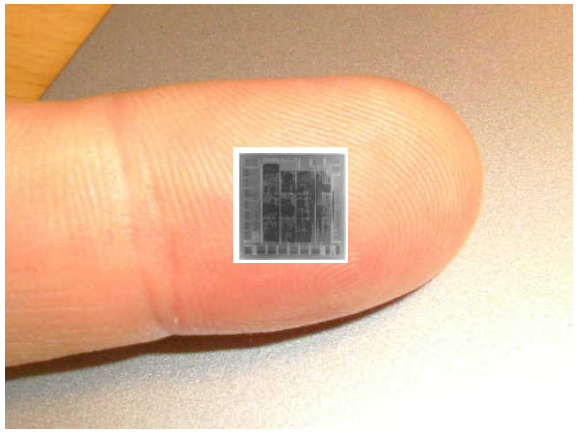
SEMICONDUCTOR TECHNOLOGY
-CMOS-

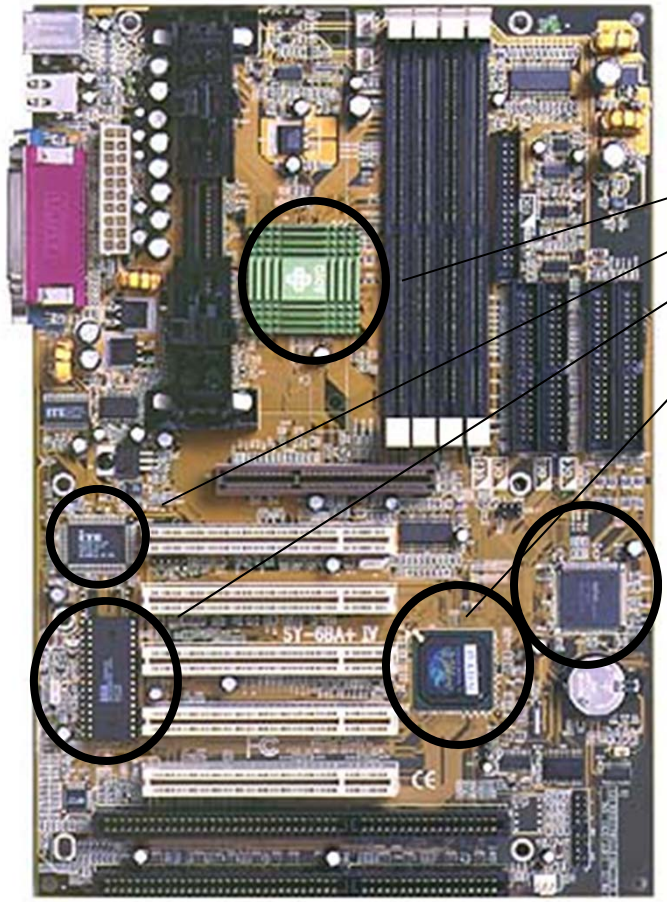
Fire Tom Wada

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, 1000M 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.

