Some Trends and Impacts of Micro/Nanoelectronics

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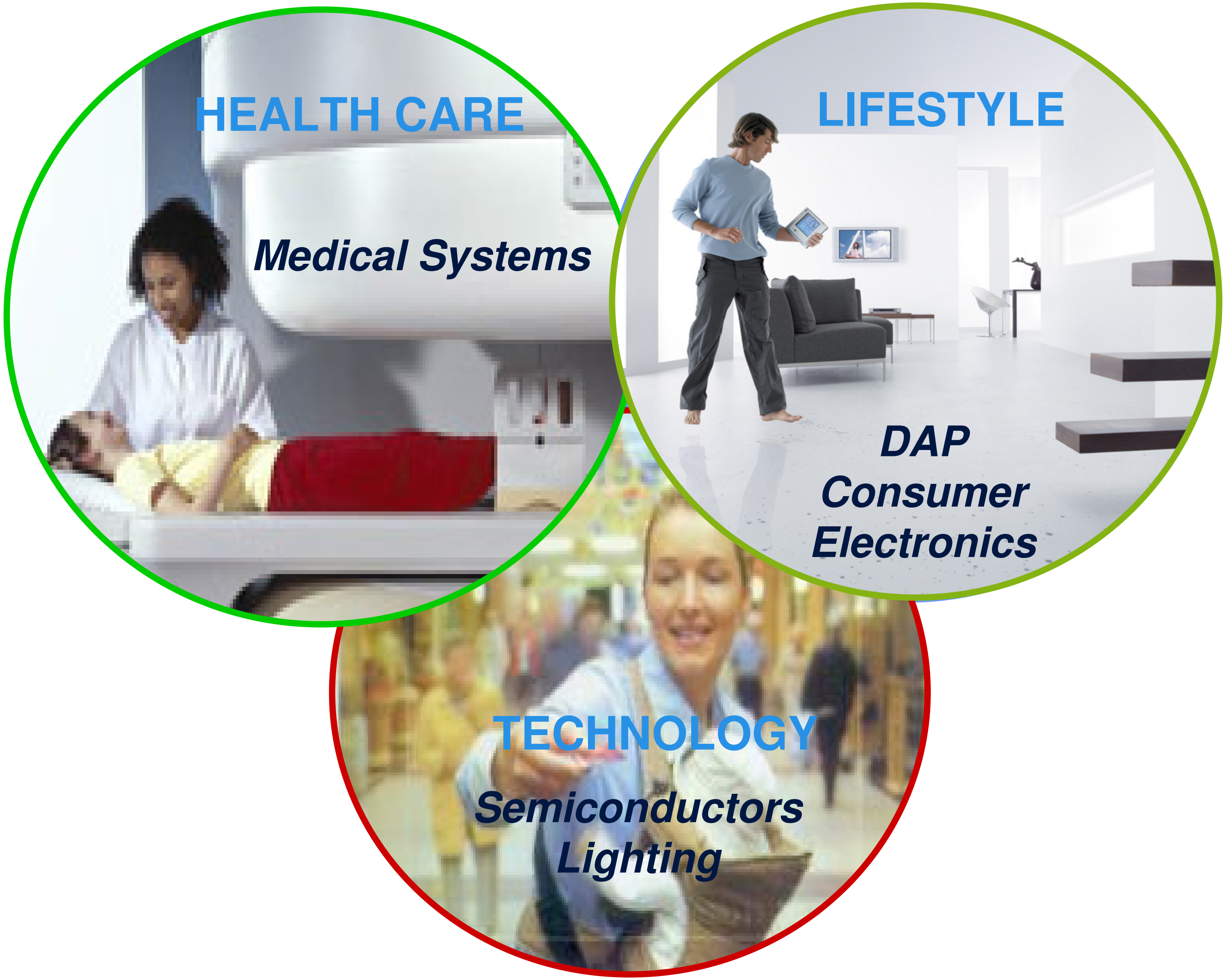
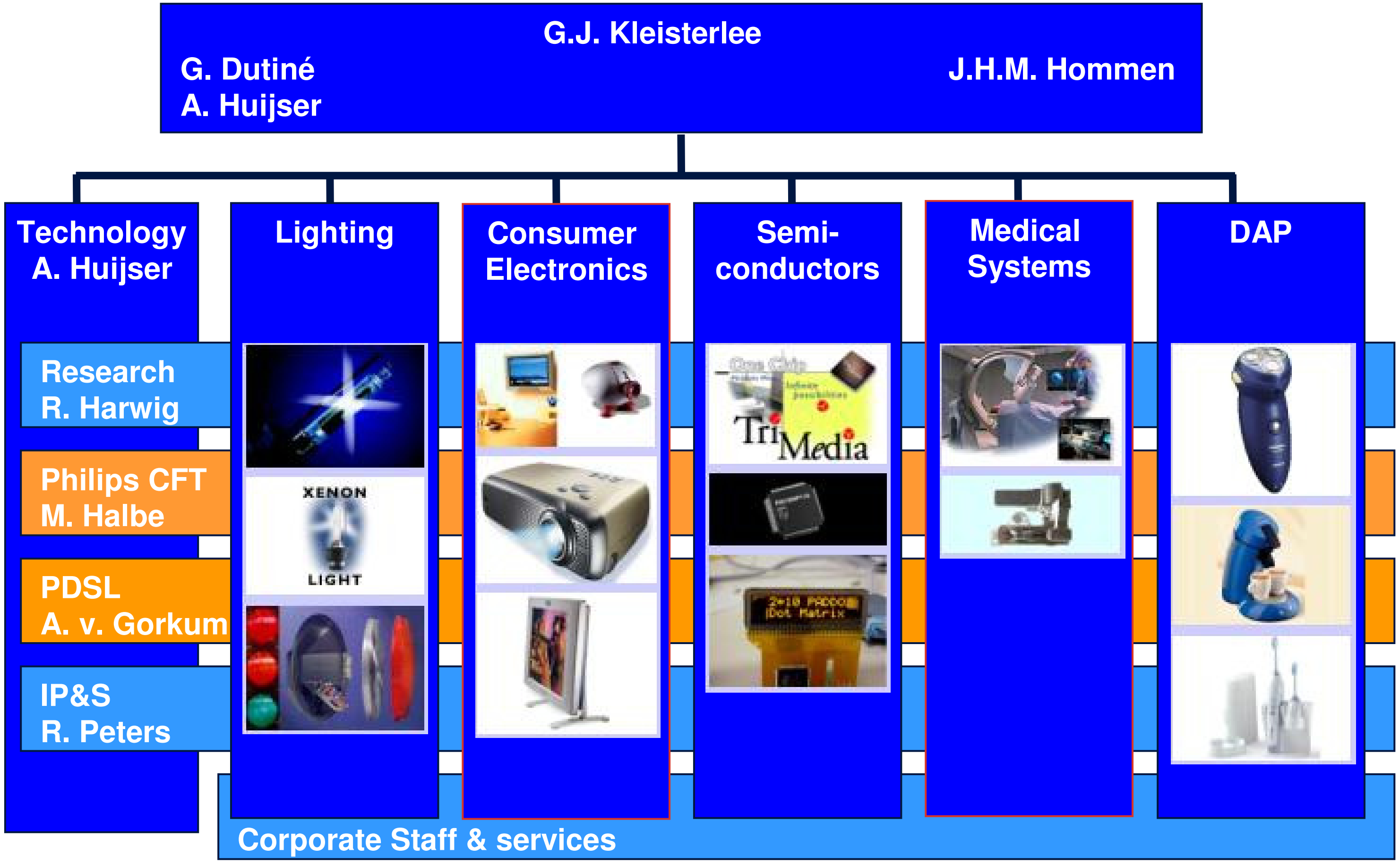
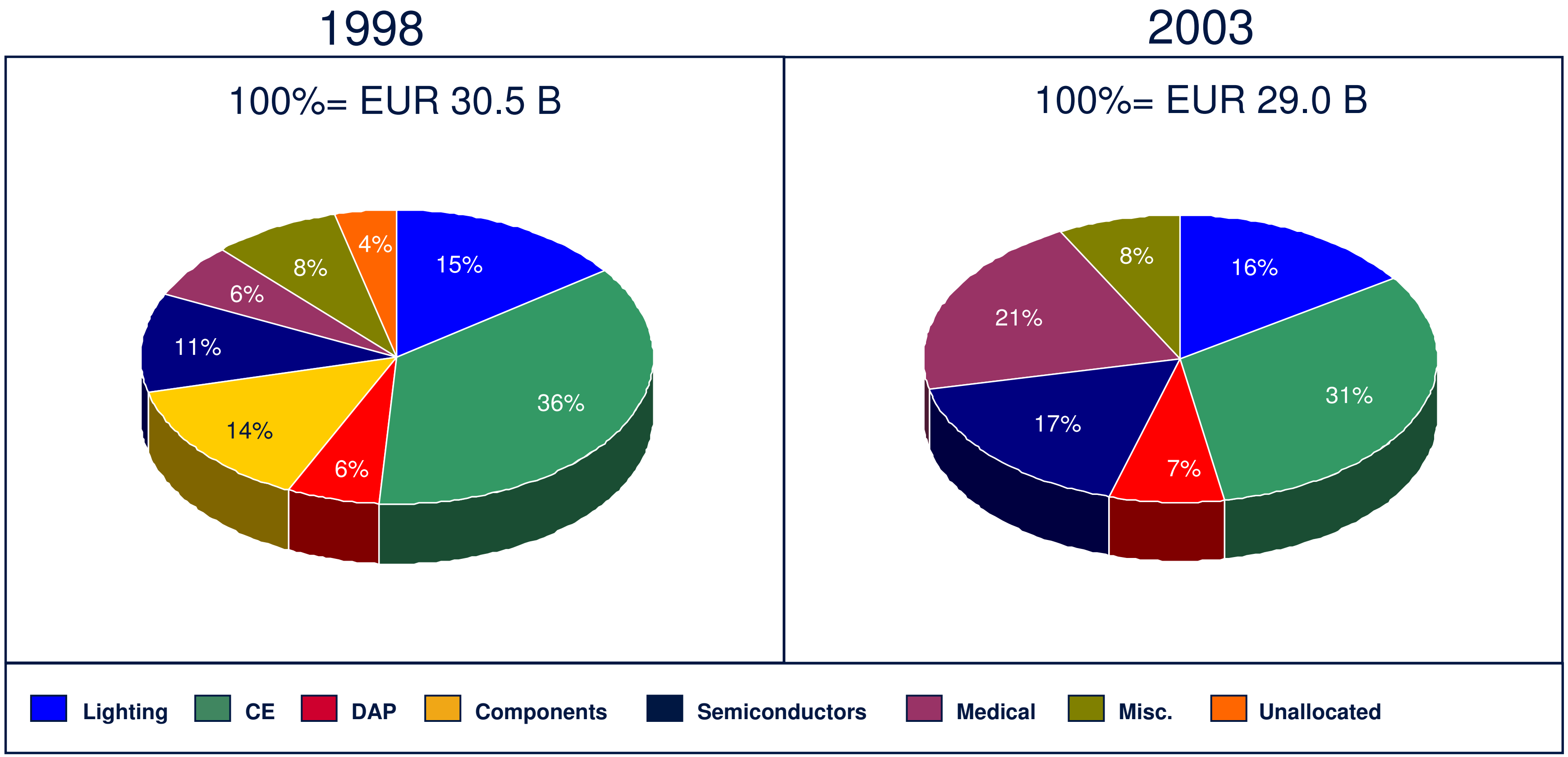

HEALTH CARE
Medical Systems
LIFESTYLE
DAP
Consumer
Electronics
TECHNOLOGY
Semiconductors
Lighting

