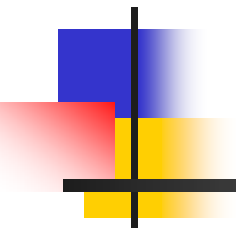
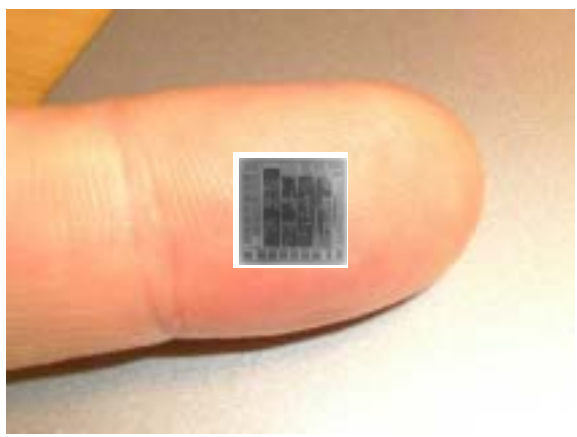


SEMICONDUCTOR TECHNOLOGY -CMOS-

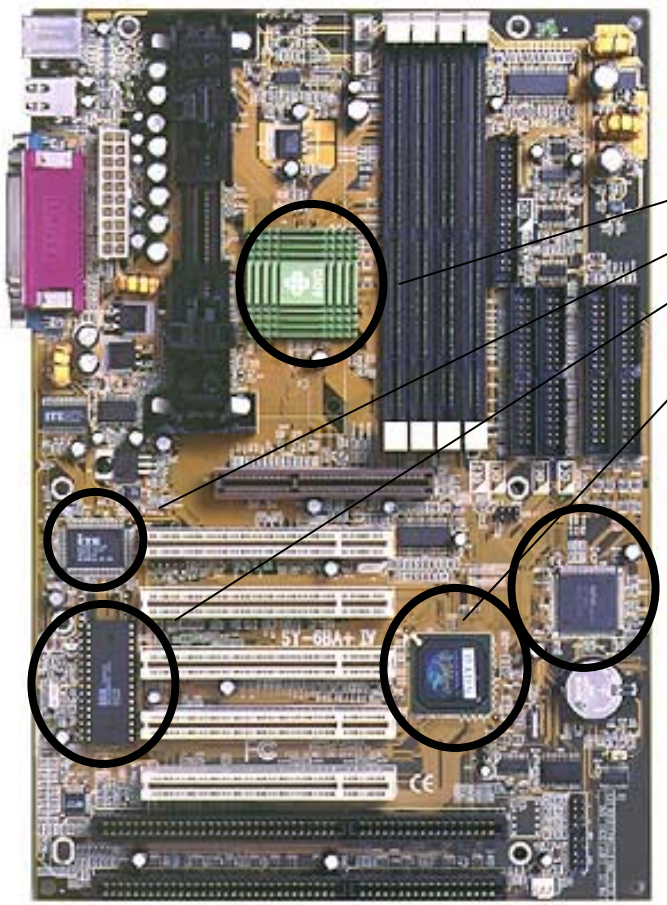
Fire Tom Wada

What is semiconductor and LSIs

- Huge number of transistors can be integrated in a small Si chip.
- The size of the chip is roughly the size of nails.
- Currently, 10M transistors can be integrated.
- 1000 times integration comparing to 20 yrs ago.
- The cost of the chip is roughly same.
- All electronic equipments are powered by LSIs.
- PCs, Cellular phones, 3D graphics, Internet.