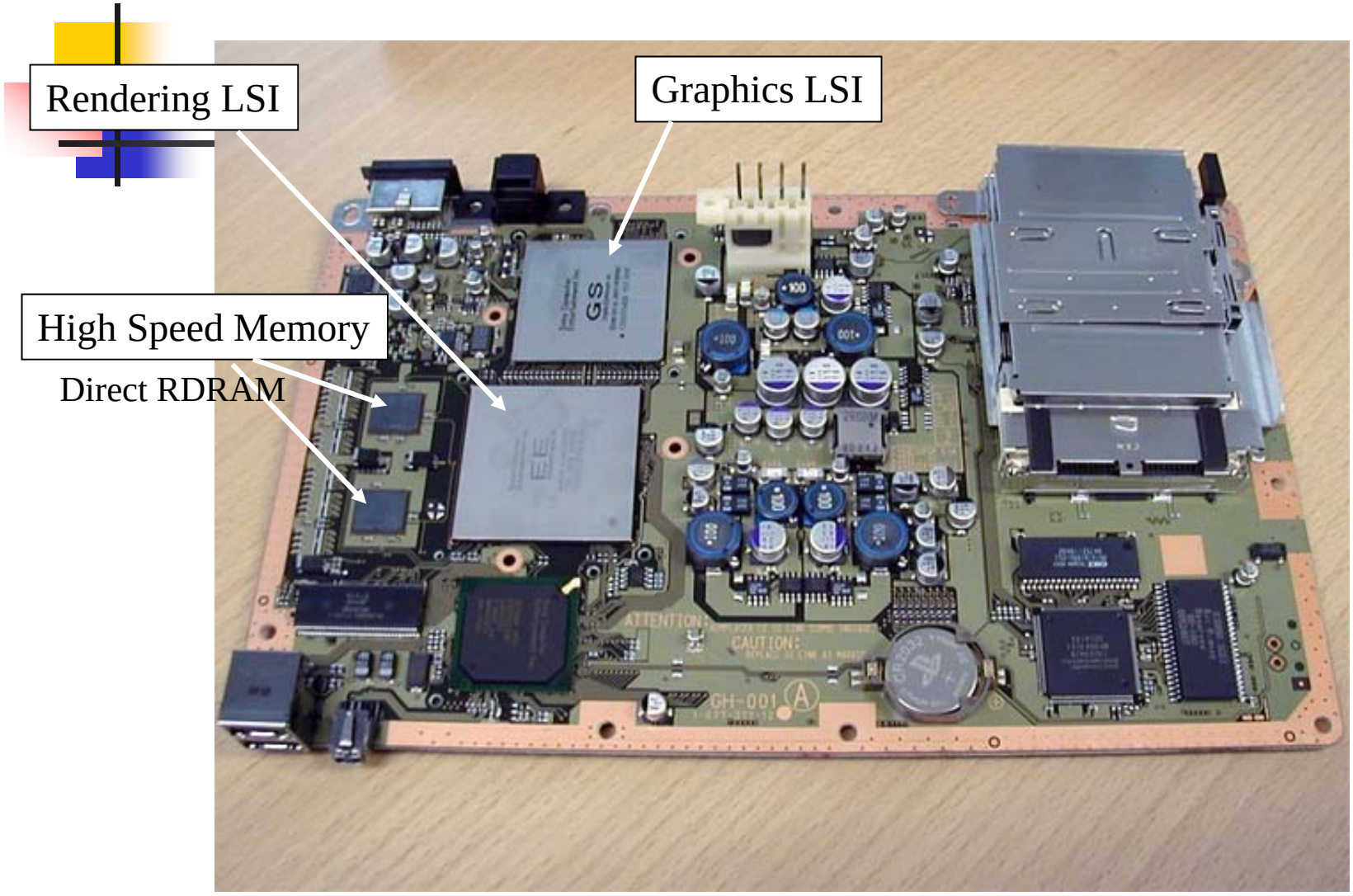


PC mother board



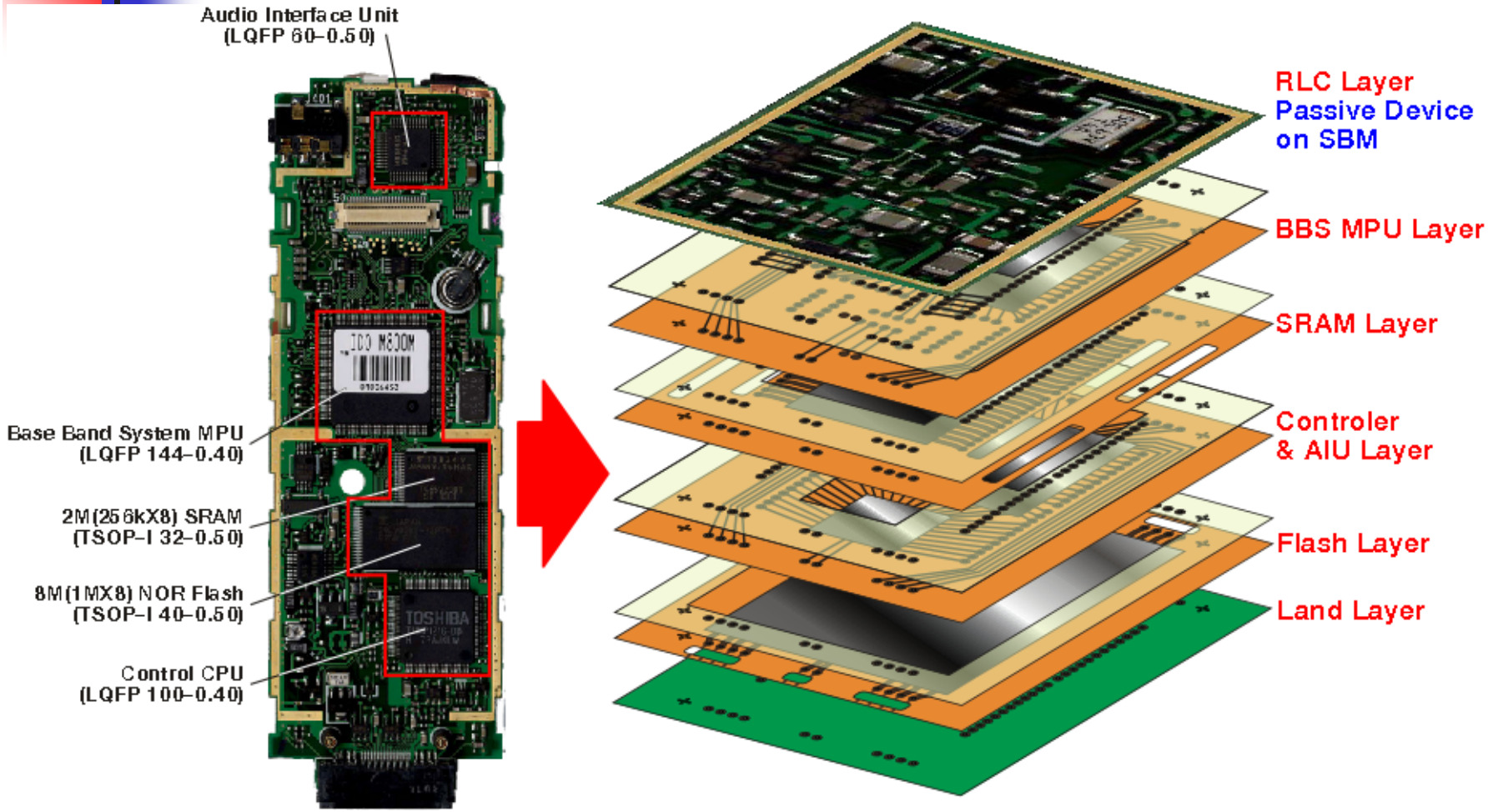
Large Scale Integration

SONY PLAYSTATION 2 MAINBOARD



Mobile Phone Mainboard

Memory, Logic, Analog



iPhone5

TOUCH PANEL & LCD

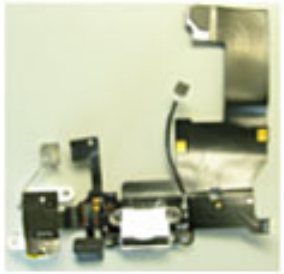
CENTER PANEL

PCB#1

UPPER FPC

LI-ION POLYMER BATTERY

REAR COVER



LOWER FPC

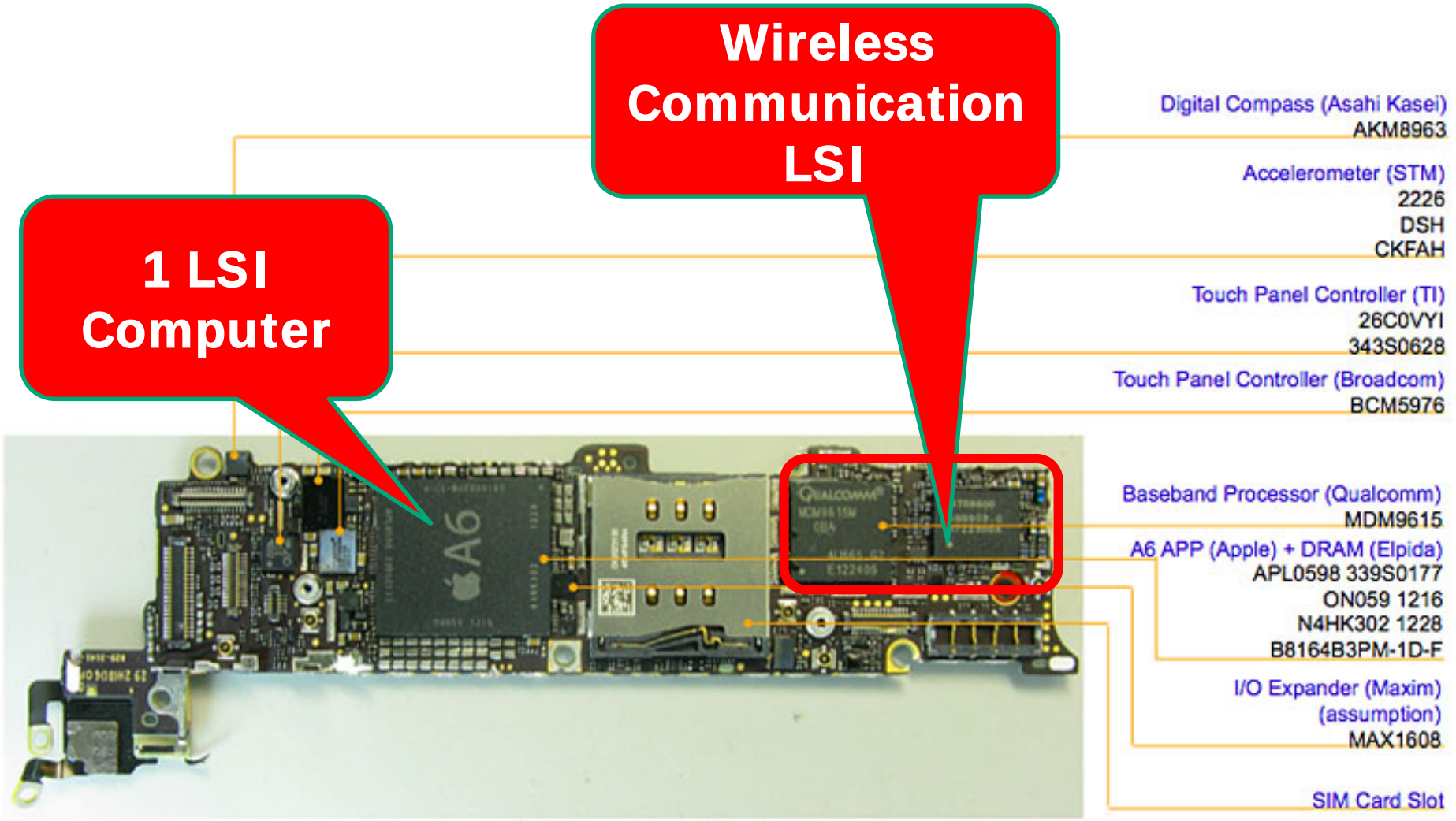
Battery

LCD Display

Electronic Board

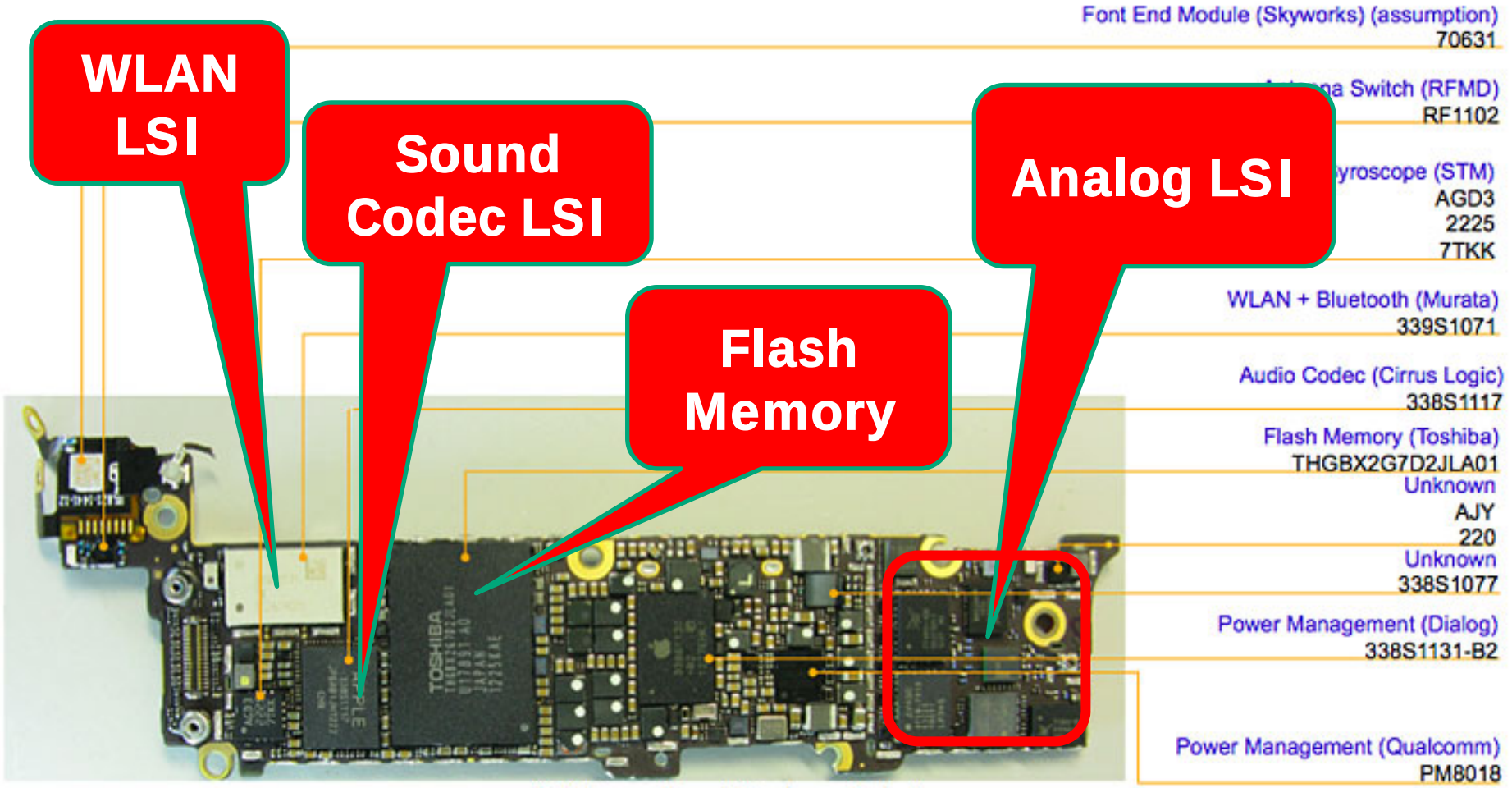
Body

Electronic Board (front side)



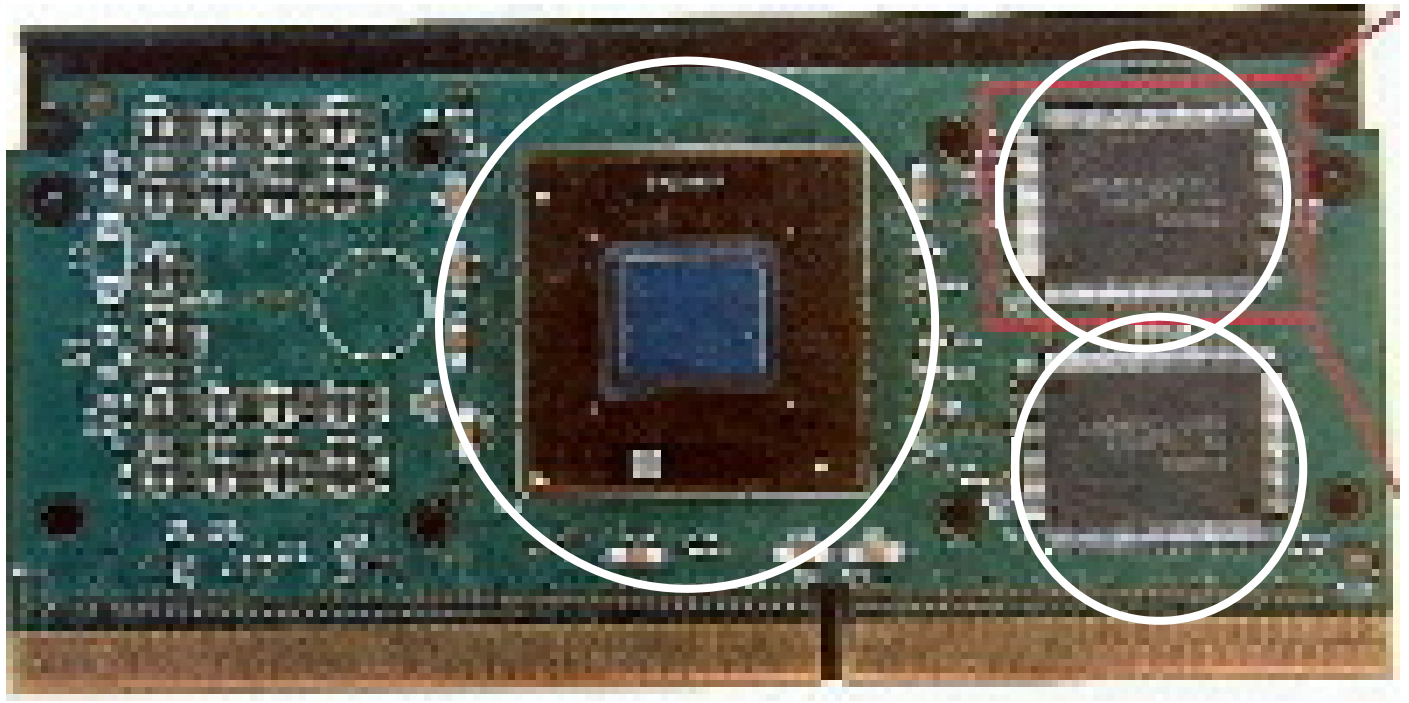
(C) Fomalhaut Techno Solutions

Electronic Board (back side)



