

## Level 0 Packaging:







Interconnections within semiconductor IC chips







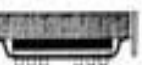
Not considered 'packaging' in the common parlance

## Level 1 Packaging

### Single Chip Module (SCM)

- ❖ In-line packages
- ❖ Small out line packages
- ❖ Quad packages
- ❖ Array packages

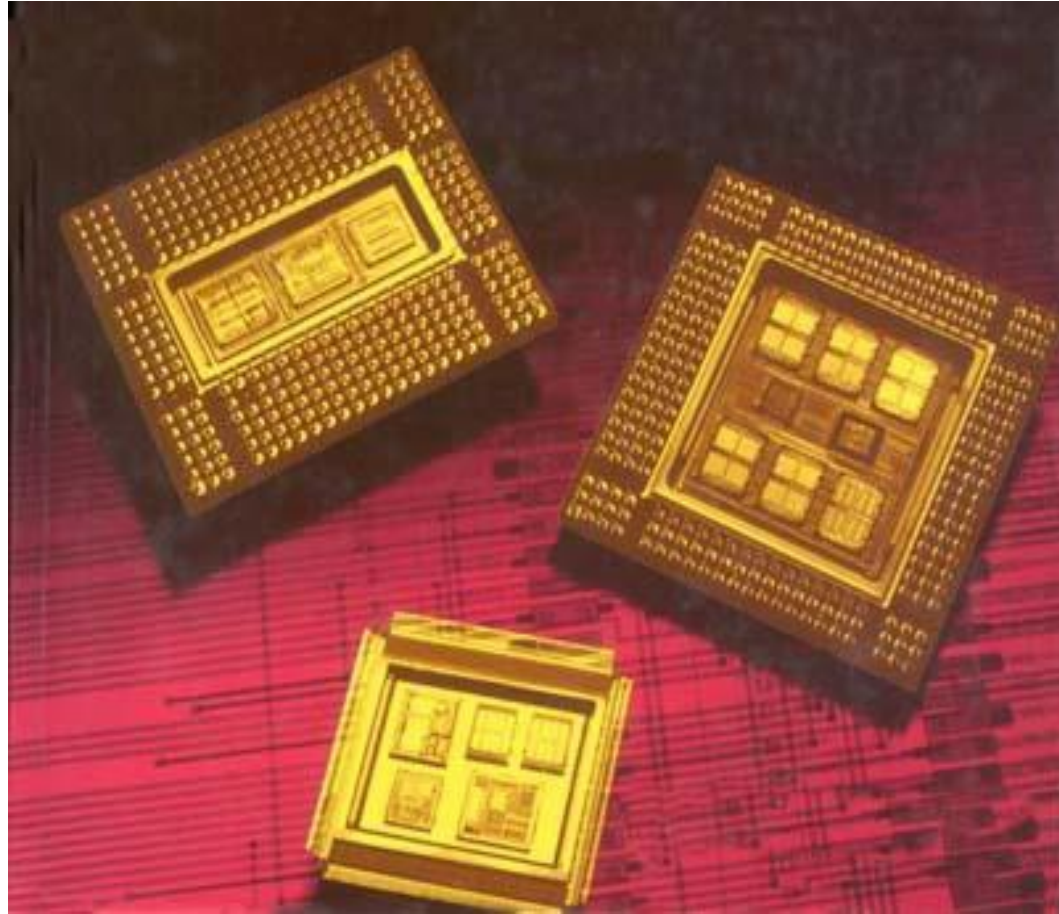
Through Hole Package	
a	 DIP (Dual In-line Package)
b	 SH-DIP (Shrink DIP)
c	 SK-DIP, SL-DIP (Skinny DIP, Slim DIP)
d	 SIP (Single In-line Package)
e	 ZIP (Zig-zag In-line Package)
f	 PGA (Pin Grid Array) or Column Package

Surface Mounted Package	
g	 SO or SOP (Small Out-line Package)
h	 QFP (Quad Flat Package)
i	 LCC (Leadless Chip Carrier)
j	 PLCC, SOJ (Plastic Loaded Chip Carrier with Butt Leads)
k	 BGA (Ball Grid Array)
l	 TAB (Tape Automated Bonding)
m	 CSP (Chip Scale Package)

