MOORE &
More than MOORE

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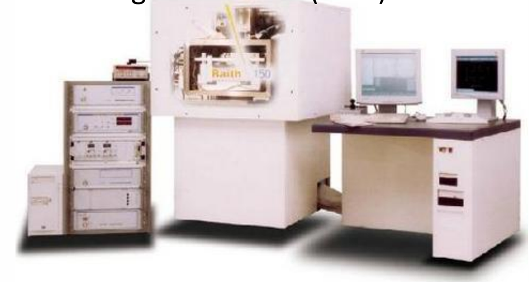
www.ek-cer.hu | www.mems.hu | www.biomems.hu

MEMS NEMS BIOMEMS

MEMS/NEMS INFRASTRUCTURE in CER MICROSYSTEMS LAB

RAITH 150 E-BEAM
Ultra high resolution (8nm)



Micromachining techniques:

- Patterning – mask design, laser pattern generator, 1μm photolithography, (double side) alignment, electron beam lithography (E-Beam), Focused Ion Beam processing – FIB milling, nanoimprinting
- Structured polymer layers – PMMA, PI, SU8 patterning, micromoulding, soft lithography – PDMS
- Wet chemistry – chemical wafer cleaning, isotropic and anisotropic etching techniques
- Dry etching – deep reactive ion etching, plasma etching techniques (DRIE, RIE)
- High temperature processes – thermal oxidation, diffusion, annealing, rapid thermal annealing (RTA)
- Physical thin film depositions – Thermal and electron beam evaporation, DC and RF Sputtering
- Chemical thin film depositions – Atmospheric and Low Pressure Chemical Vapour Deposition (CVD, LPCVD, LTO) thermal and plasma enhanced Atomic Layer Deposition (ALD)
- Liquid Phase Epitaxy (LPE) of III-V compound semiconductors (LED manufacturing)
- Wafer bonding – Si-glass, glass-glass, polymer-glass anodic and thermal bonding
- Chip dicing, wire bonding especially for sensor applications
- Special packaging techniques and methods

- multi-domain Finite-Element Modelling (FEM), and process simulation.

Zeiss-SMT LEO 1540 XB SEM/FIB
SCIOS-2 type dual-beam SEM/FIB
nanoprocessing systems

- SEM with focused ion beam (FIB),
- gas injection system (GIS for EBAD/IBAD)

Characterisation techniques:

- optical (fluorescent) and electron microscopy (SEM / TEM and EDS), atomic force microscopy (AFM), profilometry, electrochemical impedance spectroscopy (EIS), mechanical vibration and climate test chambers, UV / VIS / IR / FTIR spectroscopy, etc.

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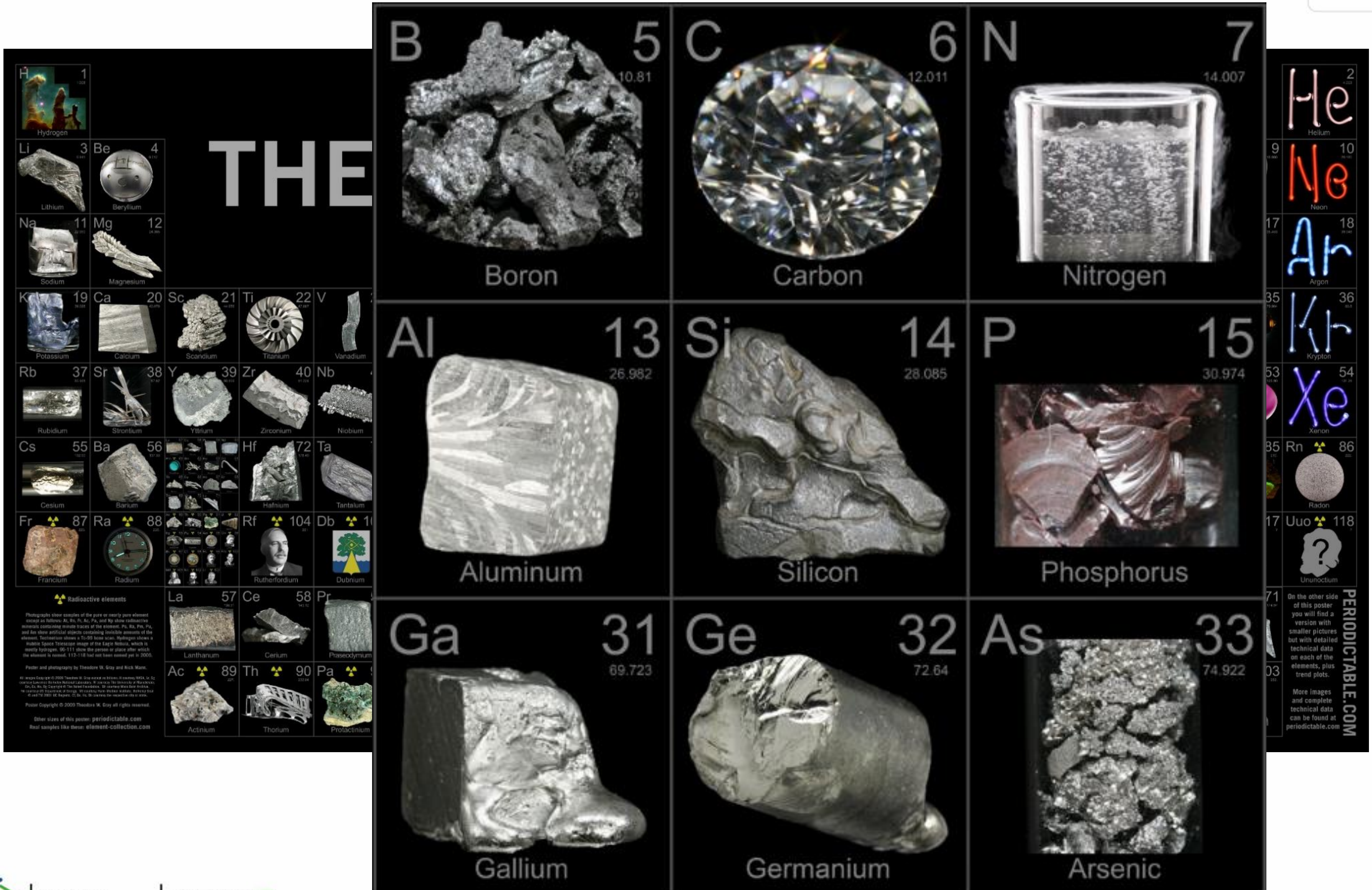
SILICON (silex)



SILICON (silex)

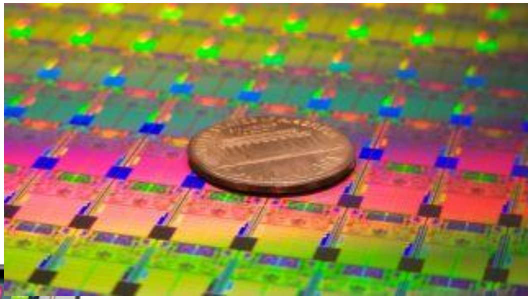
Discoverer: Jons Berzelius
1823, Sweden

Natural presence:
granite, quartz, clay, sand

2nd in incidence in the Earth

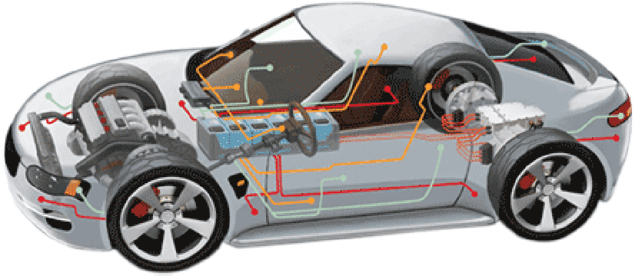
Other applications…



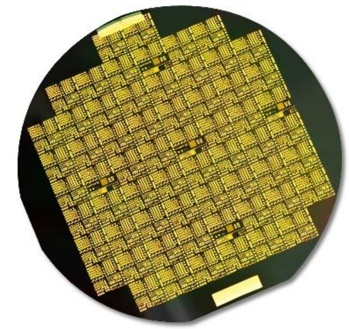









SILICON – chemical element



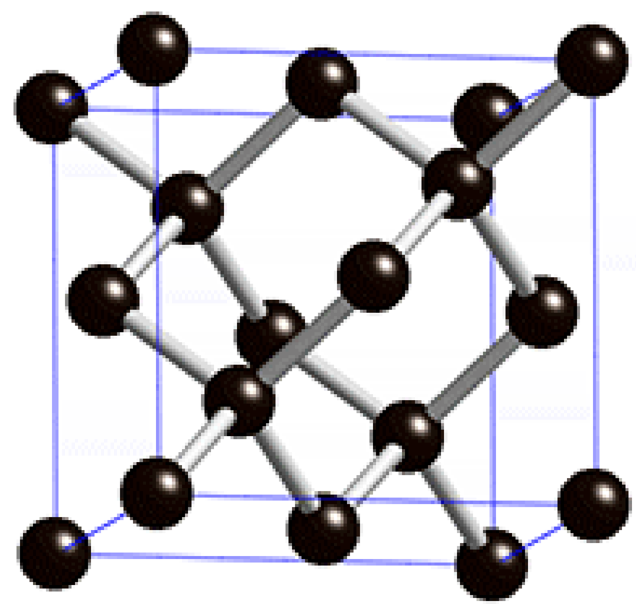
Properties: gray, metallic, extremely hard material

Atomic number: 14 (1s2 2s2 2p6 / 3s2 3p2)

4th group / tetravalent metalloid

Crystal: similar to diamond

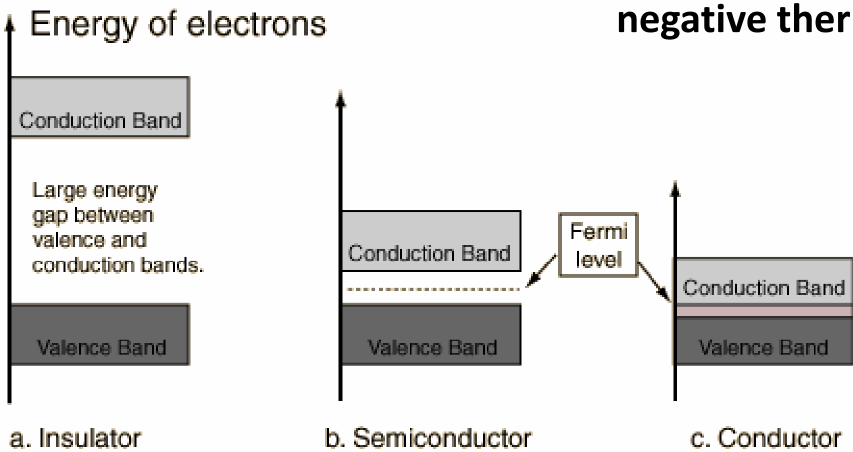
Electronic property: semiconductor



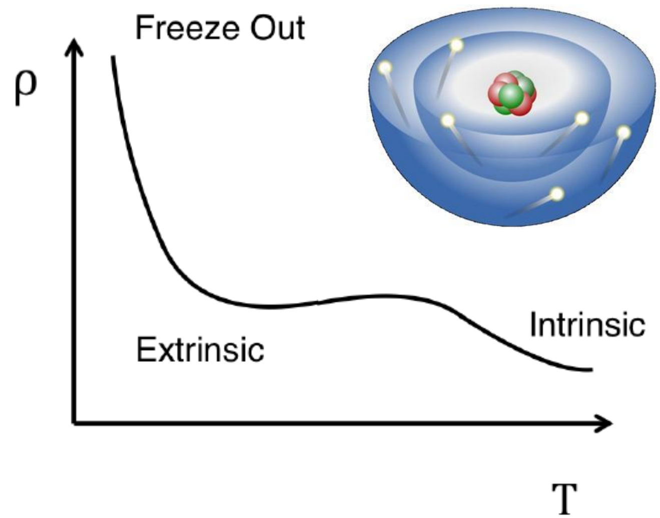
SEMICONDUCTORS

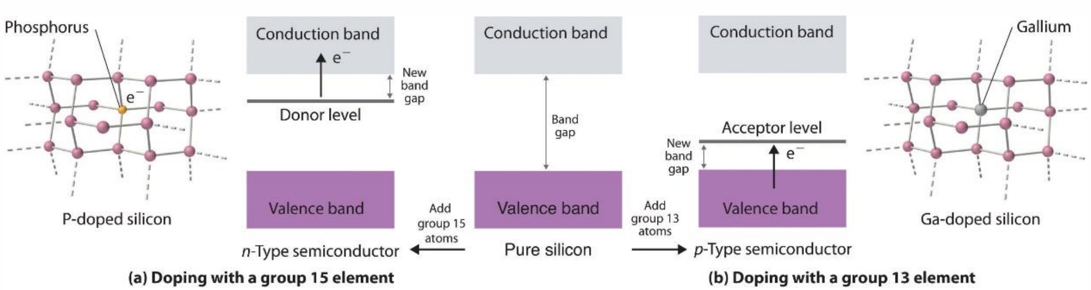
Resistance of semiconductors: $10^{-9} – 10^{3}$ 1/Ωcm