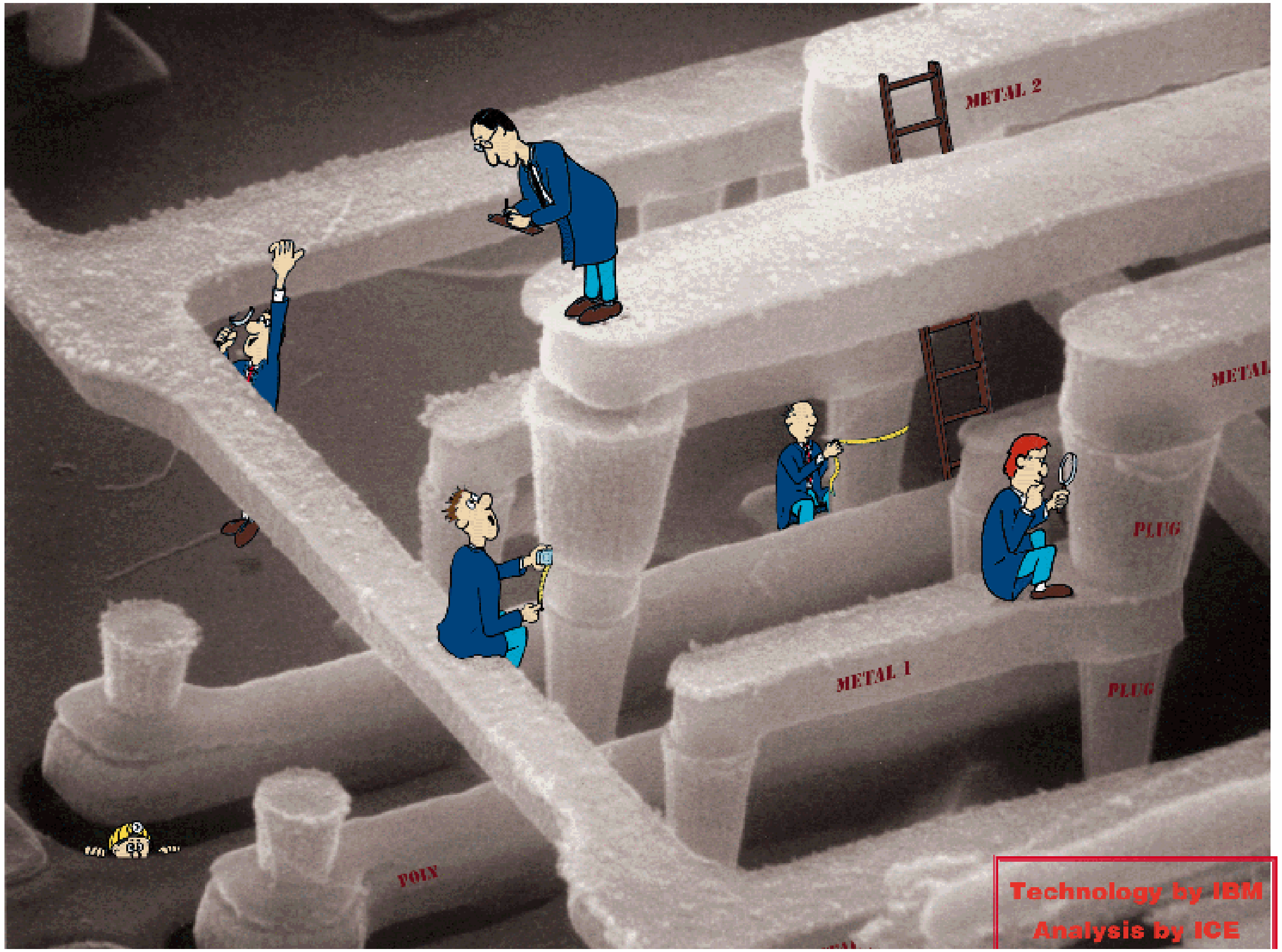
Board of Management

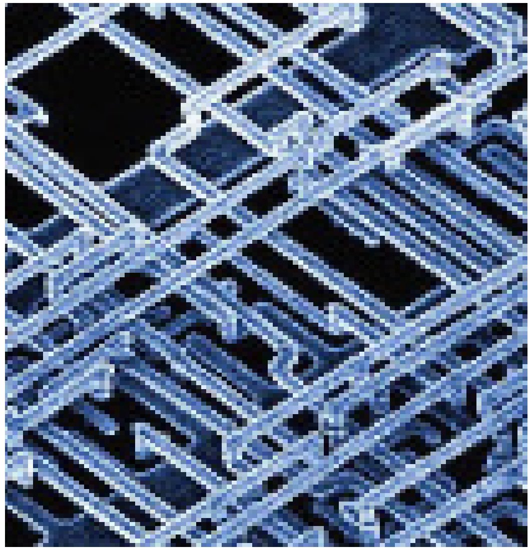


Philips today

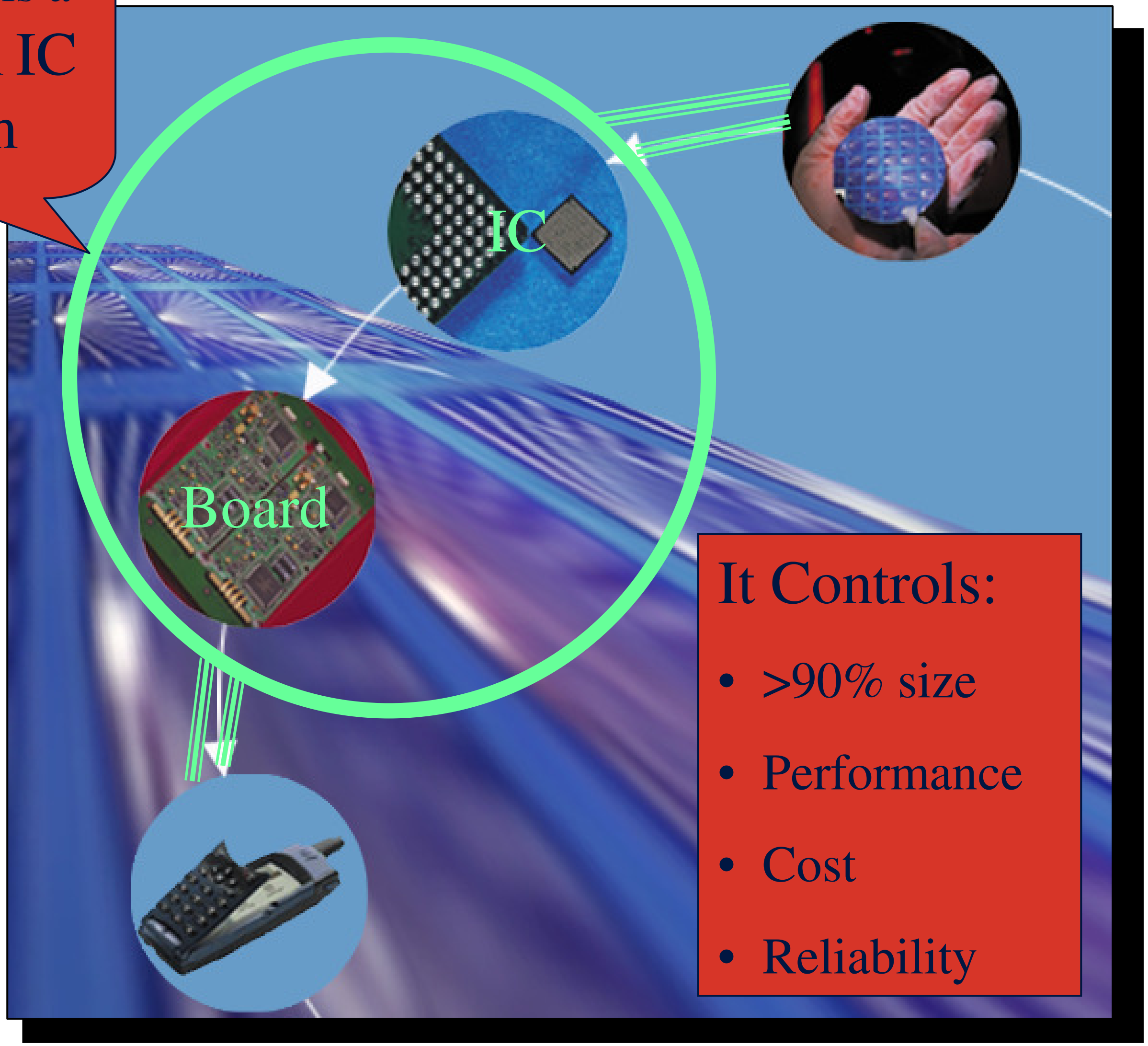
Sales per sector, *as % of total*




METAL 2
METAL
PLUG
METAL 1
PLUG
POLY
Technology by IBM
Analysis by ICE



Packaging is a Bridge from IC to System

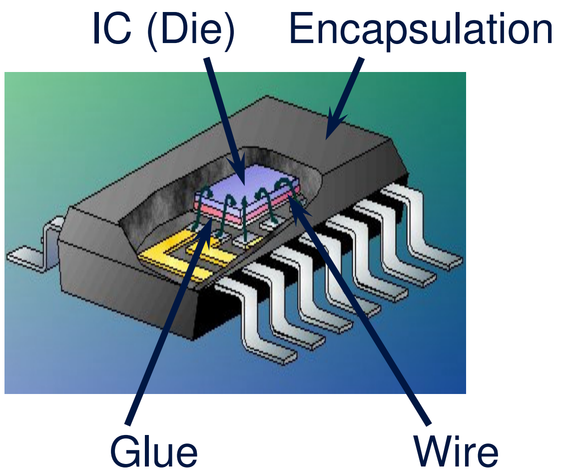


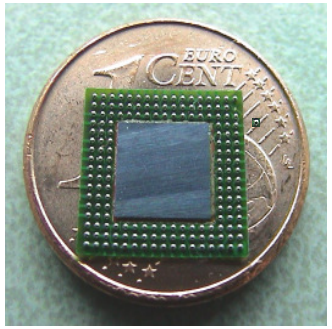
It Controls:

- >90% size
- Performance
- Cost
- Reliability

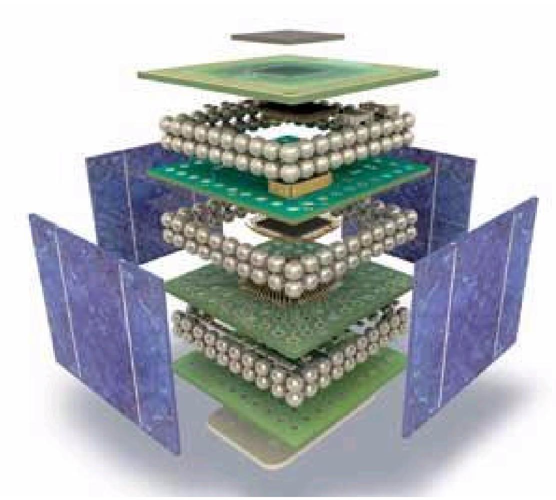
Definition

- A means of “protecting, powering, cooling and interconnecting an integrated circuit”
- An integrated circuit form factor conversion providing compatibility with mainstream second level assembly and multi-functionality

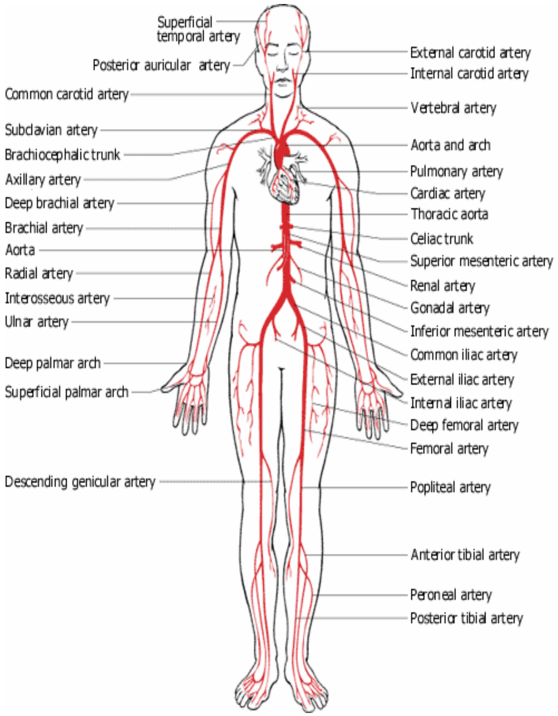




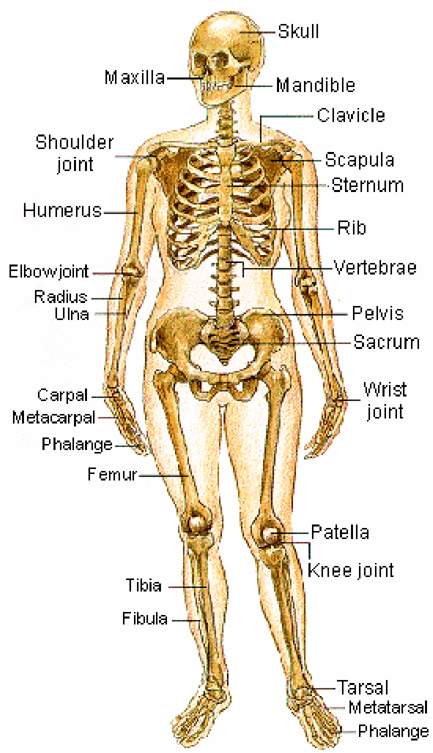
Ultra-thin BGA package
(9x9 mm, 300 um thick)



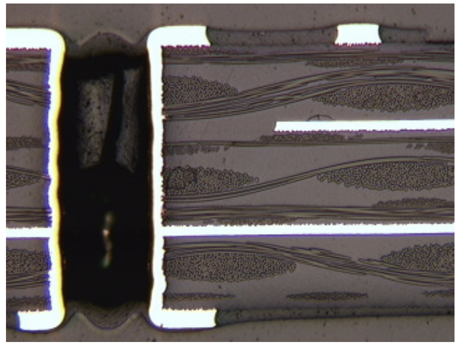
Electrical Interconnect

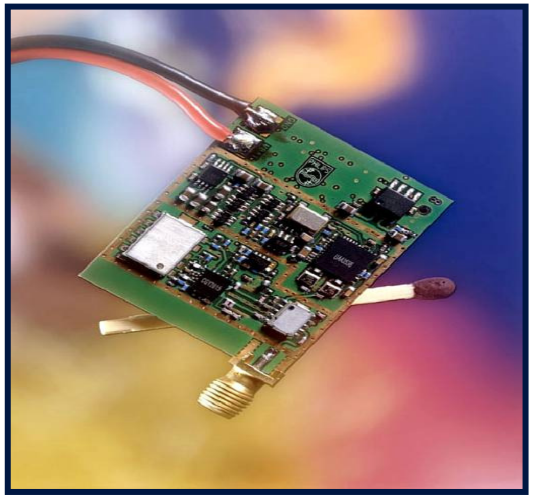


Component Carrier & Construction Part

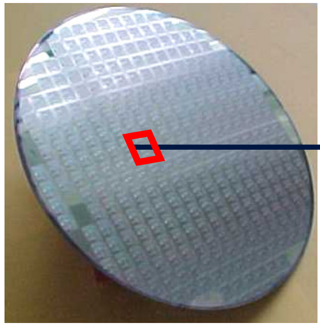


- **Single Sided**
- **Double Sided**
- **Multilayer**
- **Build-up Multilayer**

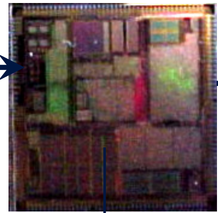




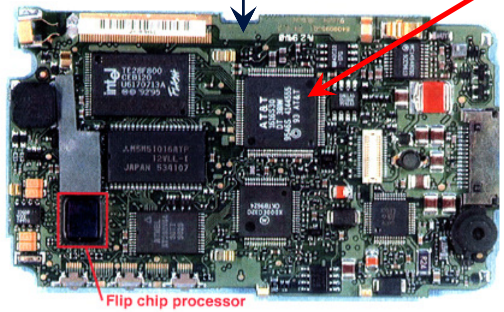
Wafer



Single IC



Package



Source: Motorola.

