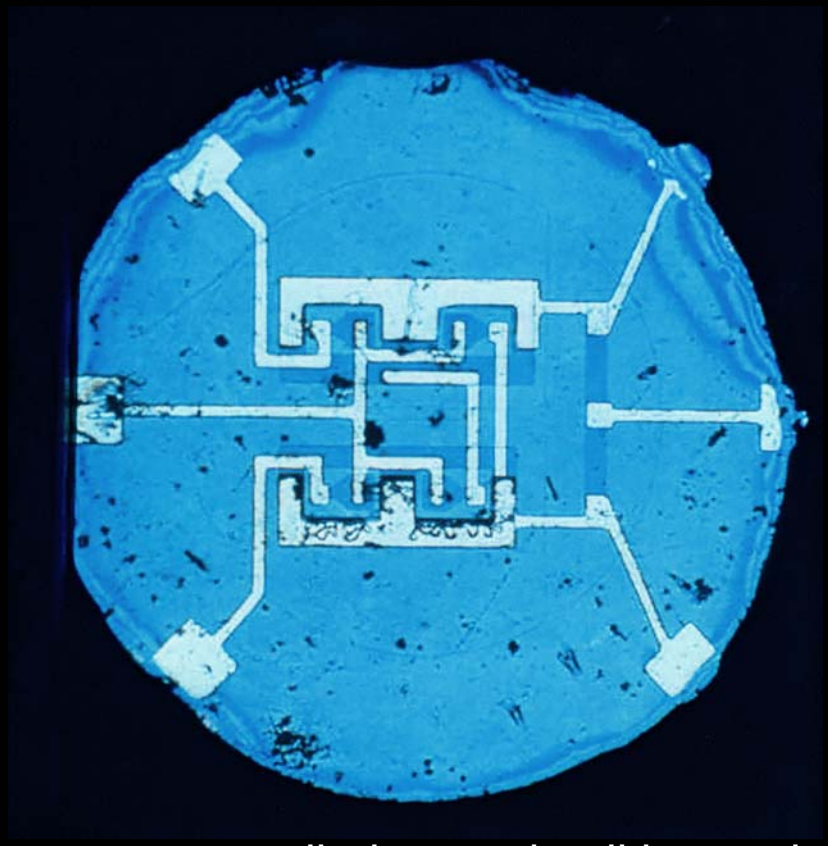


Today's Technology Applied to Tomorrow's Ideas

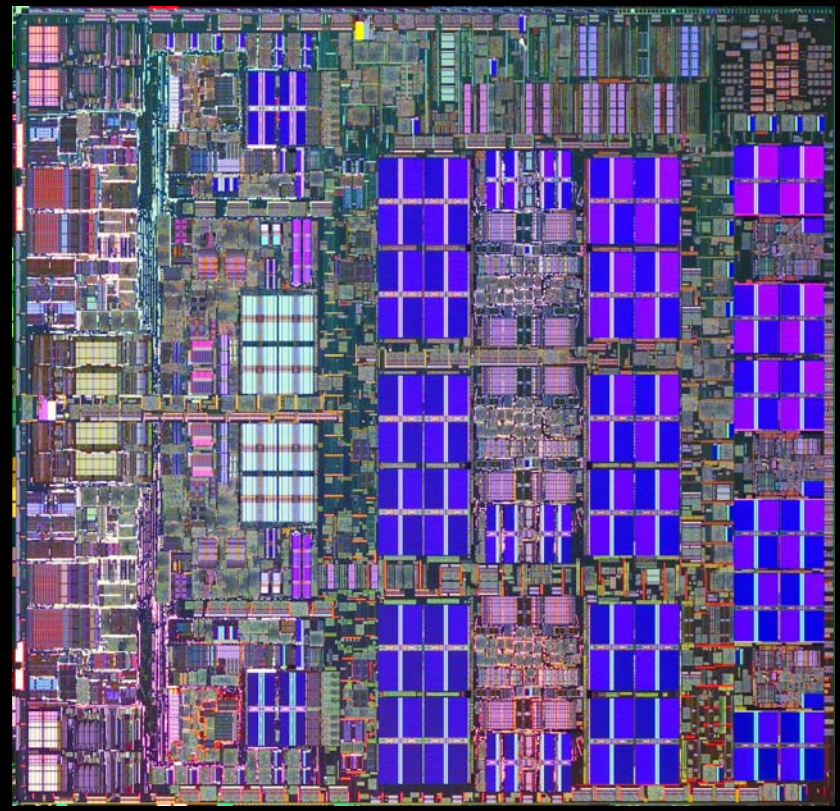
Kilby's IC evolved to this:



Tomorrow’s Technology Applied to Tomorrow's Ideas



Noyce applied emerging lithography
which would take us from here . . .

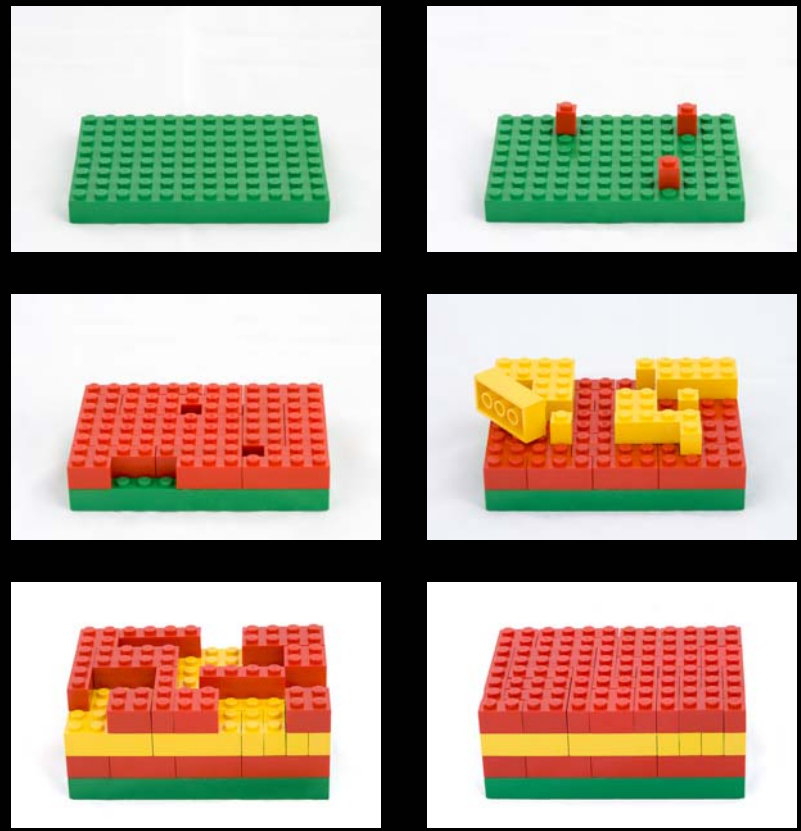


to here . . . and beyond . . .

Self Assembly:
Tomorrow's Technology

- DNA
- ALD

Source: Messiah College ©



Source: The Chip History Center

But how do we take what we know and create a patterning technology?

So there's the vision

All I can say is you, your children, your great grandchildren, etc. *have a lot of work ahead of you.*

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