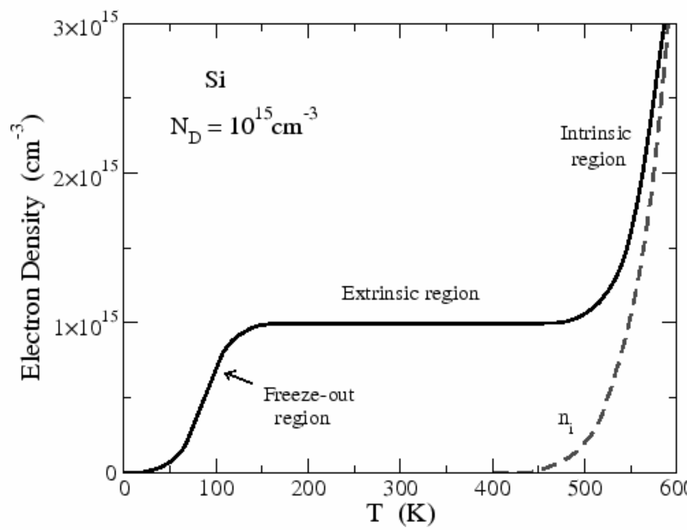
How does the resistance change with the temparature?



negative thermal coefficient of resistance







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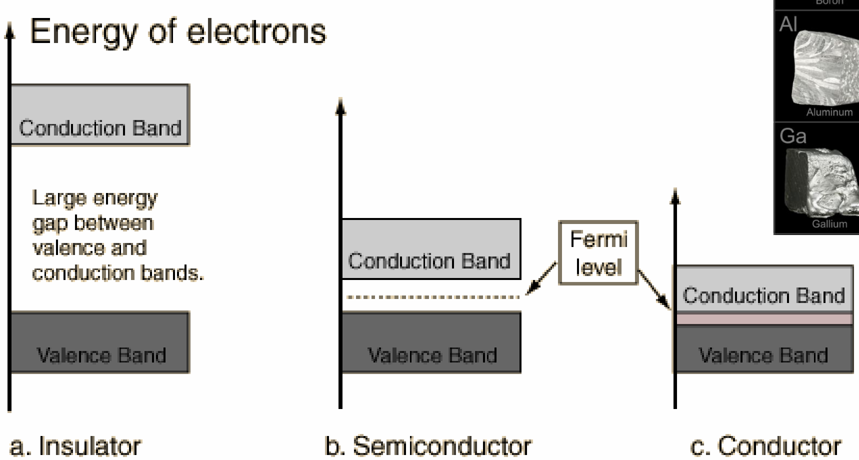
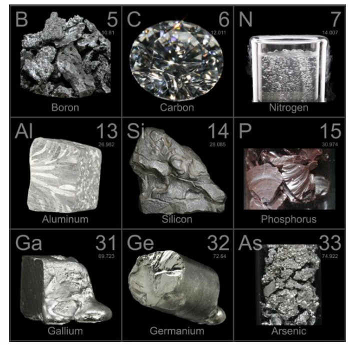
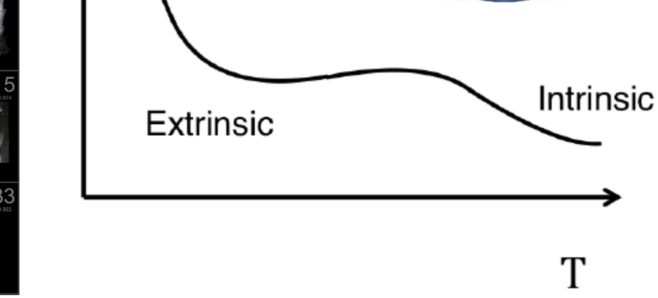
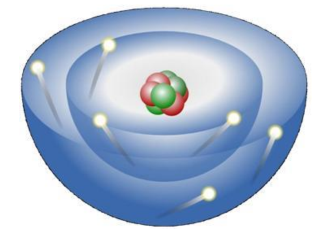
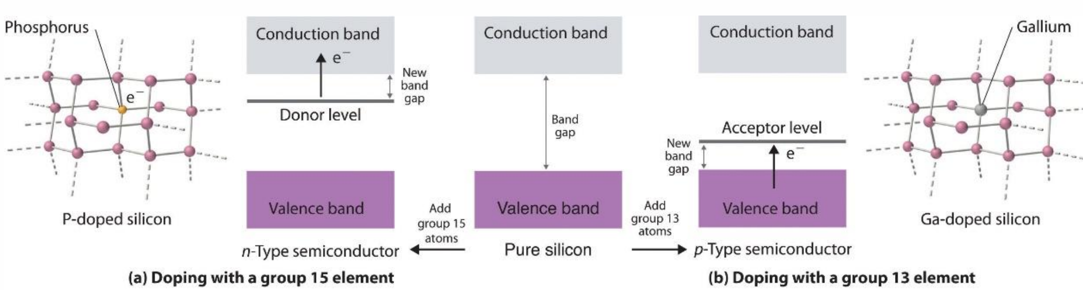
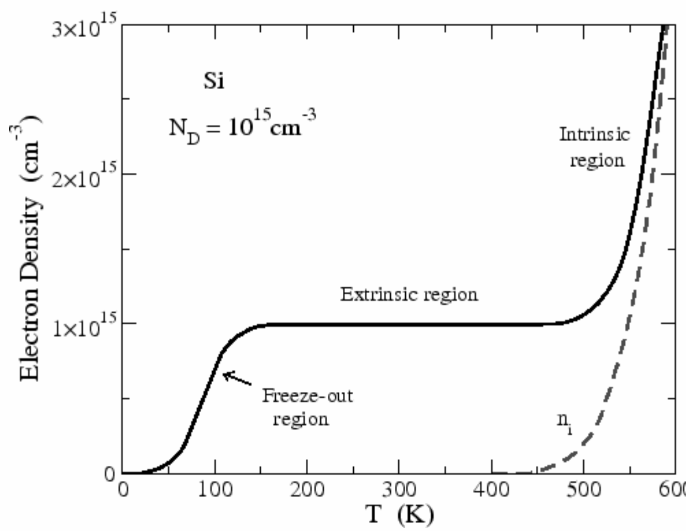