## Level 2 Packaging

### Multi Chip Modules (MCM)

- ❖ MCM-D
- ❖ MCM-C
- ❖ MCM-L



## Level 3 Packaging

Printed Wiring Board (PWB)

## Level 4 Packaging

Represents final product/system and integration

- ❖ PWBs
- ❖ Subassemblies like power supplies
- ❖ Items for user interface (displays and key boards etc.)
- ❖ Special components (transformer, CRTs, fans etc.)
- ❖ Wiring
- ❖ Protective enclosure

## EXAMPLE 1

### System Integration in a Product

#### Cellular phone

- ❖ Mascot of Communication Industry

#### Needs:

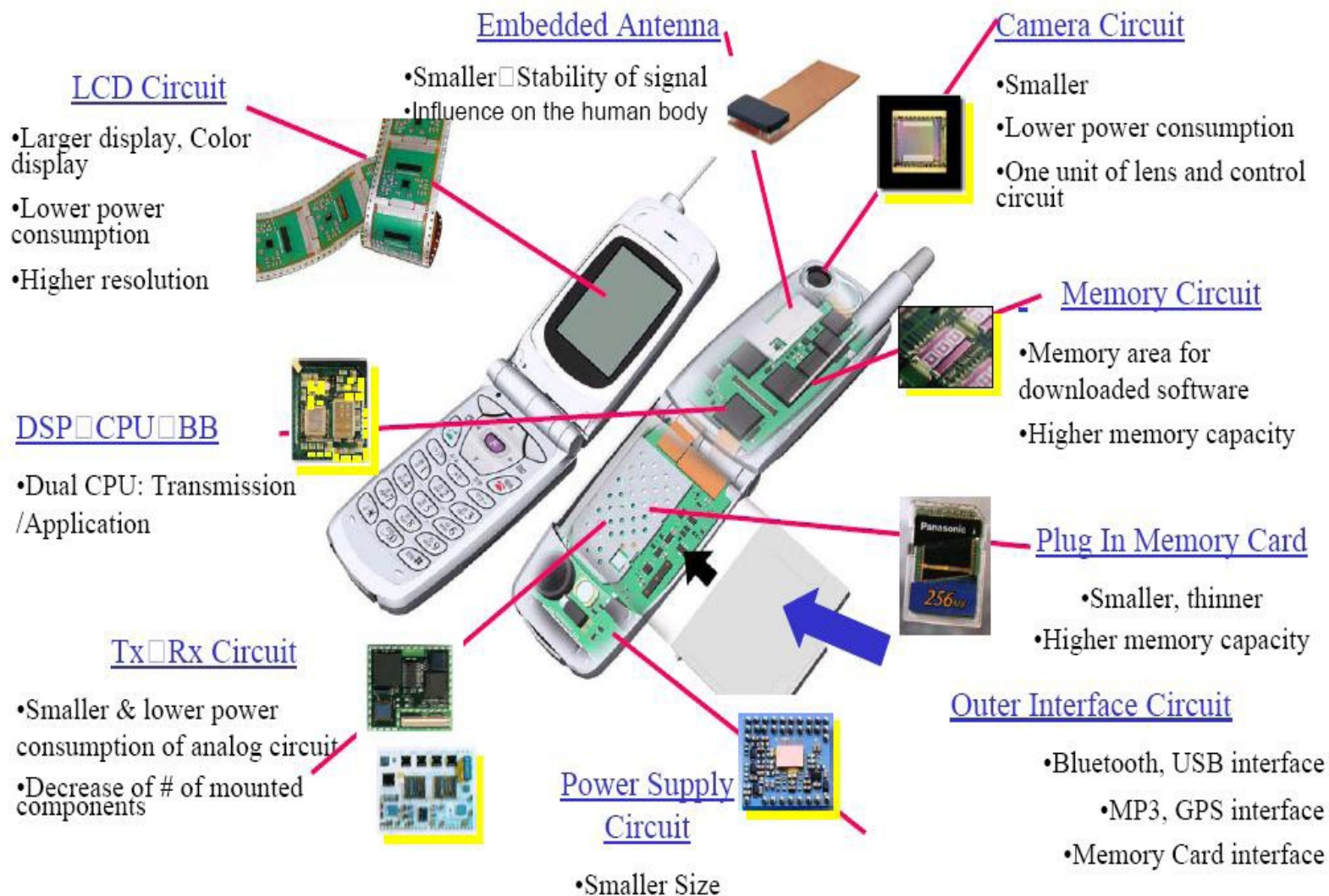
- ❖ Weight and size of the instrument are to be kept low
- ❖ Battery life should be long