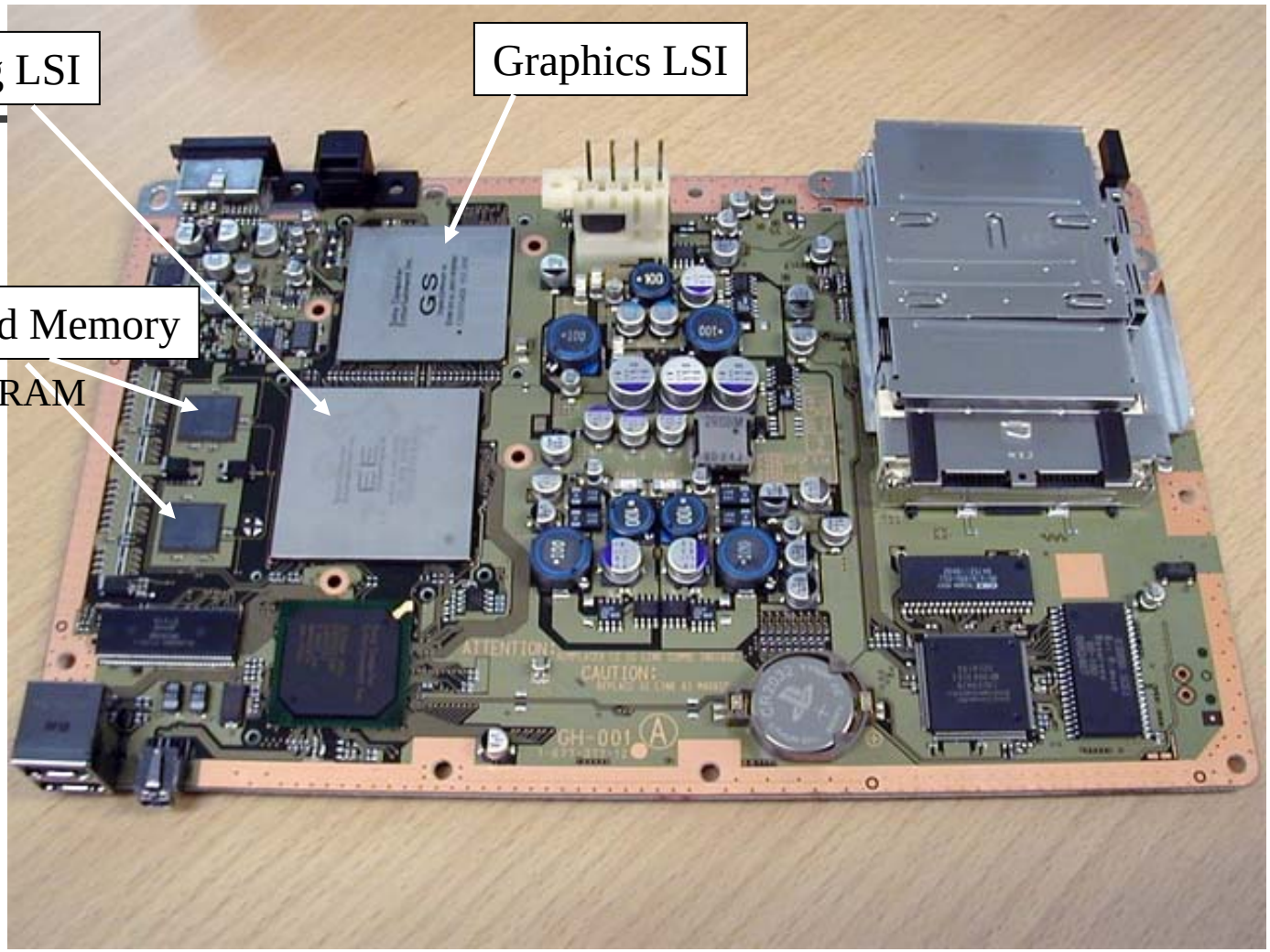


PC mother board



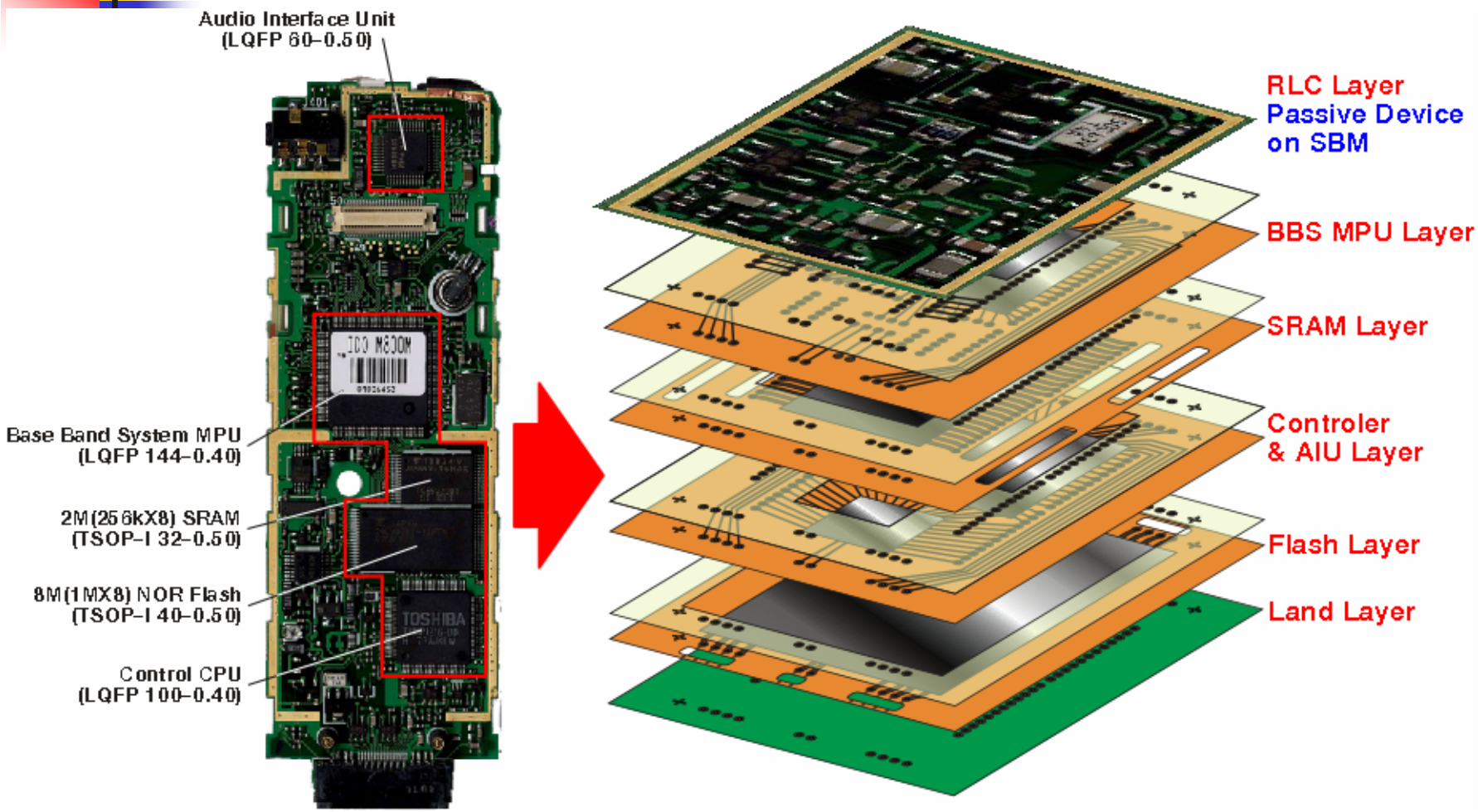
Large Scale Integration

SONY PLAYSTATION 2 MAINBOARD

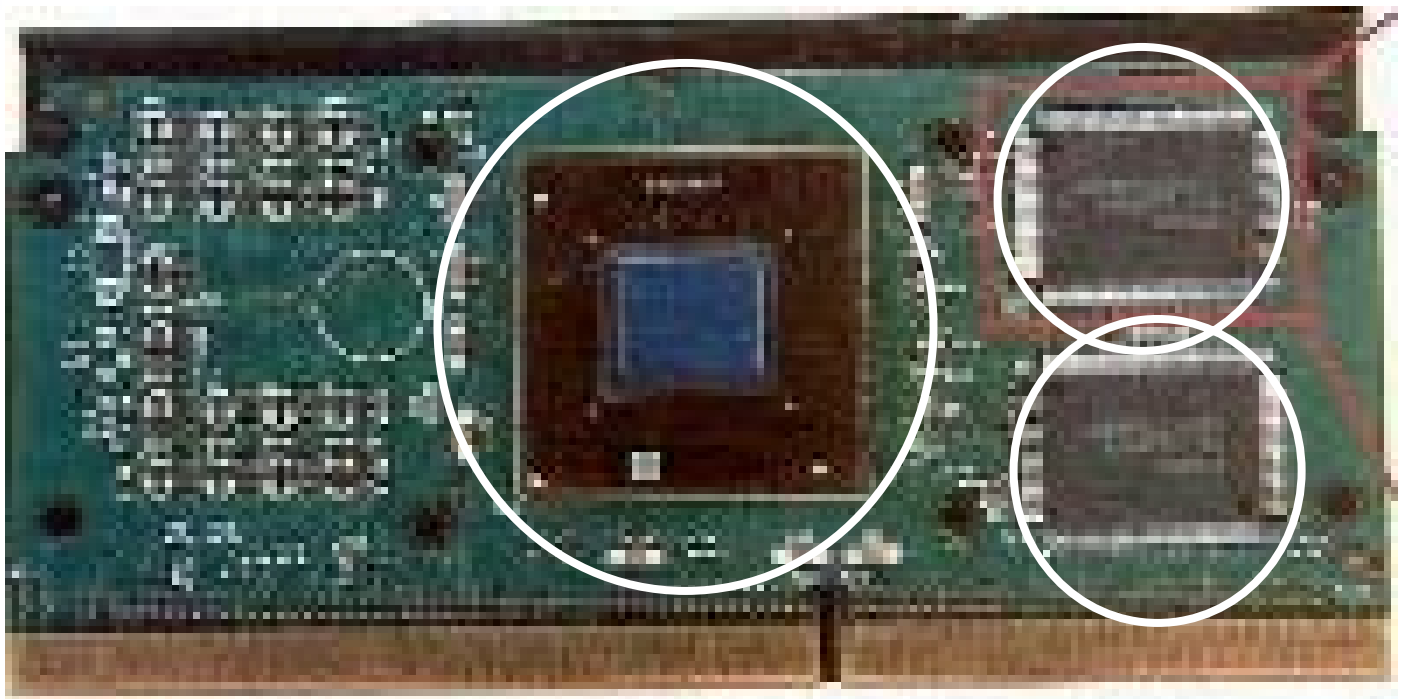


Mobile Phone Mainboard

Memory, Logic, Analog

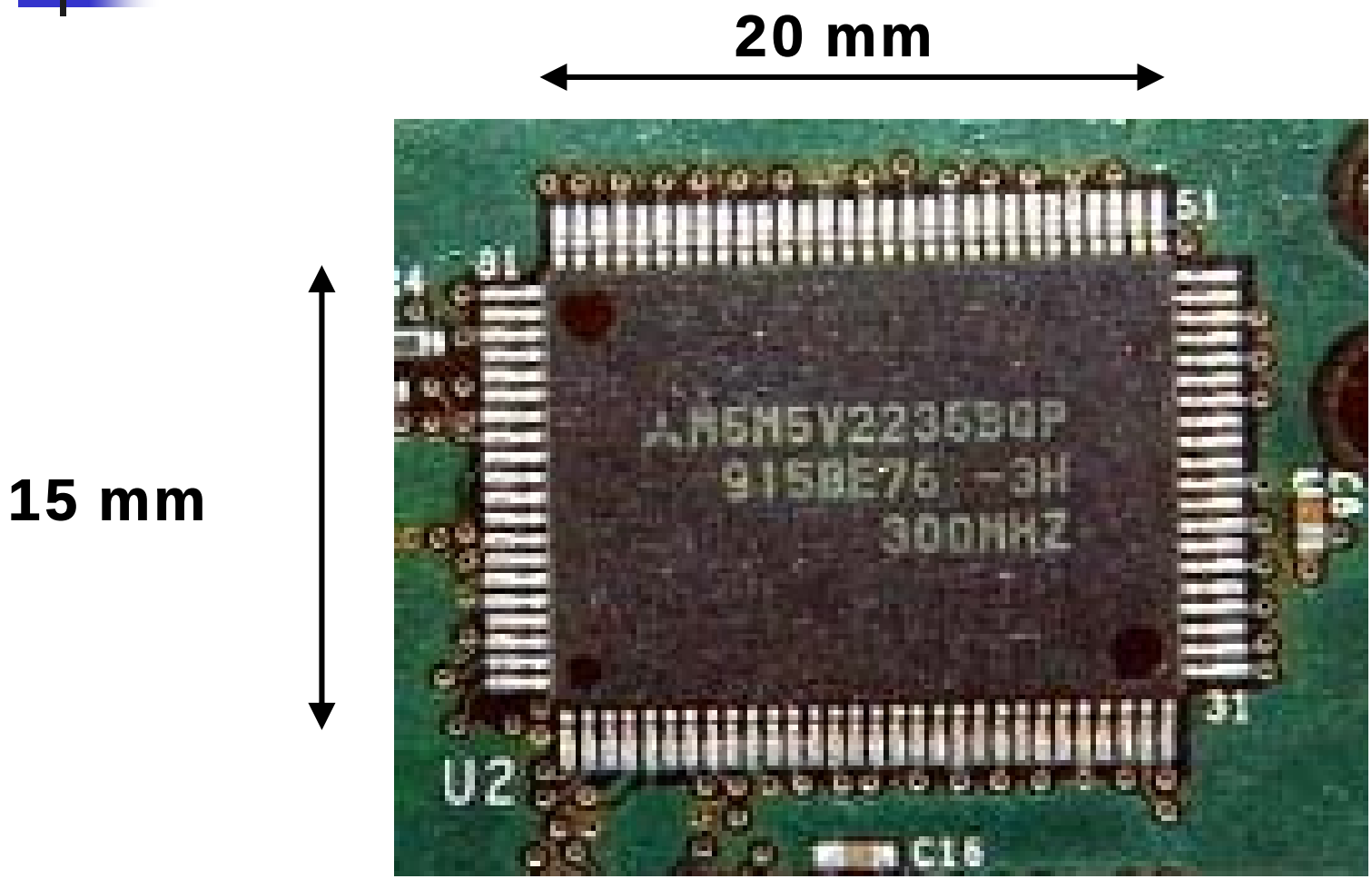


Key device is LSI