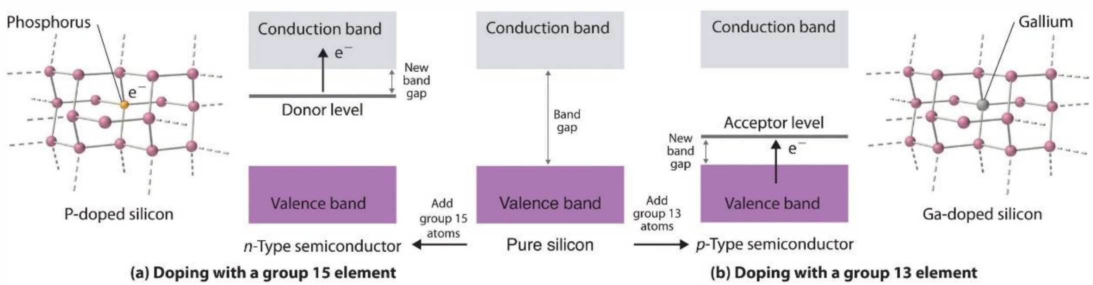


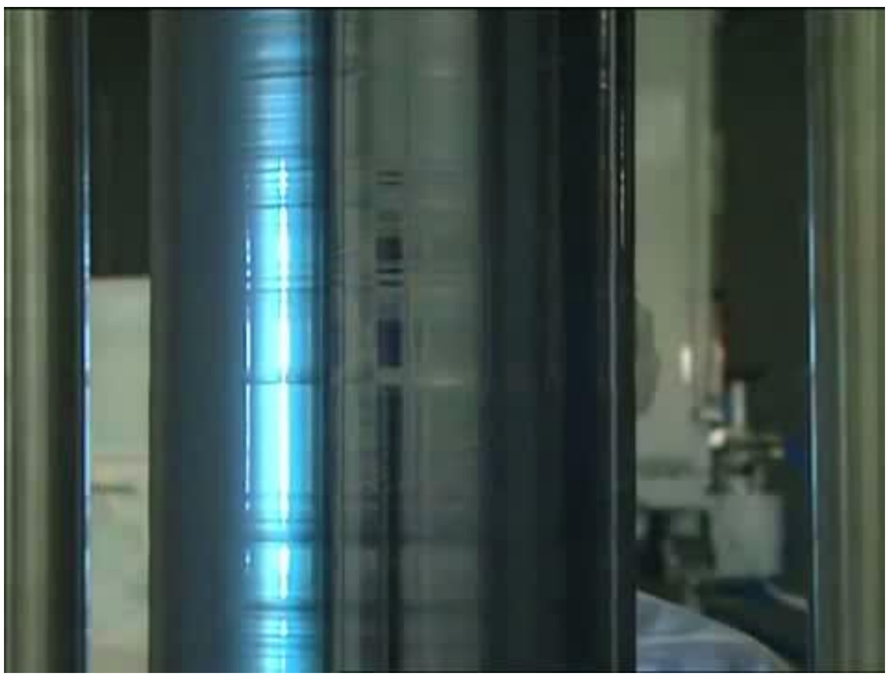


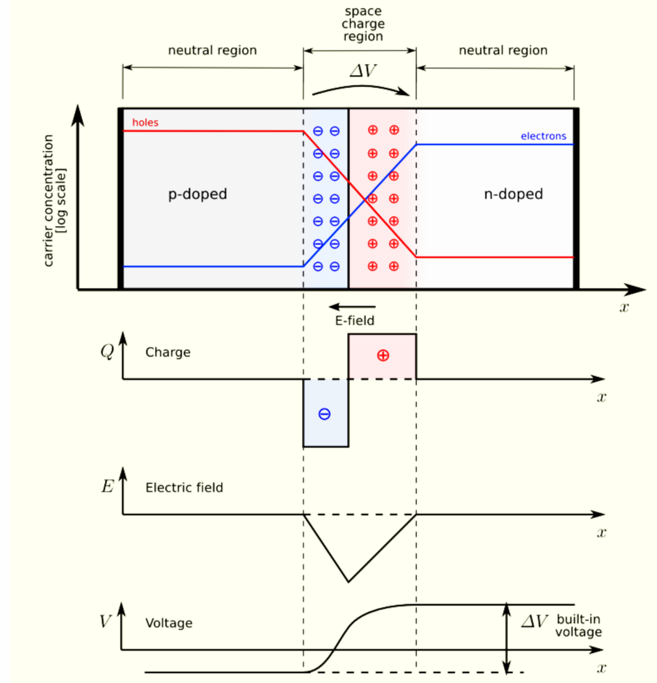


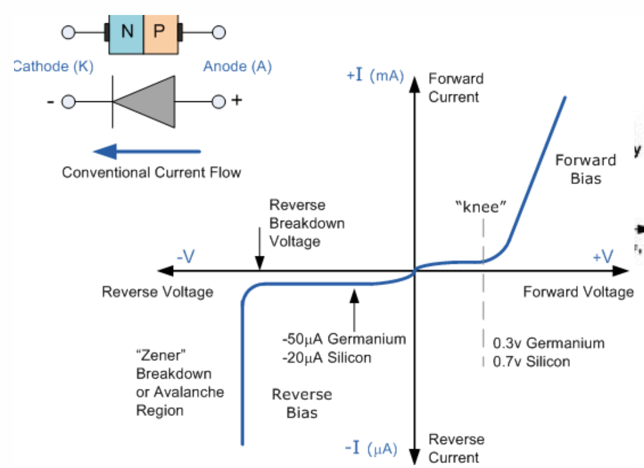
DIODE

Doped semiconductors: n (electron) and p (hole) type

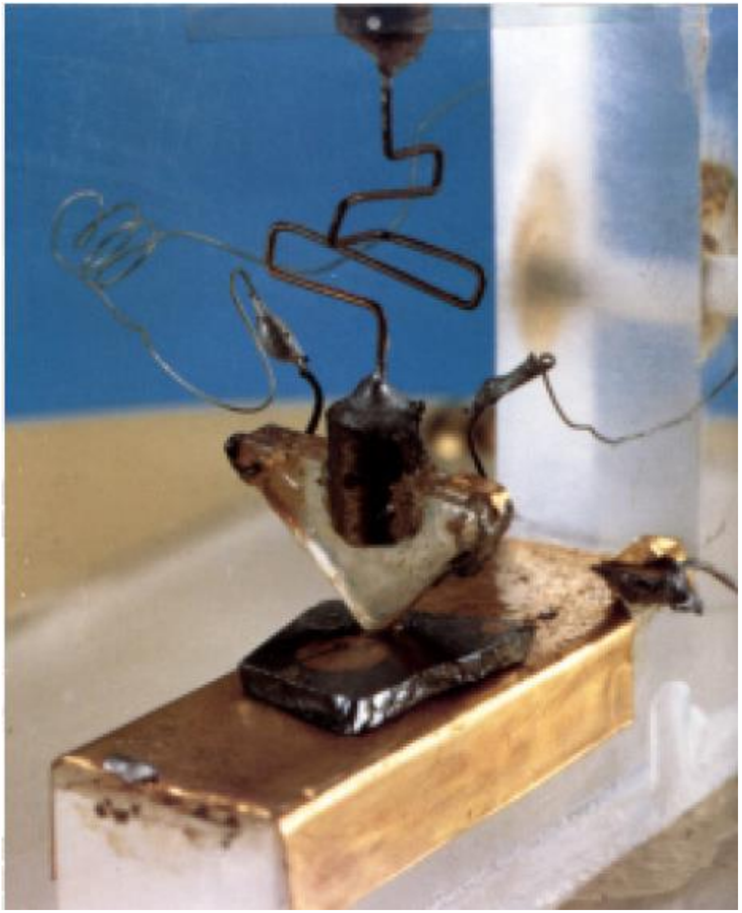








TRANSISTOR



The Nobel Prize in Physics 1956

William Bradford Shockley

Prize share: 1/3

John Bardeen

Prize share: 1/3

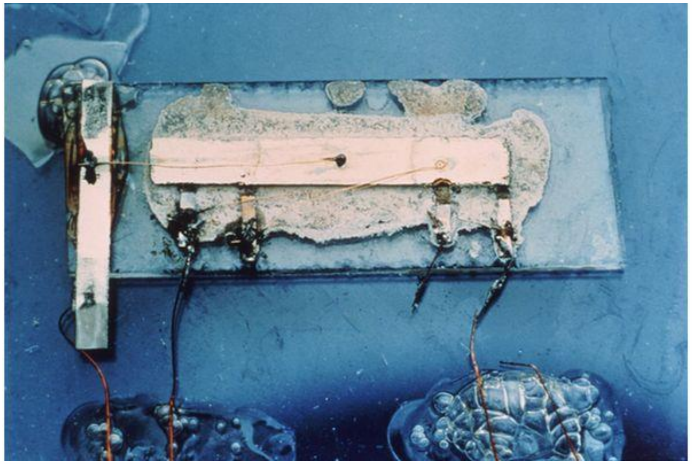
Walter Houser Brattain

Prize share: 1/3

The Nobel Prize in Physics 1956 was awarded jointly to William Bradford Shockley, John Bardeen and Walter Houser Brattain *"for their researches on semiconductors and their discovery of the transistor effect".*

Substitution of vacuum (electron) tube
Functions: switching / amplication / voltage stabilisation

THE FIRST INTEGRATED CIRCUIT



- Transistor: solution for the problems of the vacuum (electron) tube (dissipation, relability).
- Solution for connecting discrete devices (space saving).

The Nobel Prize in Physics 2000

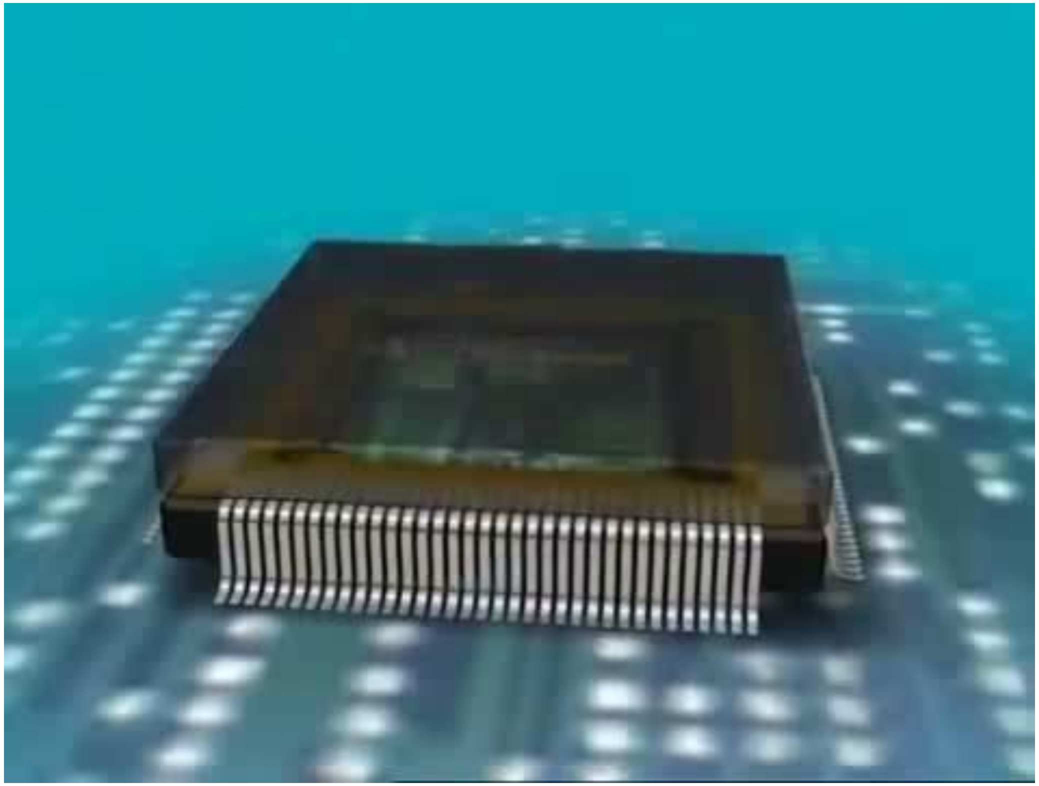
Zhores I. Alferov	Herbert Kroemer	Jack S. Kilby
Prize share: 1/4	**Prize share:** 1/4	**Prize share:** 1/2

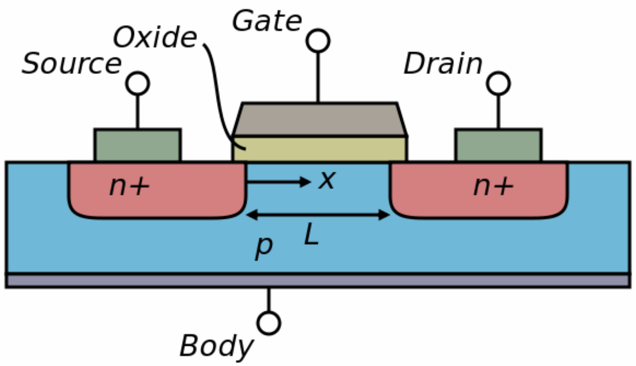
The Nobel Prize in Physics 2000 was awarded *"for basic work on information and communication technology"* with one half jointly to Zhores I. Alferov and Herbert Kroemer *"for developing semiconductor heterostructures used in high-speed- and opto-electronics"* and the other half to Jack S. Kilby *"for his part in the invention of the integrated circuit"*.

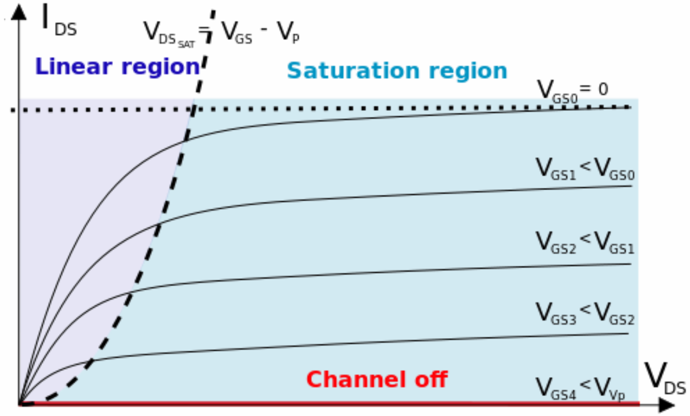
FIELD EFFECT TRANSISTOR (FET)

Main building block of CPU and memory

Functions: amplification (analog signals), switching







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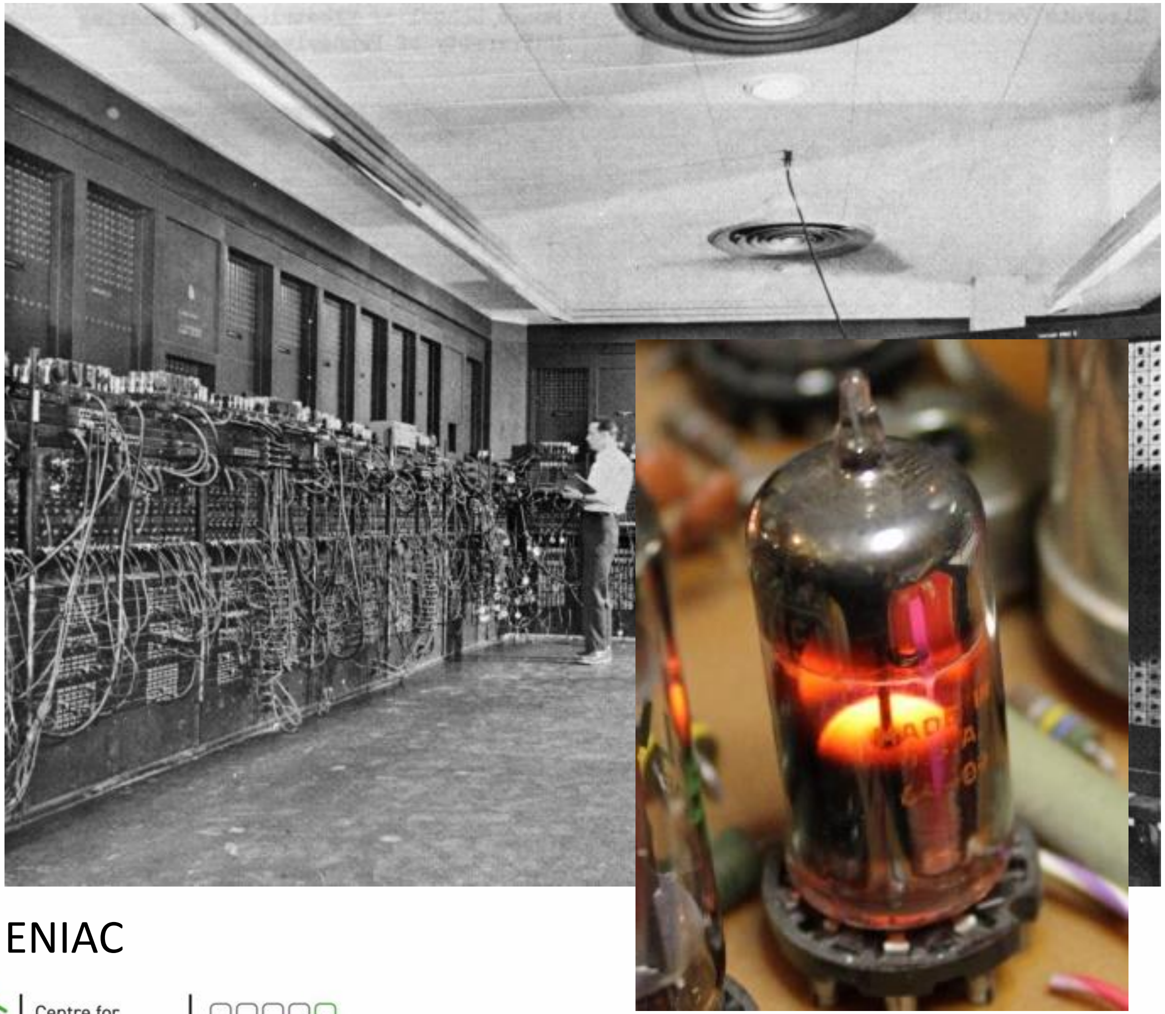
COMPUTATION

The FIRST COMPUTER

Von Neumann, János (1903-1957)