# Trend in Handheld Products

- ❖ Miniaturization
- ❖ Technology Convergence
- ❖ Application Convergence
- ❖ Ubiquity and Interconnectivity
- ❖ Affordable Cost
- ❖ Performance/Reliability



# An example of system-level integration in a cellular phone



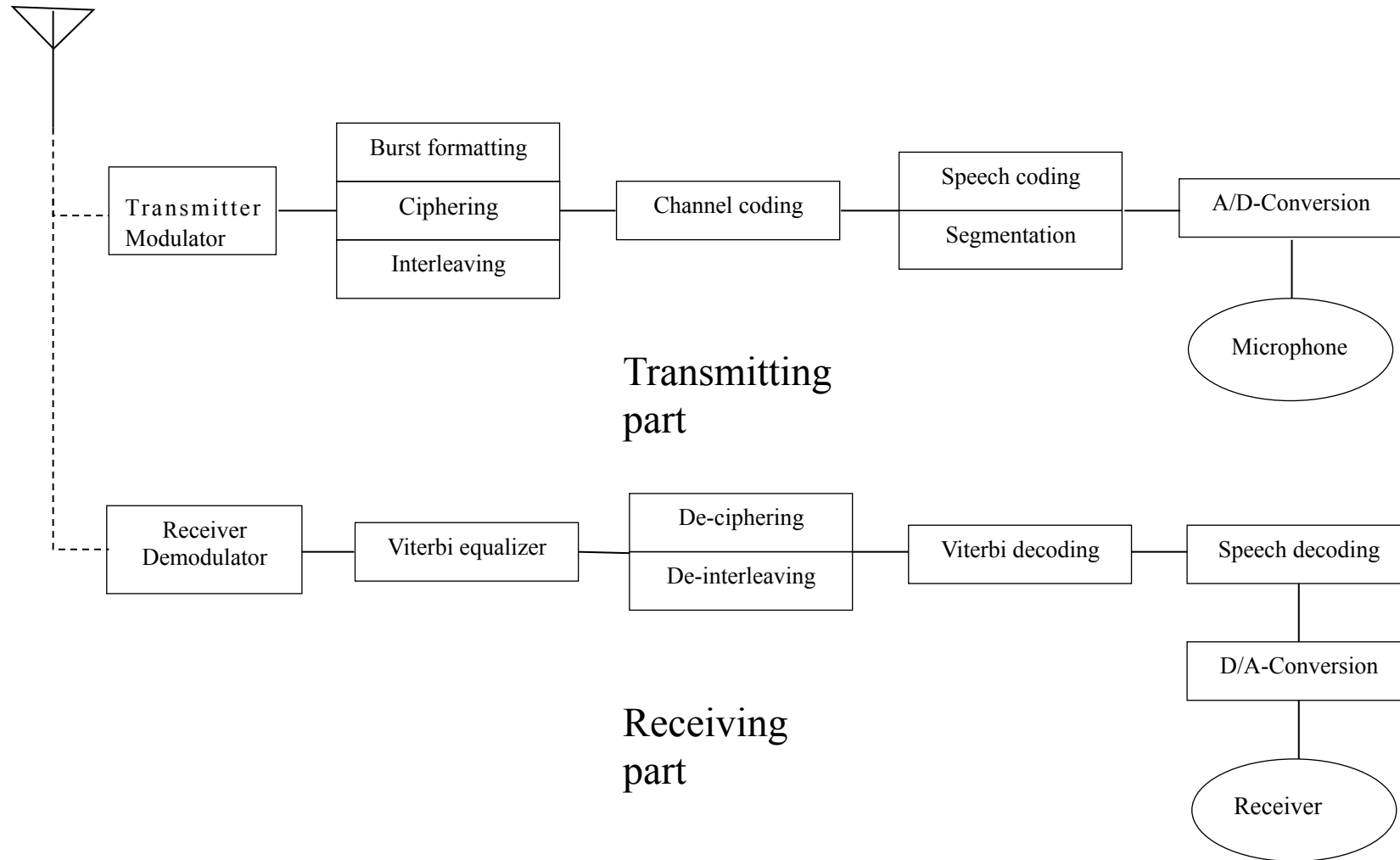
# EXAMPLE 1 of System Integration in a Product...