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Outline

1. Development trends

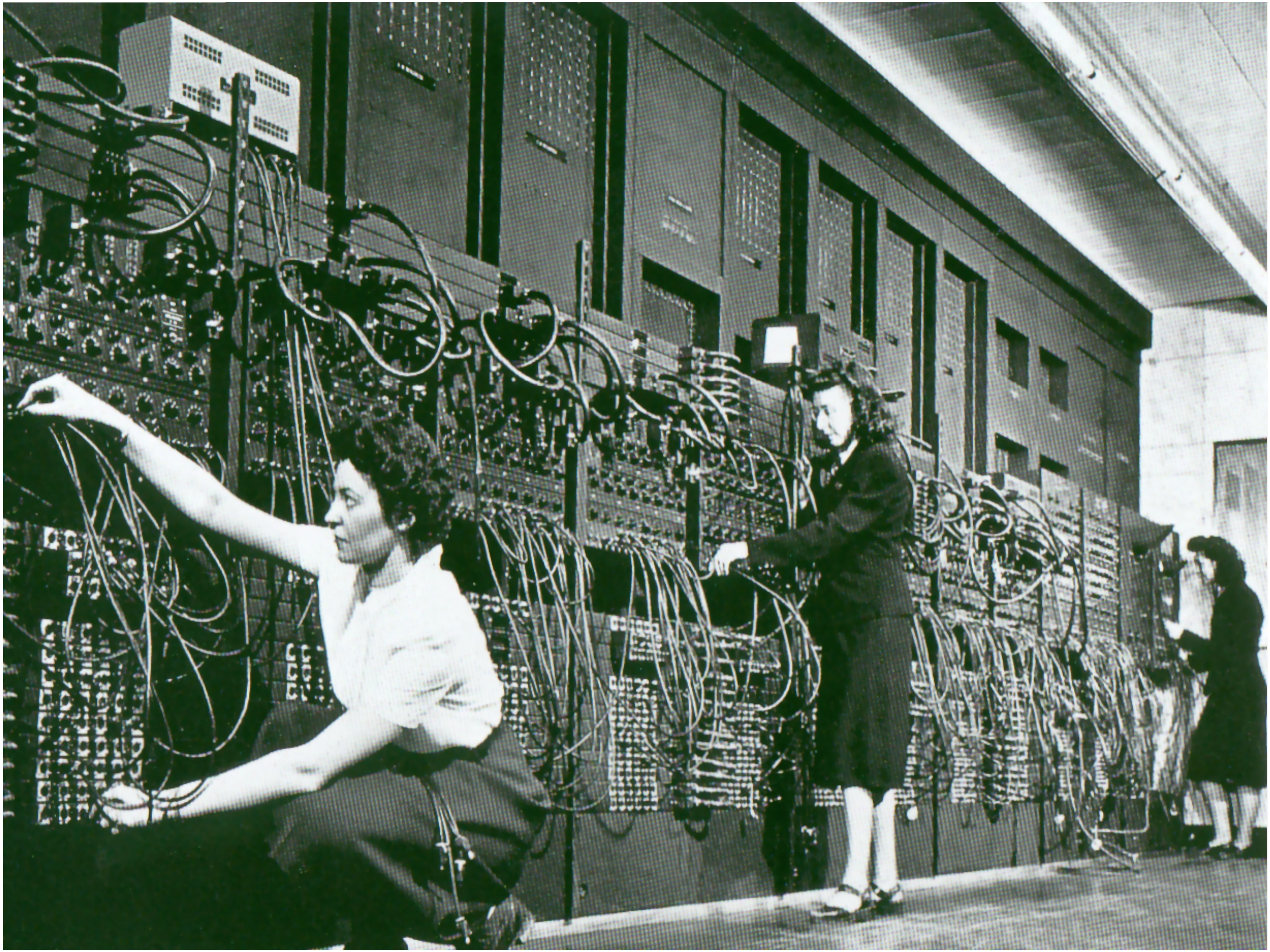
2. Characteristics and Consequences

3. Challenges

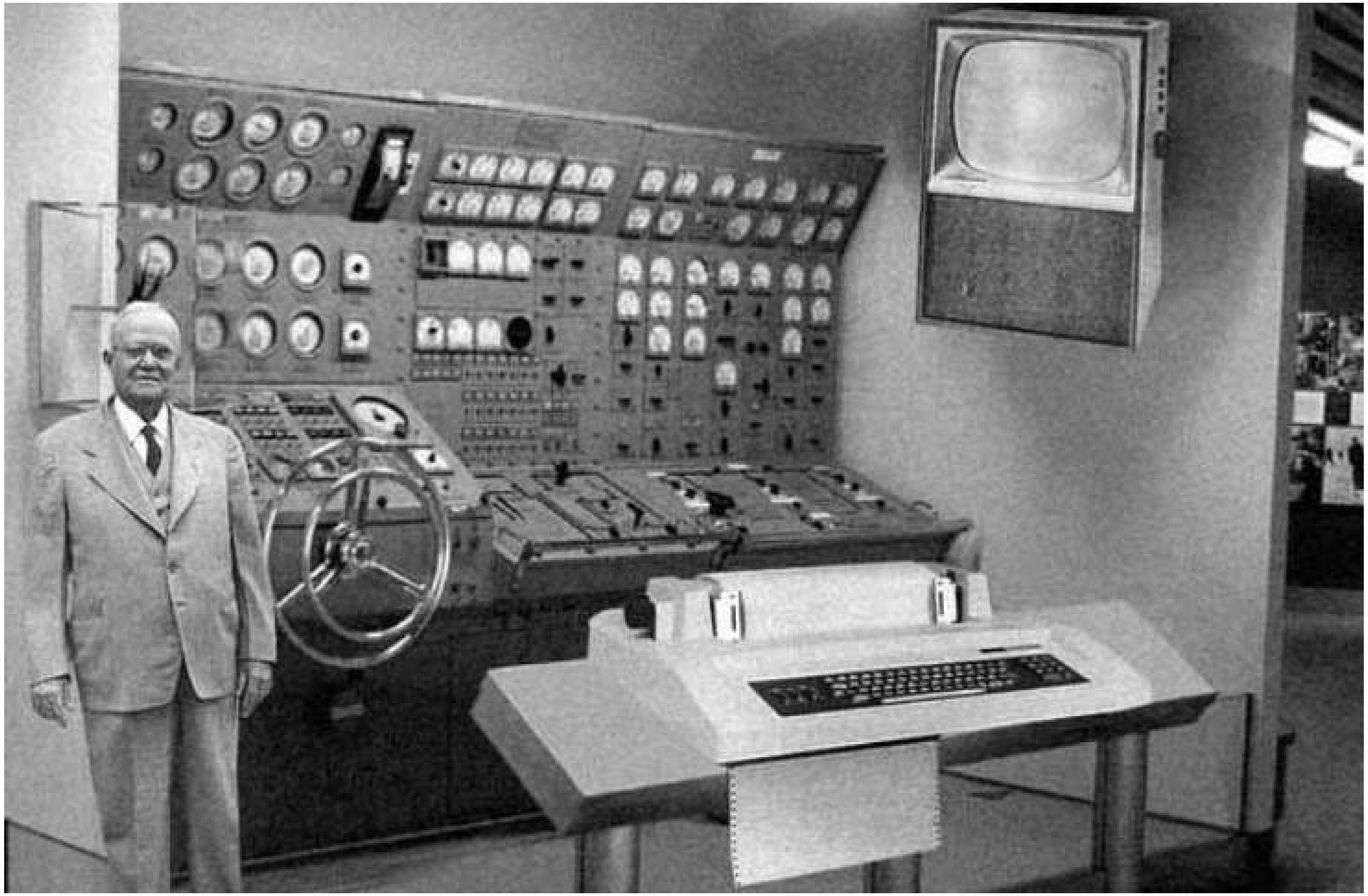
4. Eniac /7FP

5. Concluding remarks

1. Development trends



Example: A 1954 ”vision” on the home of 2004

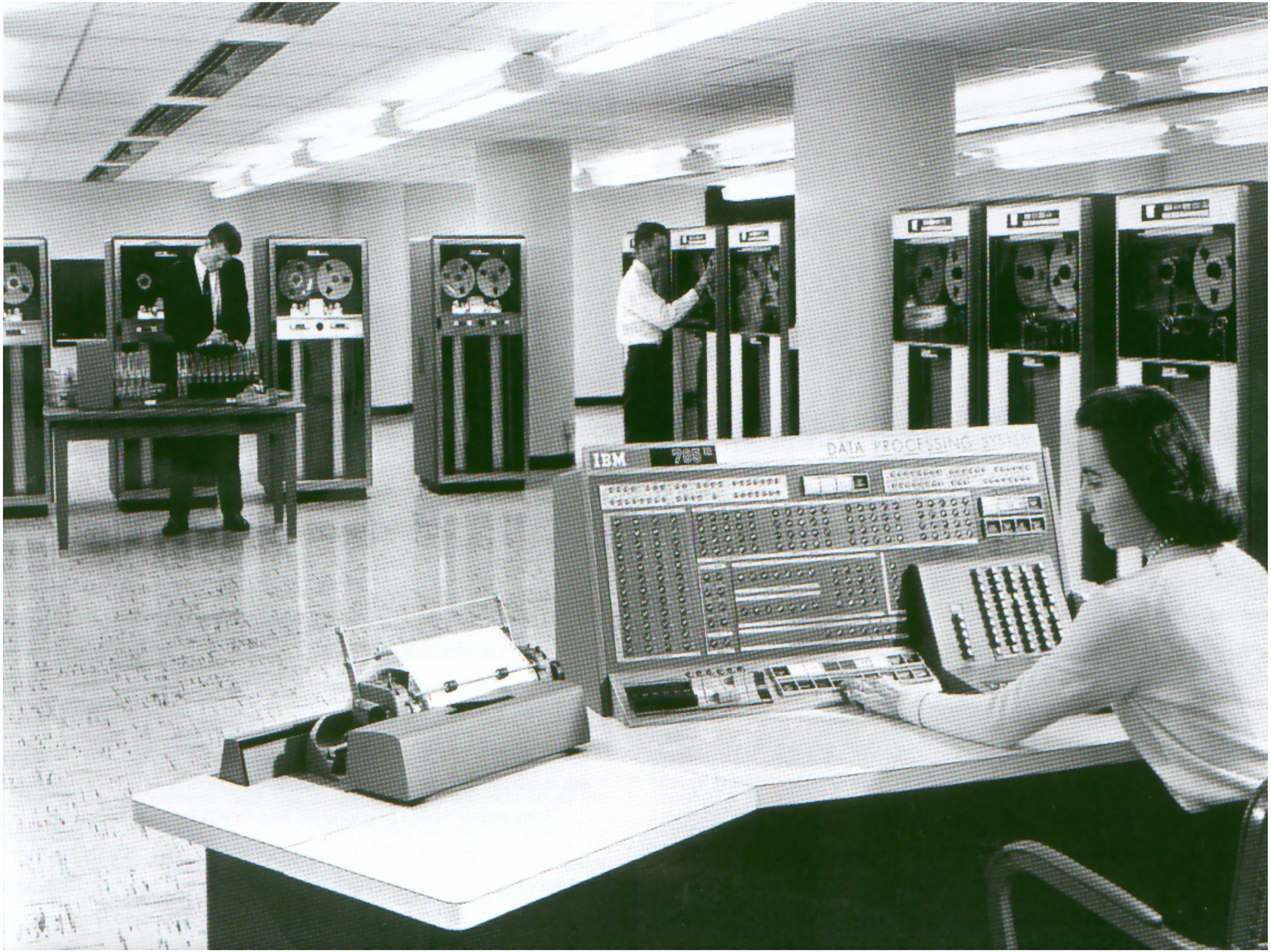


Scientists from RAND Corporation have created **this model to illustrate how a “home computer” could look like in the year 2004**.

However the needed technology will not be economically feasible for the average home.

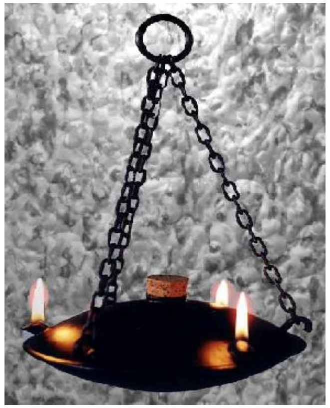
Also the scientists readily admit that the computer will require not yet invented technology to actually work, but 50 years from now scientific progress is expected to solve these problems.

With teletype interface and the Fortran language, the computer will be easy to use.


