Moore & more than Moore

Péter Fürjes

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SILICON (silex)

Moore & more than Moore - 2
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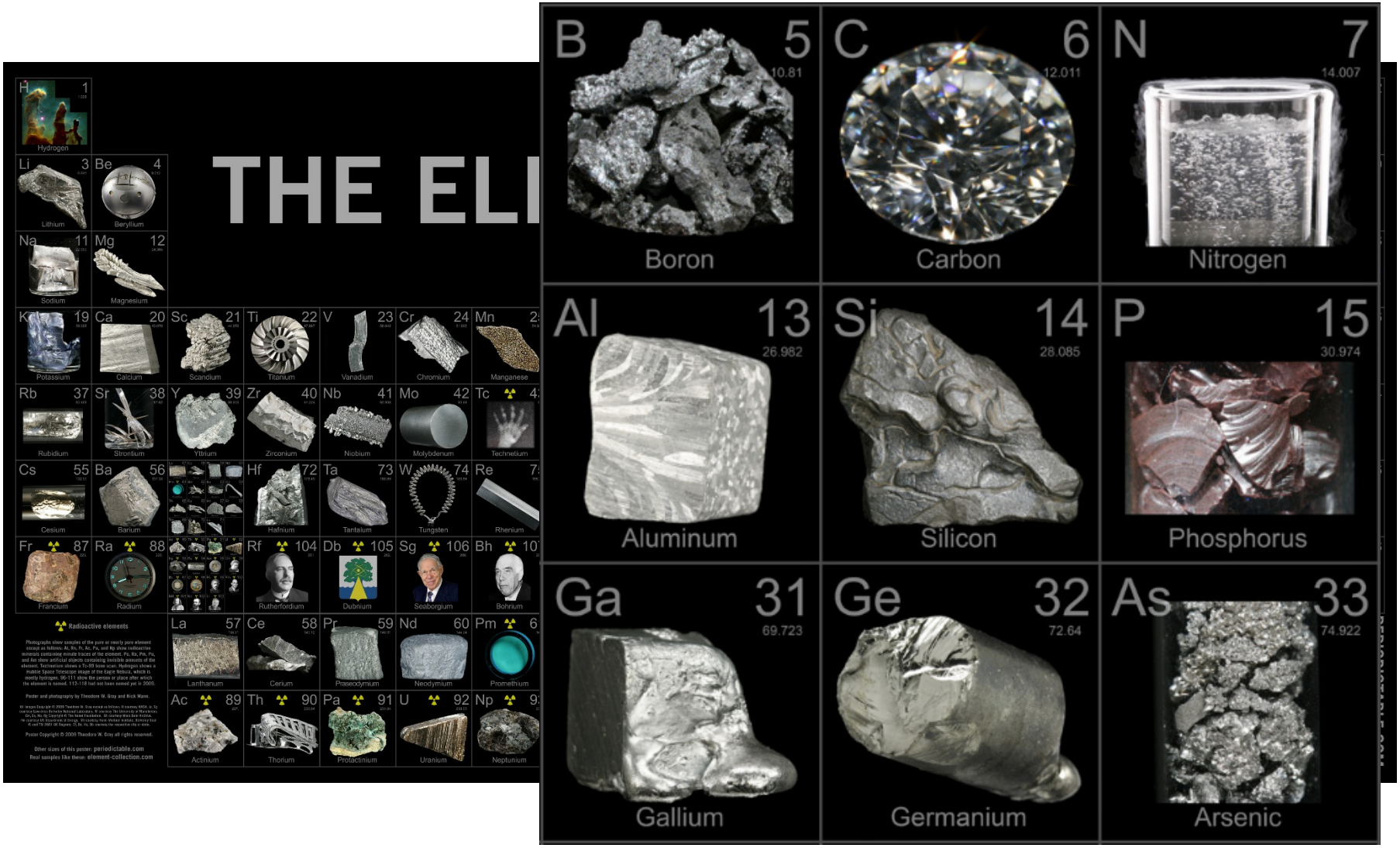
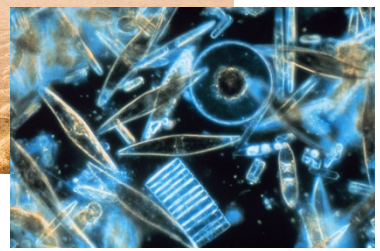