## Design decisions

- ❖ Use less number of ICs (higher levels of integration)
- ❖ The choice of all components (format types??)
- ❖ Methods of assembling them



# Functional Block Diagram of a Cell Phone



## Systems Requirements

### Battery operation\_

- ❖ Circuits are to be designed to maximize the life of the battery
- ❖ Health of the battery needs to be monitored
- ❖ User needs to be informed if its charge is going down below a minimum level
- ❖ Must have provision for charging the battery when it is plugged to a power point
- ❖ Subsystems of the unit require different power supplies generated from the same battery

## System Requirements (Contd.)

- ❖ Low weight of the unit
- ❖ Minimization of the number of ICs used (voice CODEC (coder/decoder), digital signal processor, speaker amplifiers power-conditioning units, supply voltage supervisors)
- ❖ Up to 60 discrete (R, C) components may be needed (they occupy space on the board)

## Cell phone requires

- ❖ Displays, keypads
- ❖ Battery compartments
- ❖ Housing for the microphone
- ❖ Speaker
- ❖ Antenna

## Majority of the cell phones on the market

- ❖ RF, digital sections, power supplies on one board
- ❖ LCD display, the keypad and the related circuitry on the second board
- ❖ Front cover incorporates the speaker and the microphone
- ❖ Back cover will house the antenna, and battery

## Competition for the cell phone market is intense

- ❖ Companies would not risk using new technologies whose yields and reliabilities are not completely established
- ❖ Companies use mature technologies and components

## Competitive advantages are created through

- ❖ More memory
- ❖ Functional features (through software)
- ❖ Industrial design (attractive color combinations, convenient shapes etc.)

Trends in mobile phone growth: Increased packaging efficiency due to high-density chip packages (low-cost yet high-performance)

IC Component Counts

Average number of ICs for phones made before 2000 is 21; average for 2000 and later is 12.

IC Package Areas

Average IC package area for phones made before 2000 was 18; average for 2000 and later is 9.

Average IC Pins per cm<sup>2</sup> of package area

Average IC pins per cm<sup>2</sup> of package area for phones made before 2000 was 37; for 2000 and later is 76.