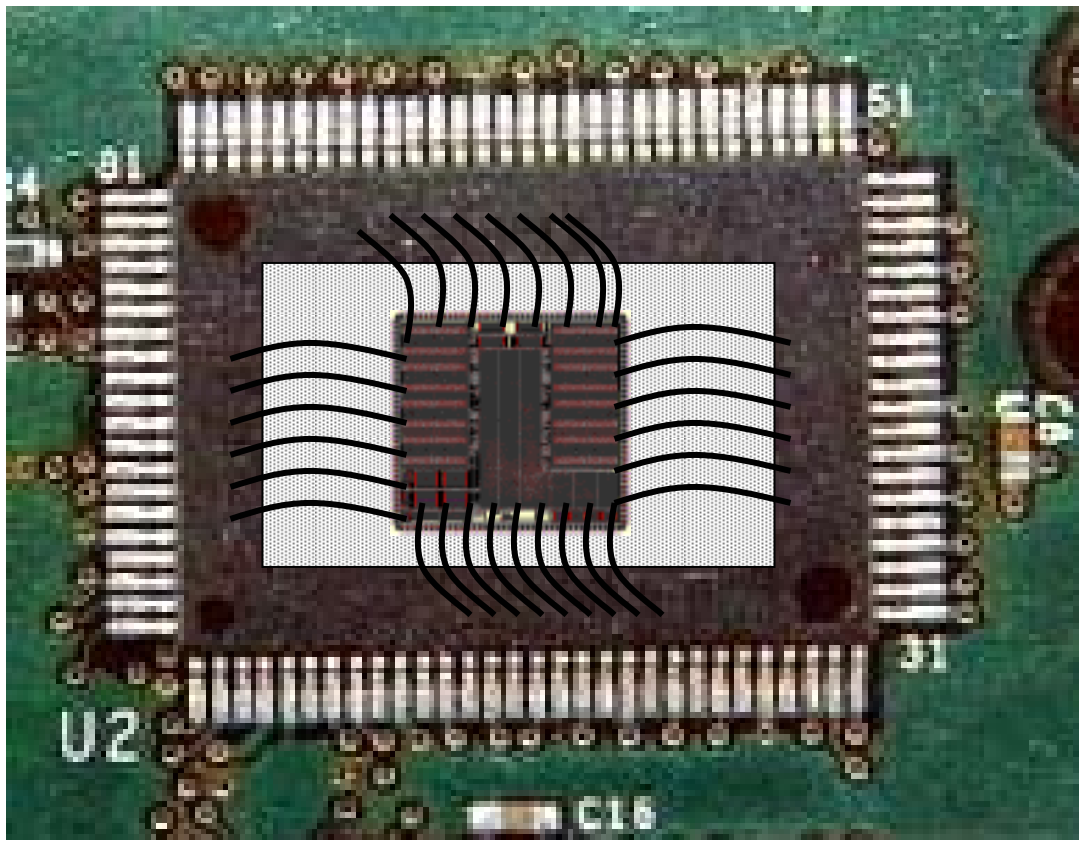


INTEL Pentium III module

This is a packaged LSI
-Pentium III 300MHz Cache LSI-

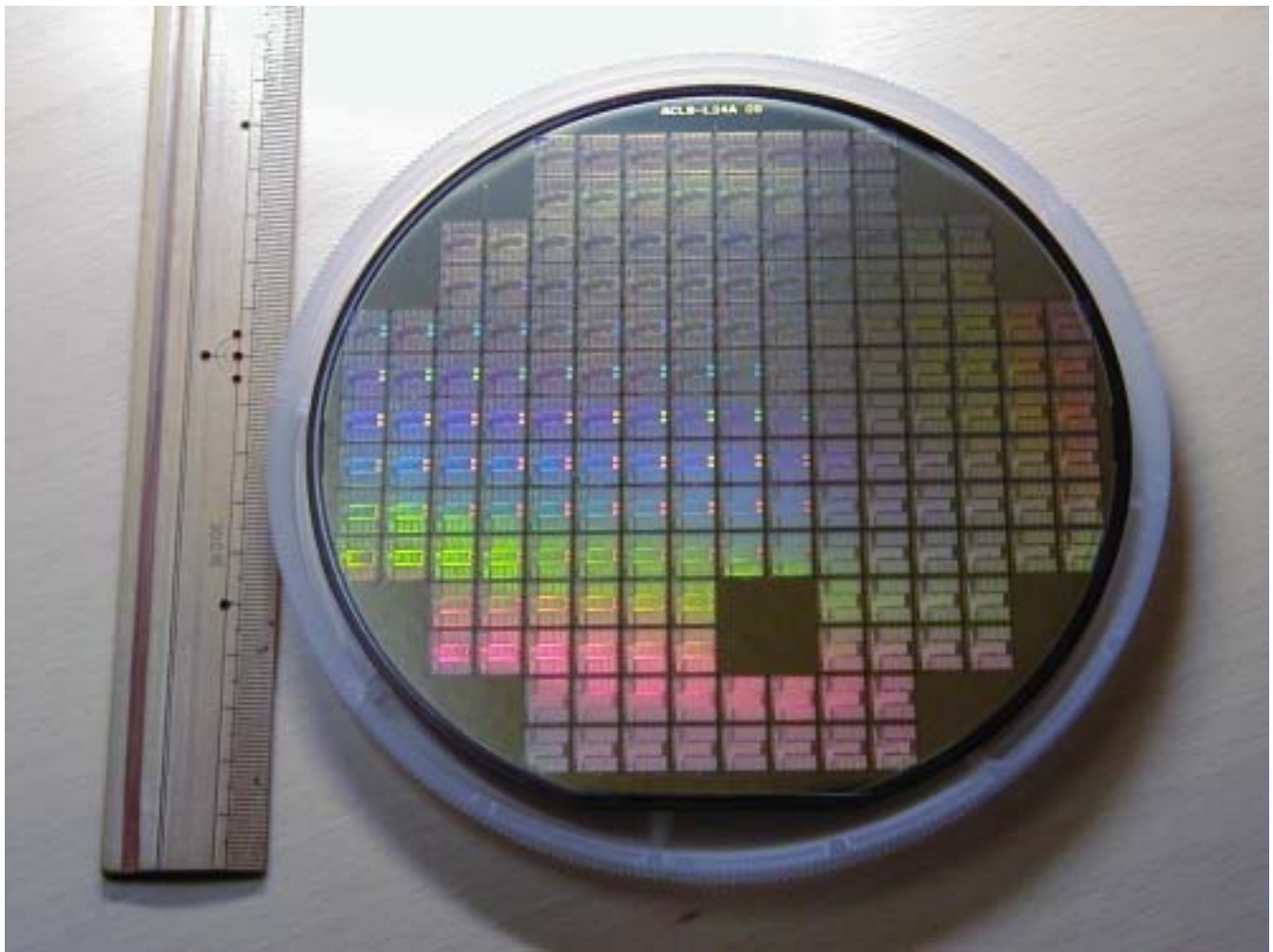


Si chip is molded in the package.

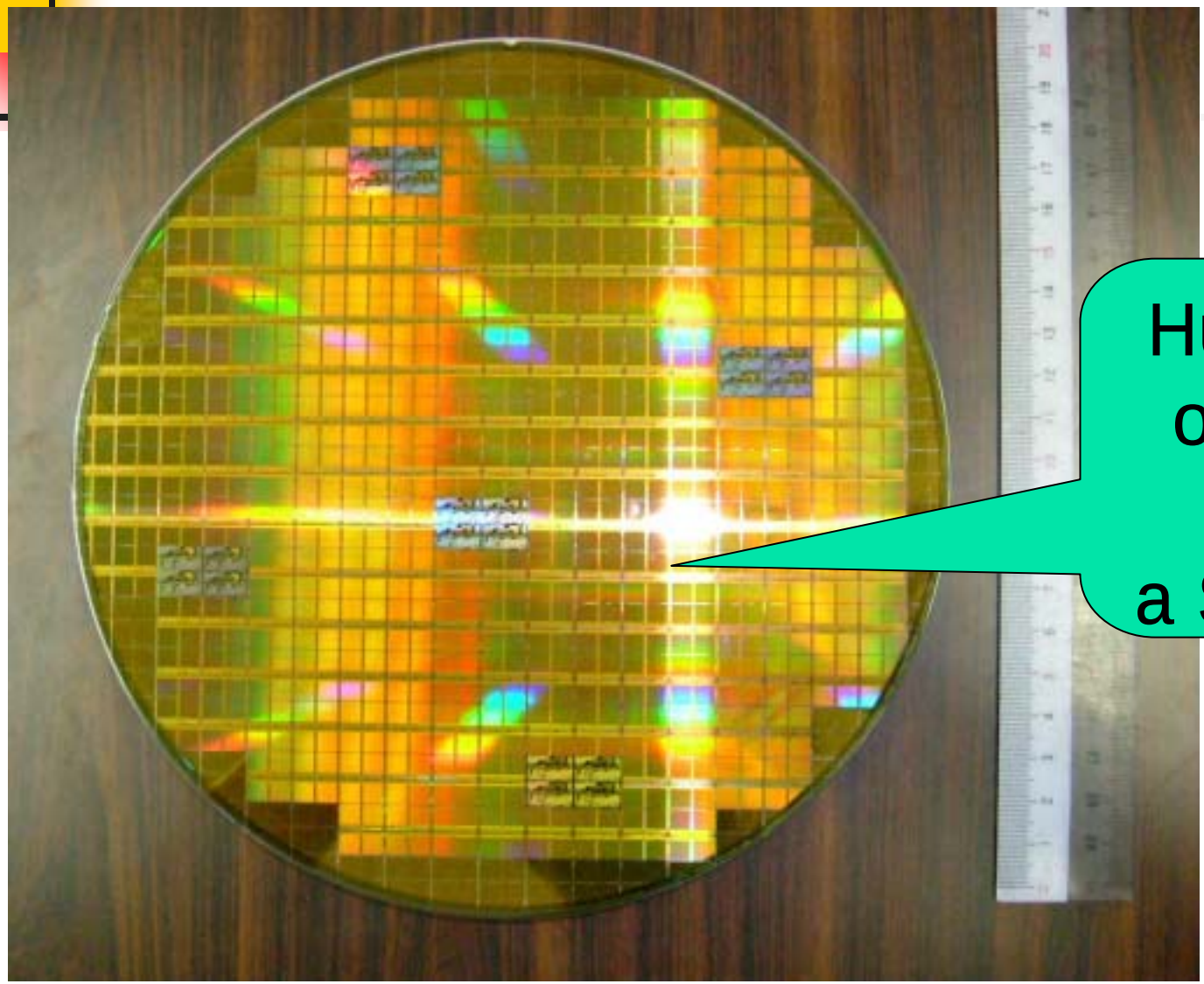


2 million transistor Chip is connected to the pins thru wires.