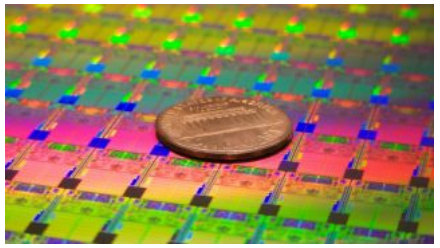
SILICON (silex)

Discoverer: Jons Berzelius
1823, Sweden

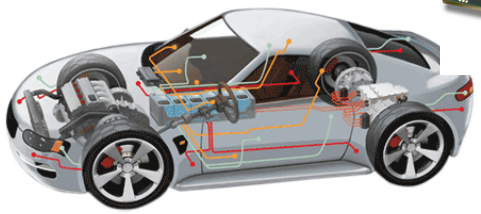
Natural presence:
granite, quartz, clay, sand

2nd in incidence in the Earth

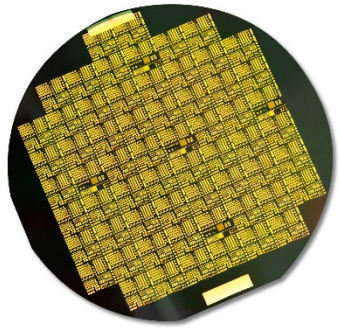




Other applications…



SILICON – as a chemical element



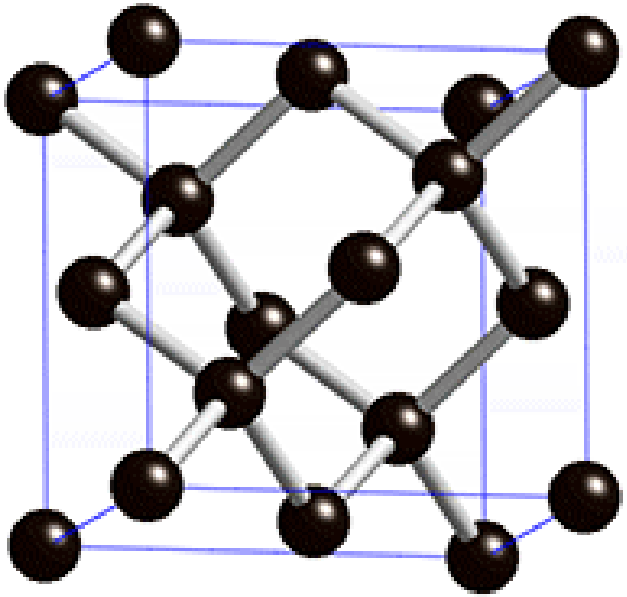
Properties: gray, metallic,
extremely hard material