# CDMA Phones

## *Past & Present*

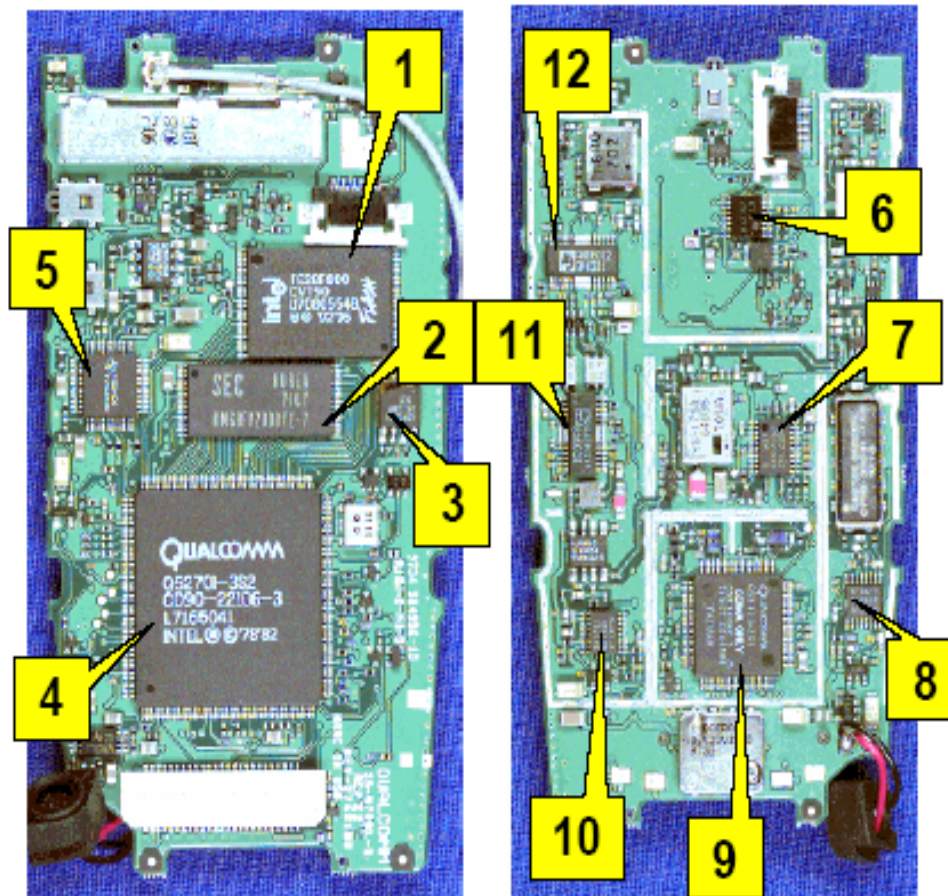


**1997 Qualcomm Q Phone**  
102 mm x 56 mm x 25 mm  
147 grams



**2001 Samsung SPH-x4200**  
89 mm x 50 mm x 24 mm  
94 grams

## Dual-Mode Phone (CDMA 800 MHz & Analog)



- All ICs packages have peripheral leads.

- All 12 of the ICs directly support phone functions in some way

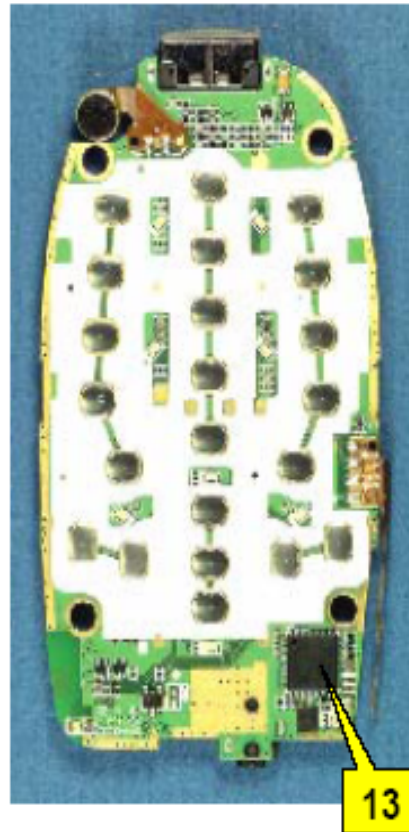
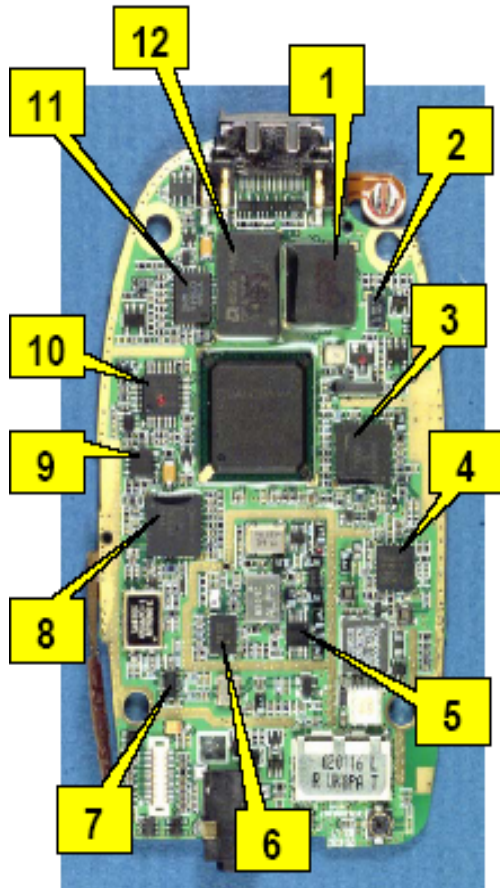
1. Flash Memory
2. SRAM Memory
3. EEPROM Memory
4. Baseband CDMA Processor
5. Controller
6. Multiplexer
7. Dual Frequency Synthesizer
8. Rx AGC Amplifier
9. Baseband Analog Processor
10. Tx AGC Amplifier
11. Power Amplifier
12. Linear Amplifier