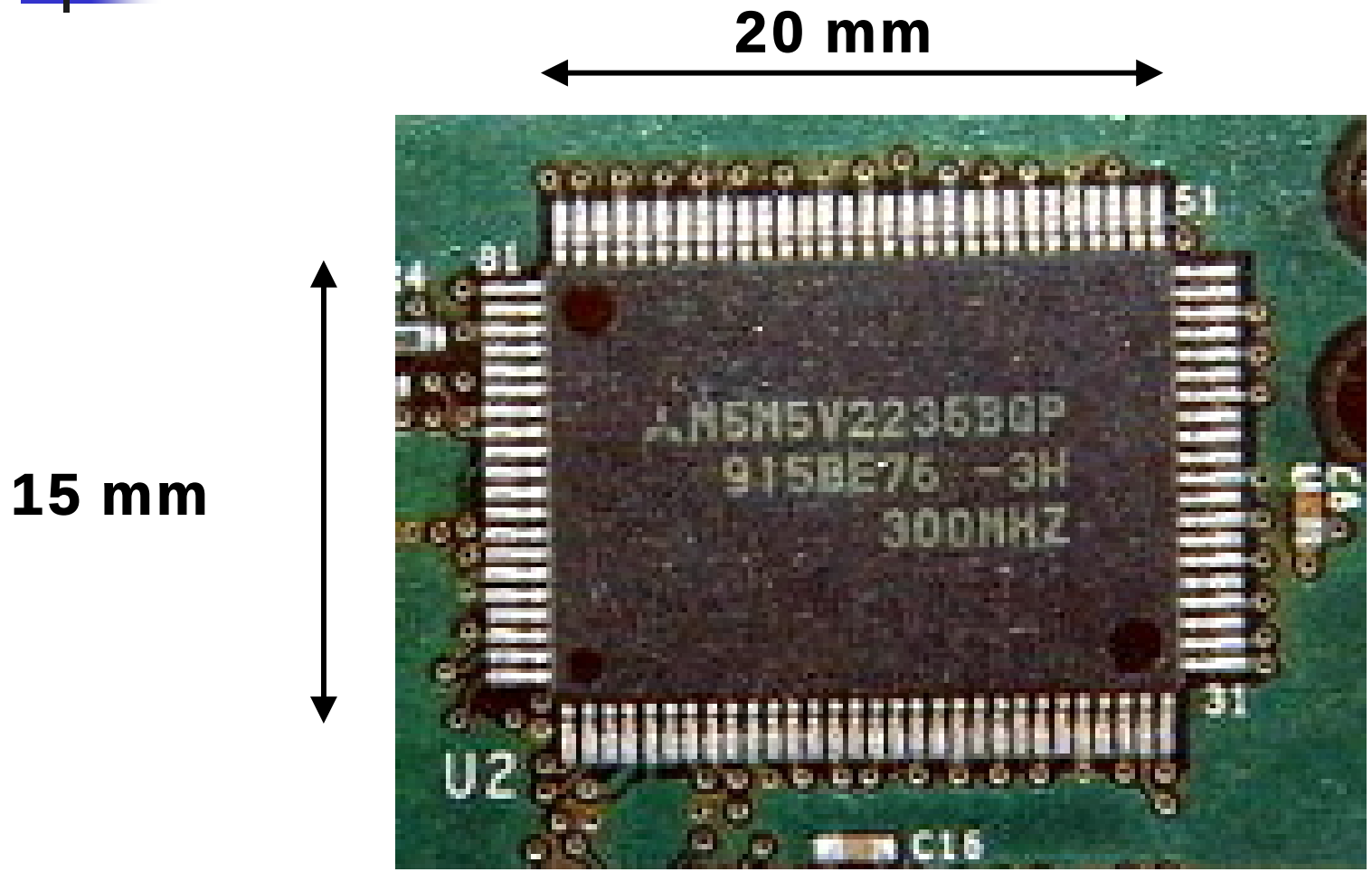
(C) Fomalhaut Techno Solutions

Key device is LSI

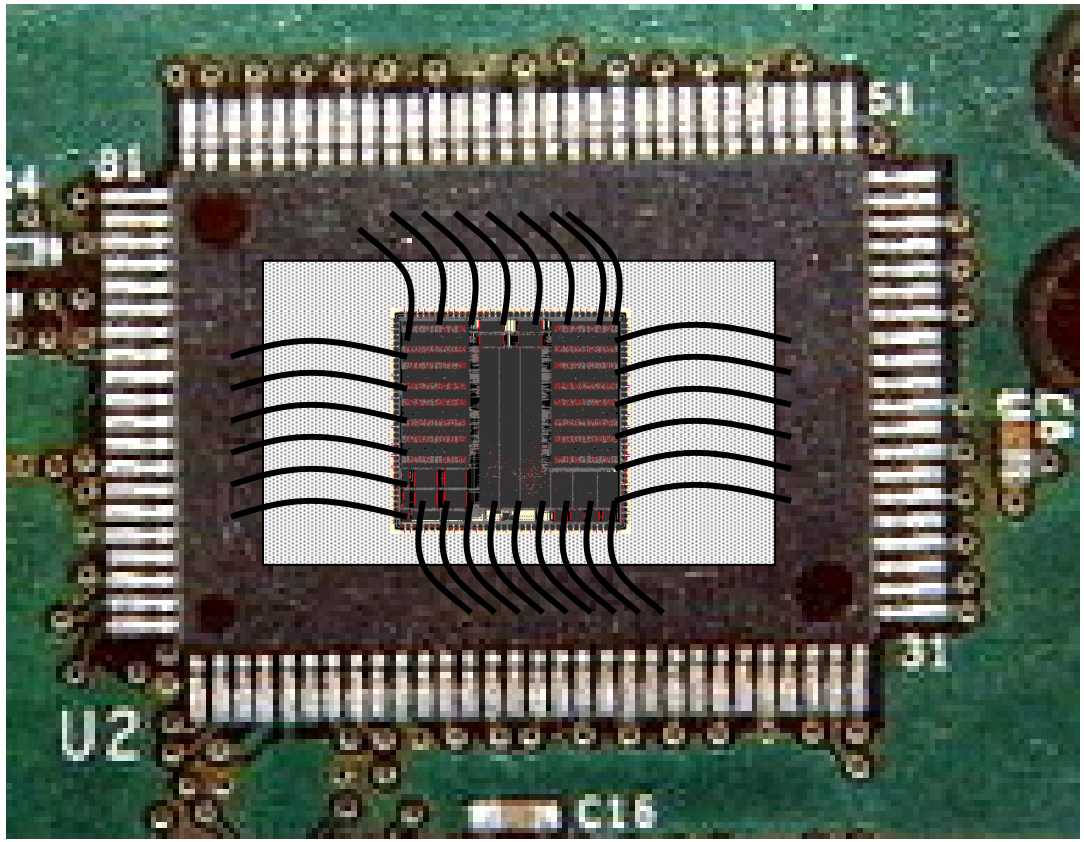


INTEL Pentium III module

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

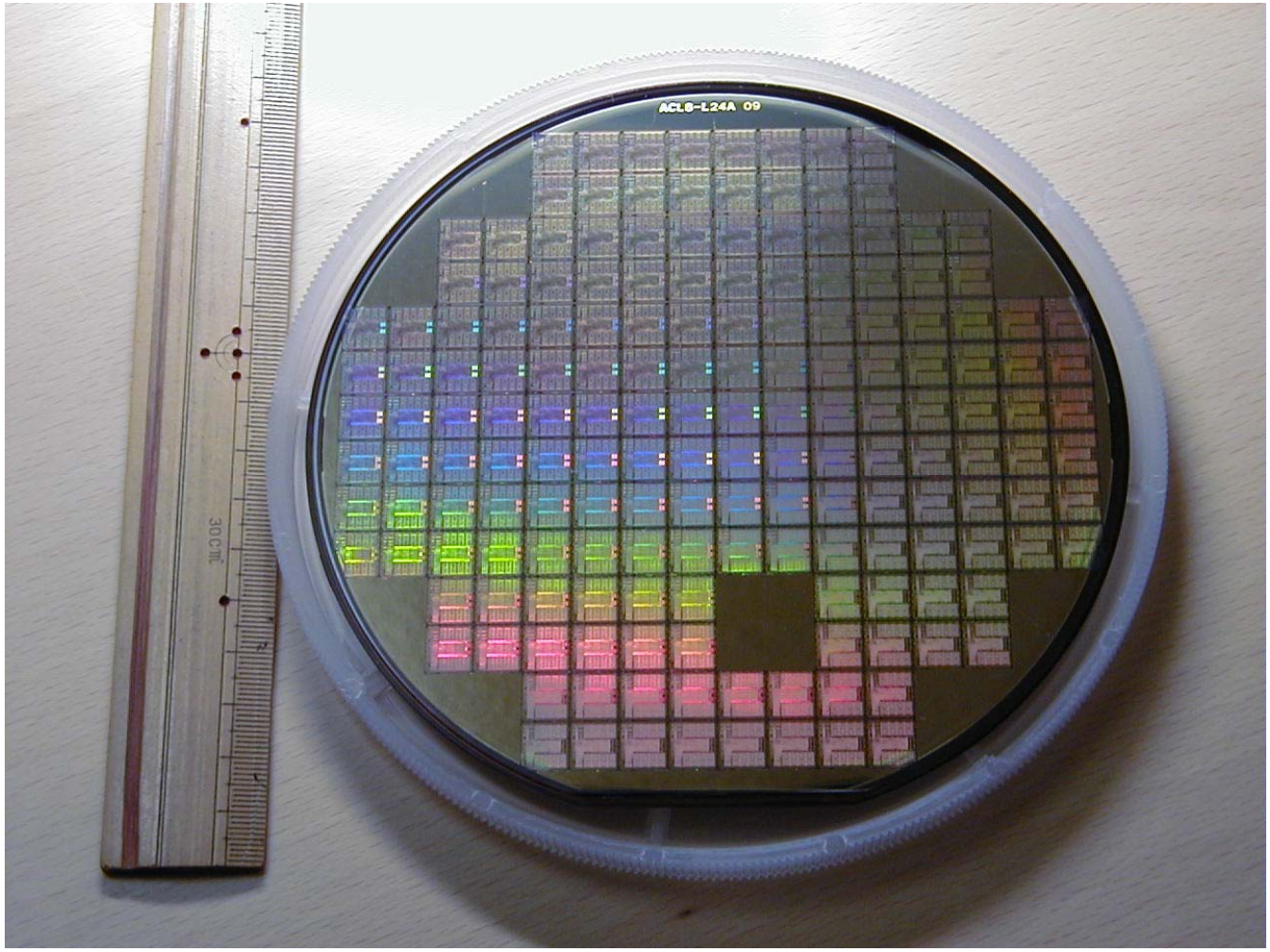


Si chip is molded in the package.