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

4th group / tetravalent metalloid

Crystal: similar to diamond

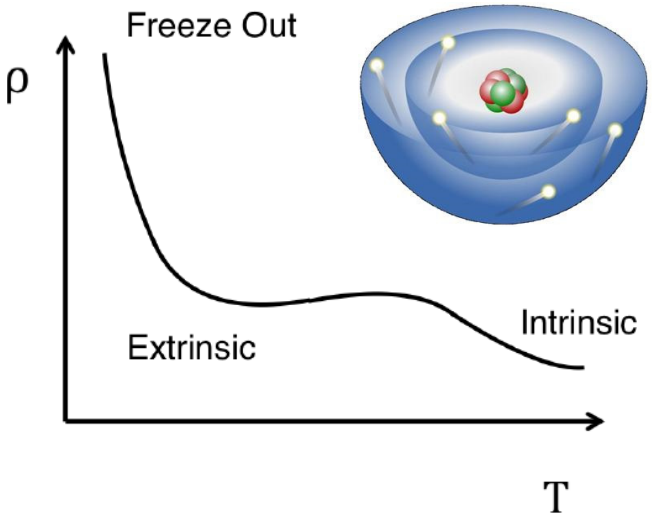
Electronic property: semiconductor

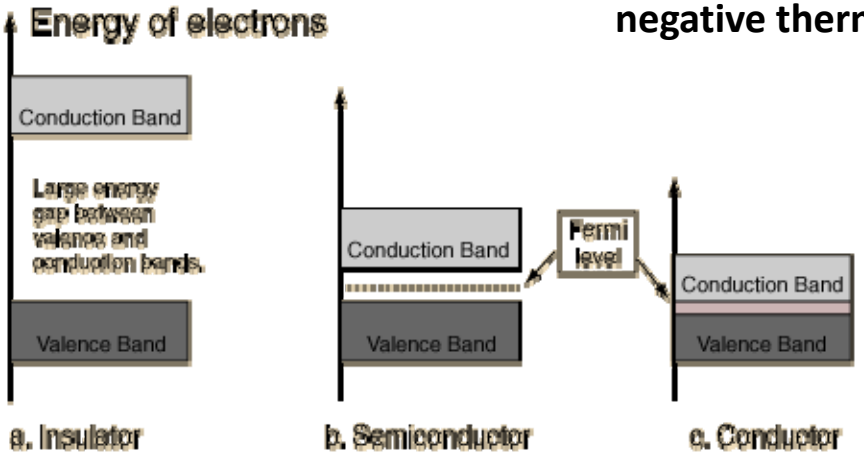


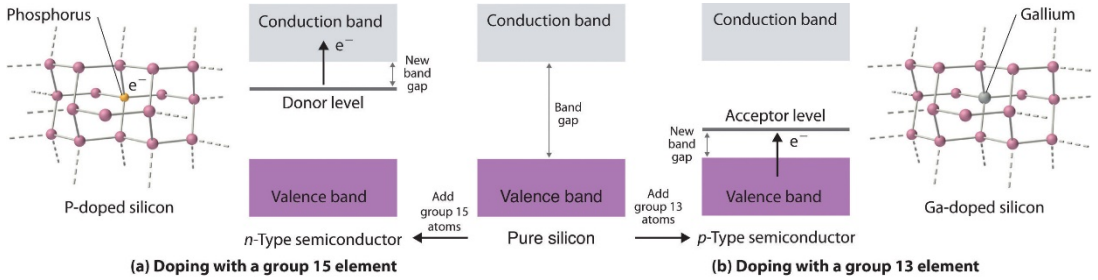
Resistance of semiconductors: 10^{-9} – 10^{3} 1/Ωcm

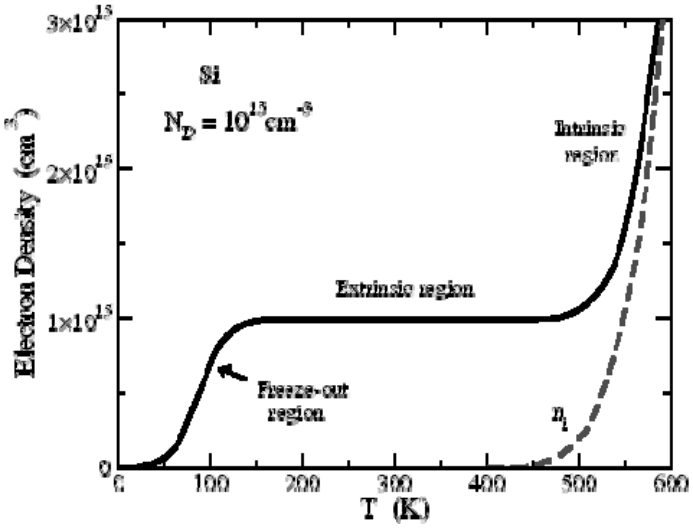
How does the resistance change with the temparature?