- 20.1 cm<sup>2</sup> of IC packaging

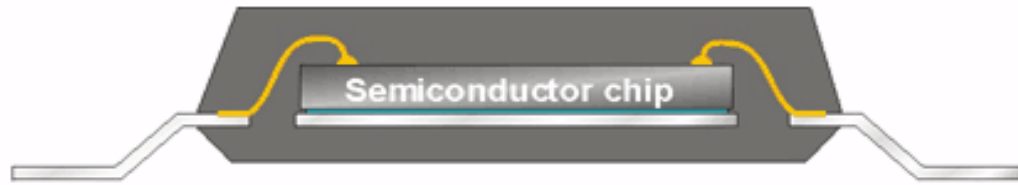
- 608 IC Pins



## CDMA-2000 Phone



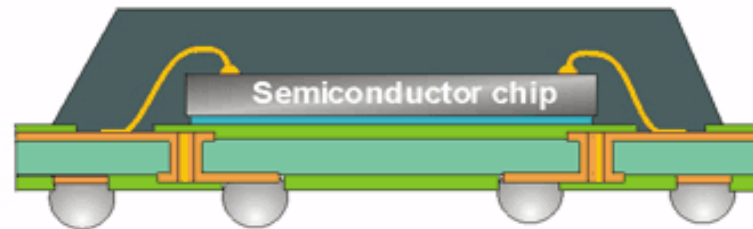
- Almost all ICs are packaged into area array type packages.
- The phone functions performed by 13 ICs:
  1. Fujitsu Flash and NEC FCRAM memory
  2. Atmel EEPROM (**WL-CSP**)
  3. Tx Processor
  4. Tx ASIC
  5. Voltage Regulator
  6. PLL / Synthesizer
  7. LNA / Mixer
  8. Rx Processor
  9. Dual Comparator
  10. Audio Processor
  11. Audio Synthesizer
  12. AMD Flash & Samsung SRAM
- **9.5 cm<sup>2</sup> of IC packaging**
- **714 IC Pins**



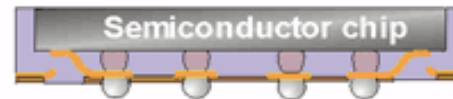
**Lead frame**



**Lead frame (CSP)**



**BGA**



**BGA (CSP)**

# GSM Phones

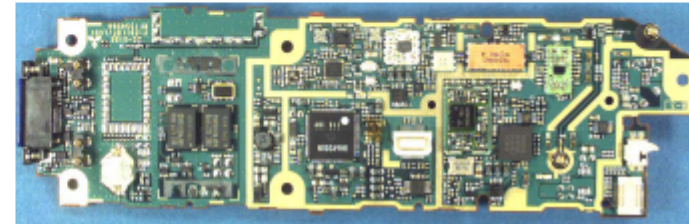
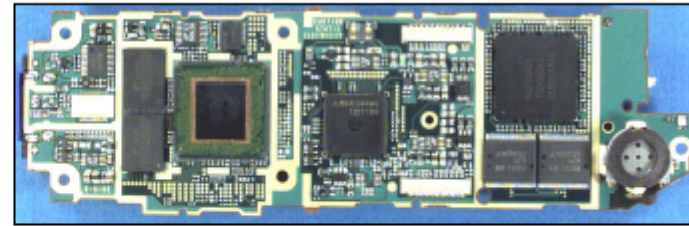
## *Past & Present*