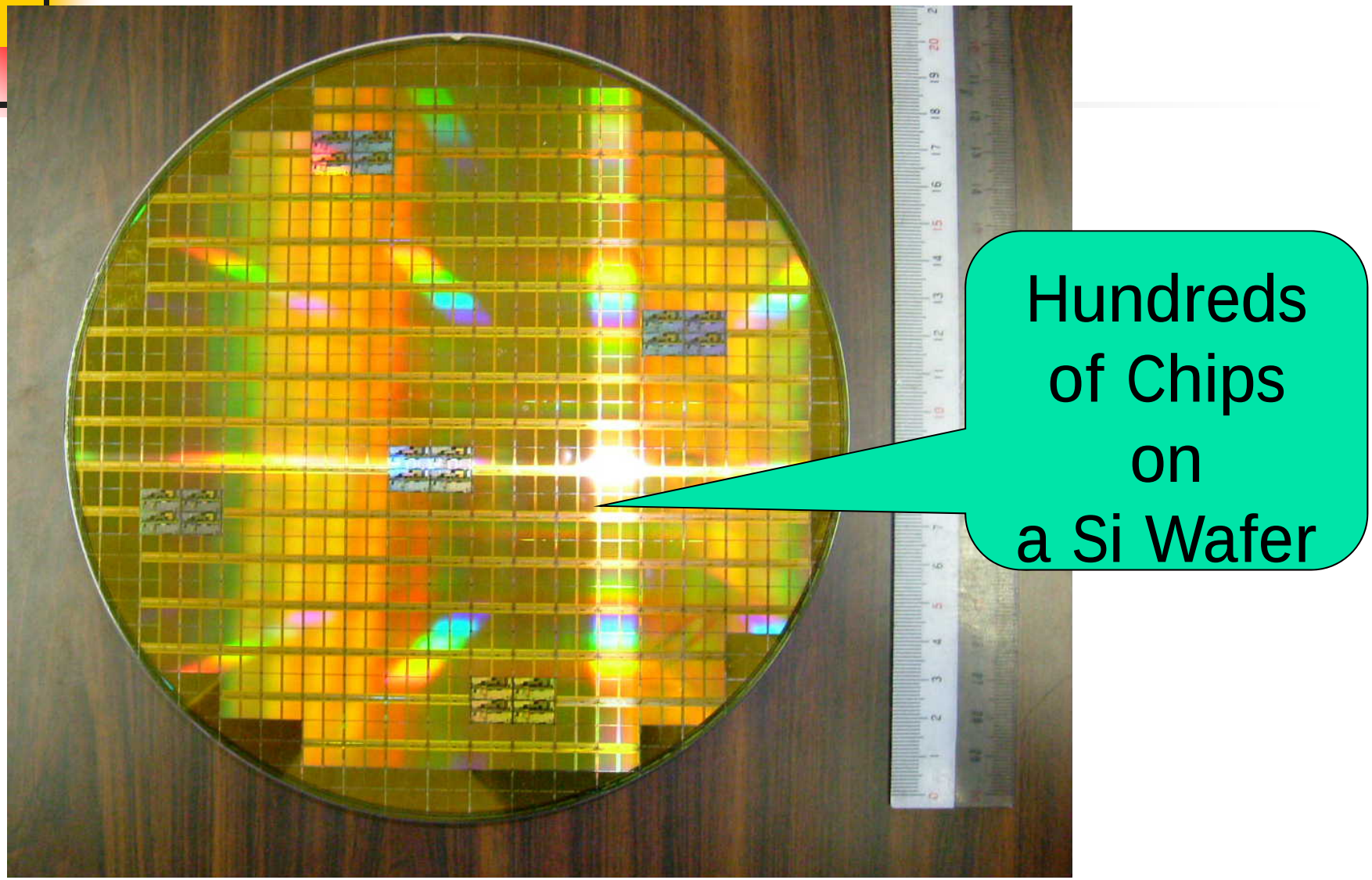


2 million transistor Chip is connected to the pins thru wires.

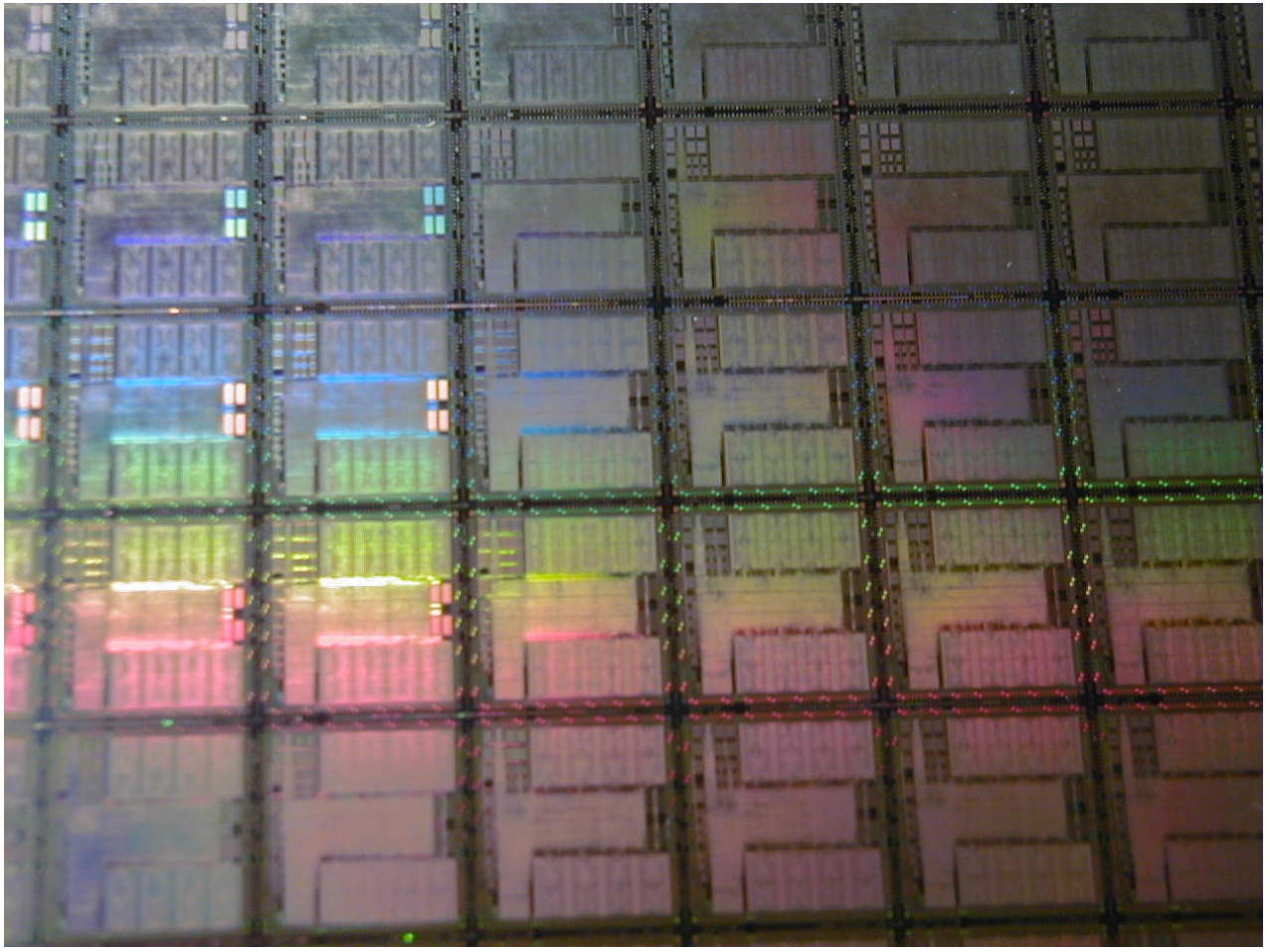
6 inches Si wafer



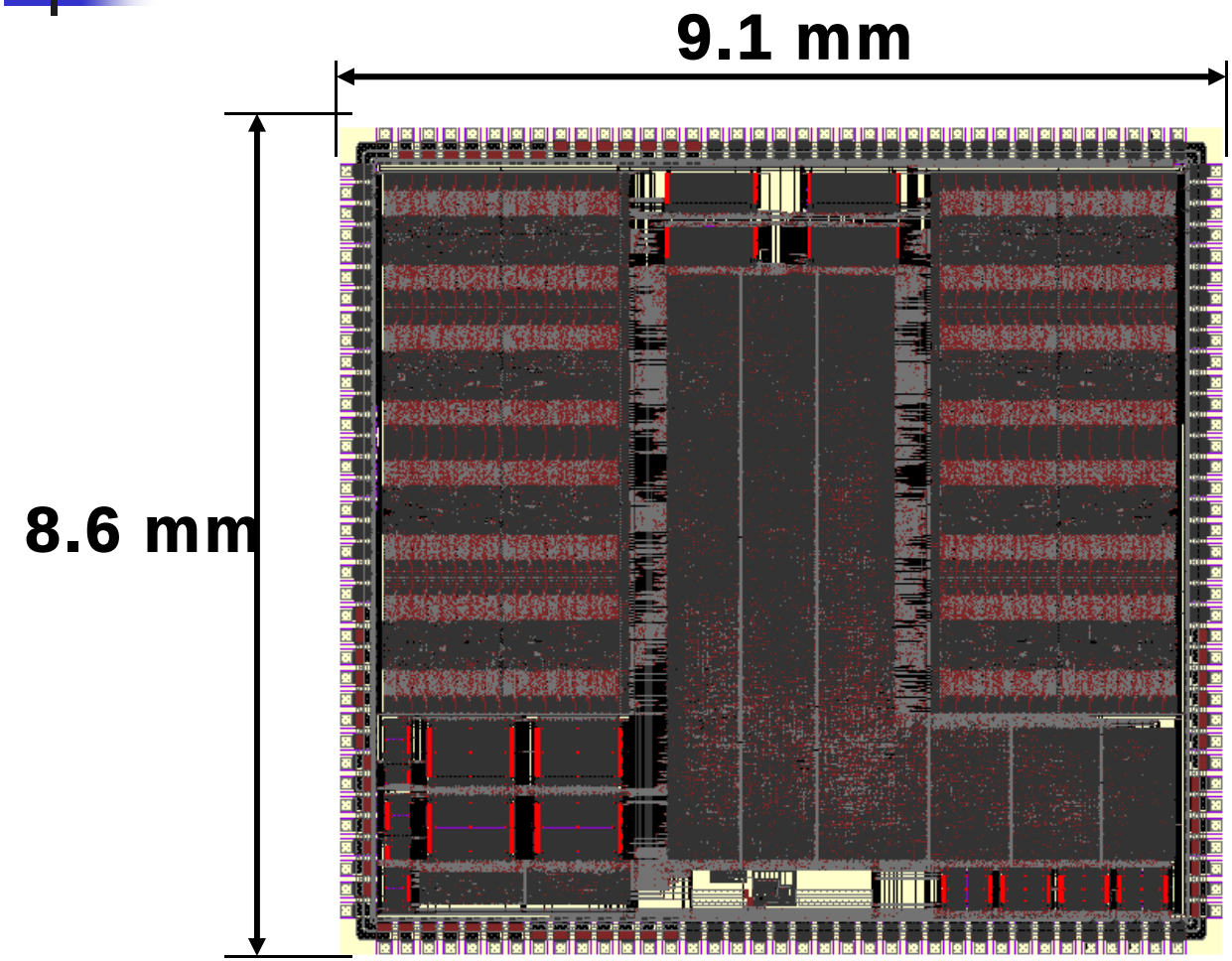
8 inches Si wafer



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.