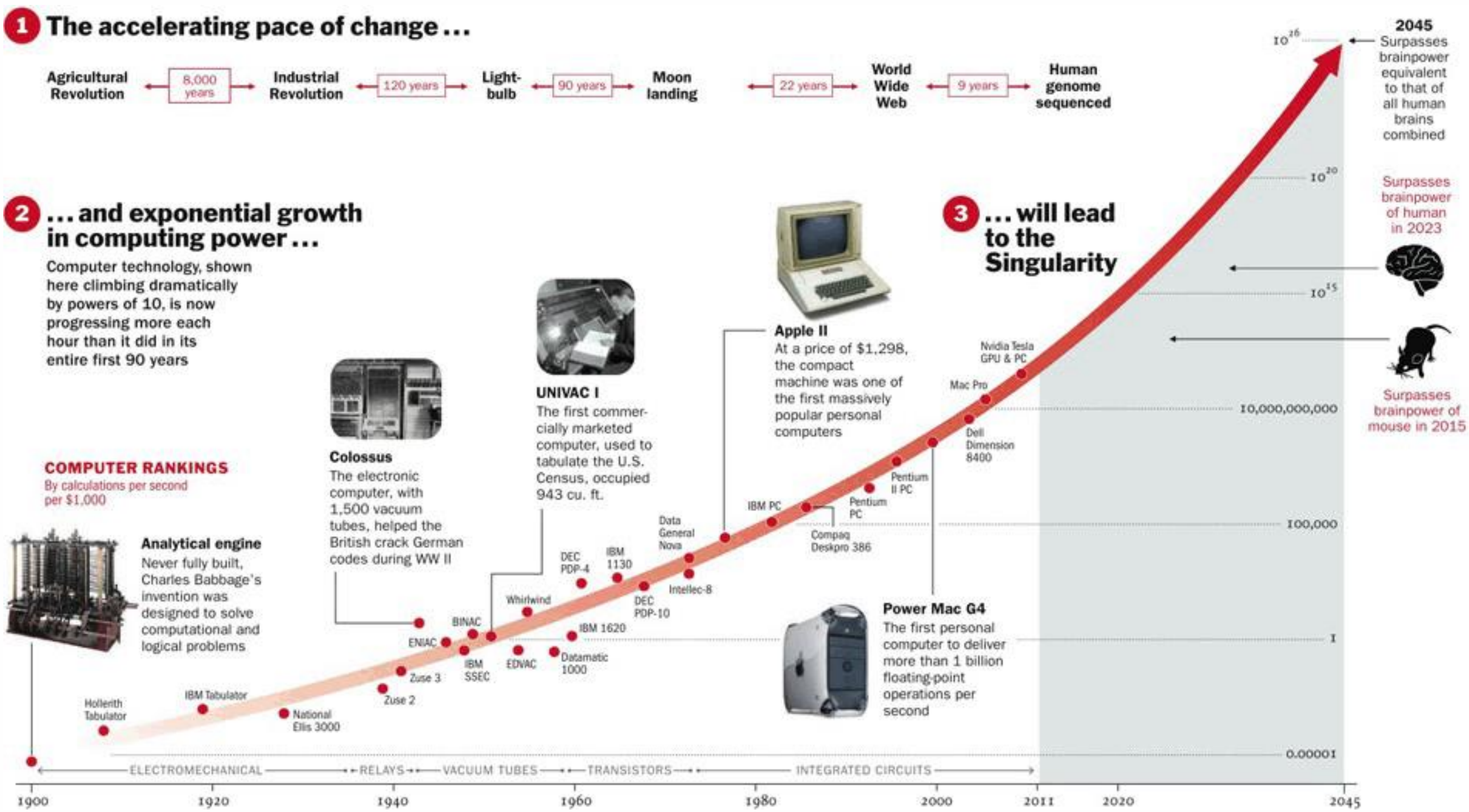


ENIAC

Development of the logical architecture of the electronic computers, based on the binary system.

Basic elements: memory, program storage, command system

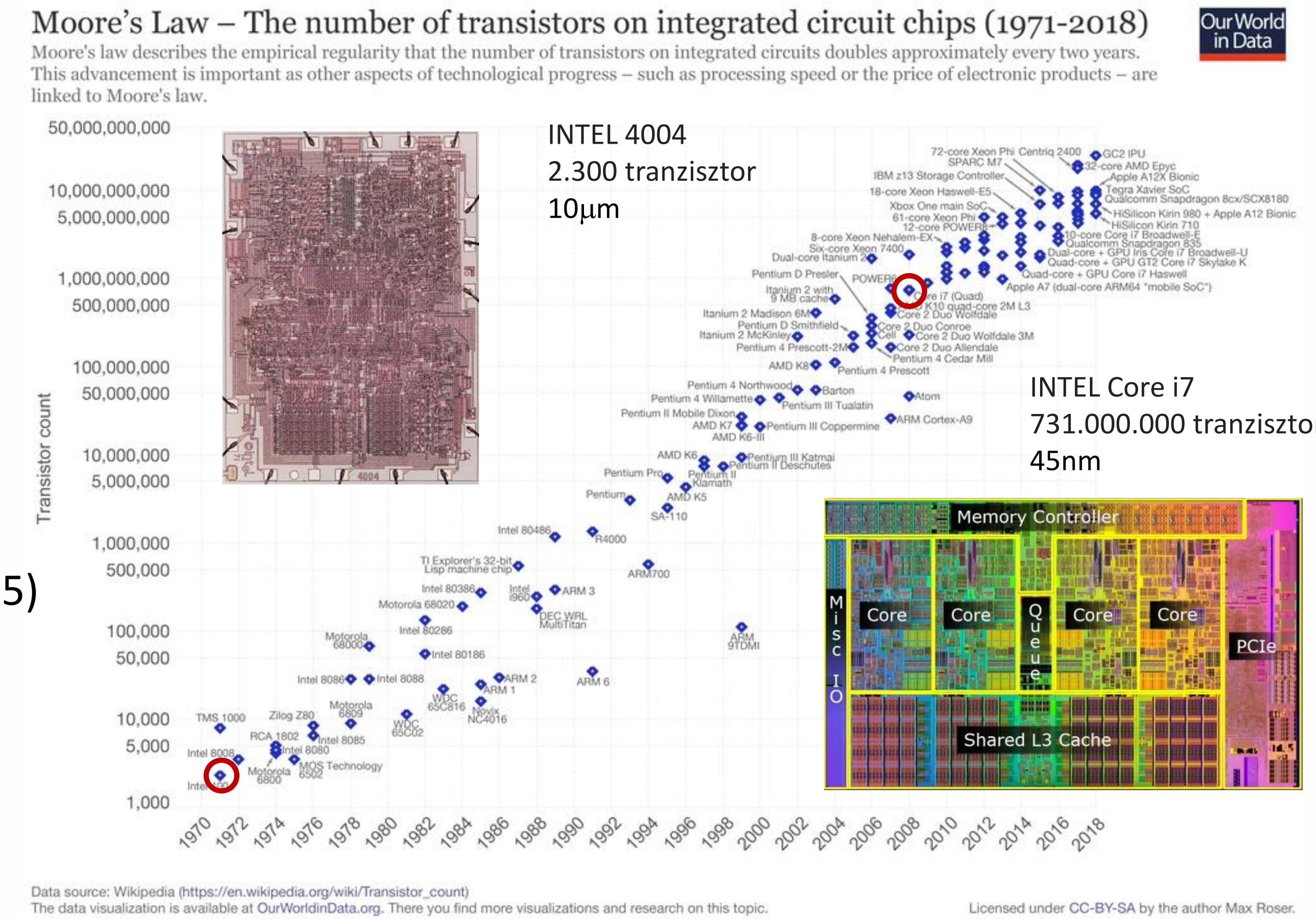
DEVELOPMENT of THE COMPUTATIONAL CAPACTY



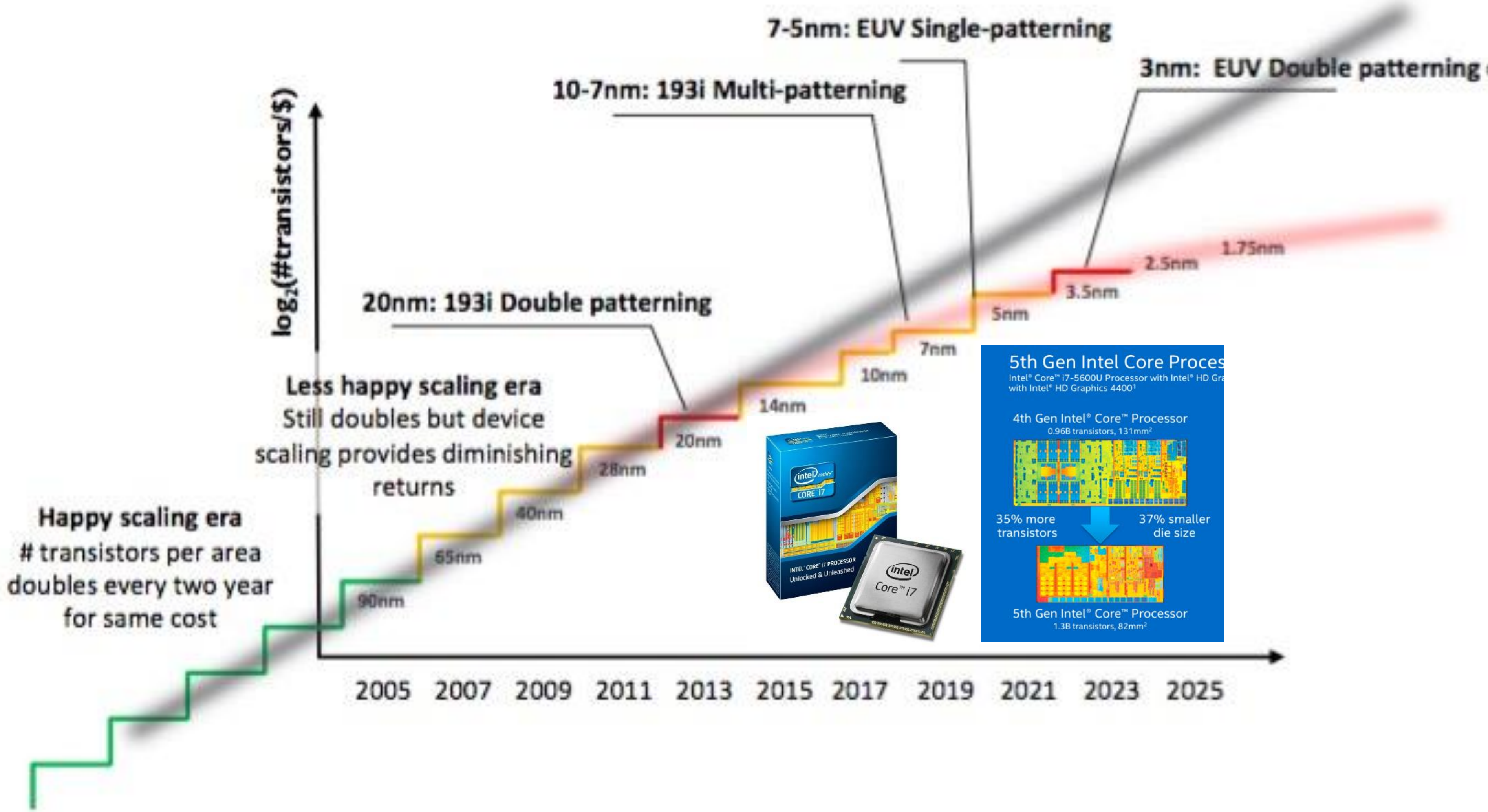
HOW MANY TRANSISTOR CAN BE PLACED ON A CHIP?