**1996 Nokia 1610**  
160 mm x 58 mm x 28 mm  
250 grams



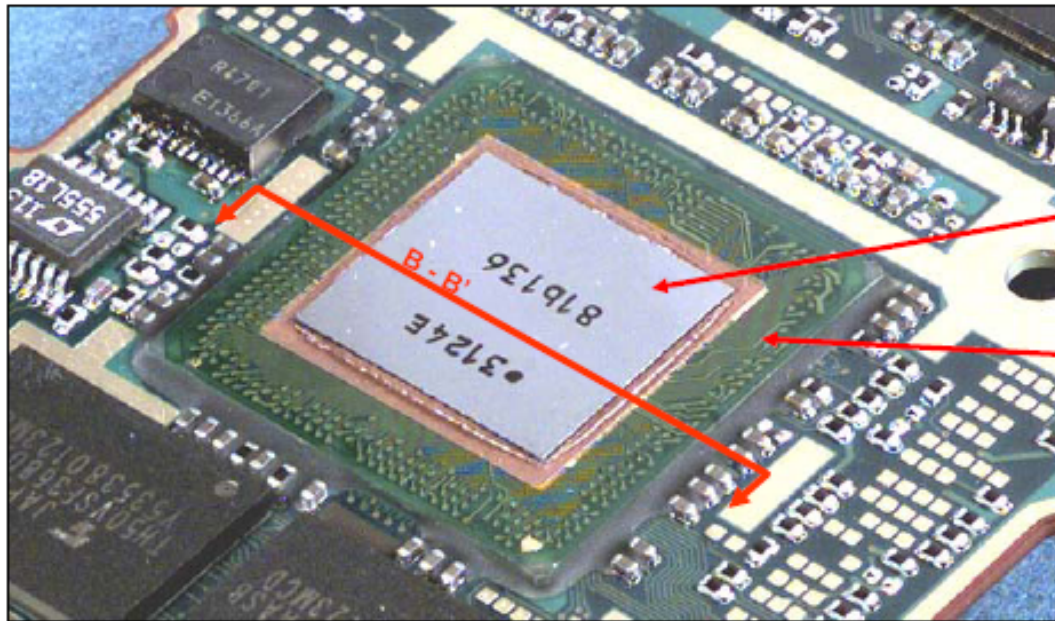
**2001 Nokia 8310**  
97 mm x 43 mm x 17 mm  
84 grams