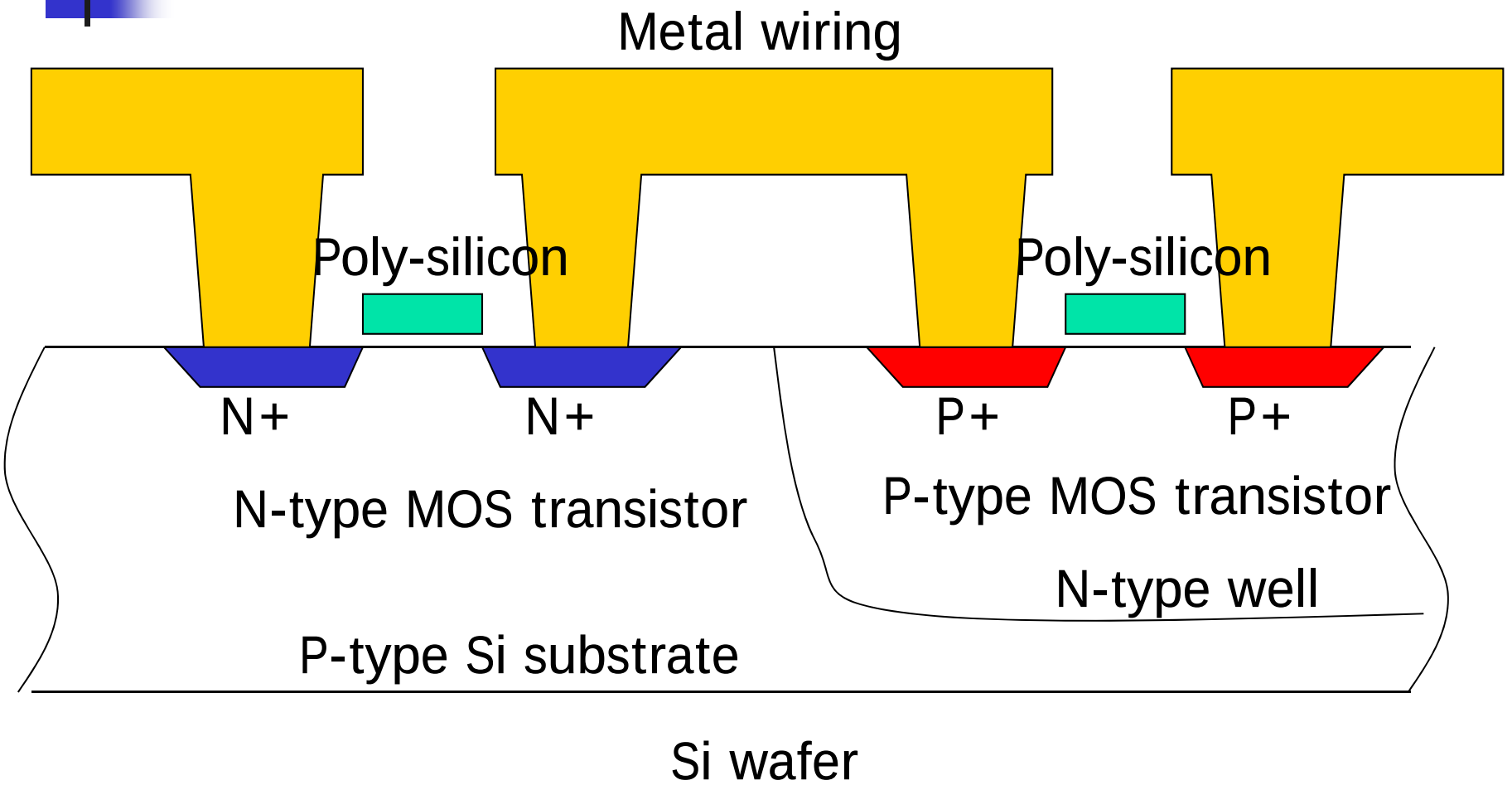
Scanning Electron Microscope photo - Cross-section of the LSI -