IBM
705 III
DATA PROCESSING SYSTEM

Revolutions in lighting

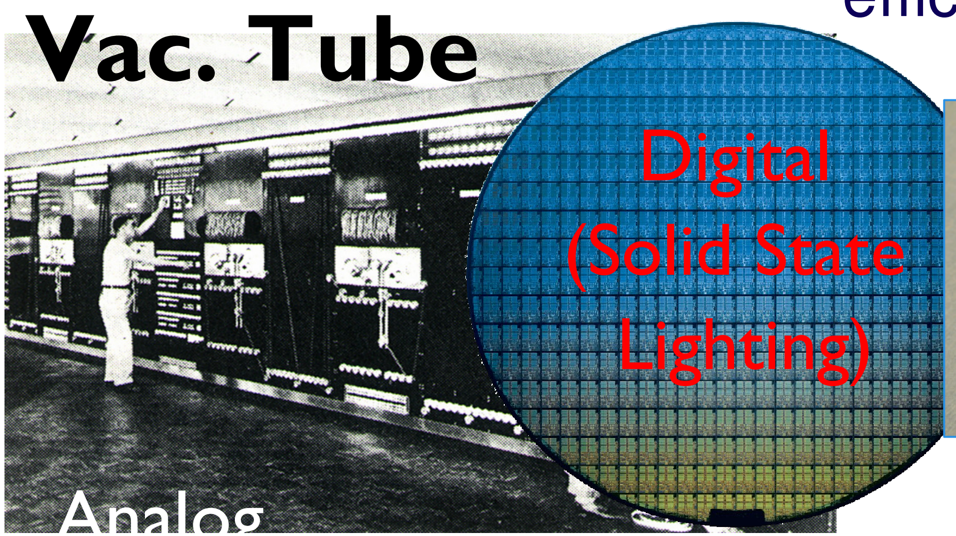
Open fire

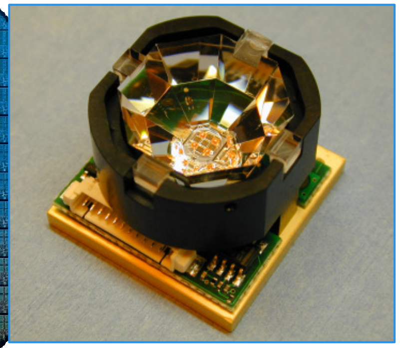


Tamed fire

more efficient

glass bulb

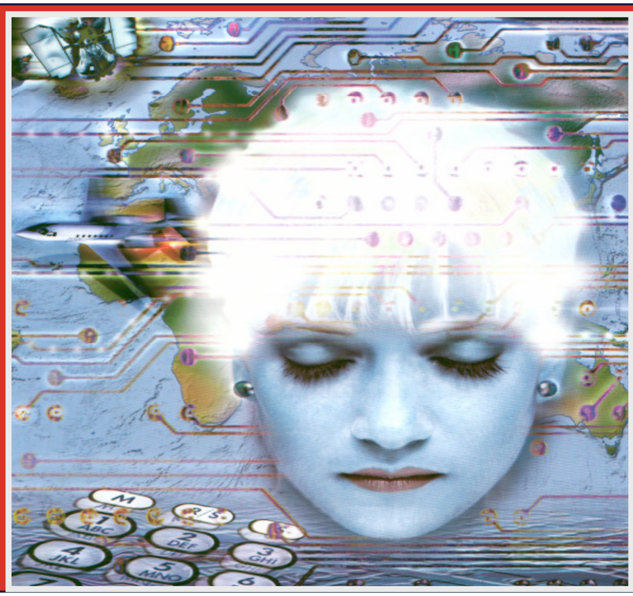





Peace And Noise
BBC1
BBC2
Canal4
ABC
Rai Uno
TV1
TV2
TV3
KetNet
15:30
Soft and wearable electronics
Conductive fabric (stretched)

Ambient Intelligence

Environments that are sensitive and responsive to the need and presence of people



Embedded	**Many invisible distributed devices throughout the environment,**
Context aware	**that know about their situational state**
Personalized	**that can be tailored towards your needs and can recognize you,**
Adaptive	**that can change in response to you and your environment**
Anticipatory	**that anticipate your desires without conscious mediation**

Ambient Intelligence

Consumer wishes

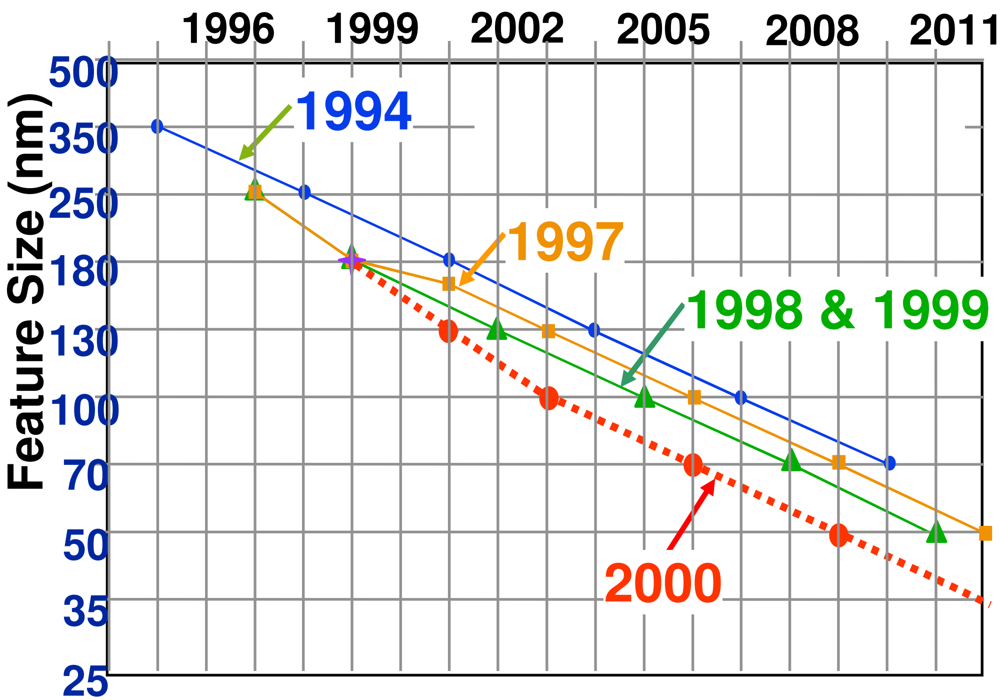
Smaller, smarter, lighter, faster, cheaper, more flexible, more convenient, more reliable and functionalities.

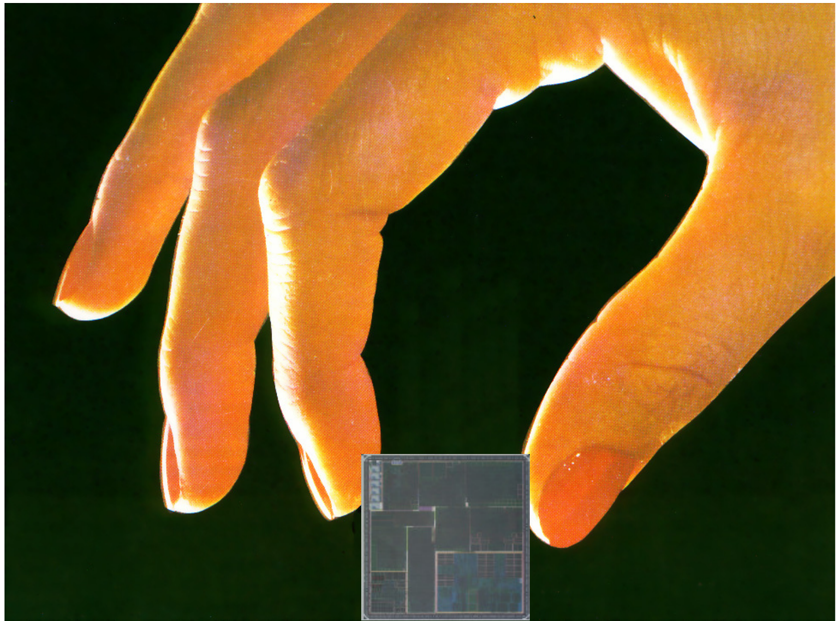
Tech development trends

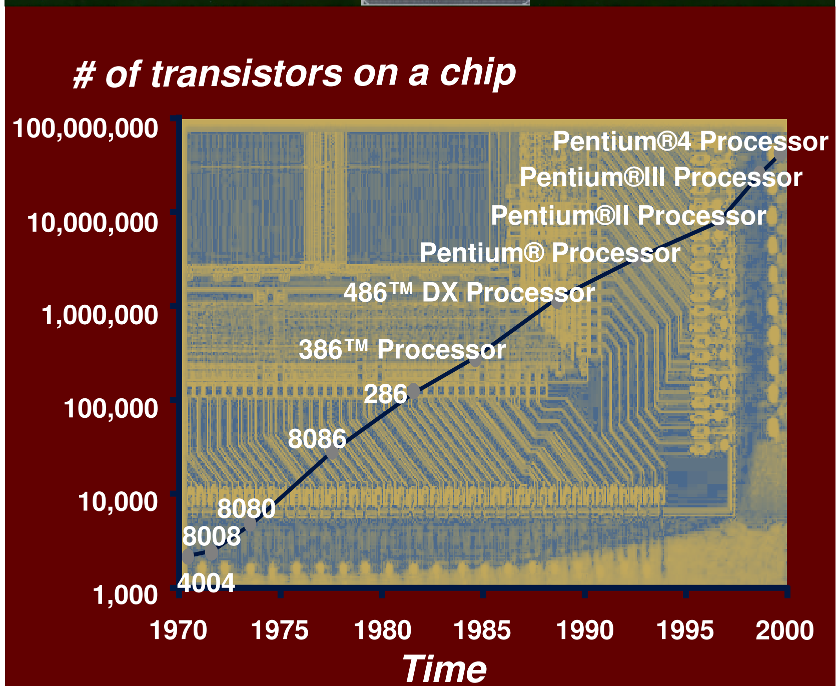
- **Moore's law**
- **More than Moore**

Moore’s law

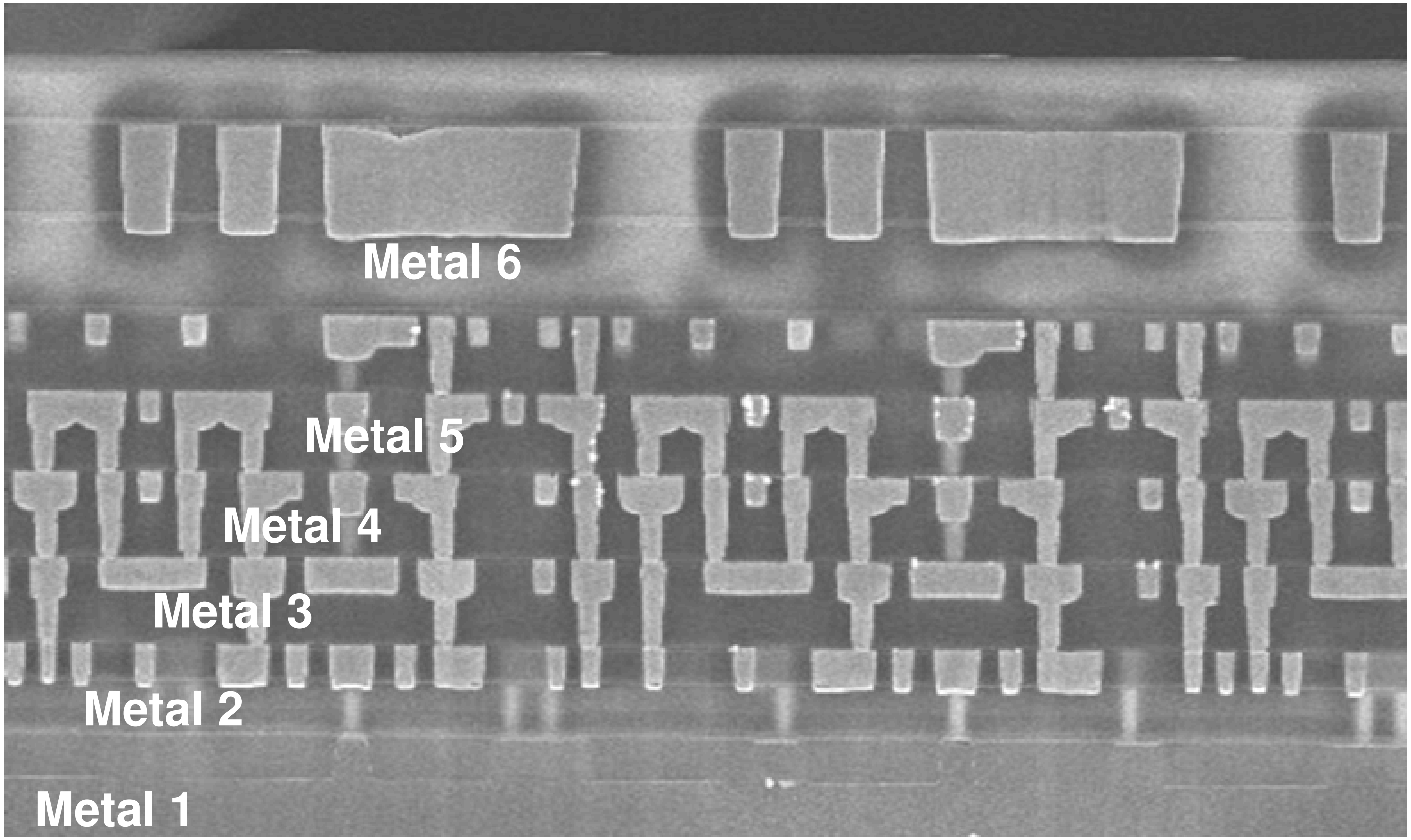
The chip circuitry will double every 18 months!







CMOS090 baseline cross section C*u-SiOC interconnect (Crolles2 300mm pilot line)*



Packaging & assembly

•Wire diameter	< 10 microns
•Interconnect pitch of NLWSP	< 20 microns
•Thickness of copper film/PCB	< 5 microns
•Microvia diameter	< 20 microns
•Wafer thickness	< 40 microns

Not only the wafer technology, packaging and assembly are also going beyond visualization!

Is the Roadmap Going to End?