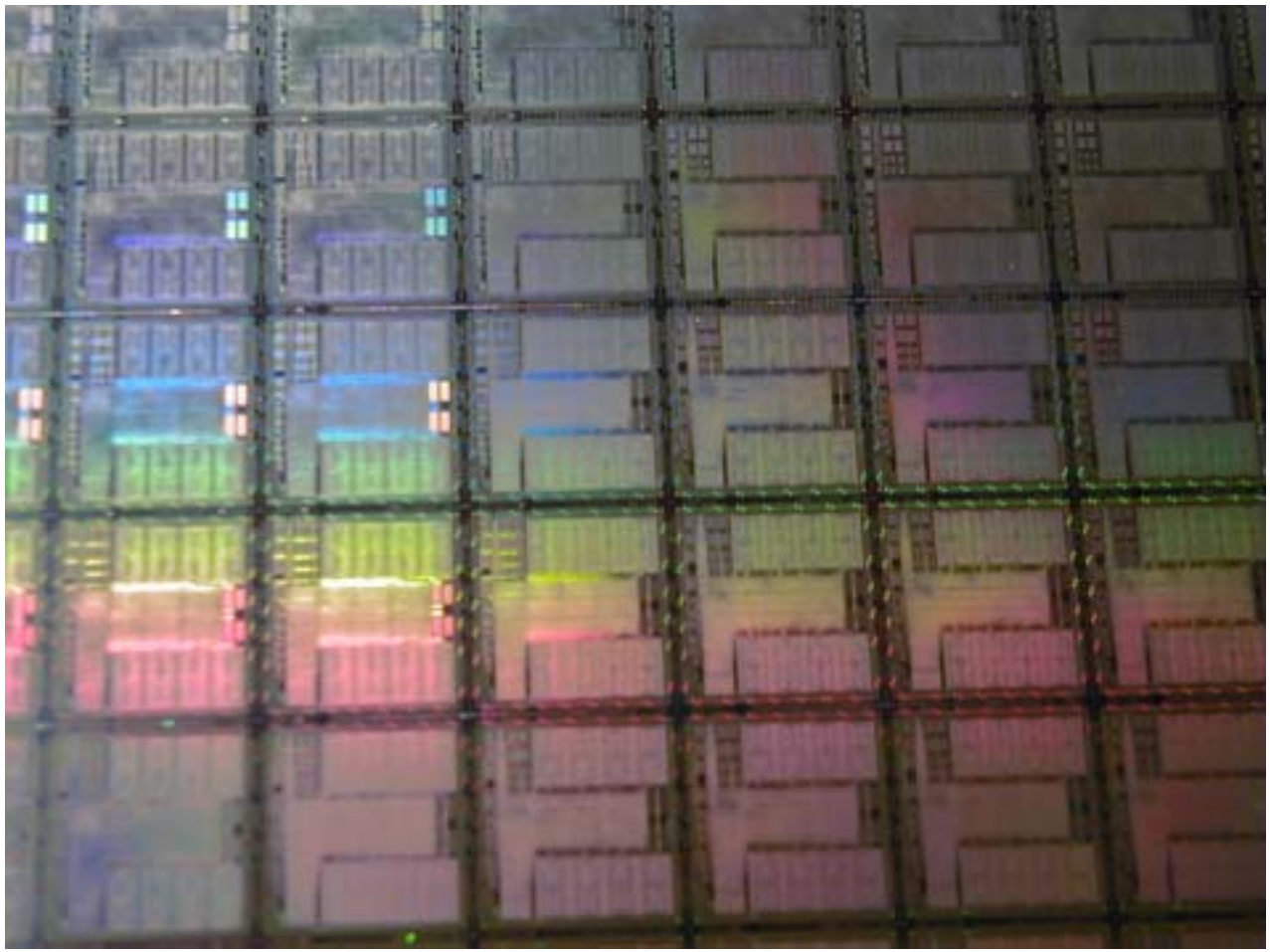
6 inches Si wafer



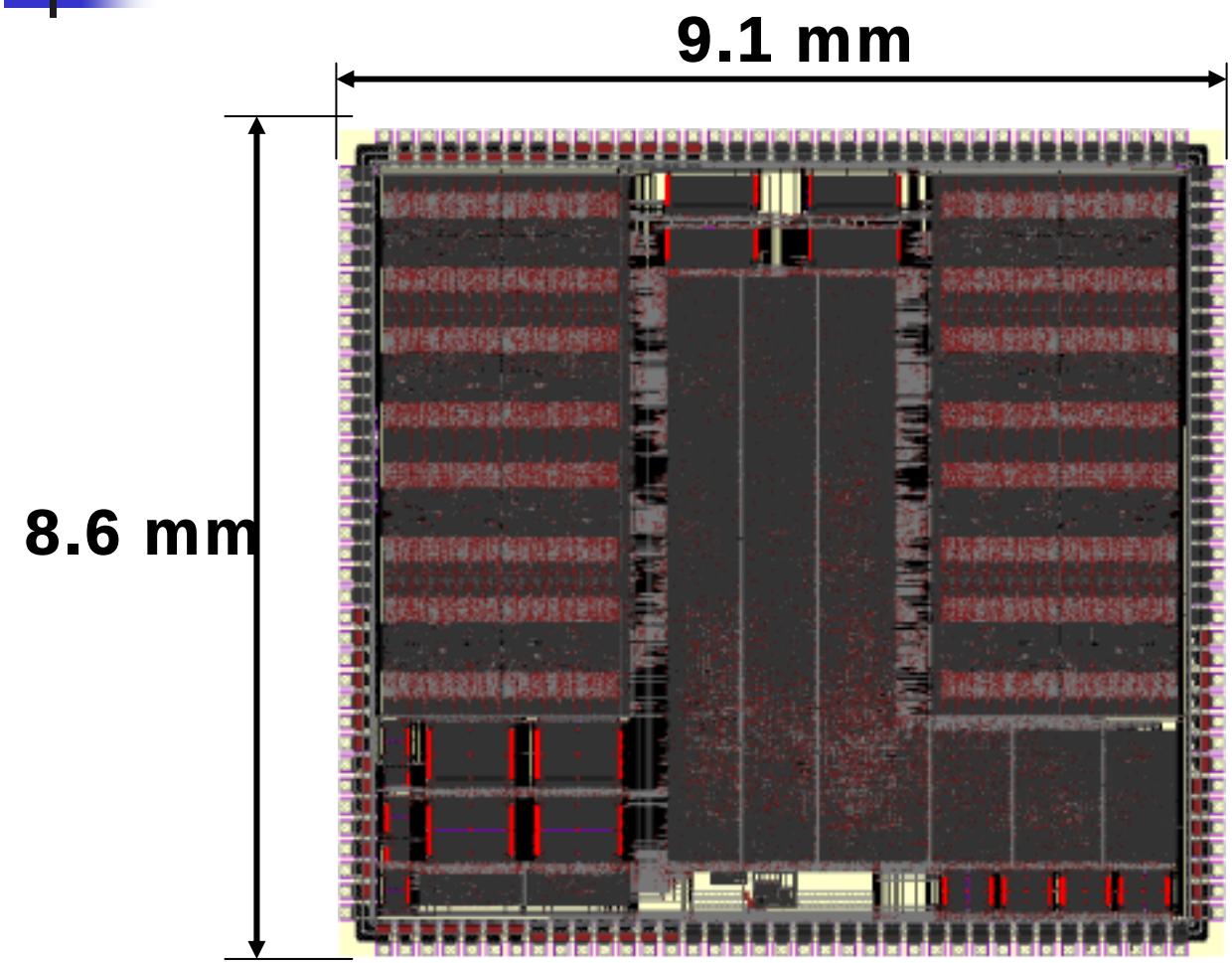
8 inches Si wafer



Several hundreds of chips are fabricated on a wafer simultaneously.



Chip photo
- Motion Estimation Chip for HDTV camera -



Your small finger's nail size. 200M transistors.