THE MOORE LAW

Gordon Moore (1965)



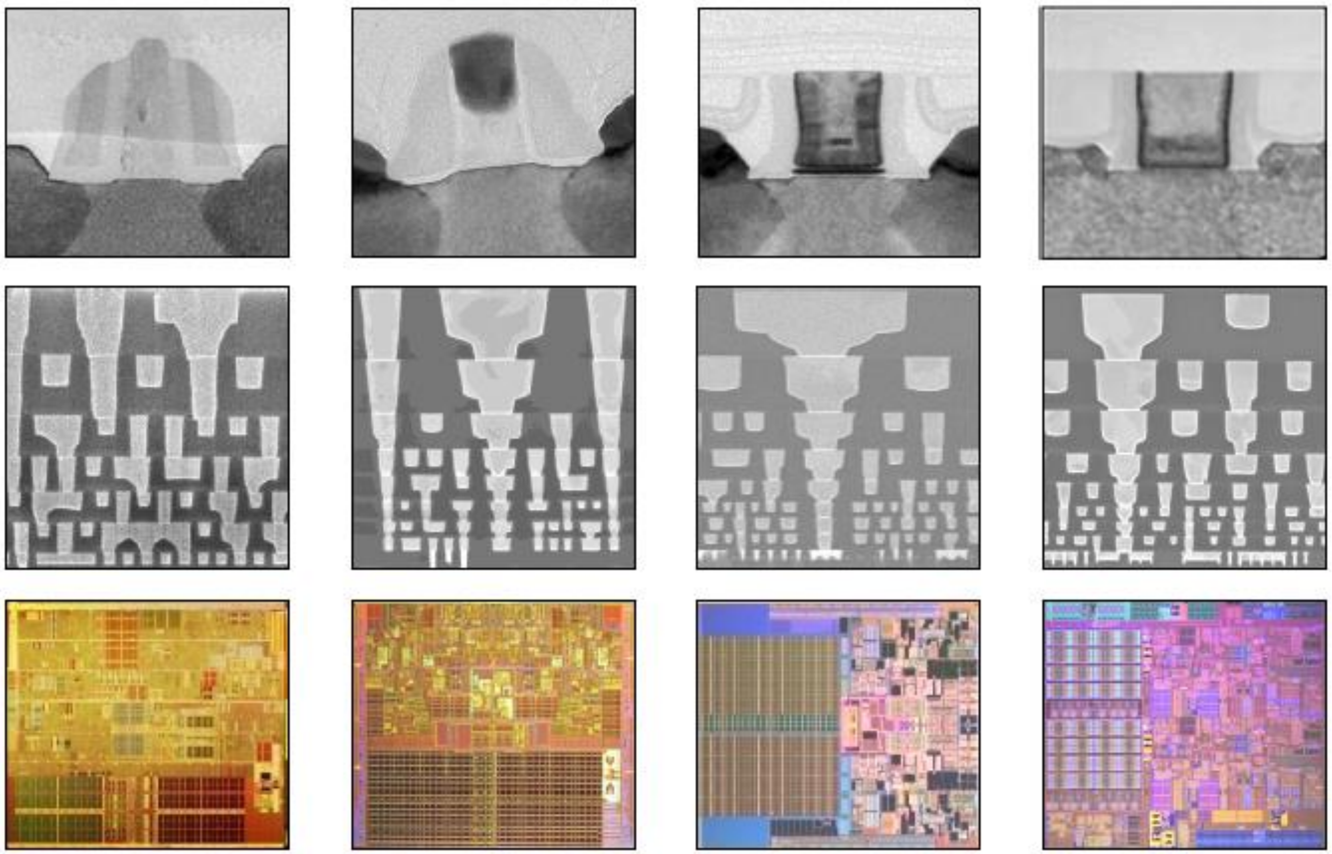
TECHNOLOGY DEVELOPMENT

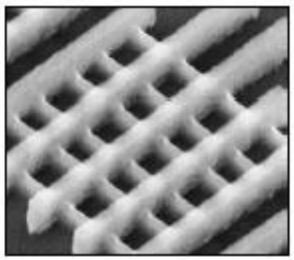


TECHNOLOGY: from SAND to PROCESSOR

INTEL 2003 - 2011

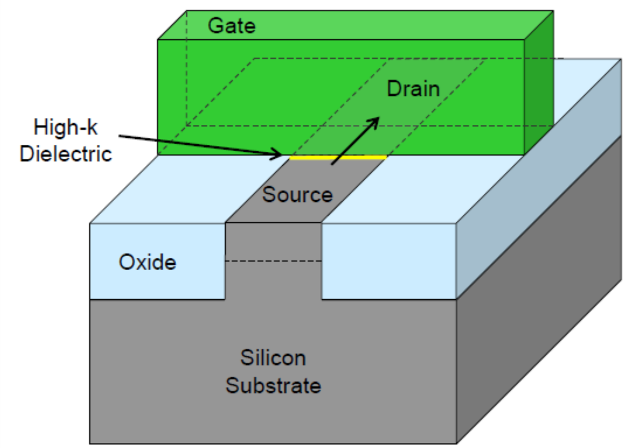
90 nm	65 nm	45 nm	32 nm	22 nm
2003	2005	2007	2009	2011

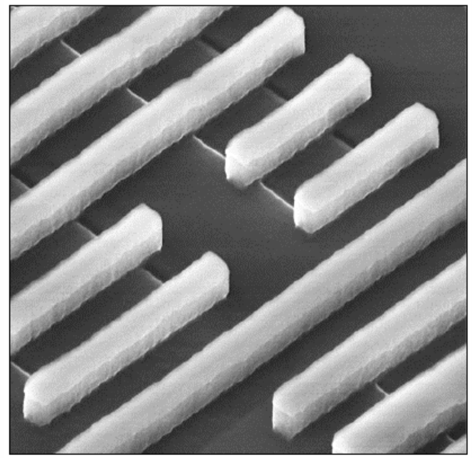


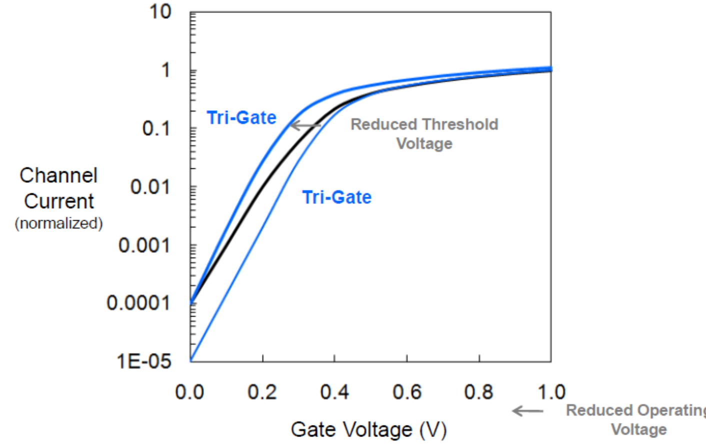


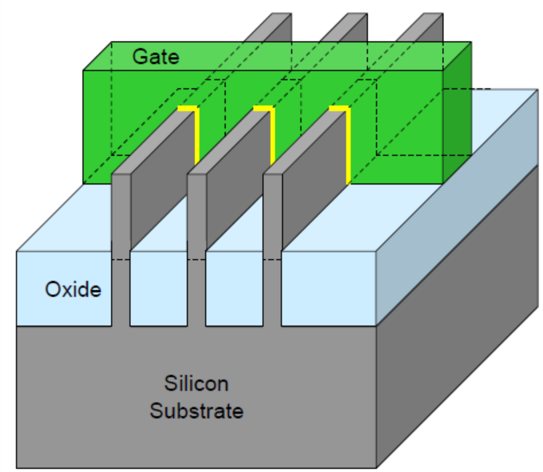
3D TRI-GATE transistor

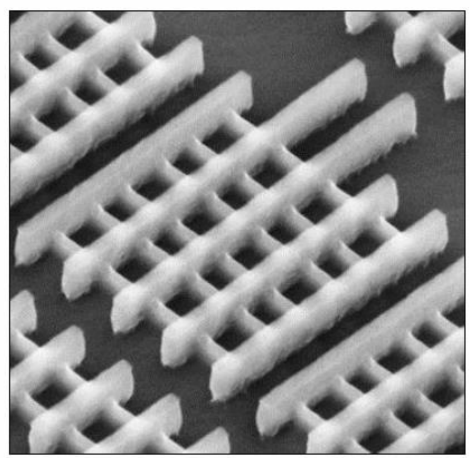
PLANAR vs. 3D TRANSISTOR

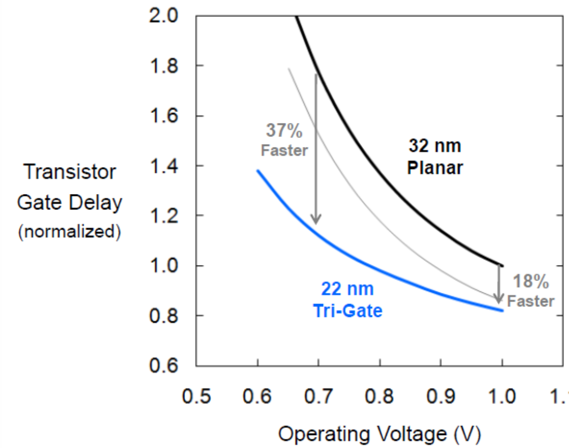












TECHNOLOGY: from SAND to PROCESSOR

(2011 - 3D TRI-GATE MOS)

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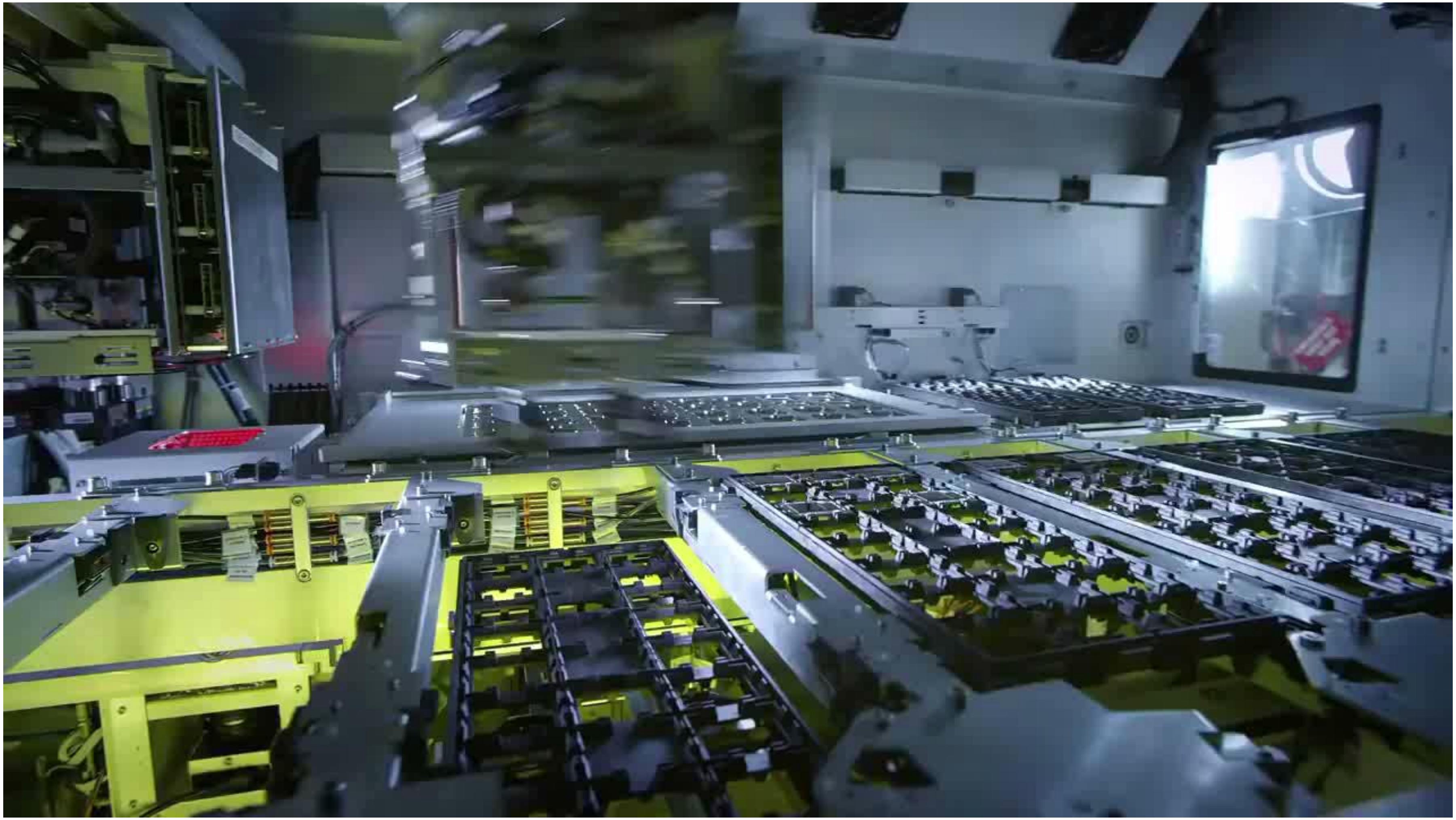
INFRASTRUCTURE – MICRO / NANO – INTEL FAB