Let’s see some famous forecasts

I think there is a world market for maybe five computers

Thomas Watson, Chairman of IBM, 1943

Computers in the future may weigh no more than 1.5 tons

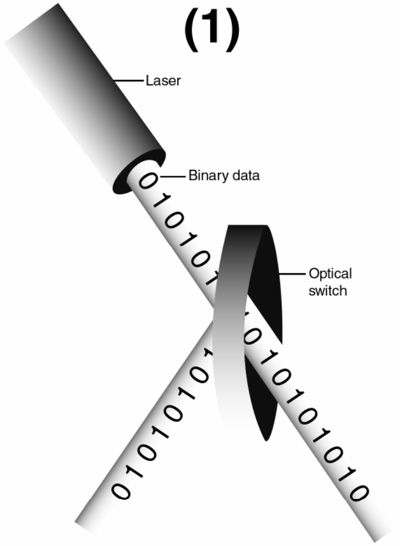
Popular Mechanics Magazine, 1949

“ 640K ought to be enough for anybody ”

Bill Gates, 1981

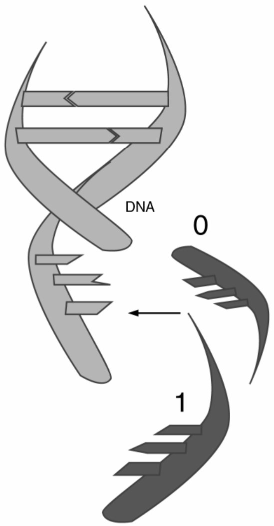
Beyond CMOS

(1)



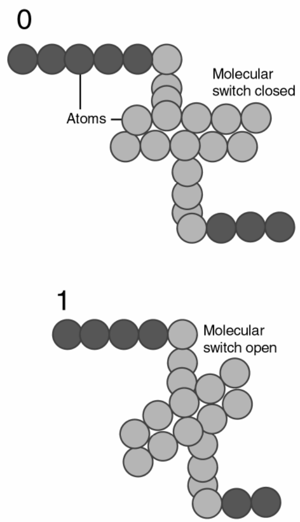
THE OPTICAL COMPUTER
Instead of using the flow of electrons to carry data, this device uses photons, which can pass by one another without interference

(2)



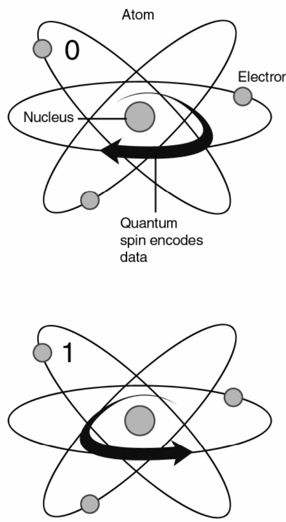
THE DNA COMPUTER
The double-stranded DNA molecule becomes a biological computer tape, and solutions are carried in the sequence of bases on the strands

(3)

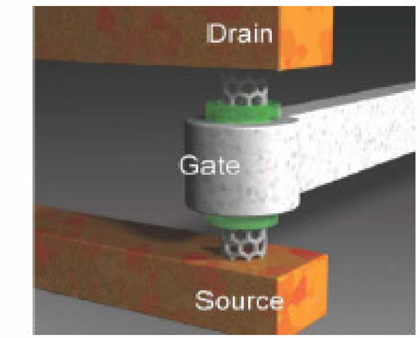


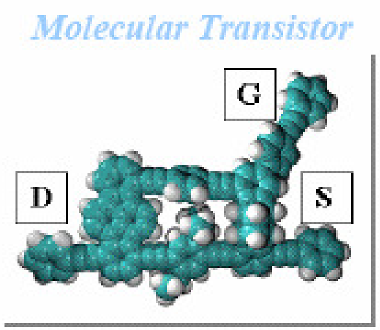
MOLECULAR/DOT COMPUTERS
In these designs, silicon transistors are replaced by molecules or electrons, respectively, which then act as tiny logic gates and switches

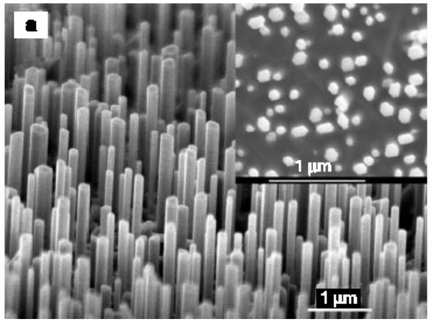
(4)



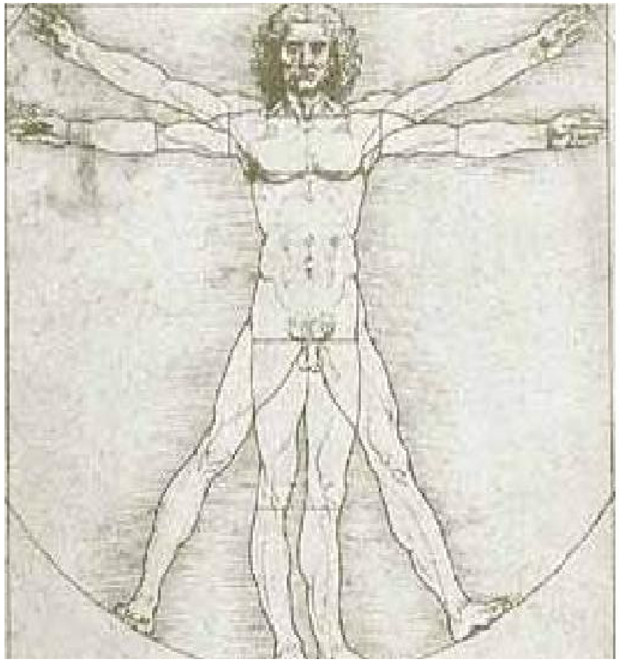
THE QUANTUM COMPUTER
The ultimate in miniaturization, this design uses the direction of the axis on which individual atoms spin(up or down) to encode information





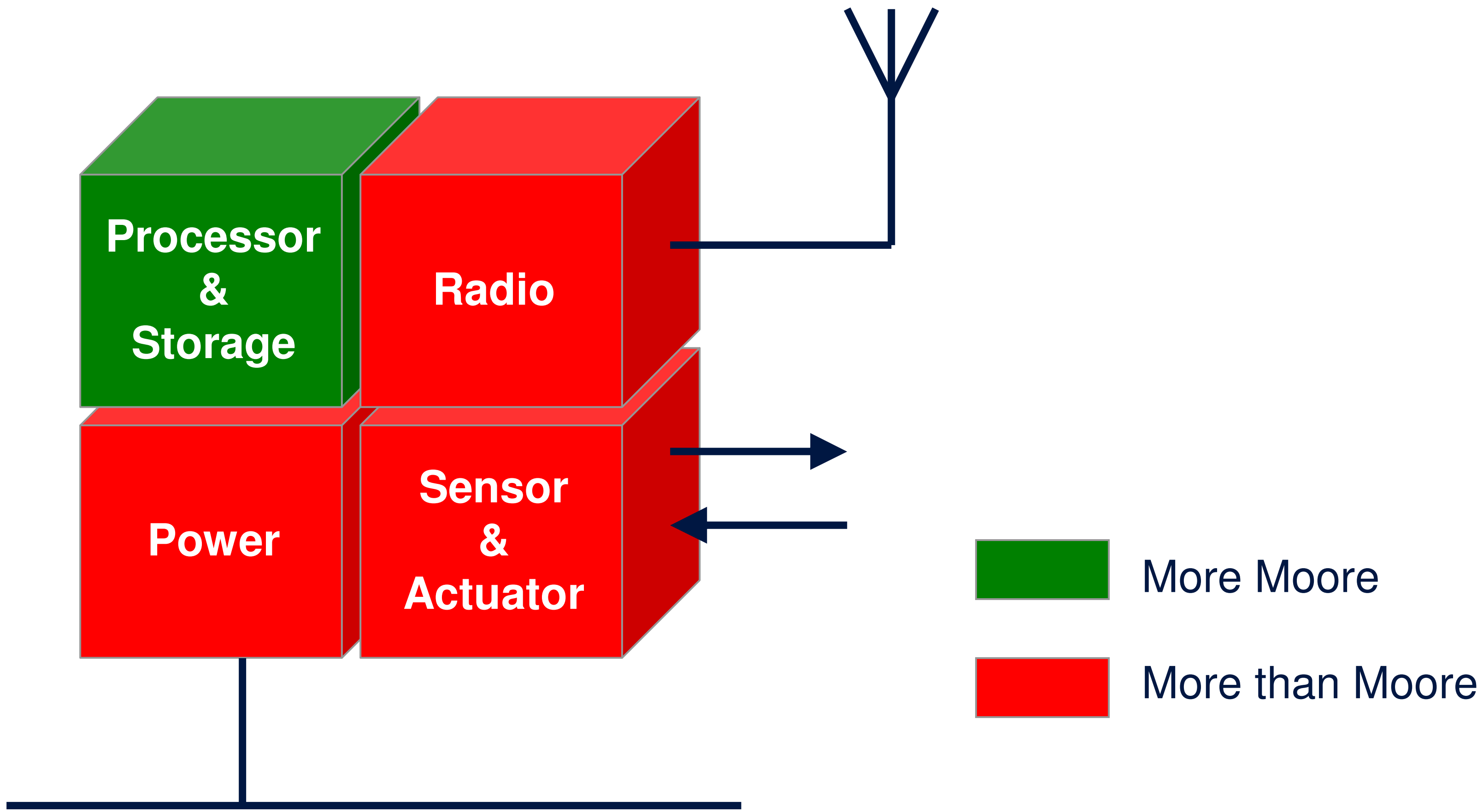


• Technologies/products
(based upon or derived from Semiconductors)
that enable functions equivalent as the eyes, ears, noses, arms, and legs of human-being, while microprocessor and memory functioning as the brain.



• Physical enabler for Ambient Intelligence of broad applications with a plethora of functions

Intelligent systems incorporate 'More Moore' and 'More than Moore'



Scope and functionality

baseline CMOS · *memory* · *RF* · *HV Power* · *passives* · *sensors actuators* · *bio, fluidics*

'More Moore'

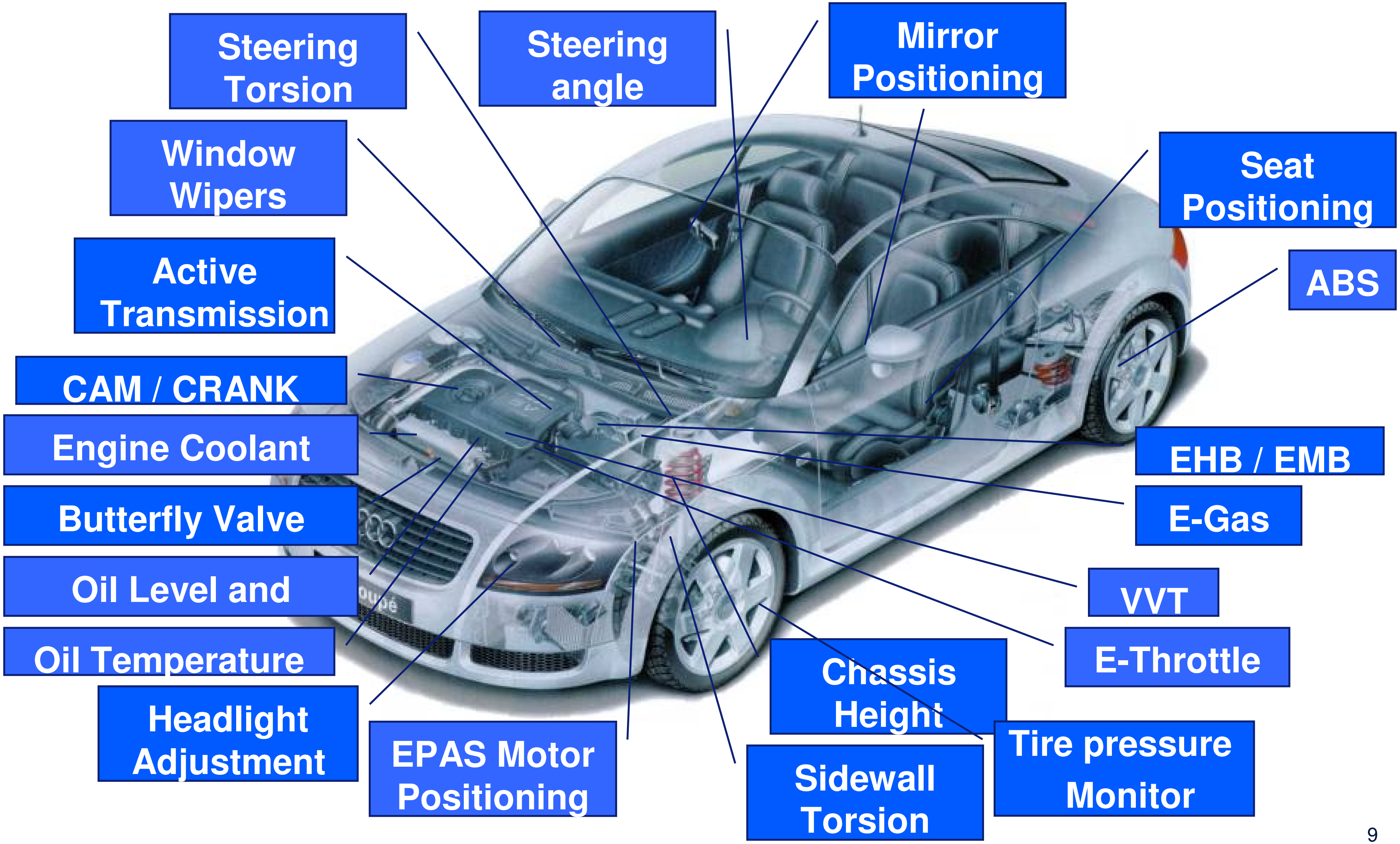
'More than Moore'

Compute/storage

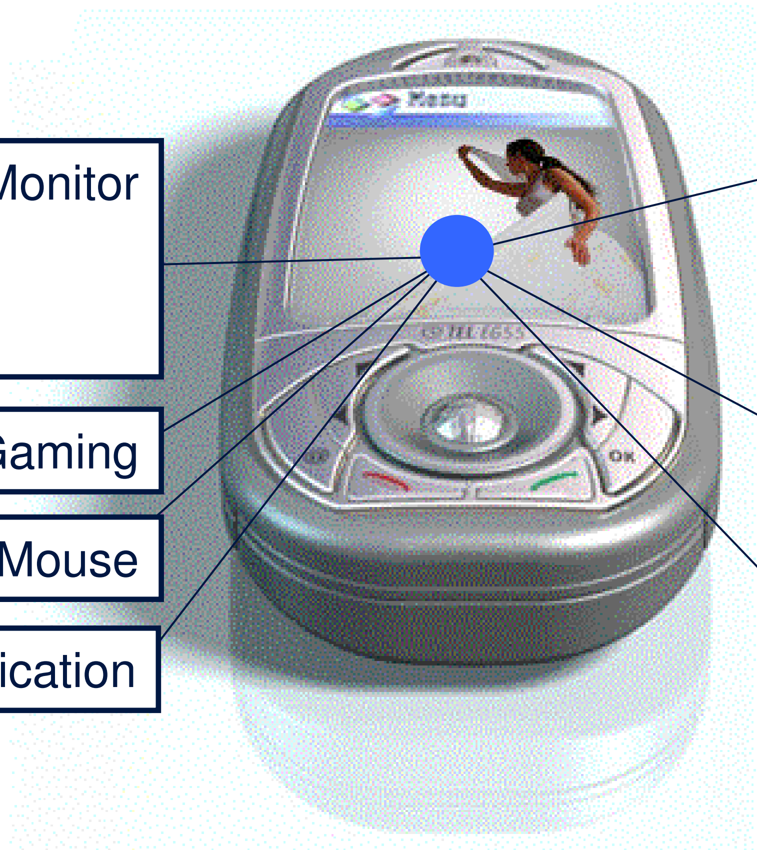
Interact with user and environment

Digital content
Complex Design (SoC)
Lots of software

Non-digital content
Hetero Integration
Lots of processes


Steering Torsion
Steering angle
Mirror Positioning
Window Wipers
Seat Positioning
Active Transmission
ABS
CAM / CRANK
Engine Coolant
EHB / EMB
Butterfly Valve
E-Gas
Oil Level and
VVT
Oil Temperature
E-Throttle
Headlight Adjustment
EPAS Motor Positioning
Chassis Height
Sidewall Torsion
Tire pressure Monitor