0.5 micron

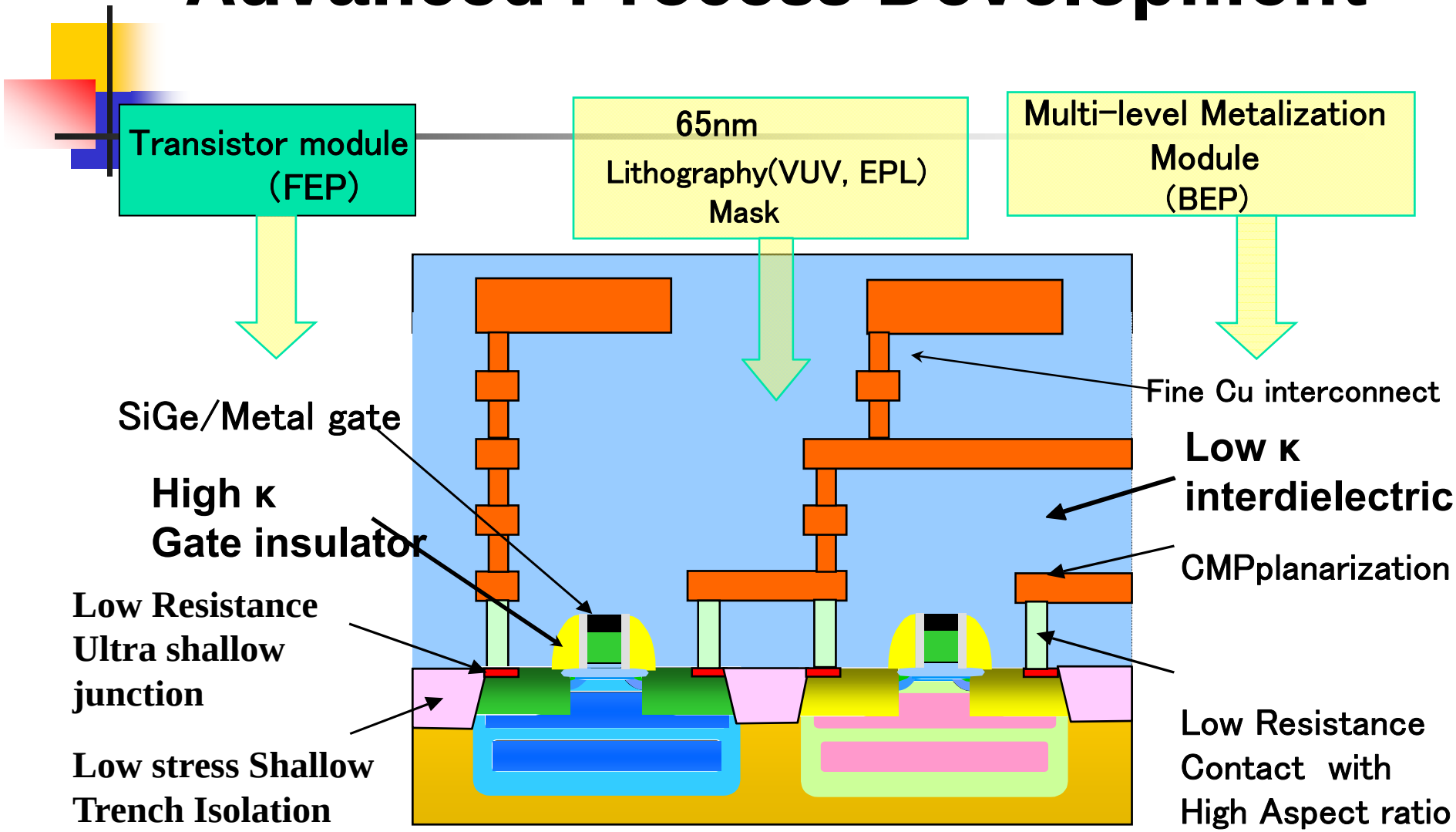
Structure Of CMOS LSI

- 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

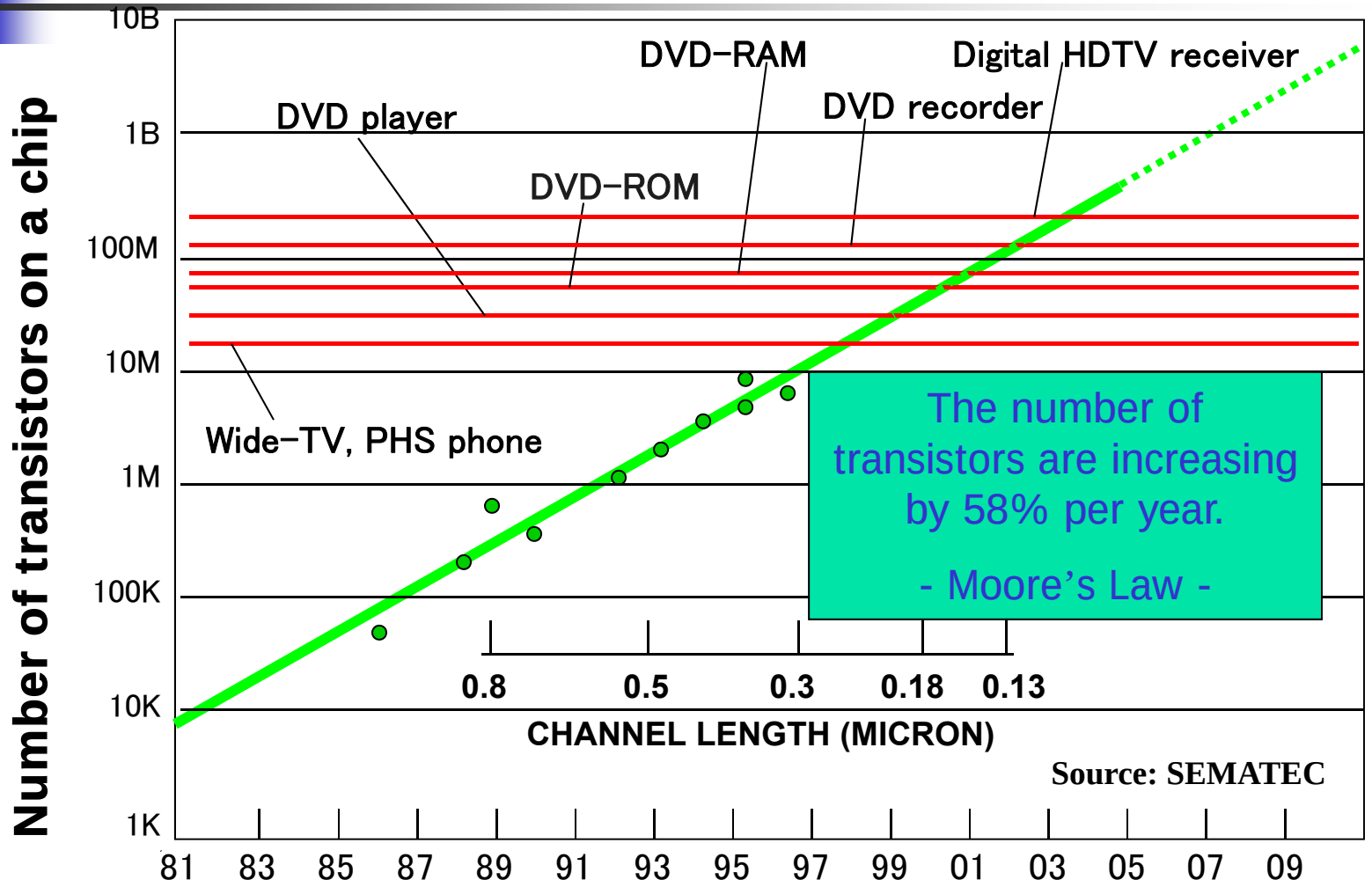
Cross-section of the LSI



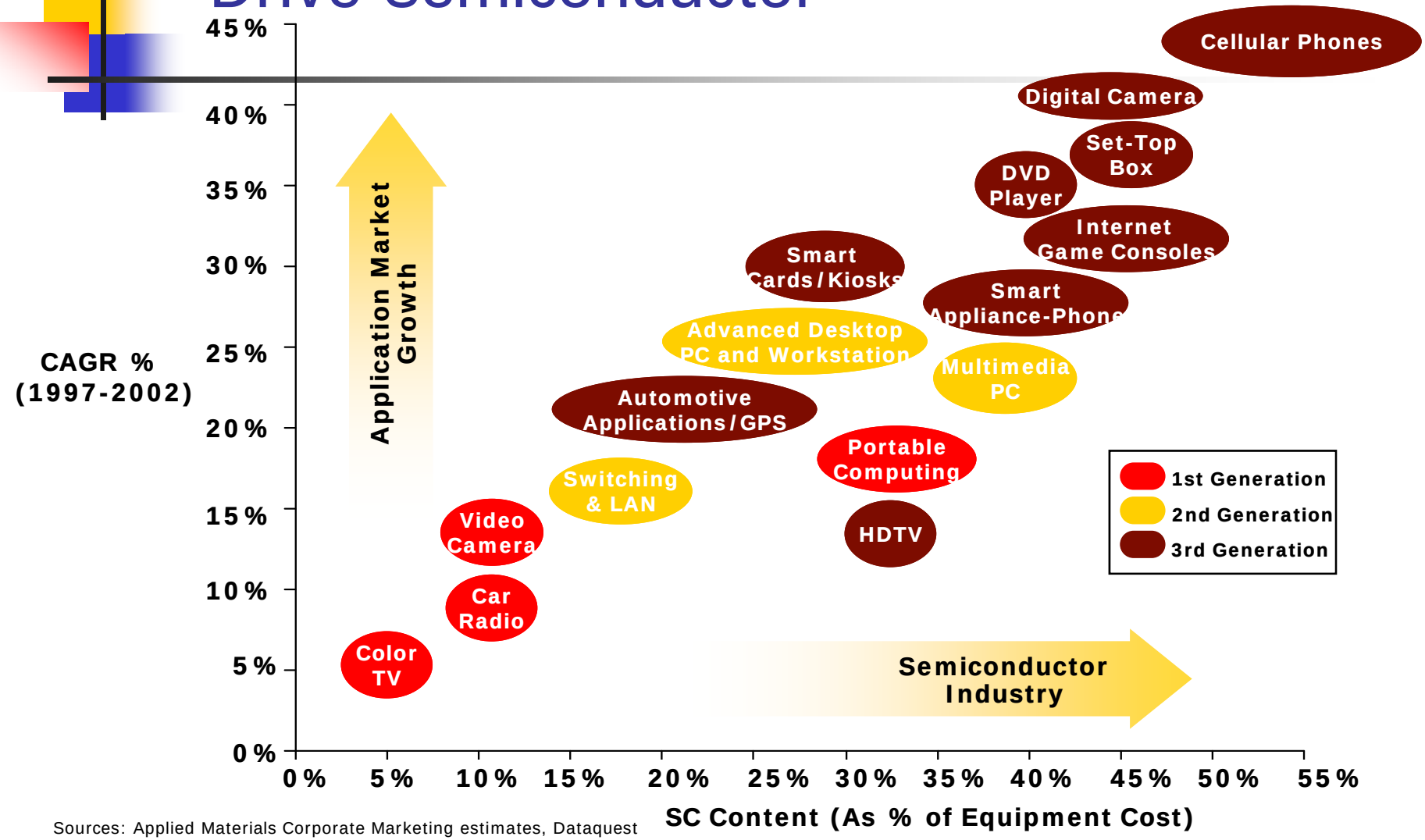
Advanced Process Development



LSI integration trend
– Moore's law –



Communications and Consumer Products Drive Semiconductor

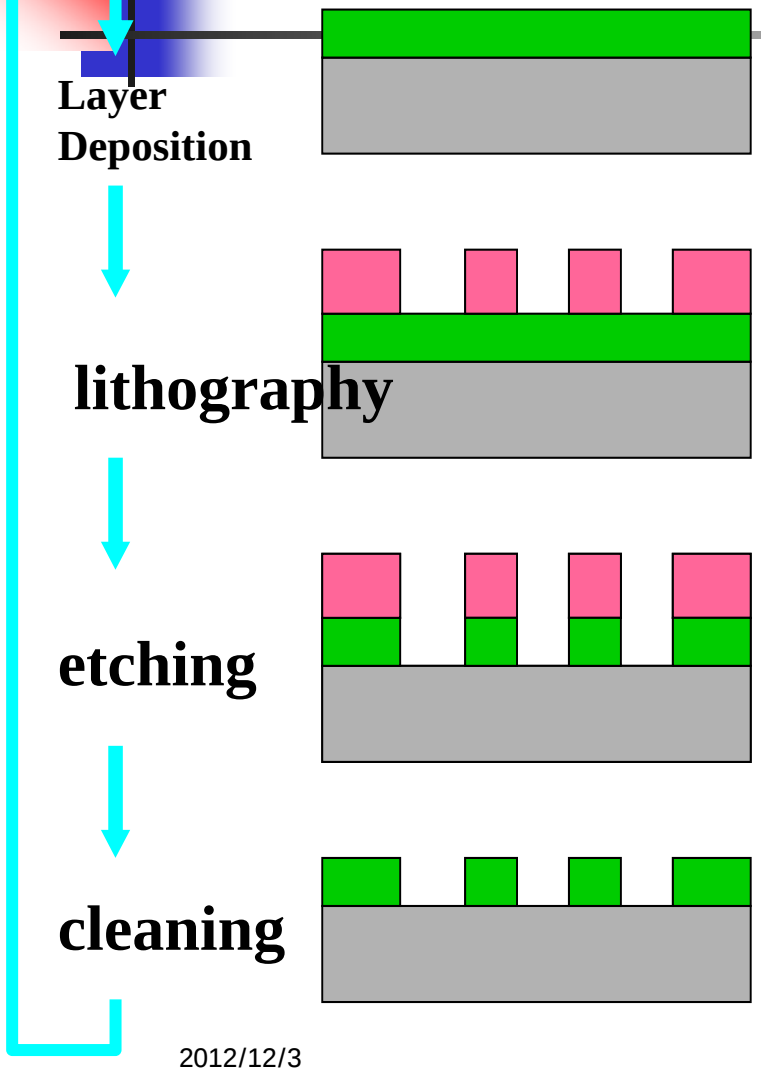


Sources: Applied Materials Corporate Marketing estimates, Dataquest

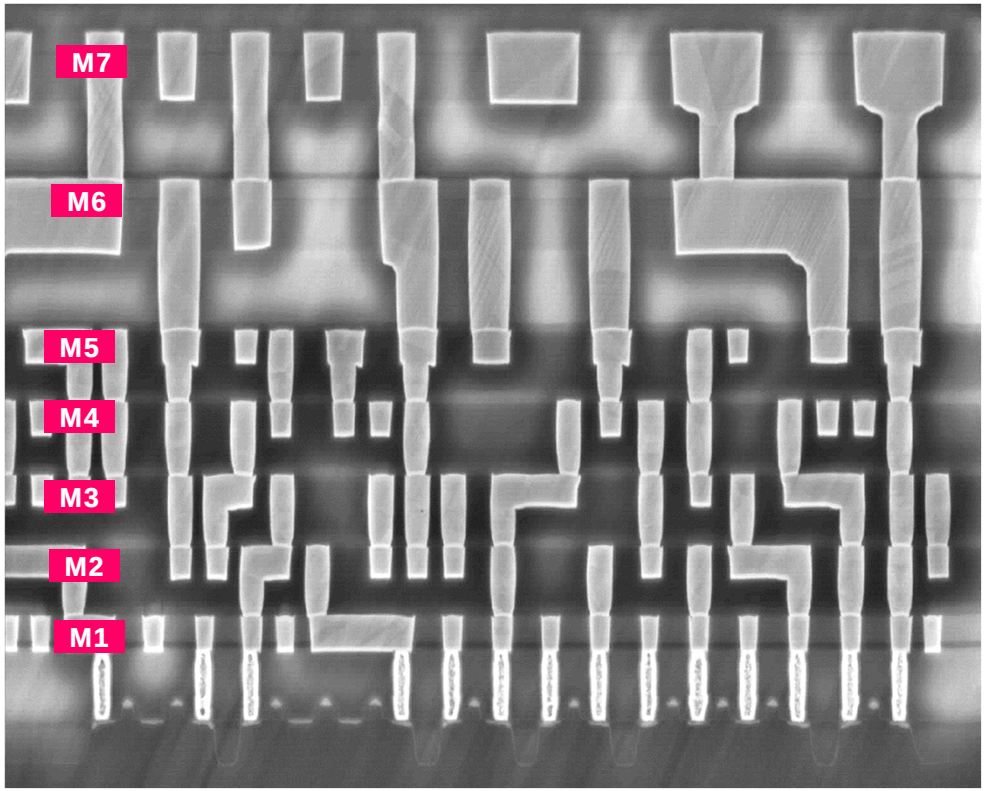
FABRICATION PROCESS ISSUES

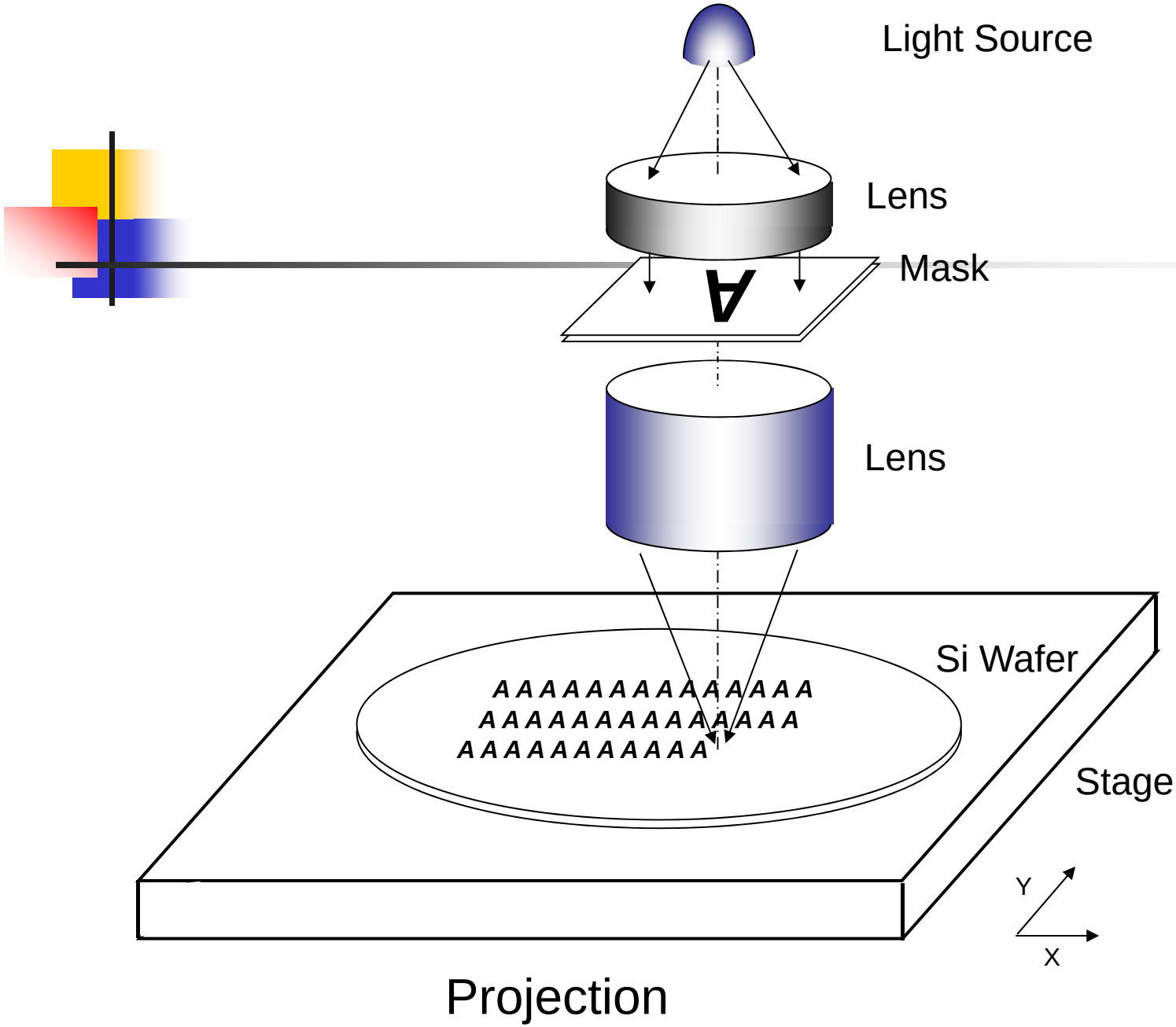