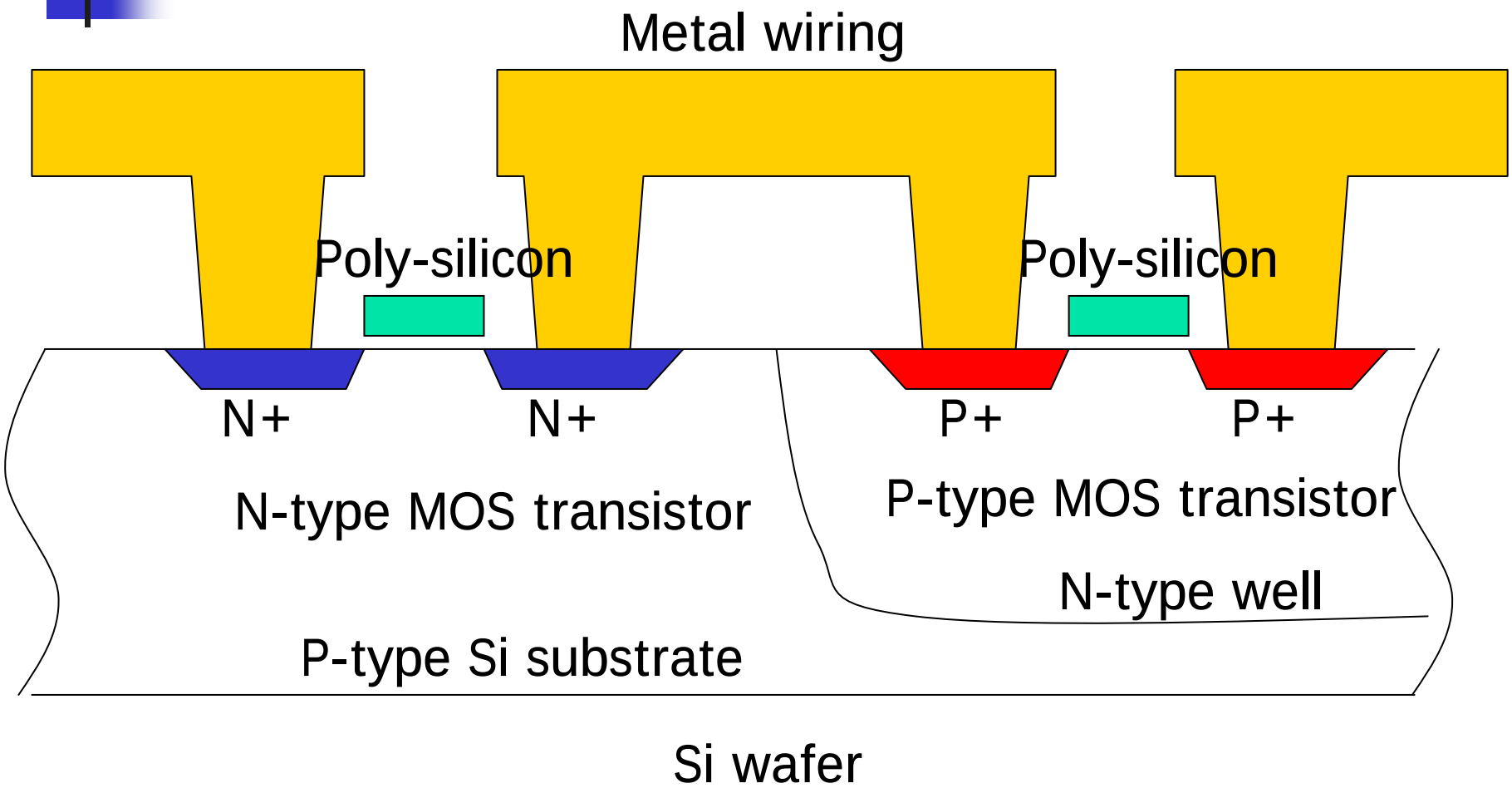
Scanning Electron Microscope photo - Cross-section of the LSI -

0.5 micron

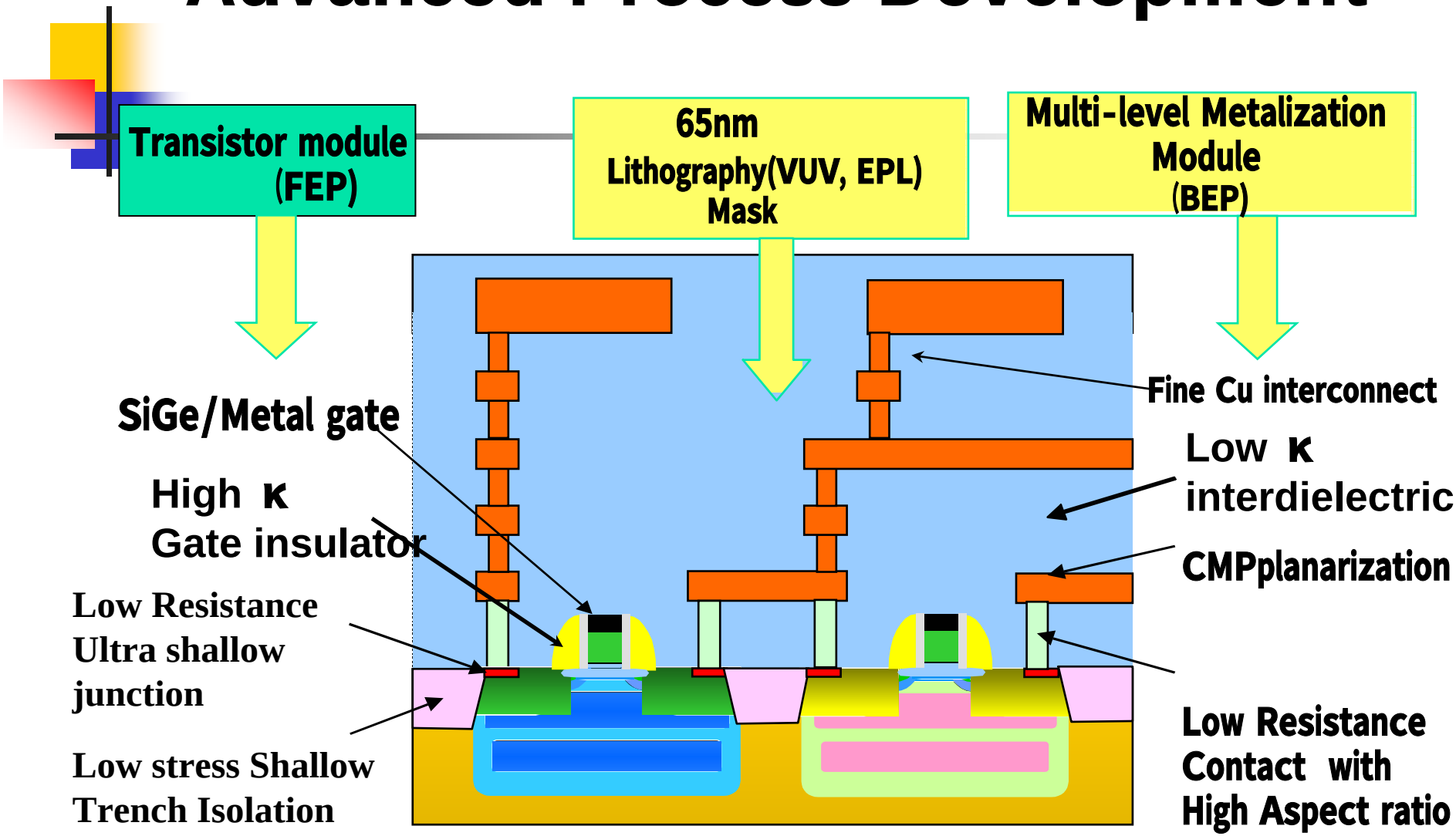
Structure Of CMOS LSI

- Isolation
  - PN-Isolation, Local oxidation
- Si Substrate
  - Bulk, epitaxial , SOI
- Well Structure
  - N-type well in P-type Substrate
- Latch Up
  - PNP Bipolar Transistor and NPN Bipolar Transistor
- Fabrication Process Technology