Intelligence applied: personal comfort



Personal Health Monitor
- Heart activity
- Blood pressure
- Glucose level

Gaming

Mouse

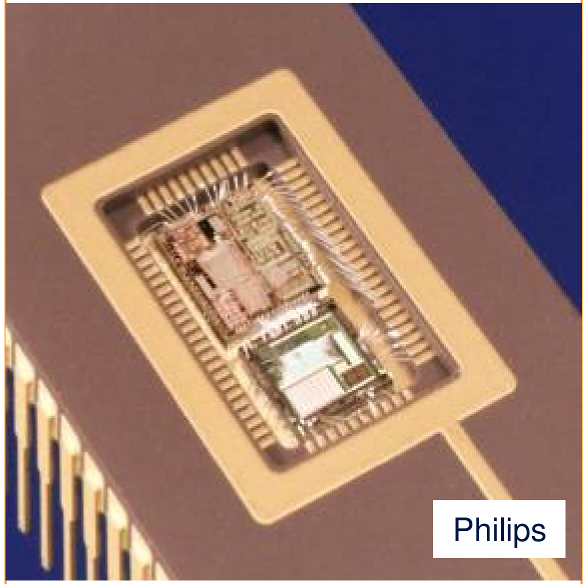
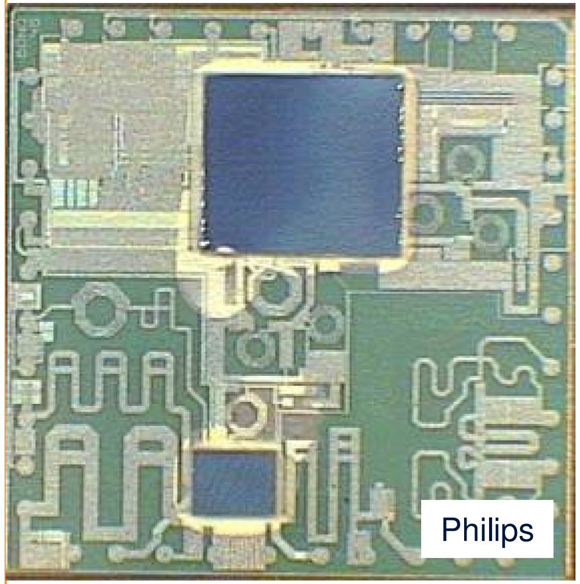
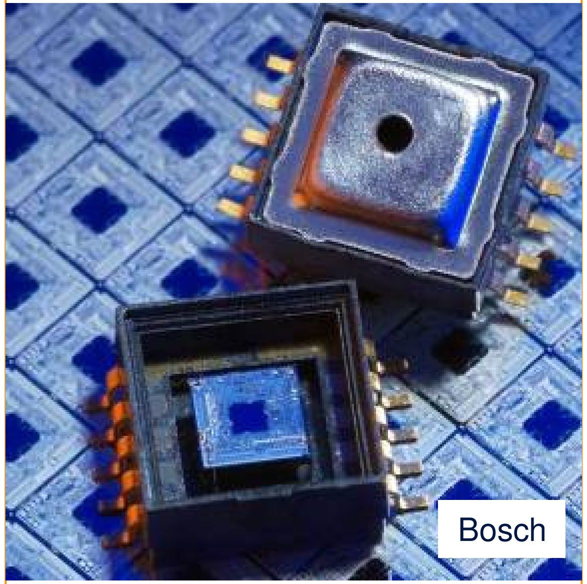
Identification

Personal Map
- Compass
- GPS
- Altitude

Personal Weather Station
- Humidity
- Pressure
- Ozone
- UV exposure

Decibel Meter

System-in-Package

SiP 1: Evolutionary More than One IC	SiP 2: Innovative More than IC Processing	SiP 3: Breakthrough More than Electronics
		
Multi-chip package: video processor	Passive integration: GSM radio	MEMS module: pressure sensor

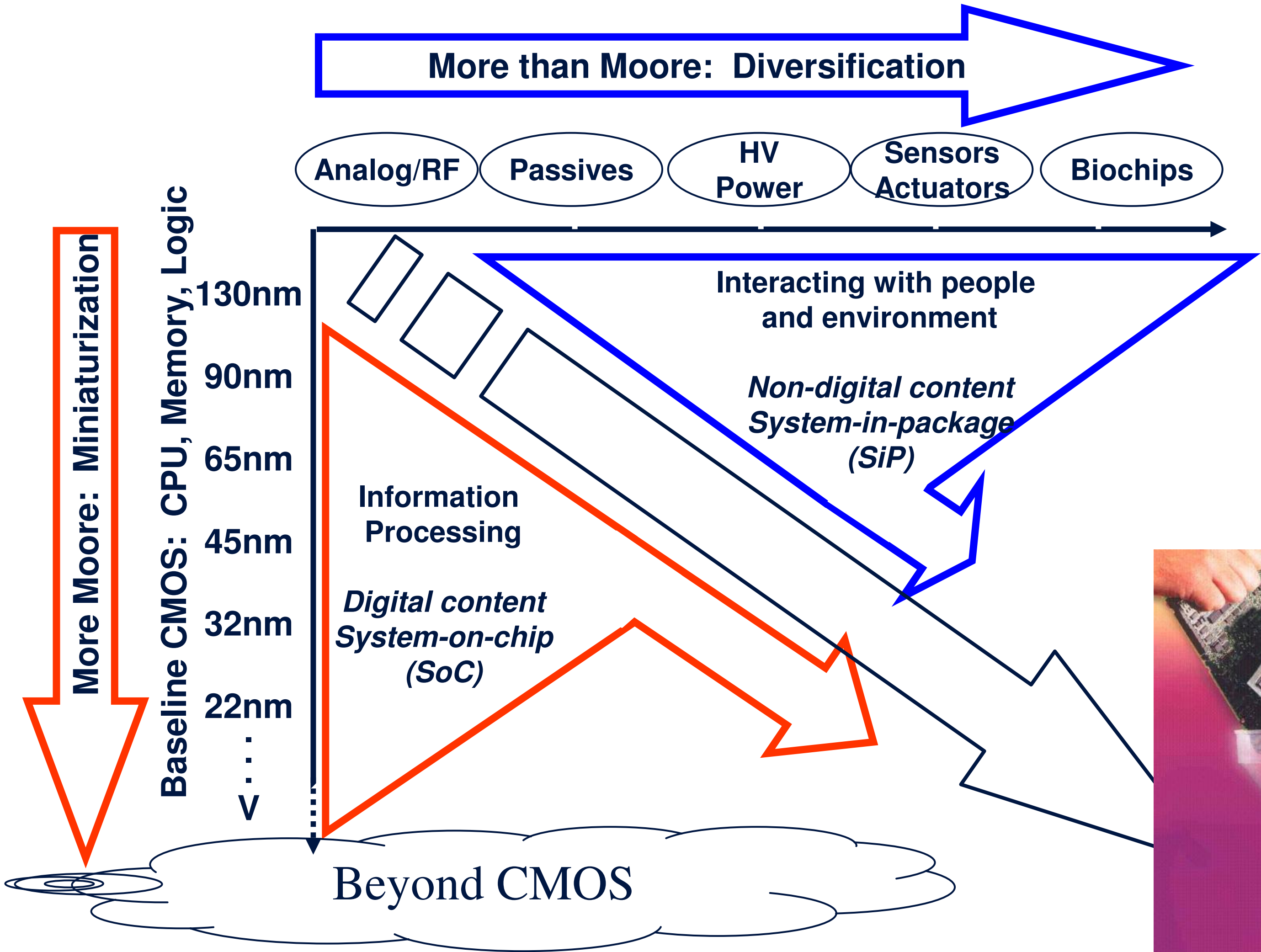
SiP vs SoC

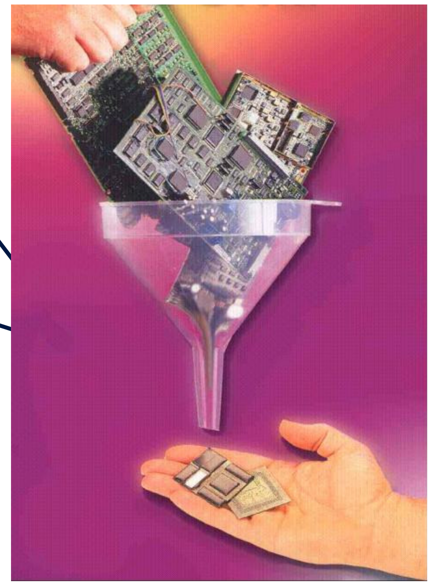
Complementing, not competing

SoC – Programmable monolithic IC – **More Moore**
- Advanced baseline CMOS,
- Maximize utilization of (expensive) mask sets
- Diversification is in the software & embedded IP mix

SiP – Multi-technology module – **More than Moore**
- Mature and/or advanced wafer processes, advanced packaging
- Maximize utilization of dedicated option fabs
- Diversification is in the components & technology mix
- Creating more values via integrating traditional and non-traditional functionality in one package

The Nanoelectronics Landscape: Moore's Law & More than Moore





Rationale of More than Moore

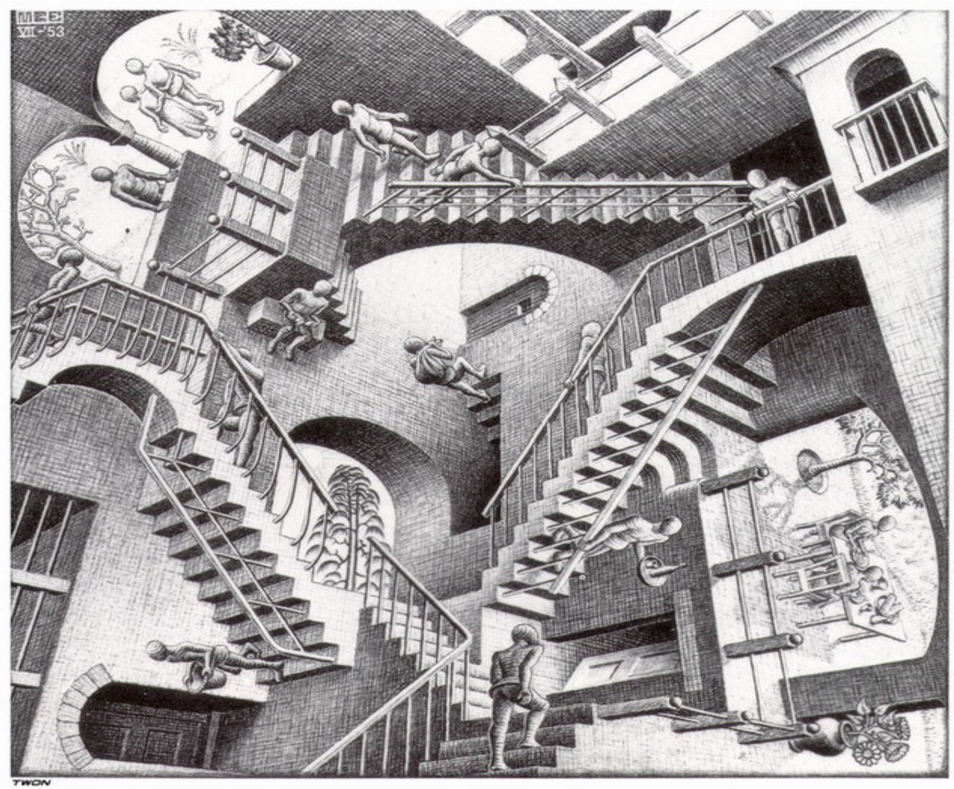
•Increased social needs for high level system integration including non-digital functions

•The necessity to speed up product innovation and to create new product portfolio of fabs in Europe (sustainability and employability)

•The limiting factors of cost and time-to-market of SoC development

• MtM adds value to society on top of and beyond advanced CMOS and conventional packaging, with fast increasing marketing opportunities and huge business potentials