negative thermal coefficient of resistance







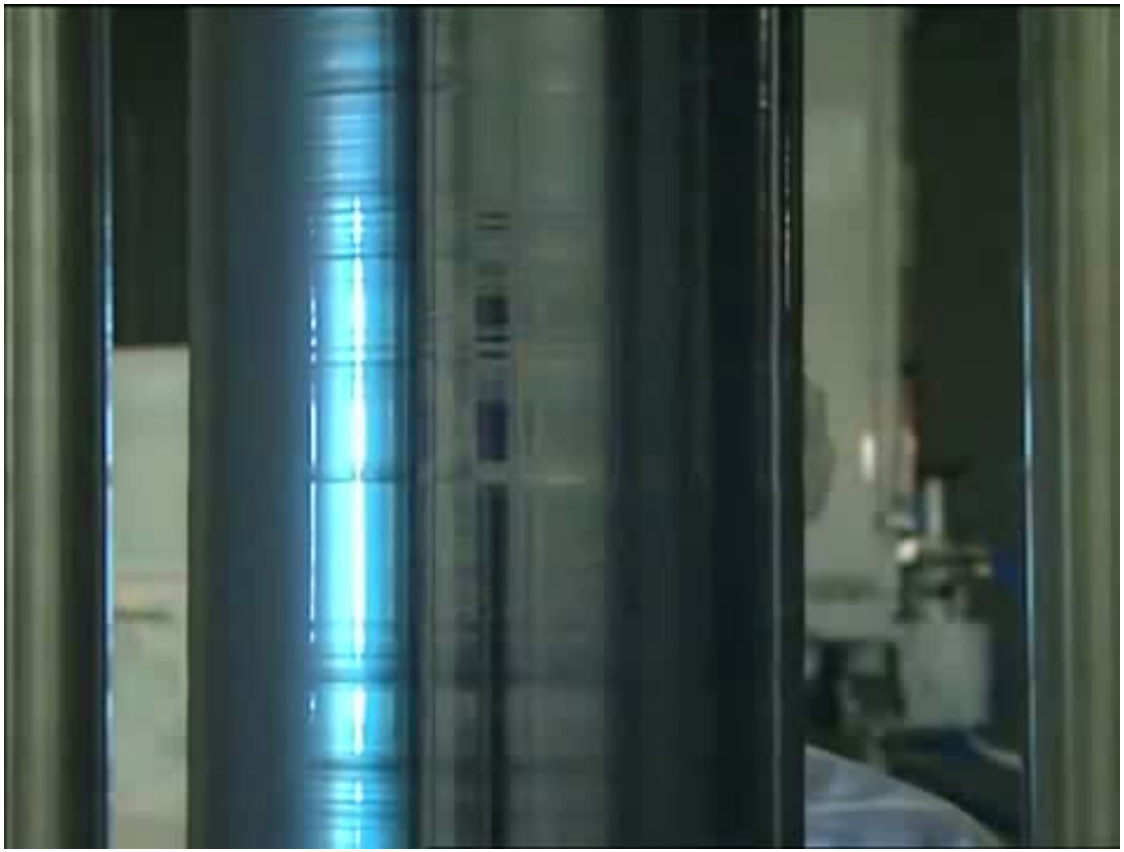


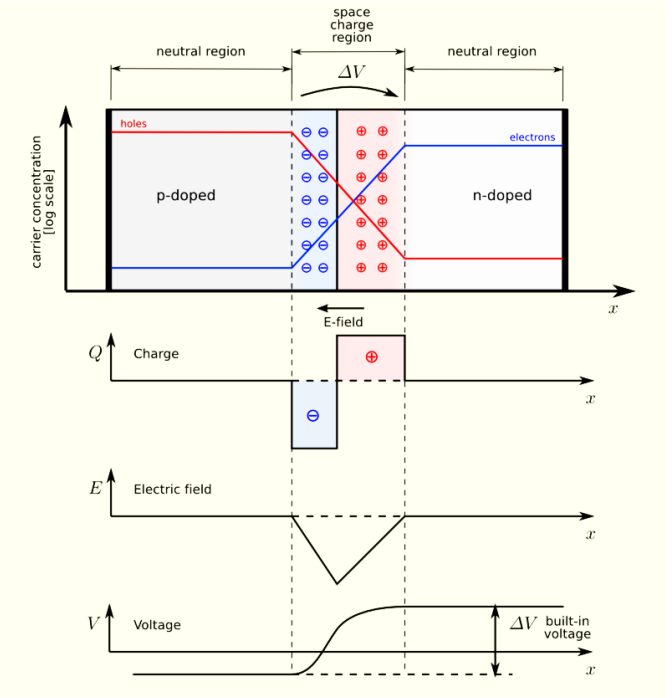
DIODE

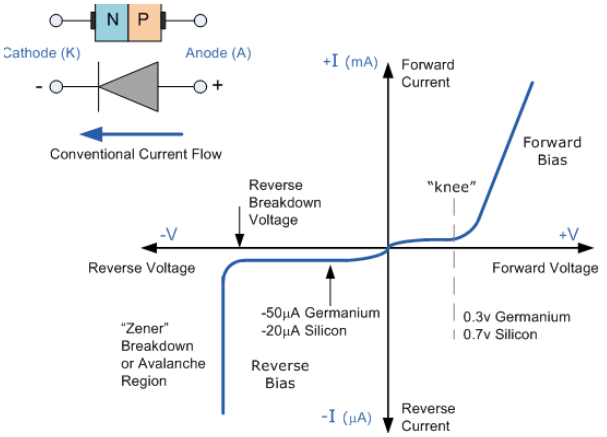
Dopped semiconductors:

n-type (electron conductance)

and p-type (hole conductance)