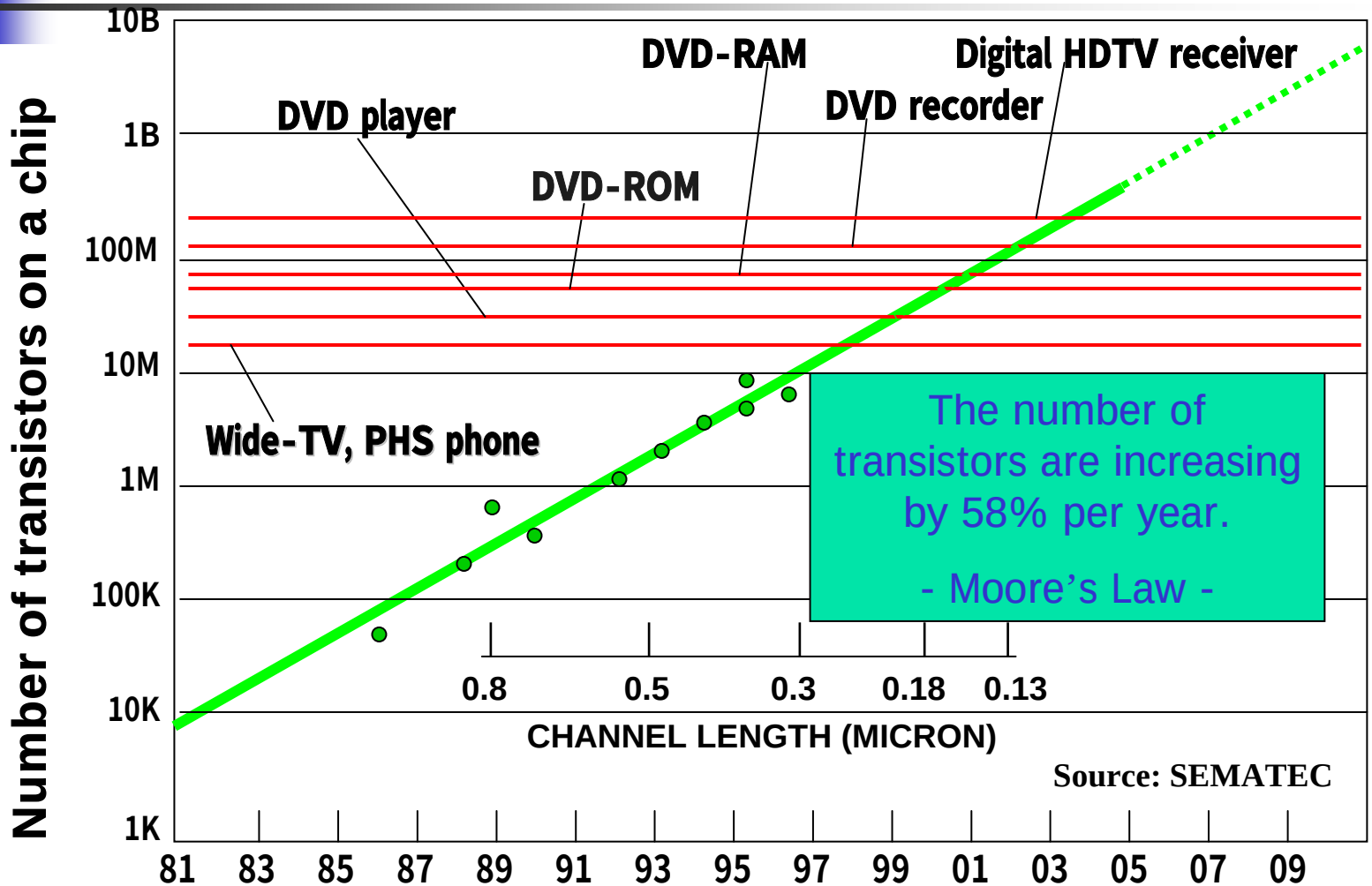
Cross-section of the LSI



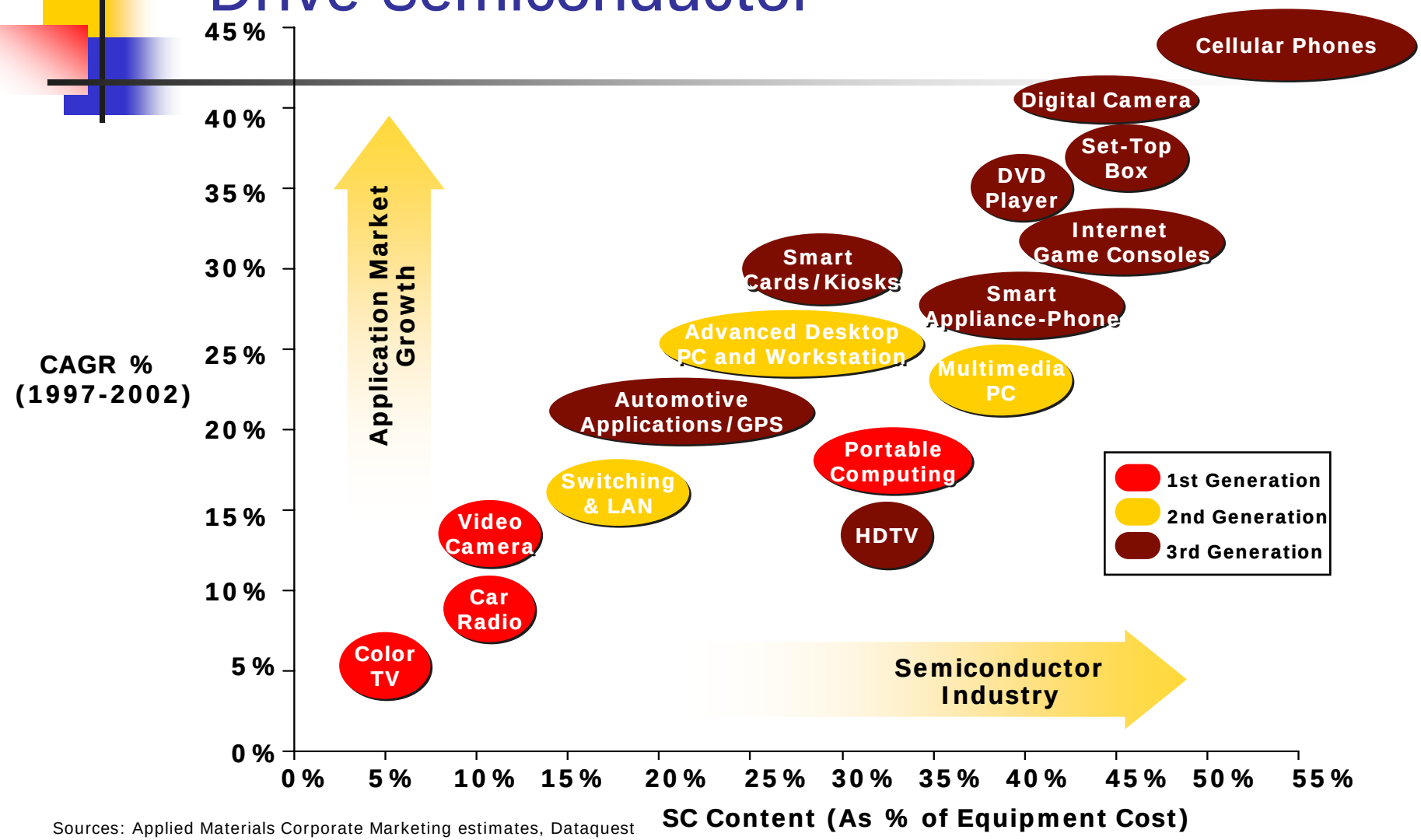
Advanced Process Development



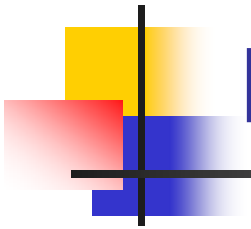
LSI integration trend
- Moore's law -



Communications and Consumer Products Drive Semiconductor



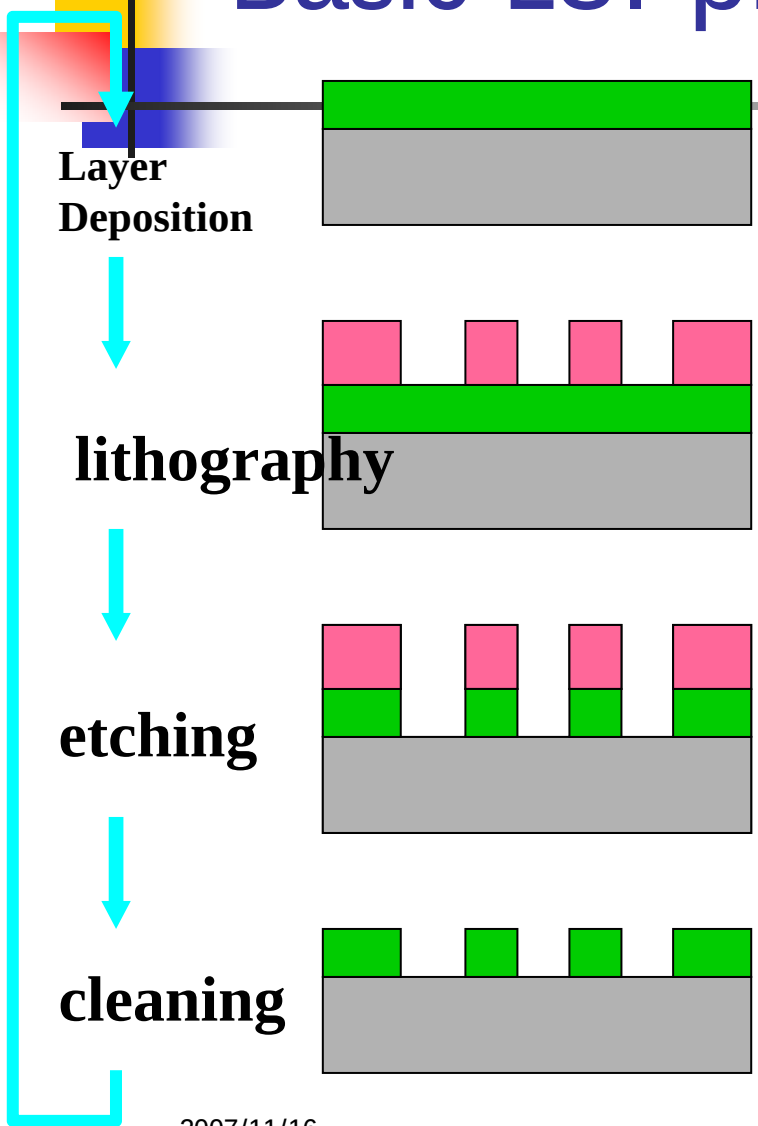
Sources: Applied Materials Corporate Marketing estimates, Dataquest