2. Characteristics and Consequences

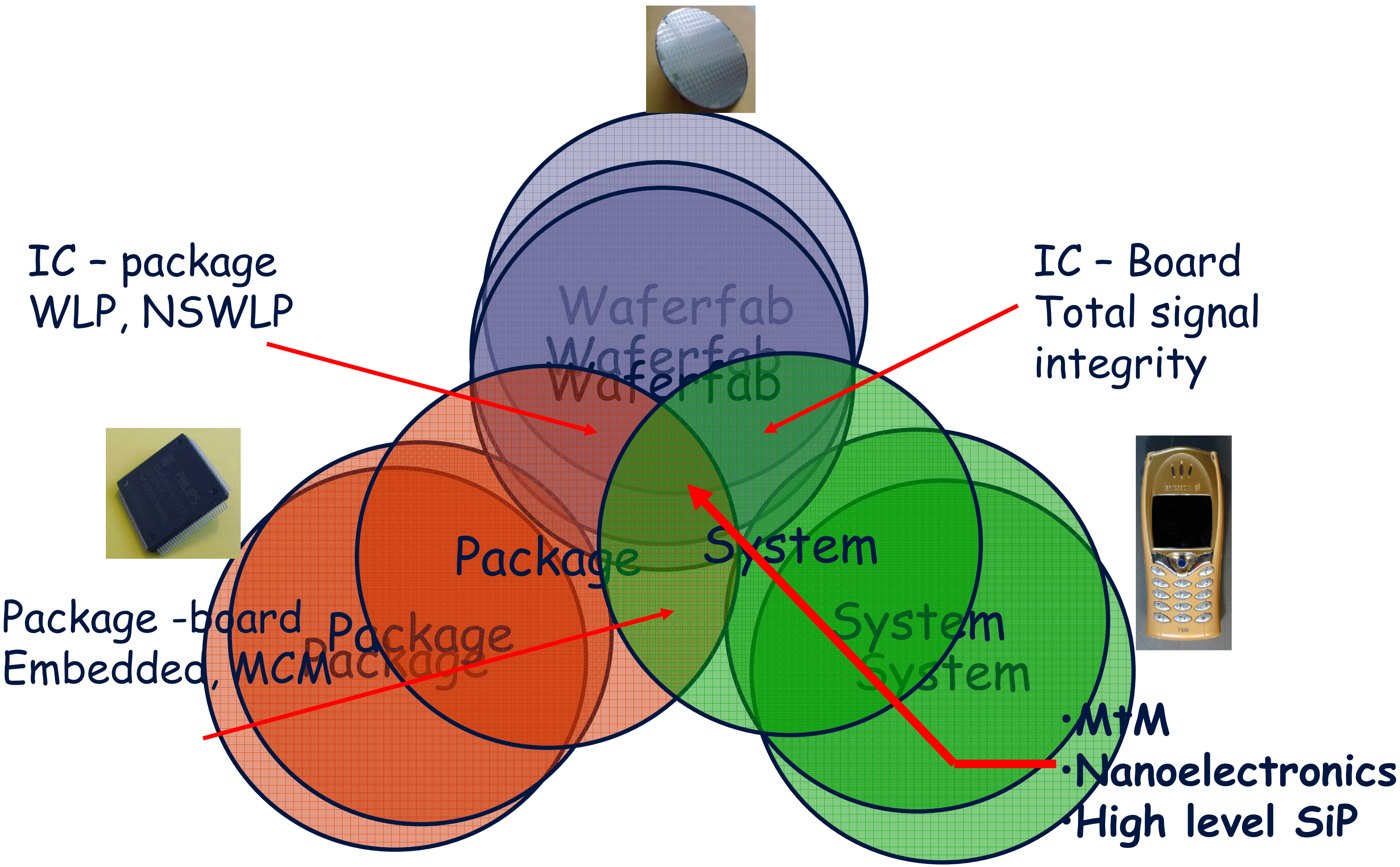


Much more than miniaturization:

multi-application/market/requirements,
multi-organization,
multi-supply chain,
multi-infrastructure,

multi-functionality,
multi-discipline,
multi-scale (in both geometry and time),
multi-technology,
multi-process,
multi-material/interface,
multi-damage and failure mode,
multi-variability.

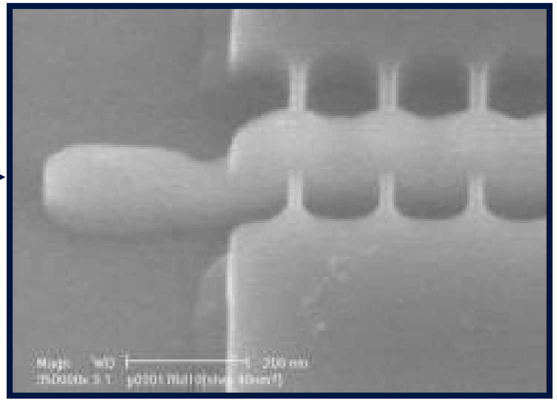
Strong Nonlinear Multi Interaction!


IC – package
WLP, NSWLP
IC – Board
Total signal
integrity
Waferfab
Package
System
Package -board
Embedded, MCM
·MtM
·Nanoelectronics
·High level SiP

Dramatically increased design complexity

Linking Giga-Scale Dreams to Nano-Scale Realities

?

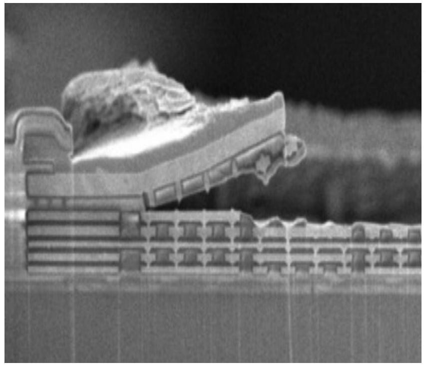


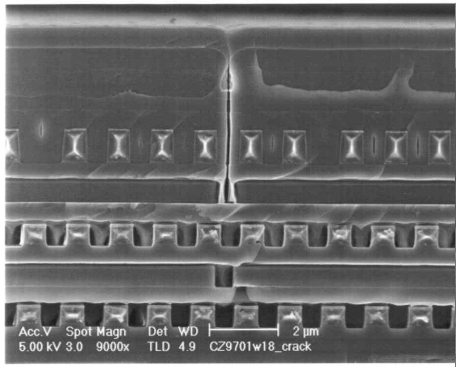
Giga-Scale Complexity

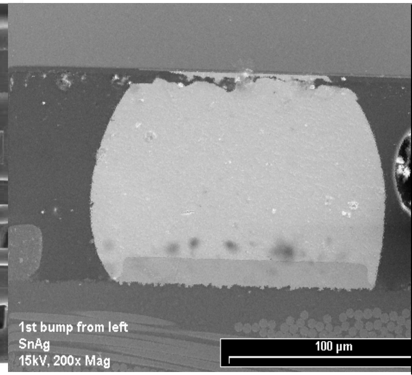
Nanoscale Realities

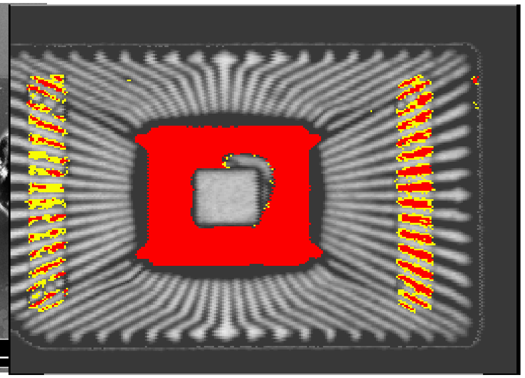
Architectural gap
Nanoscale design tolerance and process windows
Device variability impacts predictability and yield
No co-designing theories, methods and tools

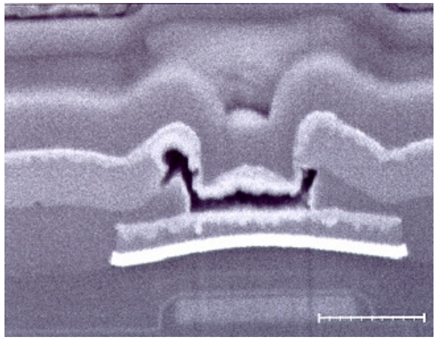
Dramatically increased chance and consequences of failures

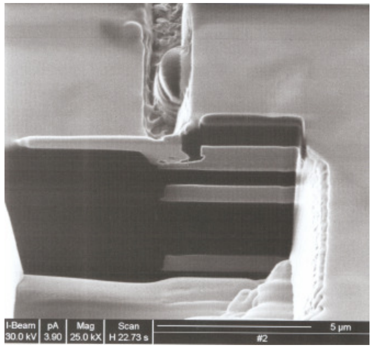


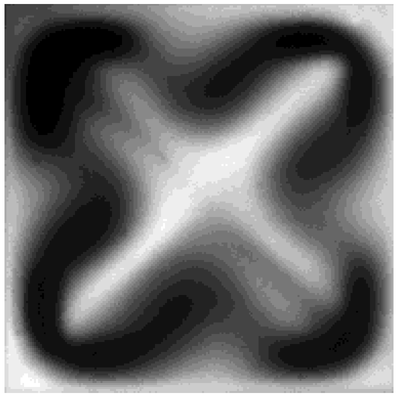


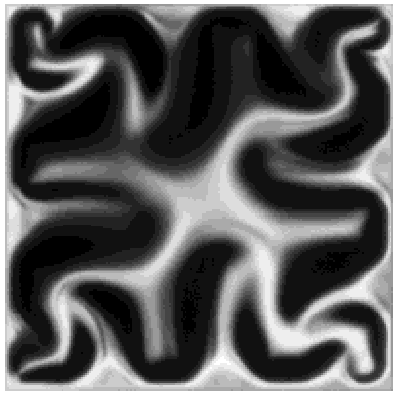


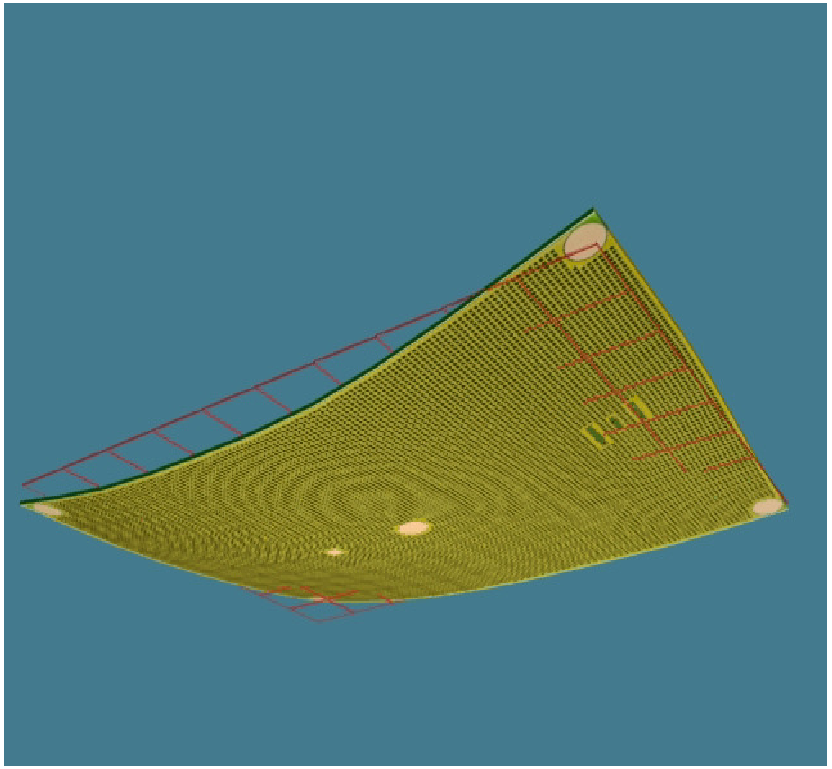












Wear out

- Fatigues
- Creep
- Wear
- .....

Overstress

- Cracks (die, plastic, wirebond, etc.)
- Delamination
- Pop-corn
- Buckling
- Yields (ball shear, pattern shift, etc.)
- Warpage
- Large deformation
- Electro/thermal/stress migration
- Voiding
- ......

- **Loading sources/levels/gradients/steps increased;**
- **Test coverage and efficiency reduced;**
- **Strongly non-linear, stochastic, time and process dependence response**

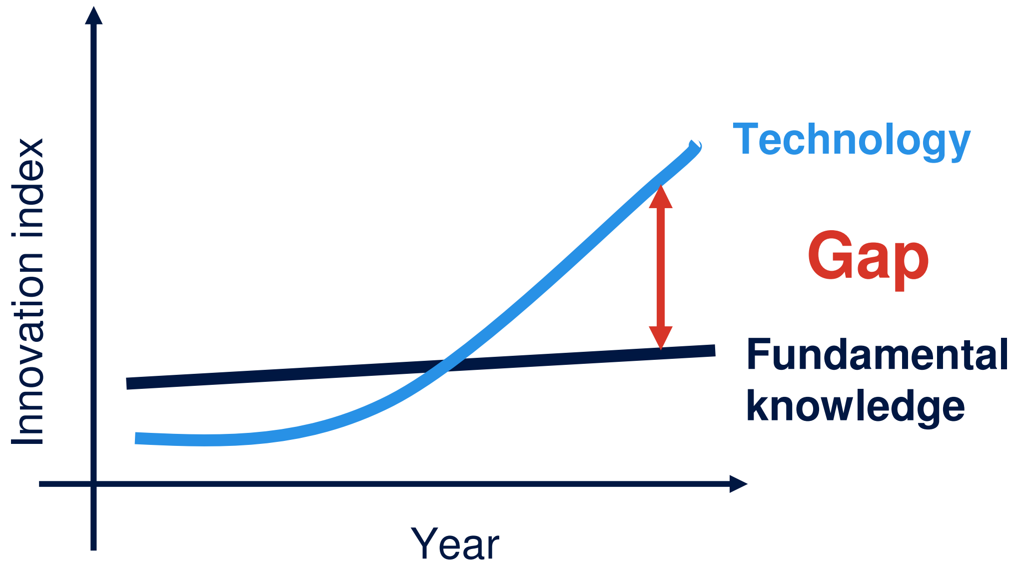
No appropriate design method

- Experience and Trial-error based
- Empirical, phenomenological, case dependent,
- Sub-optimal product/process
- High development costs

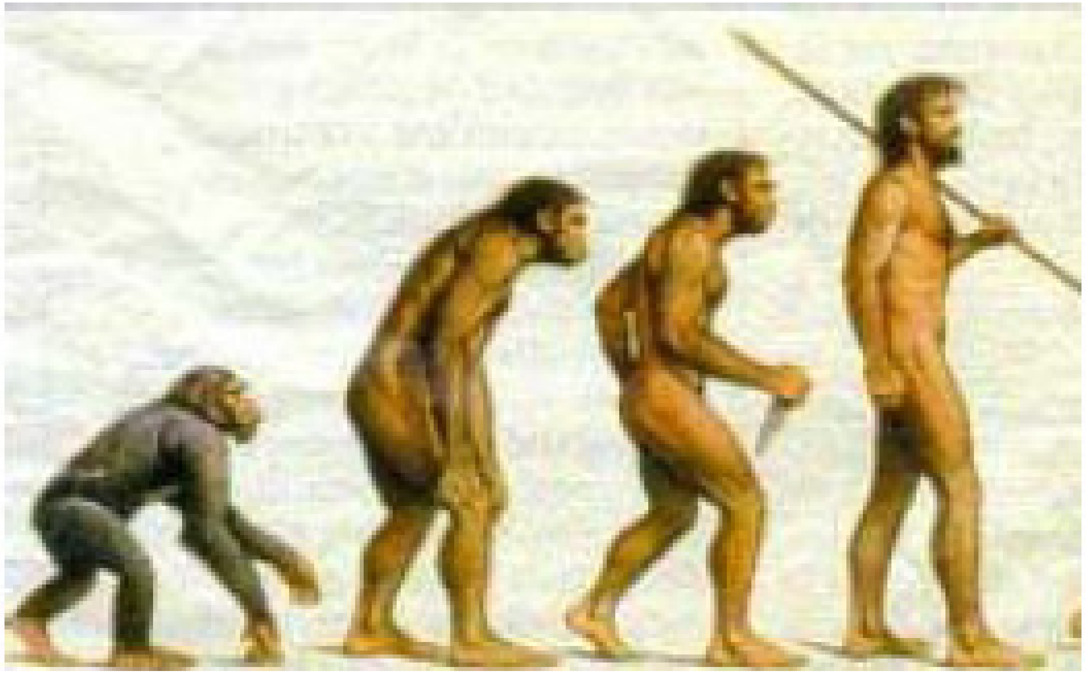
No appropriate qualification method

- Time and money consuming
- Unclear correlation between application profiles with spec. and accelerated testing
- No guarantee for extrapolating to outside of the spec.
- No satisfied coverage for quality, robustness and reliability

Increased gap between technology advance and fundamental knowledge



3. Challenges
- Predictive modeling



Reliable inputs

- **Geometry** (mediar ... efect)
- **Material** (type/prop
- **Loading** (history an ... embly/functionality testing/ reliability qualification

Determining All statistic in nature

•Life time and performance of product/process

!!!!!!!!! Inputs must be reliable !!!!!!!!!