## Mitsubishi D2101V

### *“Extreme” IC Packaging Techniques*

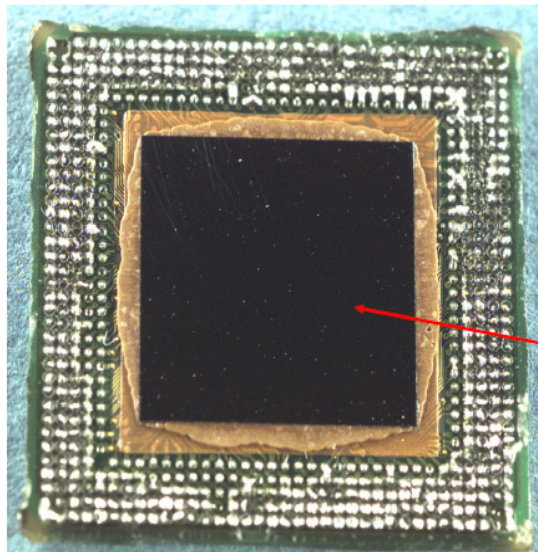
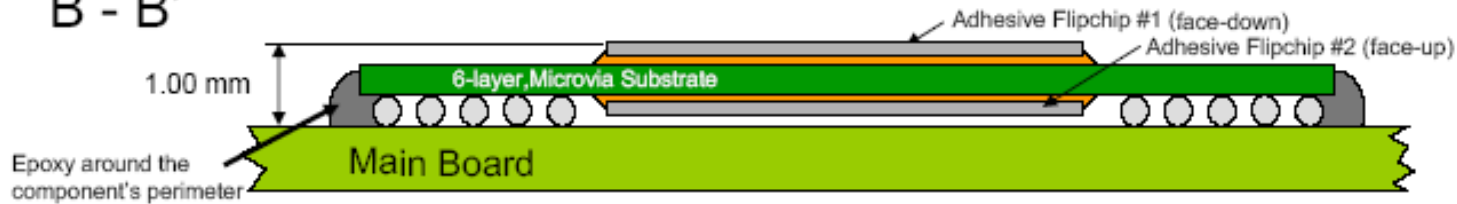
- **Dual Chip BGA Package assembled with Adhesive Flip Chip**
  - The first use of adhesive flip chip bonding of a large processor type IC that was made even more notable by having two chips bonded on both sides of a substrate. Also notable was that the chips were extraordinarily thin.
- **Stacked Processor ICs**
  - Stacked memory chips (e.g. combinations of Flash and SRAM) have become common place; but this is the first observed instance of two large processor ICs being stacked.
- **Multi-Chip Modules**
  - Two custom (hybrid) components in the form of fine-pitched BGAs.



Top Die Size  
10.6 x 11.8 x 0.2 mm

Package Size  
22.0 x 22.0 x 1.0 mm

B - B'



620 IOs on a 0.5 mm pitch.

Bottom Die Size  
10.6 x 10.6 x 0.15 mm

IC Pin Counts

Average pin count for phones made before 2000 is 623; average for 2000 and later is 643.

CDMA: IC die area to package area ratios

Average IC chip area to package area ratio for phones made before 2000 is 0.17; average for 2000 and later is 0.27.

## EXAMPLE 2- Personal Computers (PCs)

- ❖ IBM-compatible computers using the DOS, OS/2 or Windows (NT) operating system
- ❖ The first PC: IBM in 1982
- ❖ The first PC was built with 8086 CPU from Intel and DOS operating system supplied by Microsoft

### Present day PC is multifunctional:

- ❖ number crunching application
- ❖ multimedia entertainment
- ❖ Internet access

## Greatest strength of the PC is its modularity

PCs are made up of many different individual modules, which can be mixed and matched in thousands of different configurations.

### Components of a PC

- ❖ System Case
- ❖ Mother Board
- ❖ Hard disk Drive
- ❖ Floppy Drive
- ❖ CD-ROM Drive/DVD Drive
- ❖ Peripheral Interfaces
- ❖ Monitor
- ❖ Mouse
- ❖ Keyboard
- ❖ Peripherals

Available with a wide range of performances and capacities from multiple vendors



## System Case

- ❖ Metal and plastic box that houses the main components of the computer
- ❖ Not considered very important part of the computer
- ❖ Not as critical to the system as some other computer components

## Features

- ❖ Motherboard mounts into the case
- ❖ Internal components mount into either the motherboard or the case itself

## Features...

- ❖ Must provide a solid structural framework for these components to ensure that everything fits together and works well
- ❖ Protects the inside of your system from the outside world, and vice-versa
- ❖ Forms a critical part of proper system cooling
- ❖ Organization and Expandability
- ❖ Aesthetics
- ❖ Status Display

## Motherboard

- ❖ Provides working place for all of the components of the PC to interface
- ❖ Divided into a **bus board** (with slots) and a **separate processor board** in a Modular PC
- ❖ Slots for main memory and additional adapter cards
- ❖ Adapter cards include graphics adapters, controllers, multimedia

## Low Cost PC

- ❖ Total area of PCBs is reduced
- ❖ Significant reduction in PCBs associated with the peripherals
- ❖ Board density is less
- ❖ Uses a last-generation microprocessor
- ❖ Power dissipation lower, and lower cost heat sinks are used