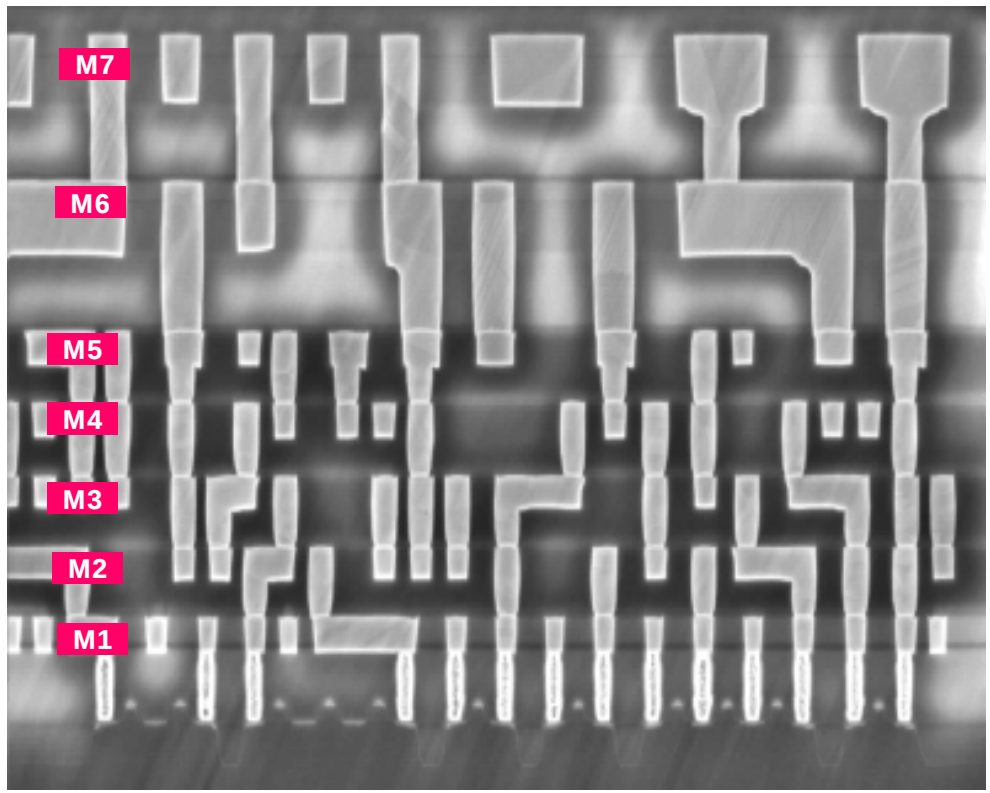
Fabrication Process Issues

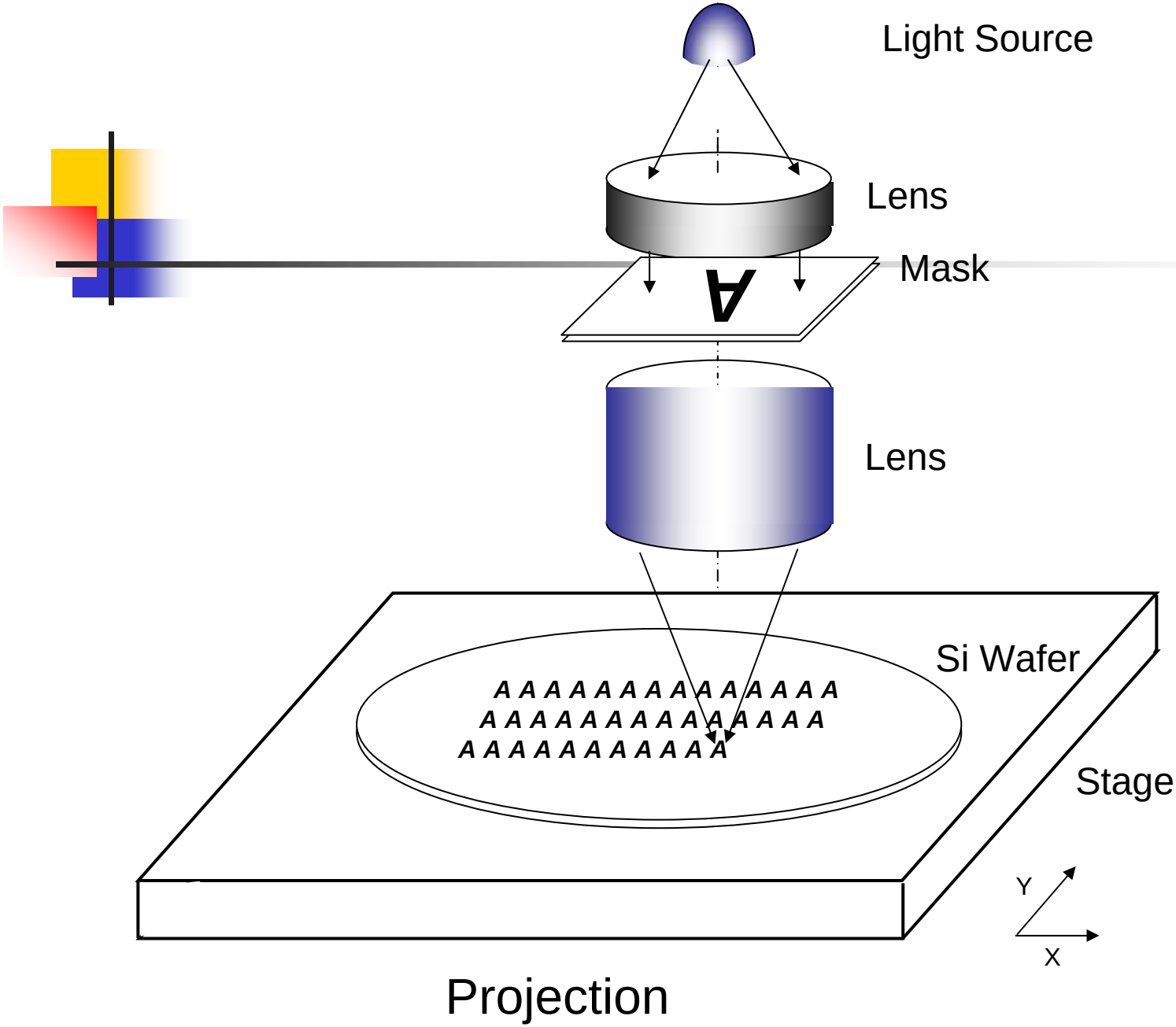
Ultra Clean Room

Basic LSI process



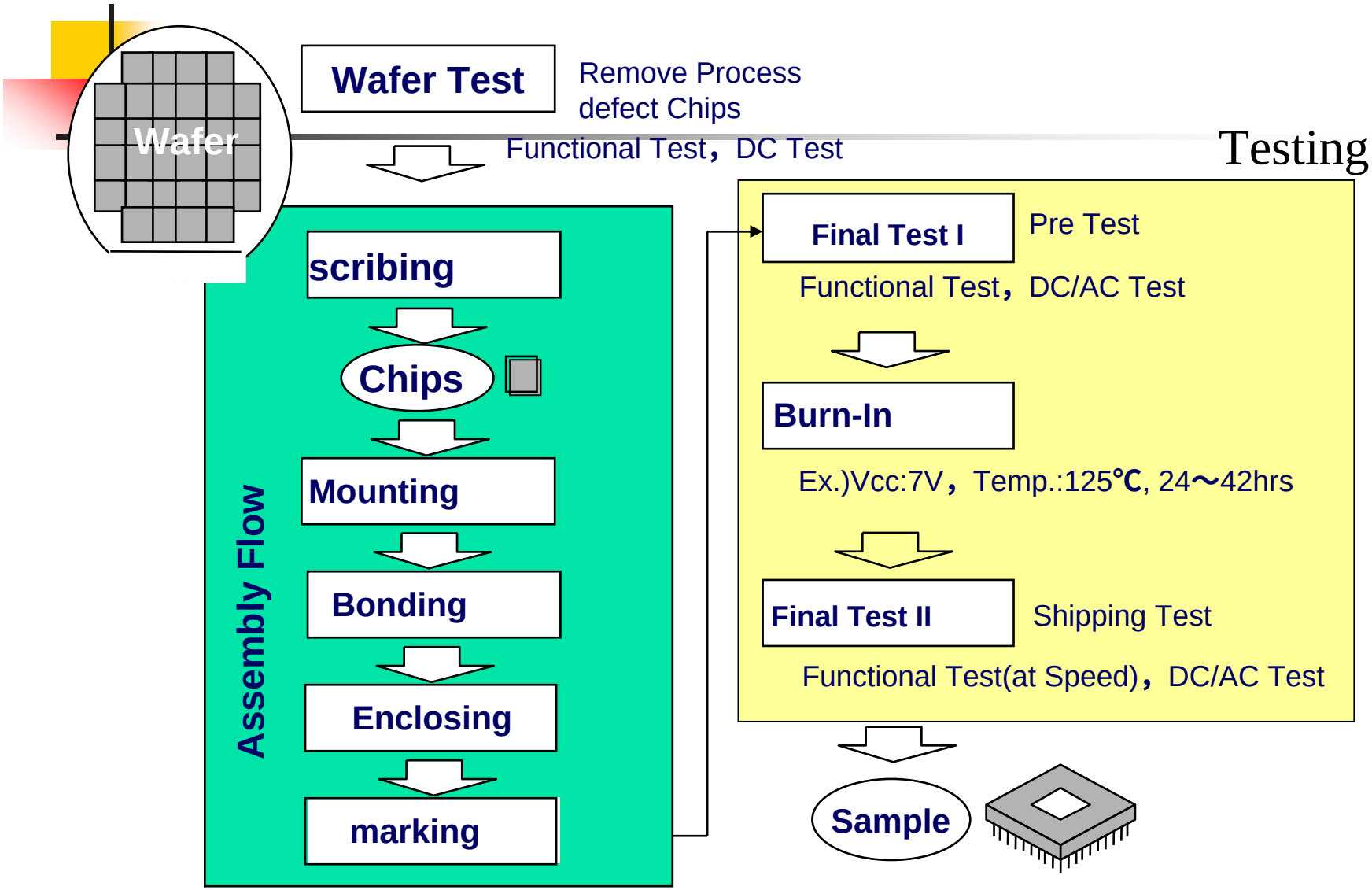
SEM photo of Logic LSIs

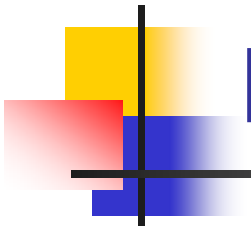



Light Source
Lens
Mask
A
Lens
Si Wafer
A A A A A A A A A A A A A A
A A A A A A A A A A A A A A
A A A A A A A A A A A A A A
Stage
Y
X

Projection

Packaging & Test

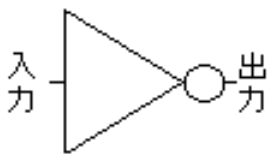


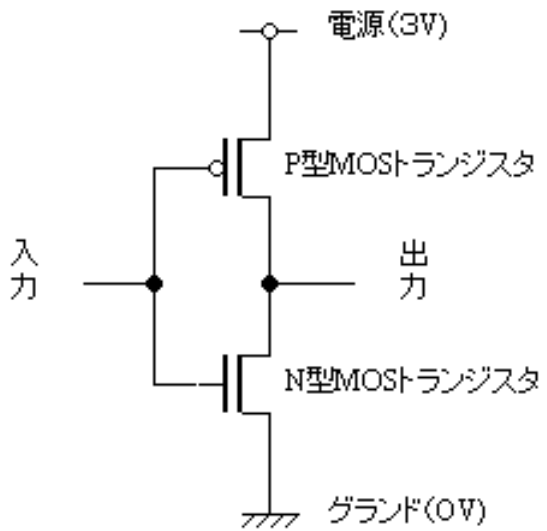


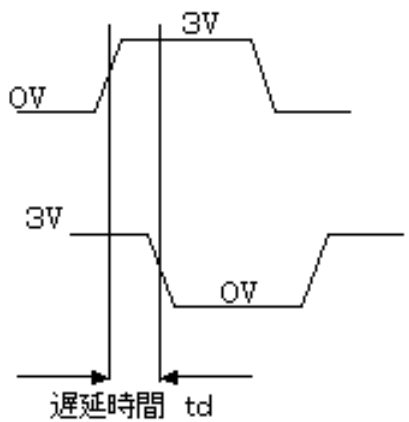
Large Scale Integration

- NMOS , PMOS and Wiring
  - All Logic Function can be made
  - Memory Element Can be made
- Billions of Transistors and wiring make LSI!