40C for 21 days

140C for 3 minutes

Predictive modeling capability

- Algorithms, solvers and tools for
  - Non-continuum(atomistic/nanoscale)
  - Multi-scale (bridging gaps)
  - Multi-physics
  - Both deterministic and stochastic
  - Multi-failure mode and interaction
  - Process history
  - Nonlinear
  - 3D applications
- Accurate, Robust and Efficient

Novel experimental Techniques

- **Methods and tools for modeling inputs**
  - **Material/interface characterization**
  - **Failure analysis (mode/location/evolution/mechanisms/probability)**
- **Methods and tool for modeling verification**
  - **Representative sample preparation**
  - **Modeling validity for the whole design space**
- **General requirements**
  - **Multi-scale, from nano to macro**
  - **Both deterministic and stochastic**
  - **Multi-physics**
  - **Multi-failure mode and interaction**
  - **Process history**
  - **Accurate, robust and efficient**

ENIAC: European's Nanoelectronics Strategic Research Agenda

Modeling, simulation, optimization and design

1 **Integrated multiscale** (from atomistic to macro, including the strong size and surface effect), **multiphysics** (electrical, mechanical, thermal, physics, chemical, etc.), **multidamage** (cracks, delamination, fatigues, electromigration, voids, creep, degradations, etc.) and **multi-process** (wafer, micromachining, packaging, assembly, qualification and application profile) **modeling** incorporating the important loading history in order **to understand and predict the performance and reliability**. Herein, new algorithms and simulation tools are needed.

2 Innovative experimental methods and techniques to extract material/interface and total system behavior, in order to provide inputs for modeling and simulation, and to verify the modeling results and design rules, **covering both nano and macro scales**.

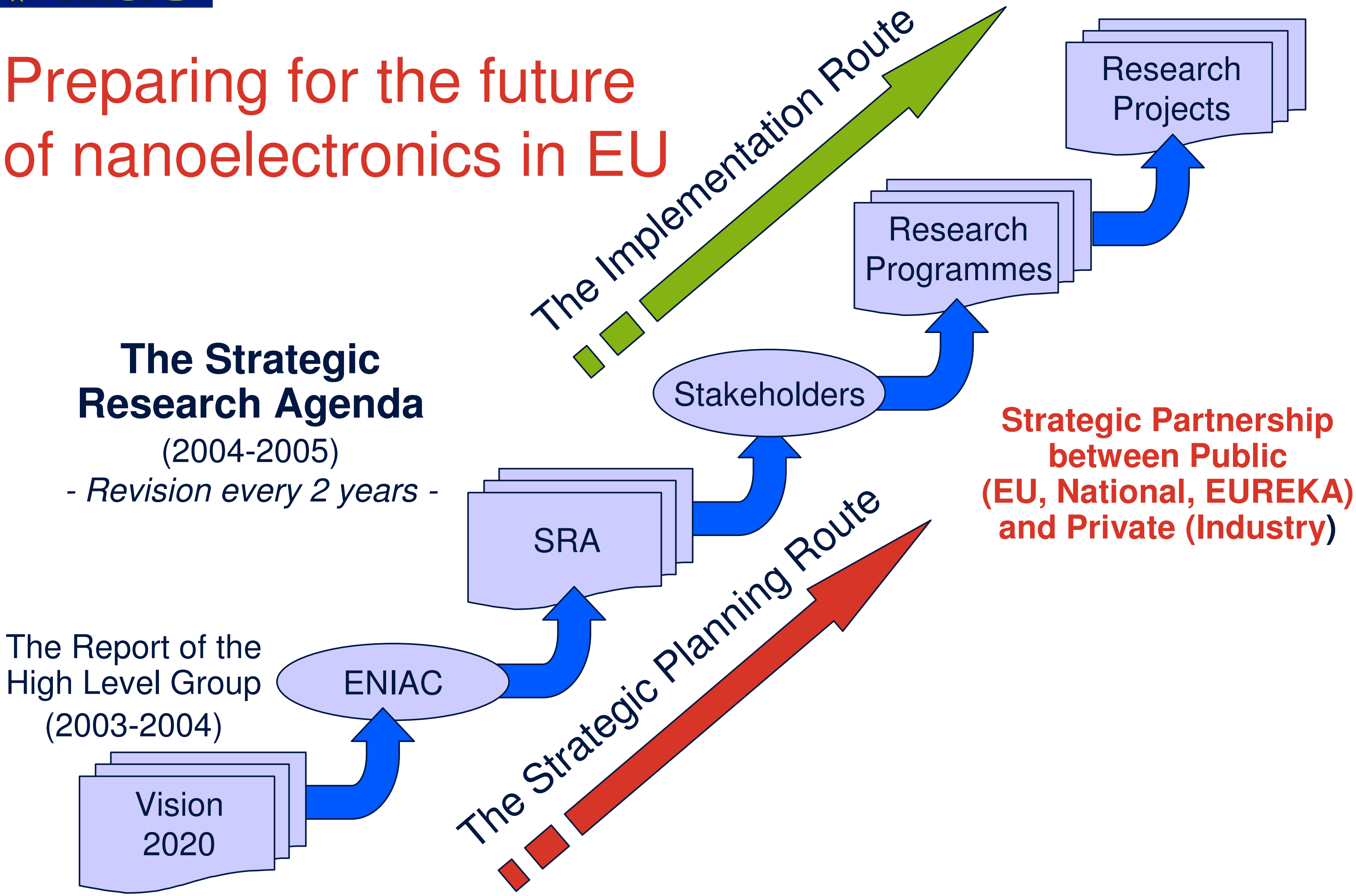
3 Efficient optimization methods for design rule development of nonlinear, stochastic and multiparameter process/product responses.

4. Eniac

European Nanoelectronics Initiative Advisory Council

European Technology Platform

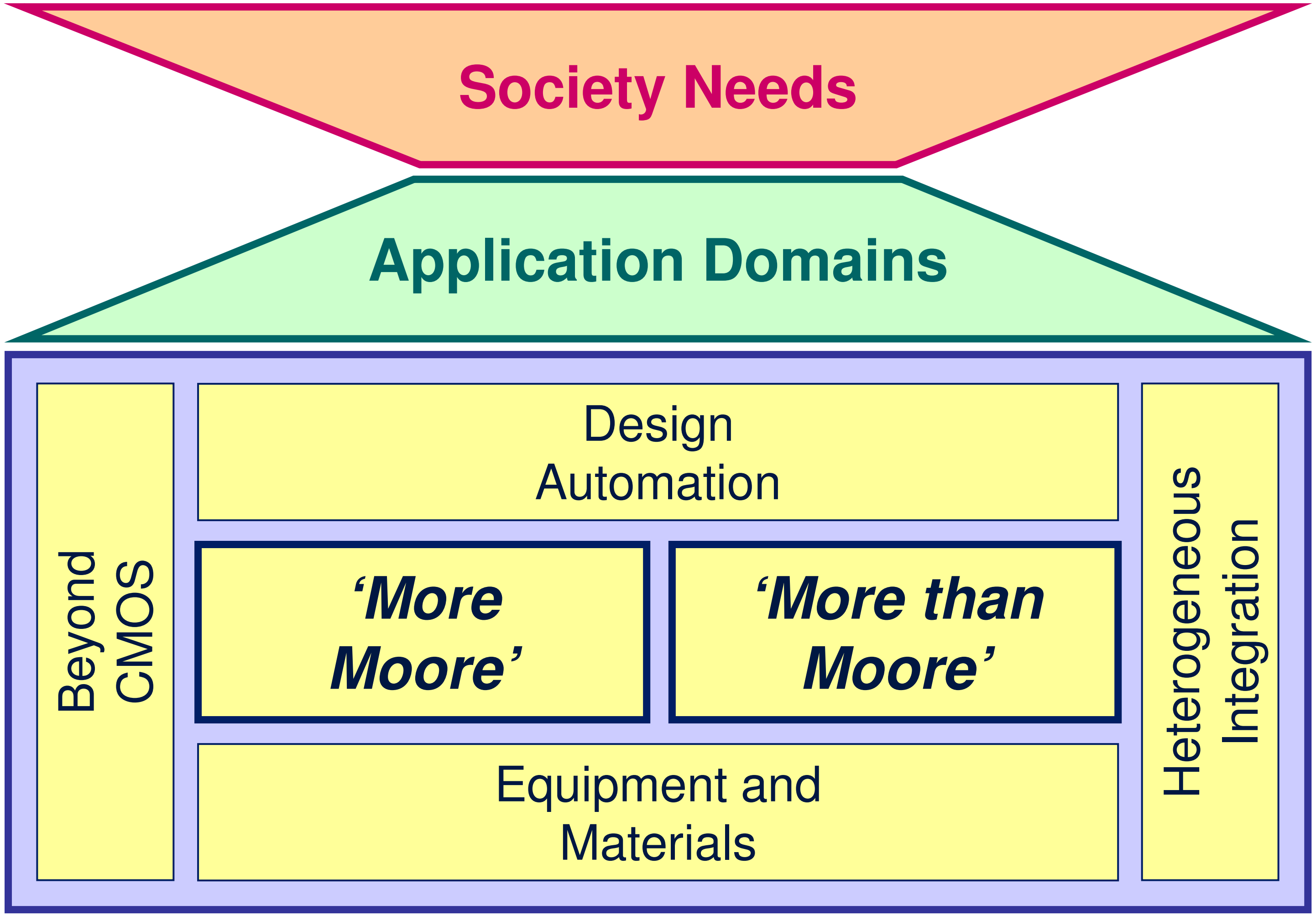
Preparing for the future of nanoelectronics in EU



ENIAC: Society Needs and Applications

Health	'The Doctor in your Pocket' Real-Time Diagnostics Bio-Chips / Body-Sensors
Mobility / Transport	100% Safety on the Road Integrated Transport Systems Prevention of Pollution
Security	Personal Emergency Systems Protection against Crime and Terrorism Secure Home Environment
Communication	Seamless Wired / Wireless Access Mobile Services without Compromise Protection of Privacy
Education / Entertainment	Learning Anywhere, Anytime Content with Best Quality (e.g. HDTV) Content Protection

Six enabling technology domains



5. Concluding remark

Any intelligent fool can make things bigger, more complex and more violent. It takes a touch of genius and a lot of courage to move
in the opposite direction.
- A. Einstein

Technological progress has merely provided us with more efficient means for going backwards

Enhancing industry and academia partnerships

- **Reducing the gaps**
- **Increasing the return on R&D**
  - Leverage infrastructure, knowledge/capability and other resources
  - Industrialization/commercialization

Managing the complexity of innovation

- **Soaring complexity and cost:**
  - –New technology, short time to market, many emerging applications, high risks
  - –HW and SW complexity
- **Solution: Open Innovation**
  - –Technology partnerships
  - –Public-private research partnerships
  - –Sharing infrastructure, services, knowledge and resource

"… firms that can harness outside ideas to advance their own business while leveraging their internal ideas outside their current operations will likely thrive in this new era of open innovation"

JetNet
Jongeren en Technologie Netwerk Nederland

Technific

Atos Origin

imec

FOM

THALES

Anteryon
LEADERS IN OPTICAL INTERFACE TECHNOLOGY

DSP VALLEY

CYTOCENTRICS

Eindhoven
leading in technology

MIREC

bioneedle

montavista

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High Tech Campus Eindhoven

HANDSHAKE SOLUTIONS

Assembléon
LEADERS IN ELECTRONIC MANUFACTURING TECHNOLOGY

Silicon Hive

PHILIPS

Adelante Technologies

Infineon technologies

NEWAYS

Provincie Noord-Brabant

FEI COMPANY

Holst Centre

océ

TU/e technische universiteit eindhoven

TNO

ASML

otb ENGINEERING

Beltone
Helping the world hear better

DALSA
Technology with vision

ST

Sun microsystems

KeyTec PRECISION COMPONENTS

BOSCH

Ministerie van Economische Zaken

REDE

fluXXion

Lucent Technologies
Bell Labs Innovations

PEEK

ADAMIND

SIEMENS VDO Automotive

Thanks for your attention!

Questions?