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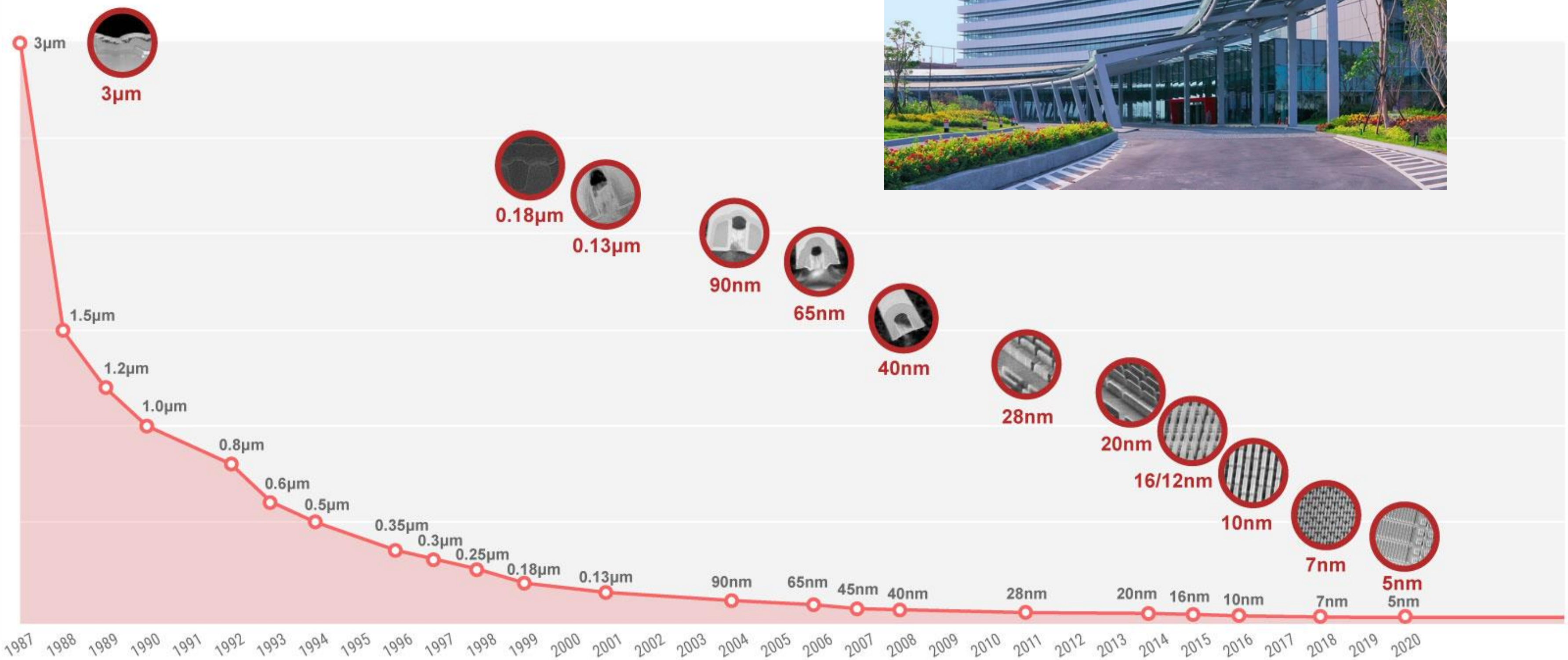
TSMC 1987 - TODAY

TSMC's 5nm (N5) Fin Field-Effect Transistor (FinFET) technology successfully entered volume production in the second quarter of 2020.



Revenue for January through September 2021 totaled NT$1,149.23 billion, an increase of 17.5 percent compared to the same period in 2020.

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BEYOND MOORE LAW …

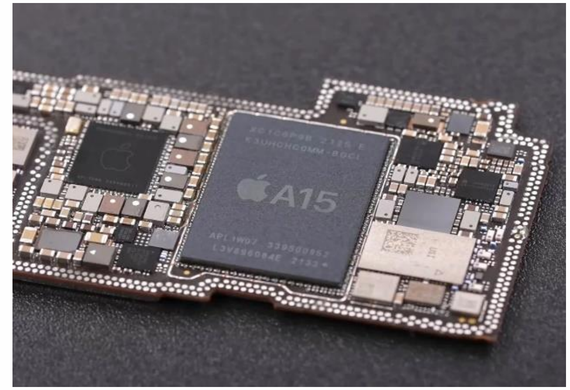
MOBILE

TSMC to Use 4nm Process For A16 Bionic Chips on iPhone 14

By Ali Salman

Nov 3, 2021 14:29 EDT

SHARE TWEET SUBMIT



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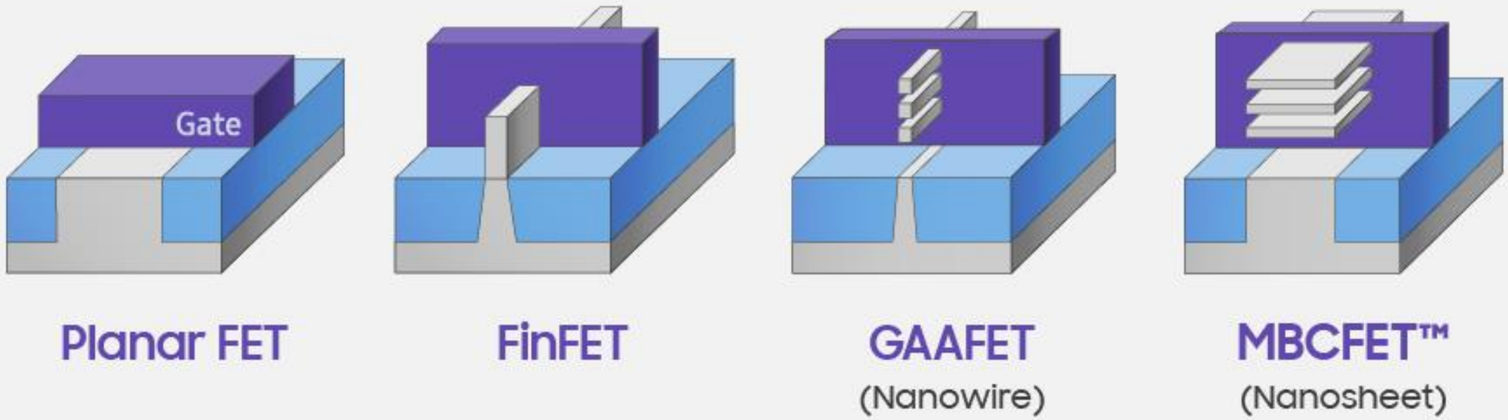
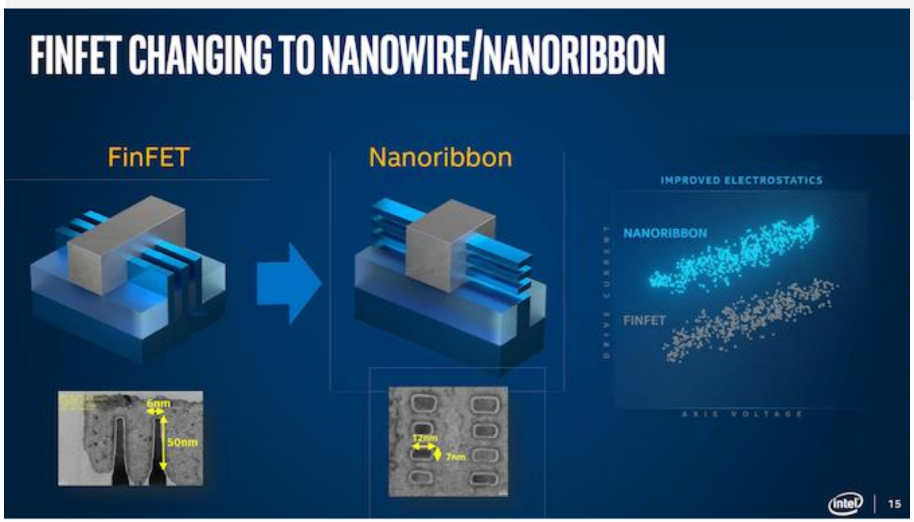
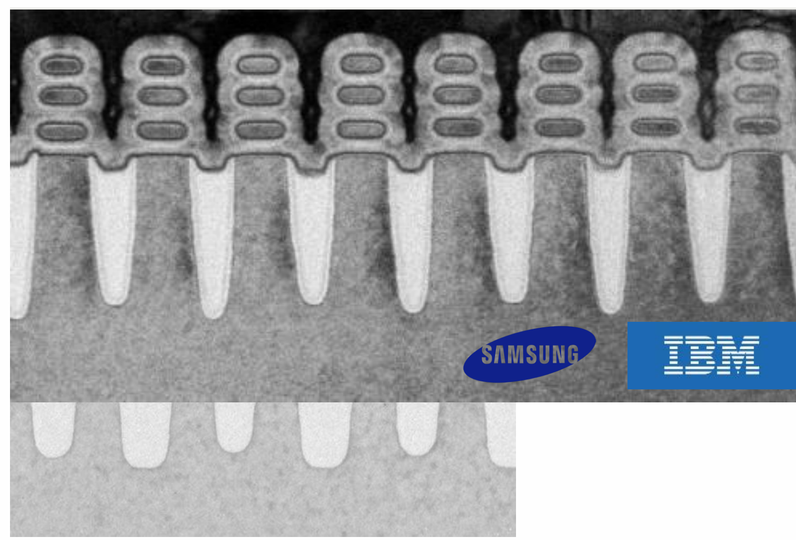
TECHNOLOGY: BEYOND 3D TRI-GATE

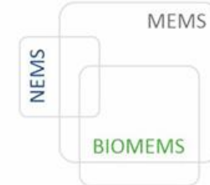
Multi-Bridge Channel FET (MBCFET)



Gate-All-Around Field Effect Transistor (GAAFET)

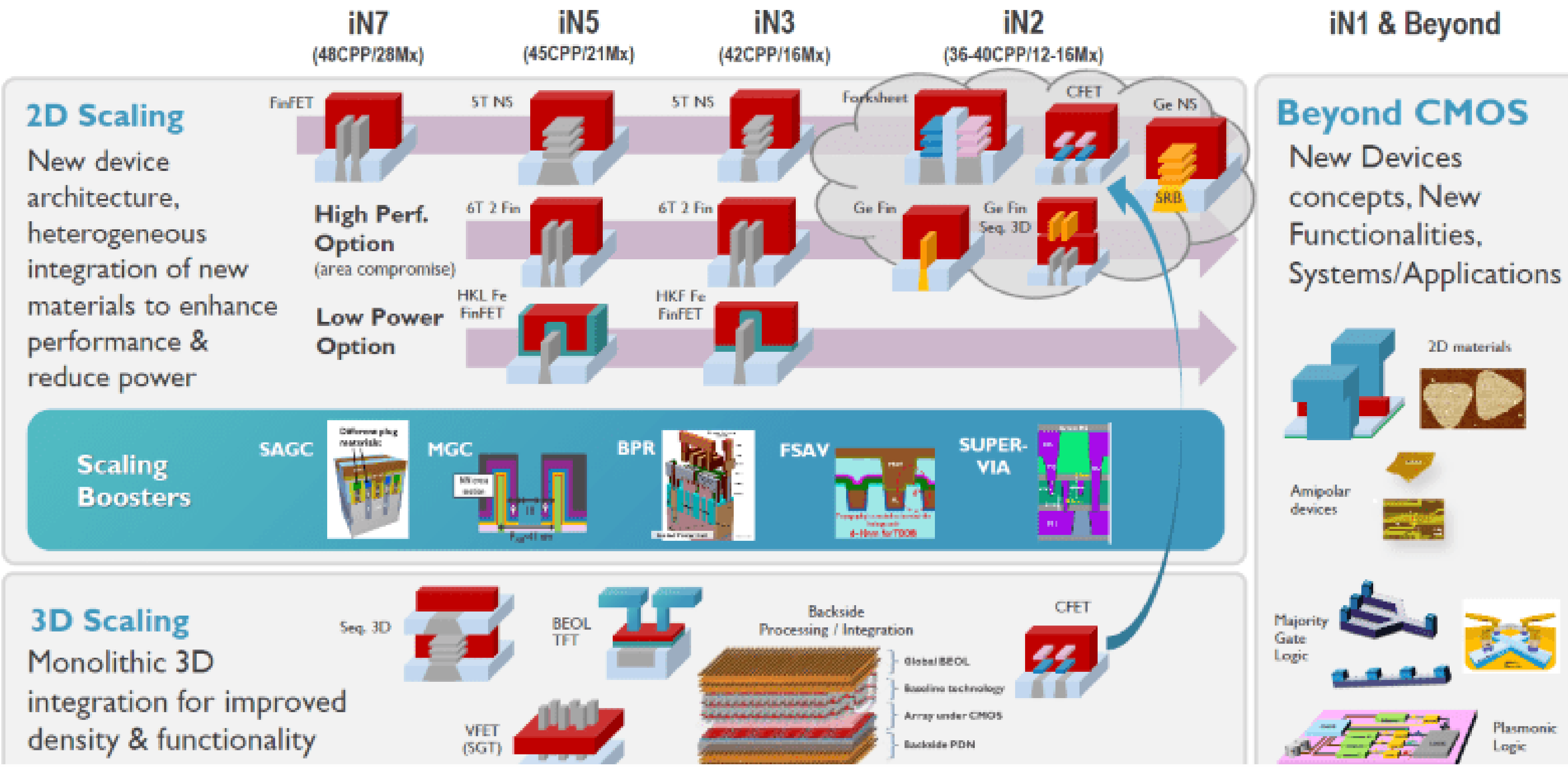






CMOS AND BEYOND CMOS

IMEC VIEW OF LOGIC ROADMAP



Alternative technologies:

Superconducting technology

Spintronics

Quantum Computing

Photonics

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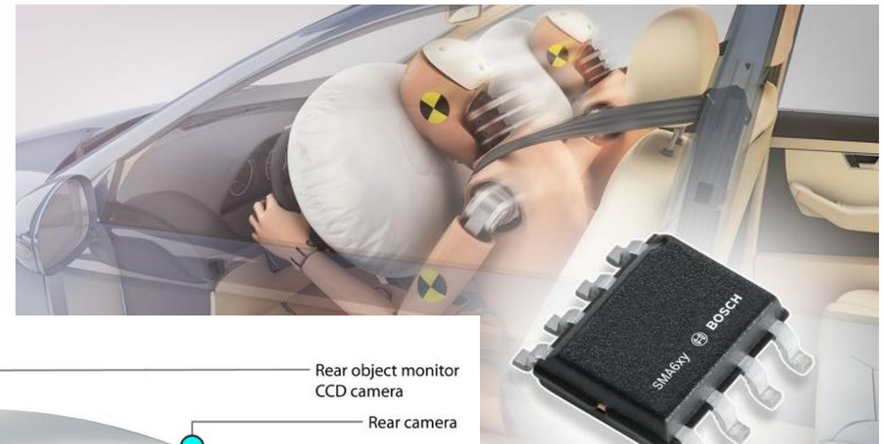
MORE THAN MOORE REVOLUTION of MEMS

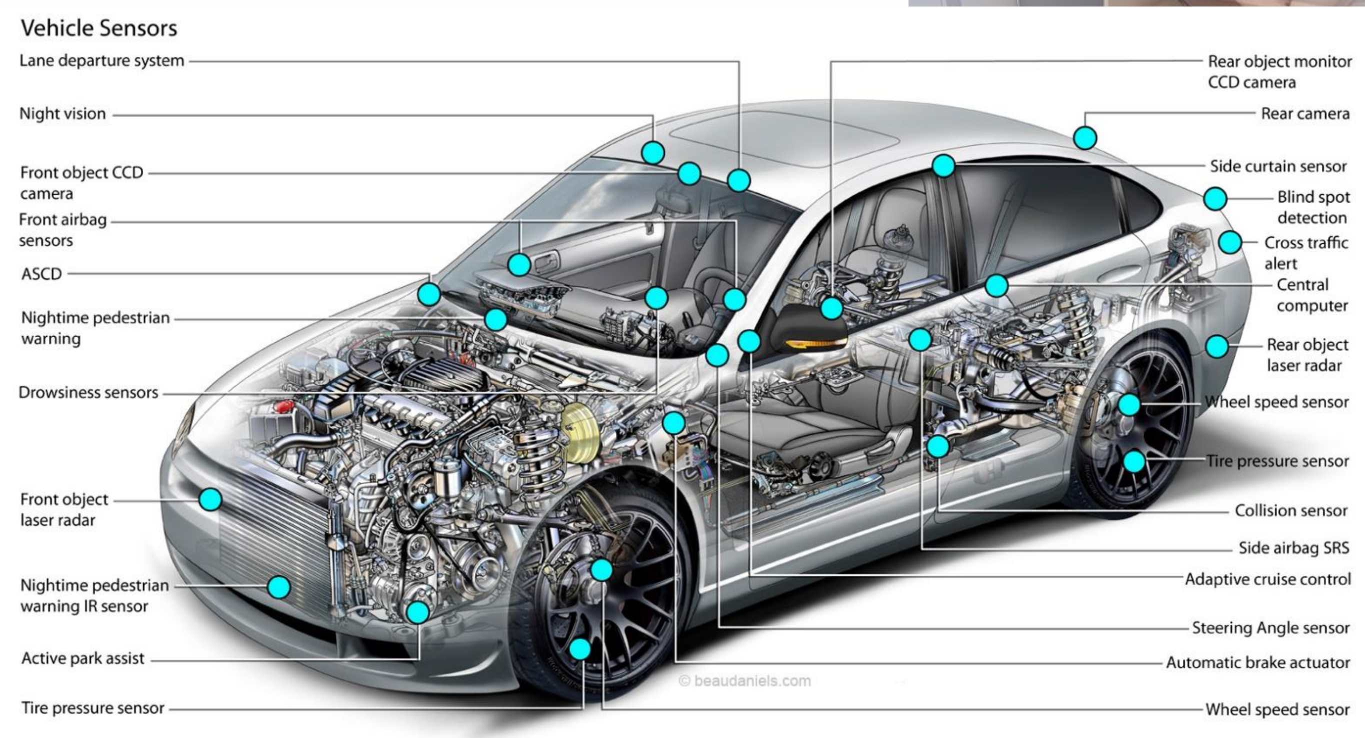
MEMS: SI (SOLID STATE) MICROSENSORS

MEMS: micro-electromechanical systems

Example: automotive applications

- Engine / gear diagnostics and control
- Life- and trafic safety
- Comfort





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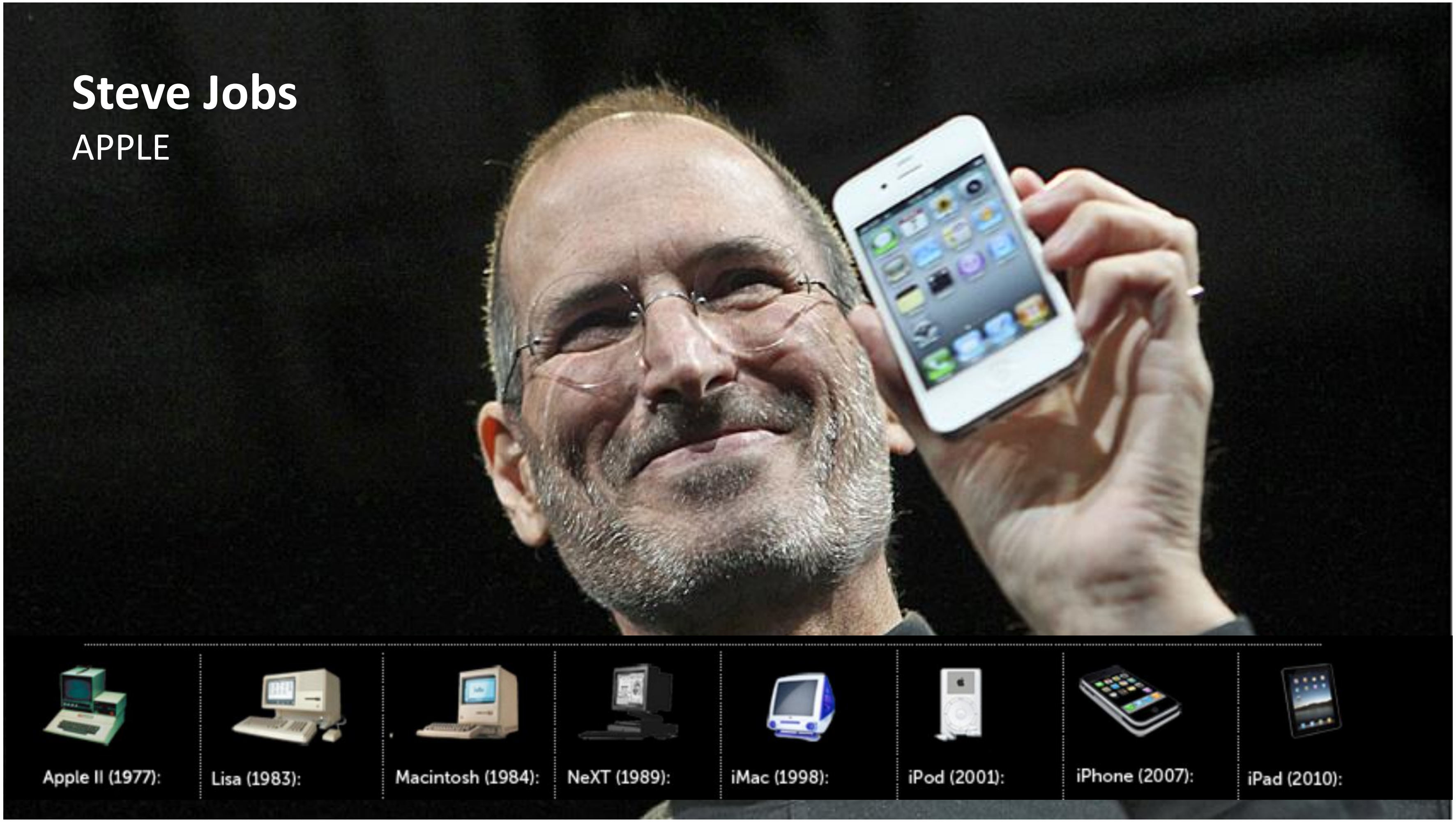
GUESS WHO?



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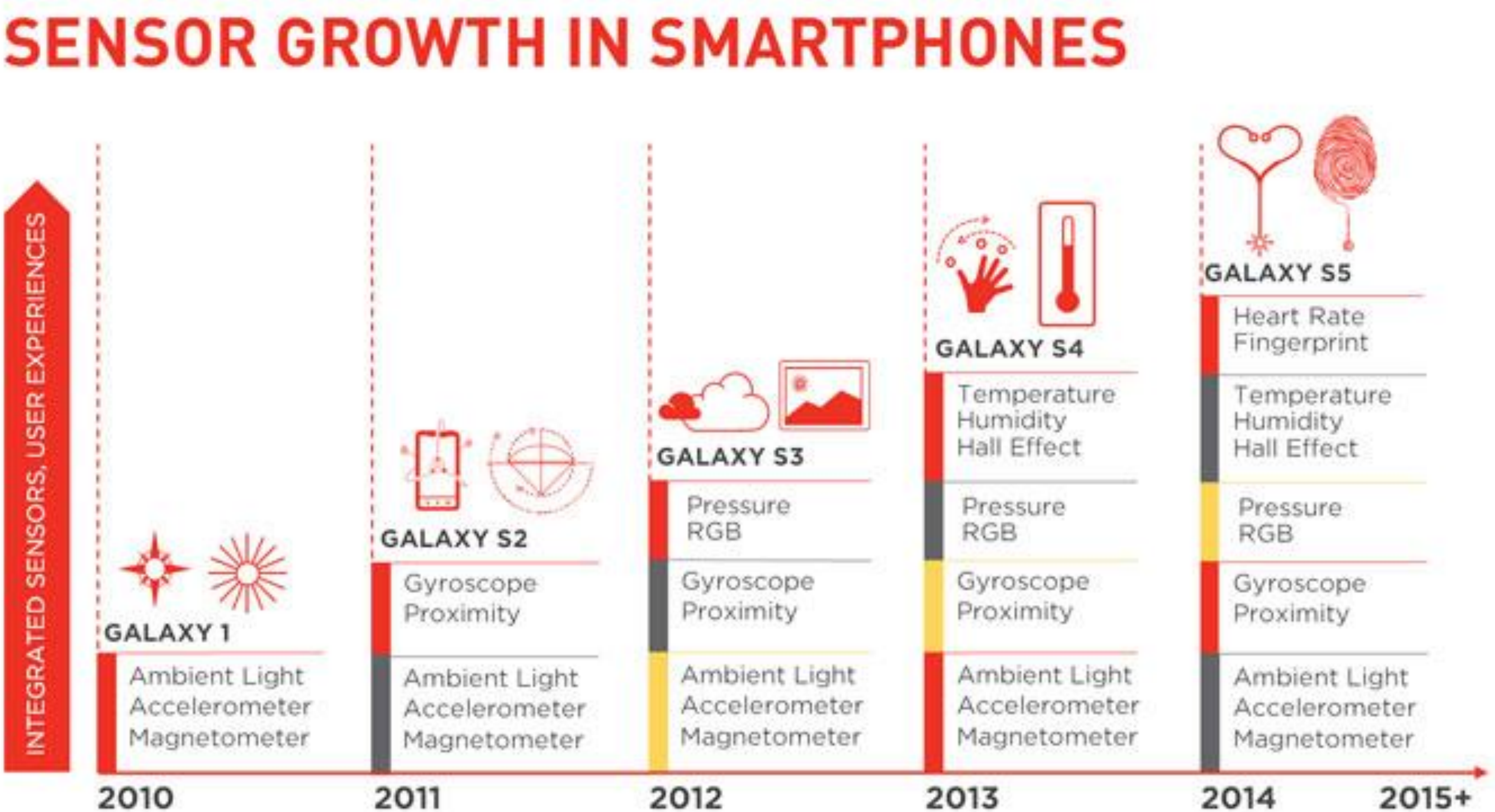
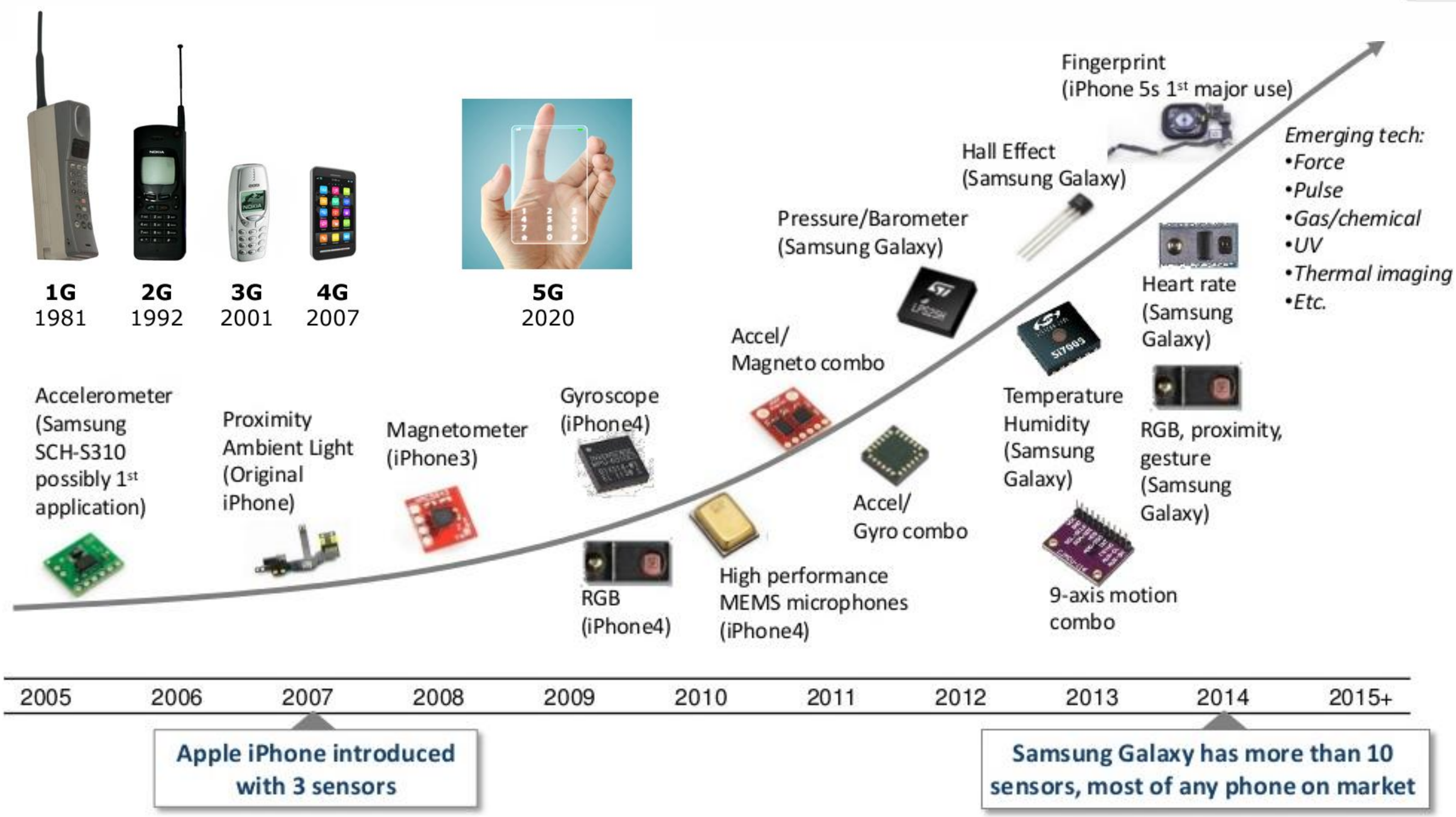
DISASSEBLE OUR VIRTUAL SMARTPHONE