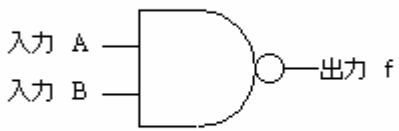
CMOS NOT (Inverter)

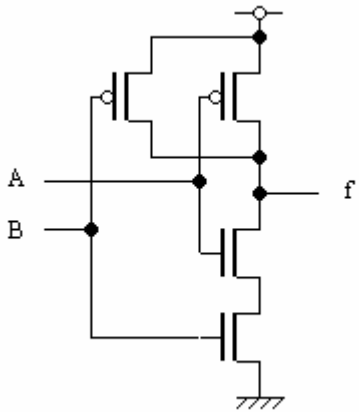




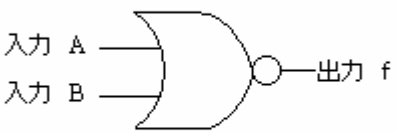


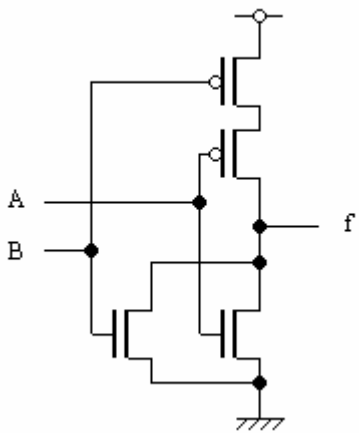
CMOS NAND と NOR





A	B	f
0	0	1
0	1	1
1	0	1
1	1	0





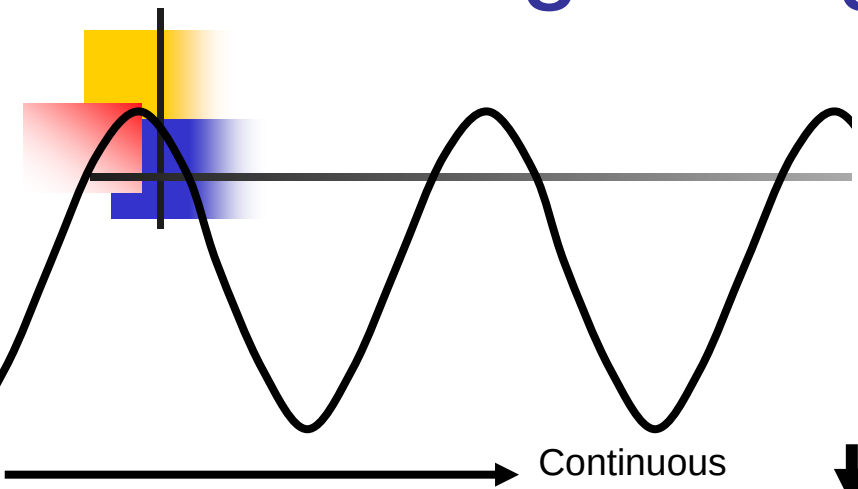
A	B	f
0	0	1
0	1	0
1	0	0
1	1	0

Classification Of LSI

1. Logic LSI: Micro Processor, Digital Signal Processor (DSP), FPGA
2. Memory LSI: RAM (DRAM, SRAM), ROM (Flash Memory)
3. Analog LSI: ADC, DAC, Filter, Amplifier

- Micro Processor (PC's central processing Unit)
  - Perform Digital computation according to the program in Memory
  - Integration in 7000 times in 25 years, (Moor's Law)
  - Clock Speed : 700 times in 25 years
- Memory LSI:
  - Dynamic Random Access Memory: Main memory for Computer, 4-times density in 4 years
  - Static Random Access Memory : work memory for mobile equipments
  - Flash Memory : Nonvolatile memory , Digital Camera Storage
- Analog LSI:
  - Used for interface, high speed RF interface, Analog to Digital Conversion, Digital to Analog Conversion

Analog to Digital Conversion

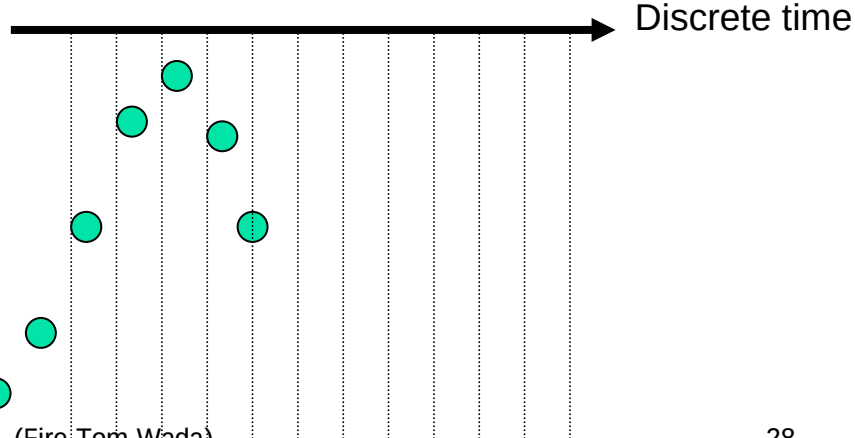


Continuous time

Analog to Digital

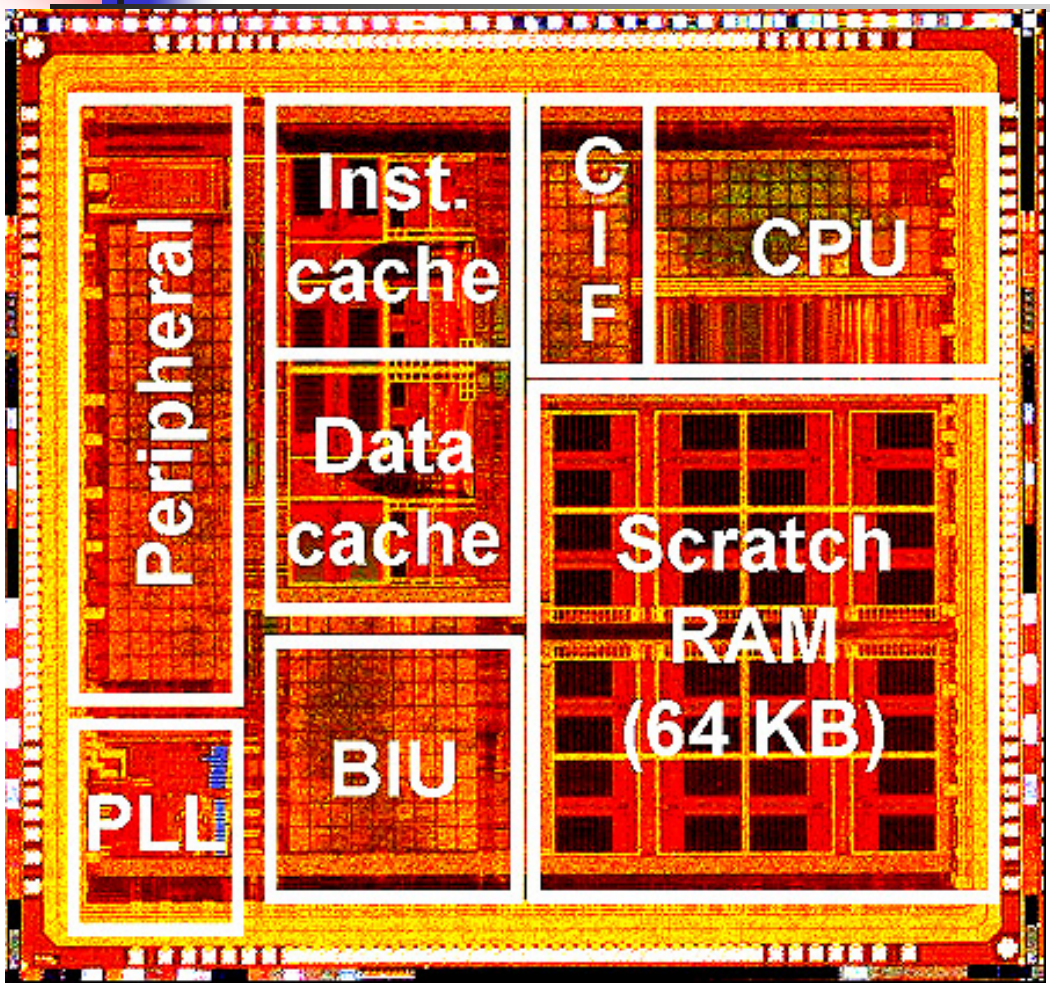
- **Sample the analog wave**
- **Convert to Digital format in Binary**
- **Same as f(t) to An**

ADC LSI



Chip photo

SoC



Flash Memory