SEMICONDUCTOR TECHNOLOGY
-CMOS-

Fire Tom Wada
What is semiconductor and LSI s

- 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 LSI s.
- PCs, Cellular phones, 3D graphics, Internet.
PC mother board

Large Scale Integration
SONY PLAYSTATION 2 MAINBOARD

- Rendering LSI
- Graphics LSI
- High Speed Memory
- Direct RDRAM
Mobile Phone Mainboard

- Audio Interface Unit (LQFP 30-0.50)
- Ease Band System MPU (LQFP 144-0.40)
- 2M (256Kx8) SRAM (TSOP-1 32-0.50)
- 8M (1Mx8) NOR Flash (TSOP-1 49-0.50)
- Control CPU (LQFP 100-0.40)

- RLC Layer
- Passive Device on SBM
- BBS MPU Layer
- SRAM Layer
- Controller & ALU Layer
- Flash Layer
- Land Layer
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

Hundreds of Chips on a 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 -
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

Metal wiring

Poly-silicon

N+  N+  P+  P+

N-type MOS transistor  P-type MOS transistor  N-type well

P-type Si substrate

Si wafer
Advanced Process Development

- Transistor module
- Lithography (VUV, EPL)
- Mask
- CMP planarization
- Low Resistance Contact with High Aspect ratio
- Gate insulator
- High
- Low Resistance
- Ultra shallow junction
- Low stress Shallow Trench Isolation
- Interdielectric
- Low stress
- Ultra shallow junction
- Trench Isolation

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System Arch 2007 (Fire Tom Wada)
LSI integration trend

-Moore's law-

Wide TV, PHS phone, DVD player, DVD-ROM, DVD recorder

Source: SEMATEC

The number of transistors on a chip are increasing by 58% per year.

- Moore's Law -

CHANNEL LENGTH (MICRON)

Number of transistors on a chip

Source: SEMATEC
Fabrication Process Issues
Ultra Clean Room
Basic LSI process

Layer Deposition

SEM photo of Logic LSIs

lithography

etching

cleaning

M7
M6
M5
M4
M3
M2
M1
Packaging & Test

**Assembly Flow**
- Scribing
- Chips
- Mounting
- Bonding
- Enclosing
- Marking

**Testing**
- **Wafer Test**
  - Remove Process
  - Defect Chips
- **Final Test I**
  - Pre Test
  - Functional Test, DC Test
- **Burn-In**
  - Ex.) Vcc: 7V, Temp.: 125°C, 24~42hrs
- **Final Test II**
  - Shipping Test
  - Functional Test (at Speed), DC/AC Test
- Sample
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

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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

- Sample the analog wave
- Convert to Digital format in Binary
- Continuous time
- Discrete time

Diagram:
- Analog signal
- ADC LSI
- Sampling
- Digital output
- Discrete time signal

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Chip photo