Ultra Clean Room

Basic LSI process



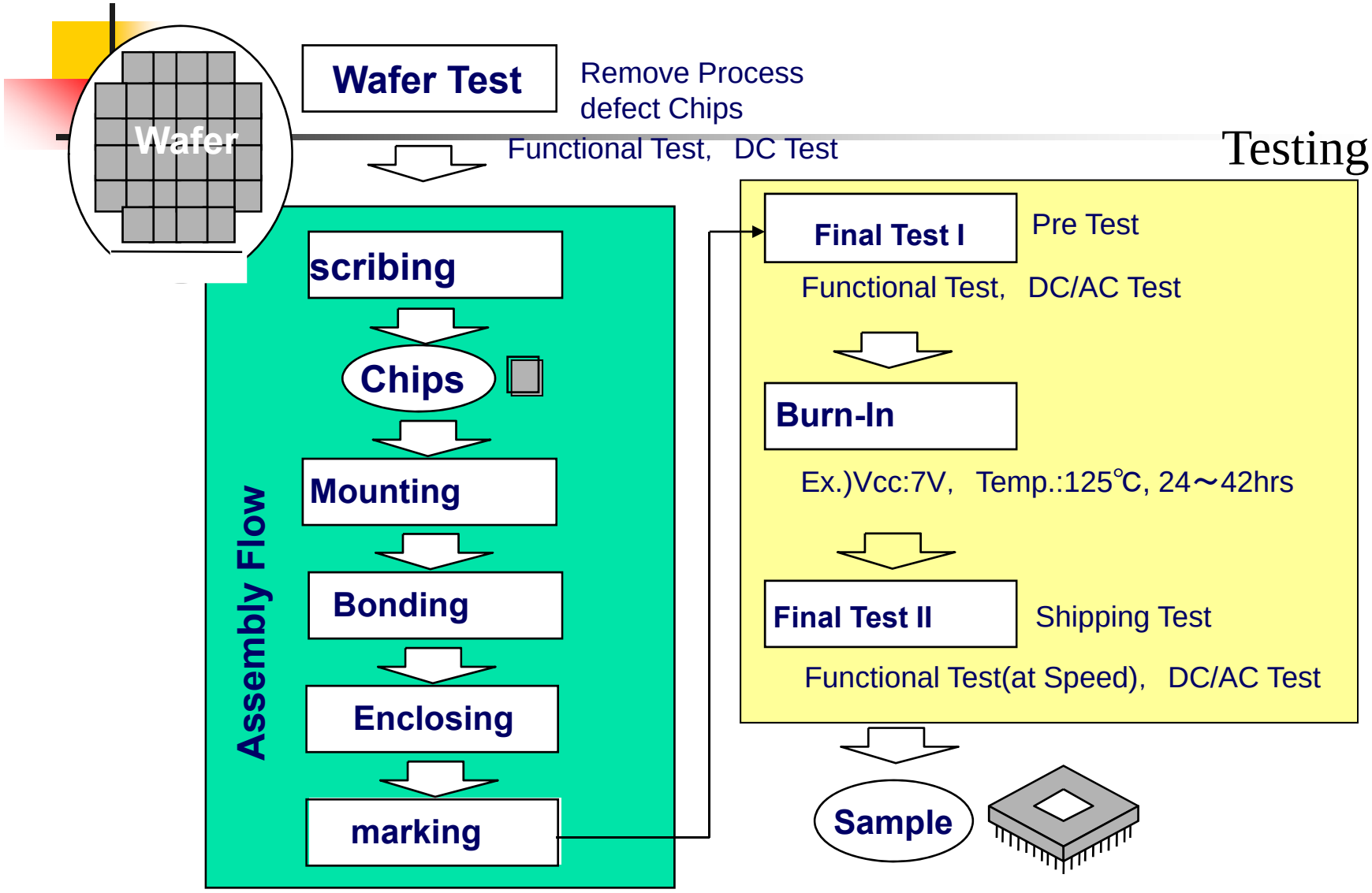
SEM photo of Logic LSIs

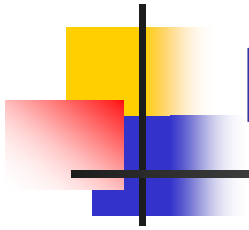



Light Source
Lens
Mask
A
Lens
Si Wafer
A A A A A A A A A A A A A A
A A A A A A A A A A A A A A
A A A A A A A A A A A A A A
Stage
Y
X

Projection

Packaging & Test

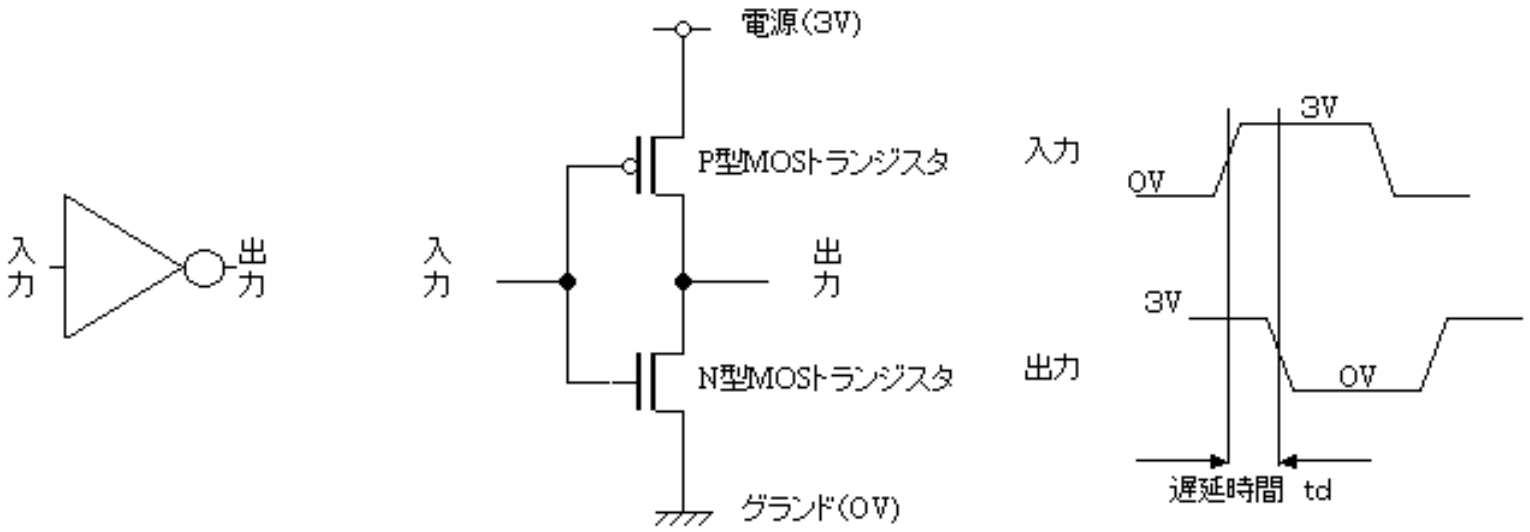




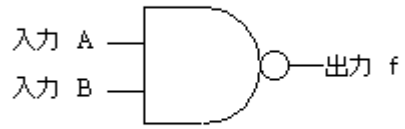
Large Scale Integration

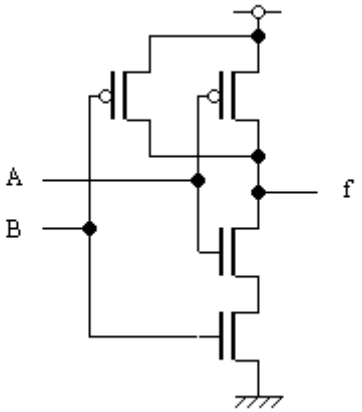
- NMOS , PMOS and Wiring
  - All Logic Function can be made
  - Memory Element Can be made
- Billions of Transistors and wiring make LSI!