Sources: Driven by Apple and Samsung, Light Sensors Achieve Double-Digit Revenue Growth, IHS, June 30, 2013; MEMS: Looking back at 2014 and 5 years outlook, IHS, November 2014; Light and Proximity Sensors - A Market Ready for Explosive Growth, Tony Rizzo, Mobility TechZone, July 30, 2013; iPhone 6 Teardown, iFixit, 2014; Apple 3G iPhone Teardown Report, Portelligent, 2008; MEMS Microphone Market Tops 2 Billion Units, Mobile Dev Design, March 4, 2013

SMARTPHONE'S FUTURE



Sources: This little motion sensor went to the market..., Sonja Thompson, IT News Digest, March 22, 2007; Willie D. Jones, IEEE Spectrum, A Compass in Every Smartphone, January 29, 2010; Consumers boost MEMS combo sensors, Electronic Product Design and Test, March 19, 2014; Samsung Turns up the Pressure on Competition with Pressure Sensor in Galaxy S4, IHS, March 20, 2013; Behind the sixth sense of smartphones: the Snapdragon processor sensor engine, Qualcomm, April 24, 2014; MEMS for Cell Phones & Tablets, Yole Developpement, May 2012; Fairchild, Emergence of a $Trillion MEMS Sensor Market, SensorCon, 2012; MEMS Microphone Market Tops 2 Billion Units, Mobile Dev Design, March 4, 2013

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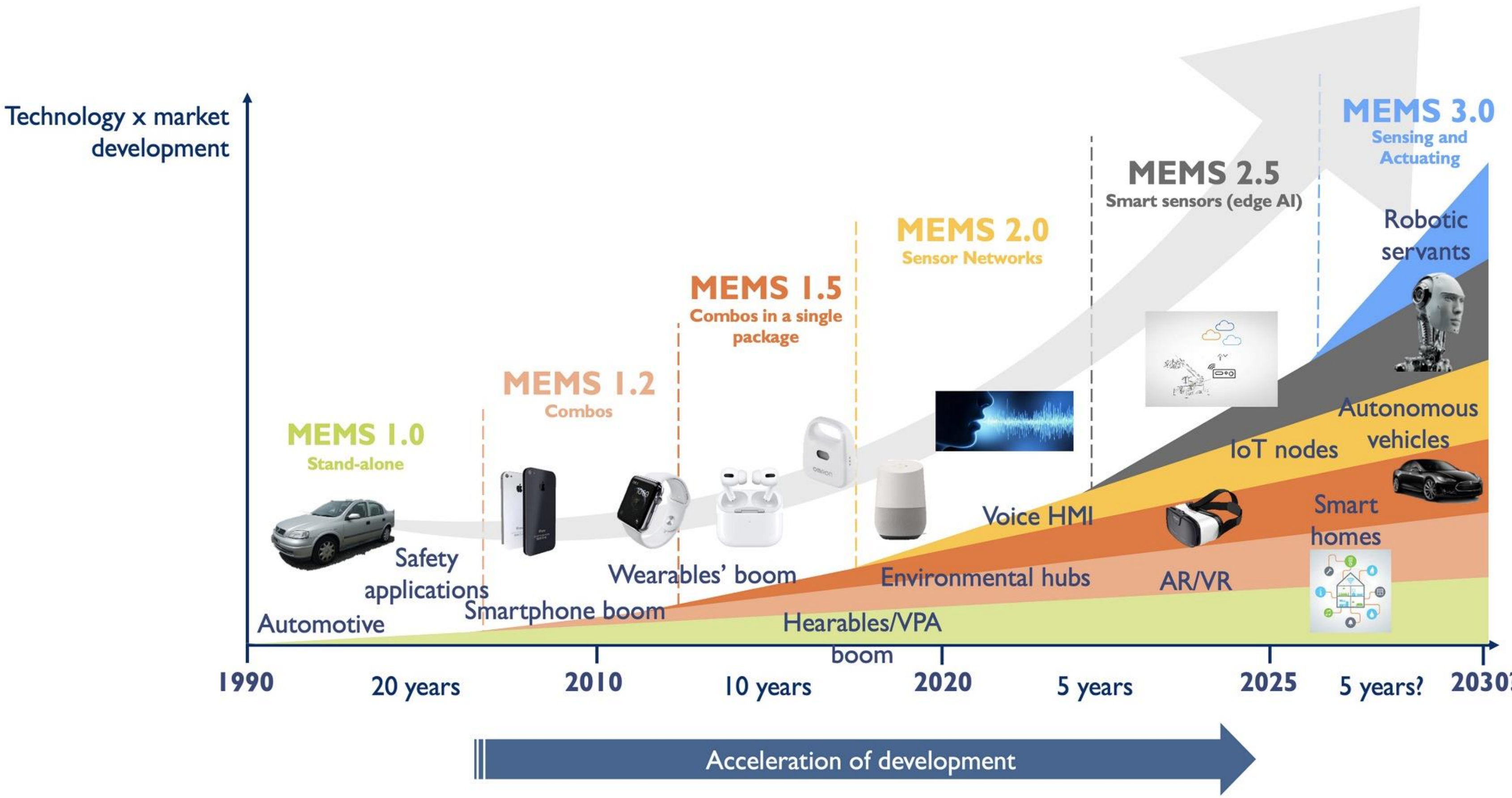
„SMART" EVOLUTION



YOLE Développement

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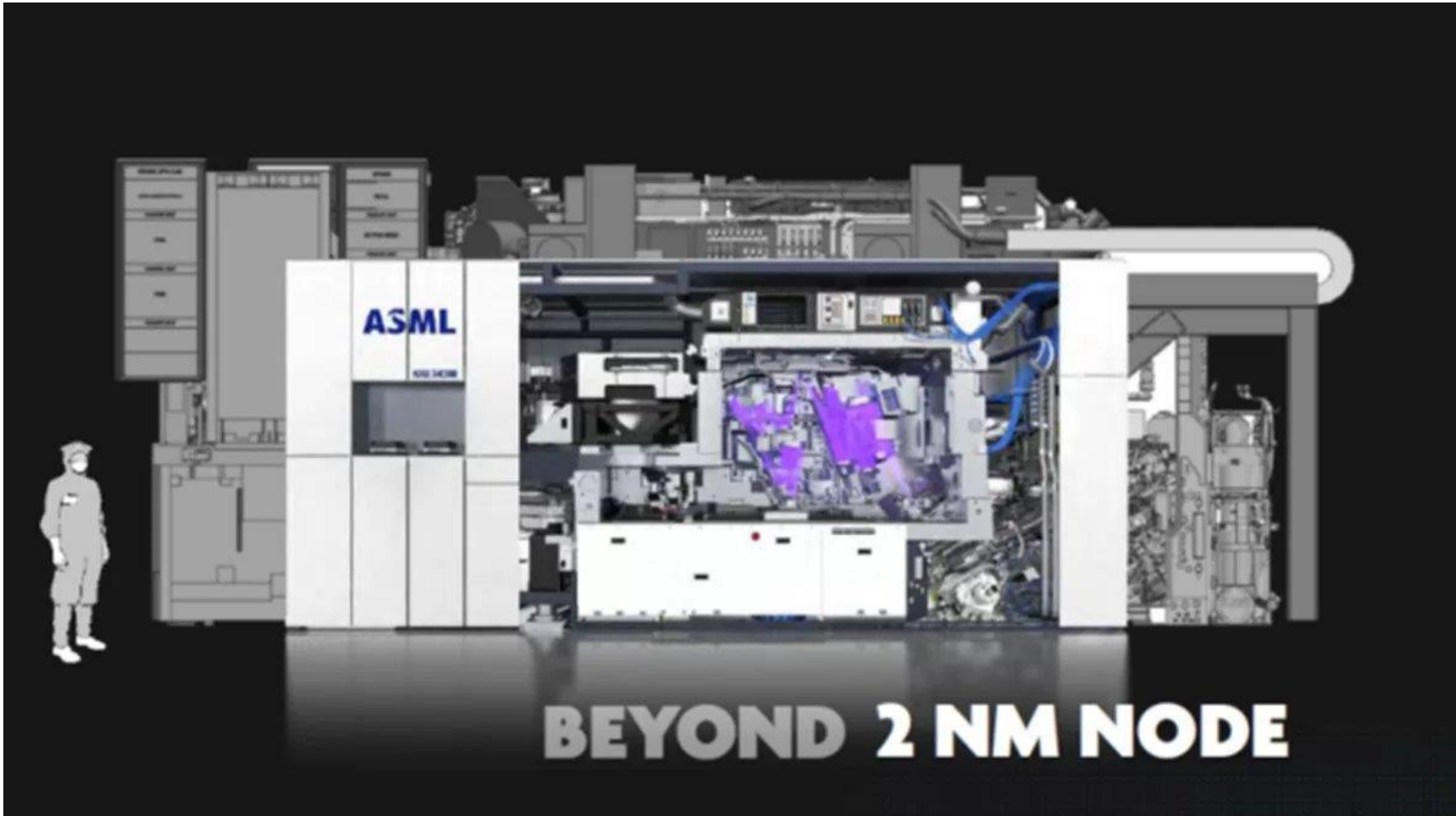
STATE OF THE ART



THX FOR ATTENTION!

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