TRANSISTOR

The Nobel Prize in Physics 1956

William Bradford Shockley

Prize share: 1/3

John Bardeen

Prize share: 1/3

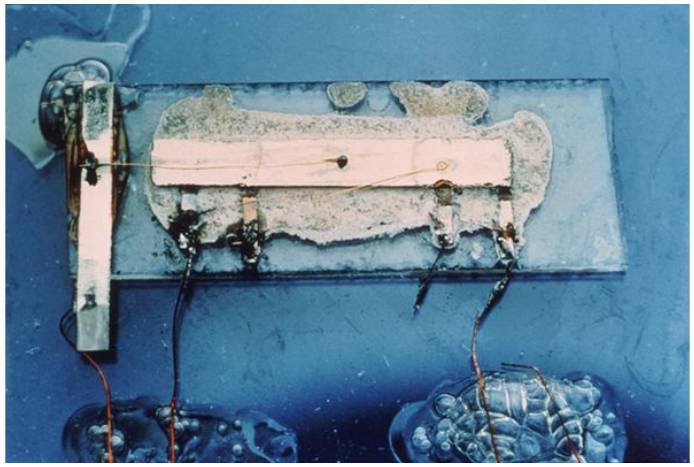
Walter Houser Brattain

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

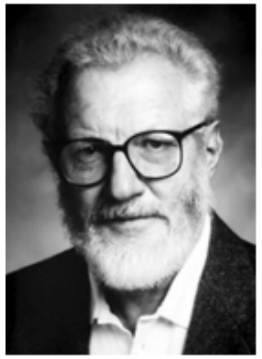
The FIRST INTEGRATED CIRCUIT



- 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
Prize share: 1/4



Herbert Kroemer
Prize share: 1/4

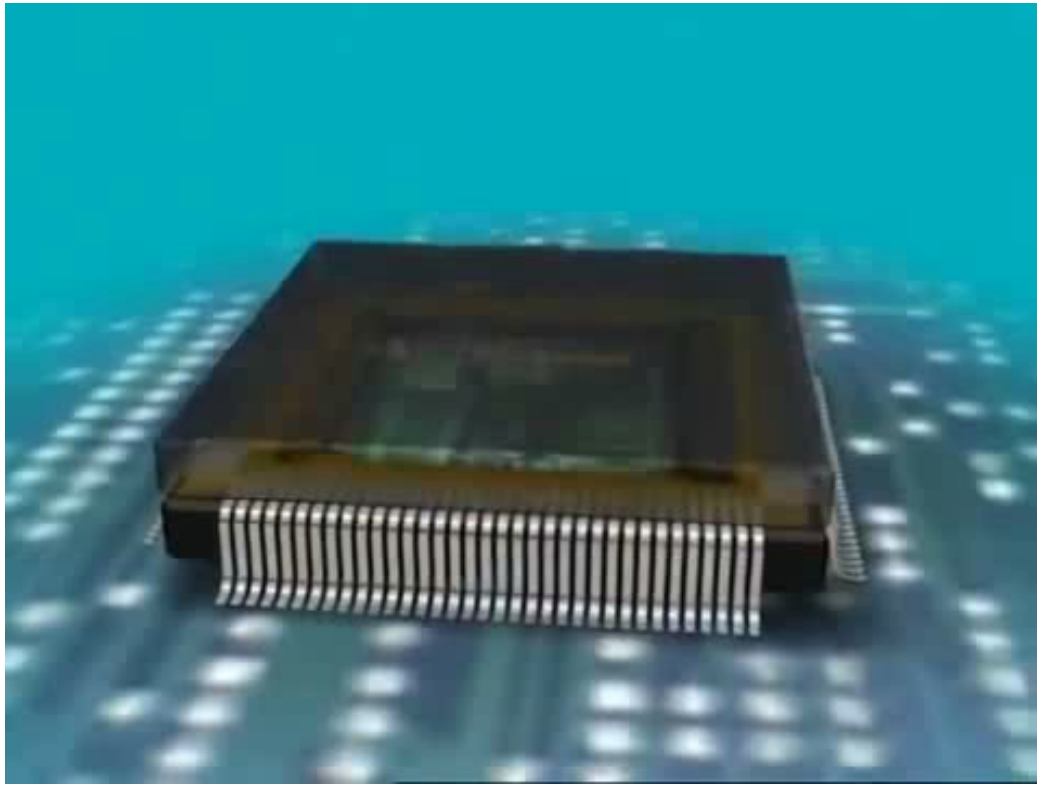
Jack S. Kilby
Prize share: 1/2

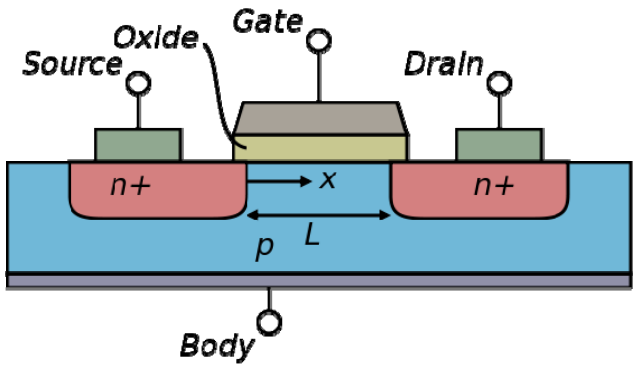