CMOS NOT （Inverter)

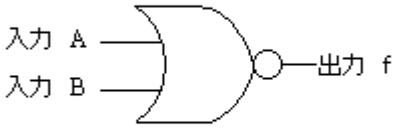


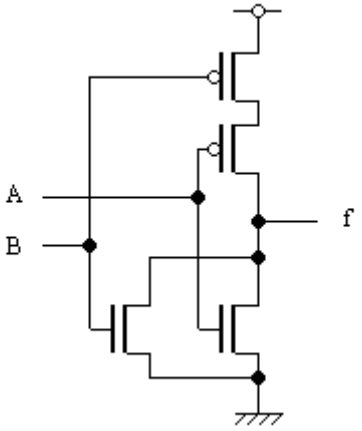
CMOS NAND と NOR





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





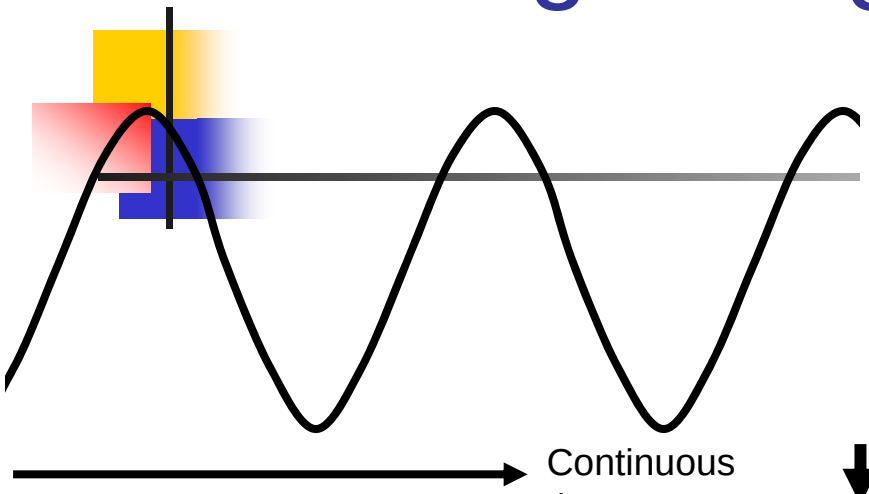
A	B	f
0	0	1
0	1	0
1	0	0
1	1	0

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

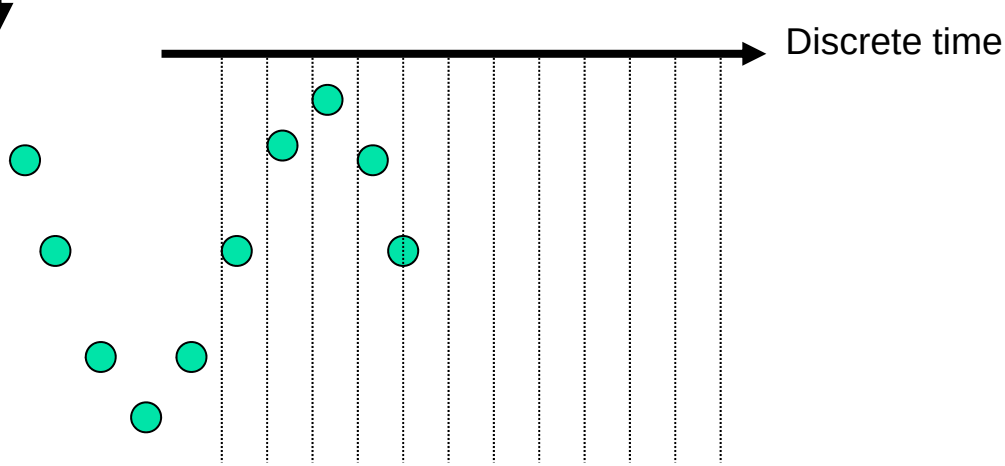


Continuous time

Analog to Digital

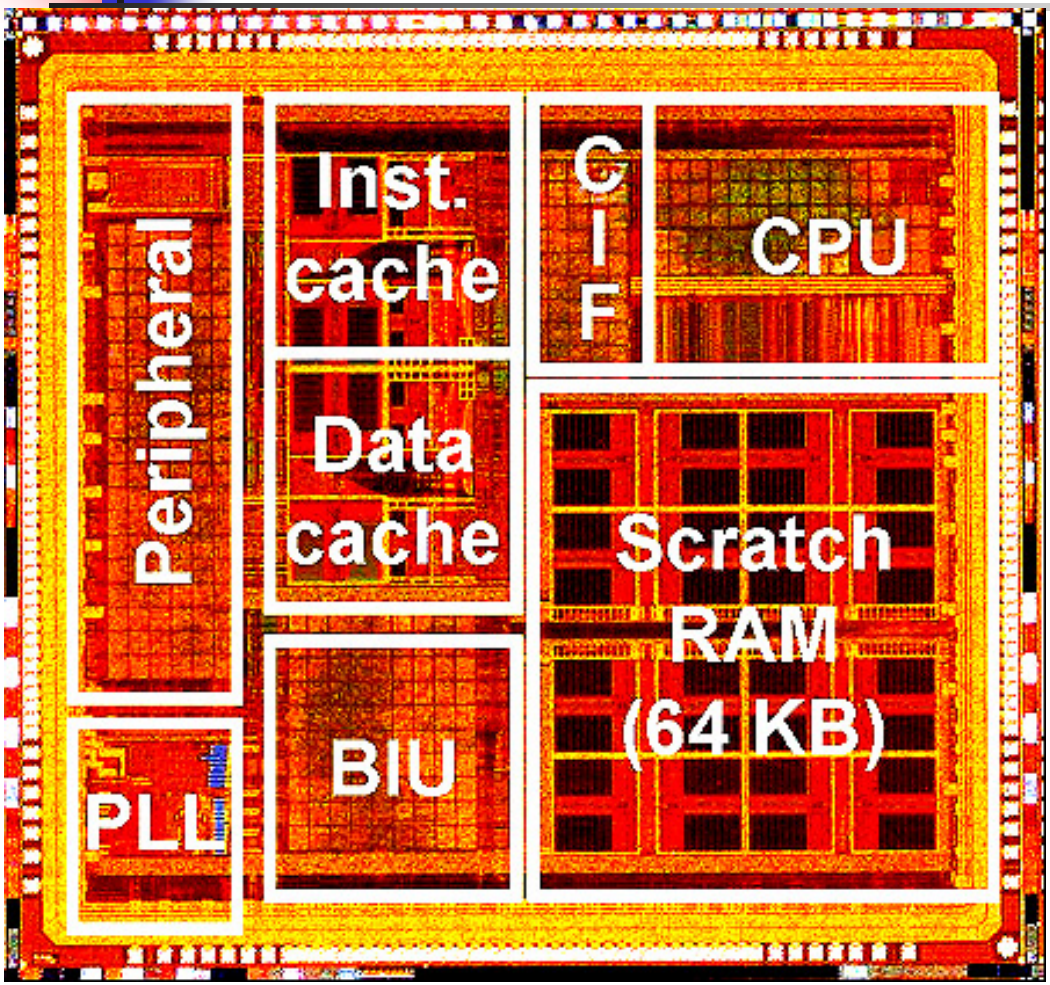
- Sample the analog wave
- Convert to Digital format in Binary
- Same as f(t) to An

ADC LSI

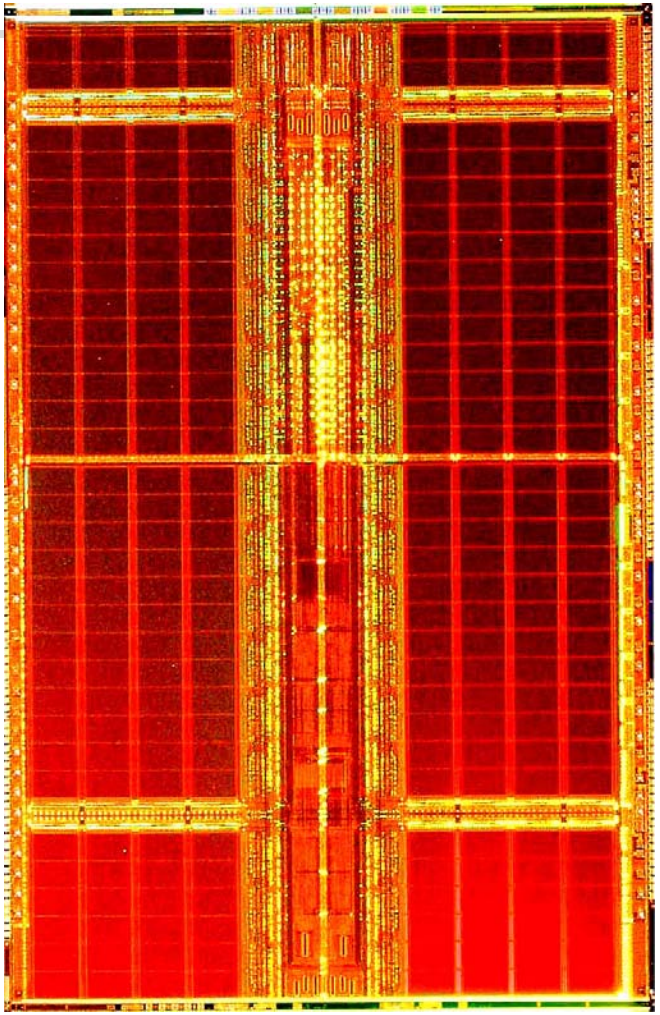


Chip photo 1

SoC



Flash Memory



Chip photo 2

Mobile Digital TV receiver