The Nobel Prize in Physics 2000 was awarded *"for basic work on information and communication technology"* with one half jointly to Zhores I. Alferov and Herbert Kroemer *"for developing semiconductor heterostructures used in high-speed- and opto-electronics"* and the other half to Jack S. Kilby *"for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

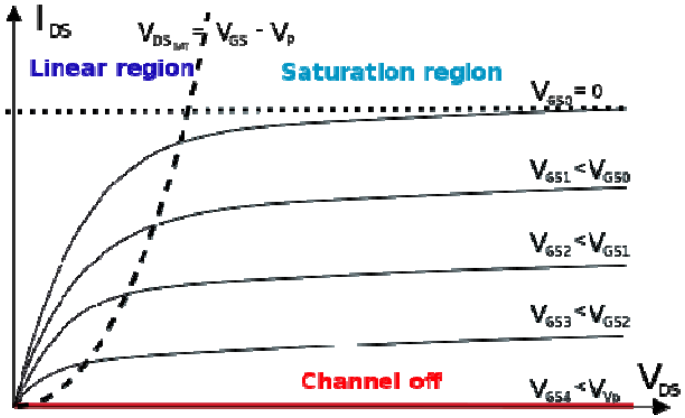
FIELD EFFECT TRANSISTOR (FET)

Main building block of CPU and memory

Functions: amplification (analog signals), switching





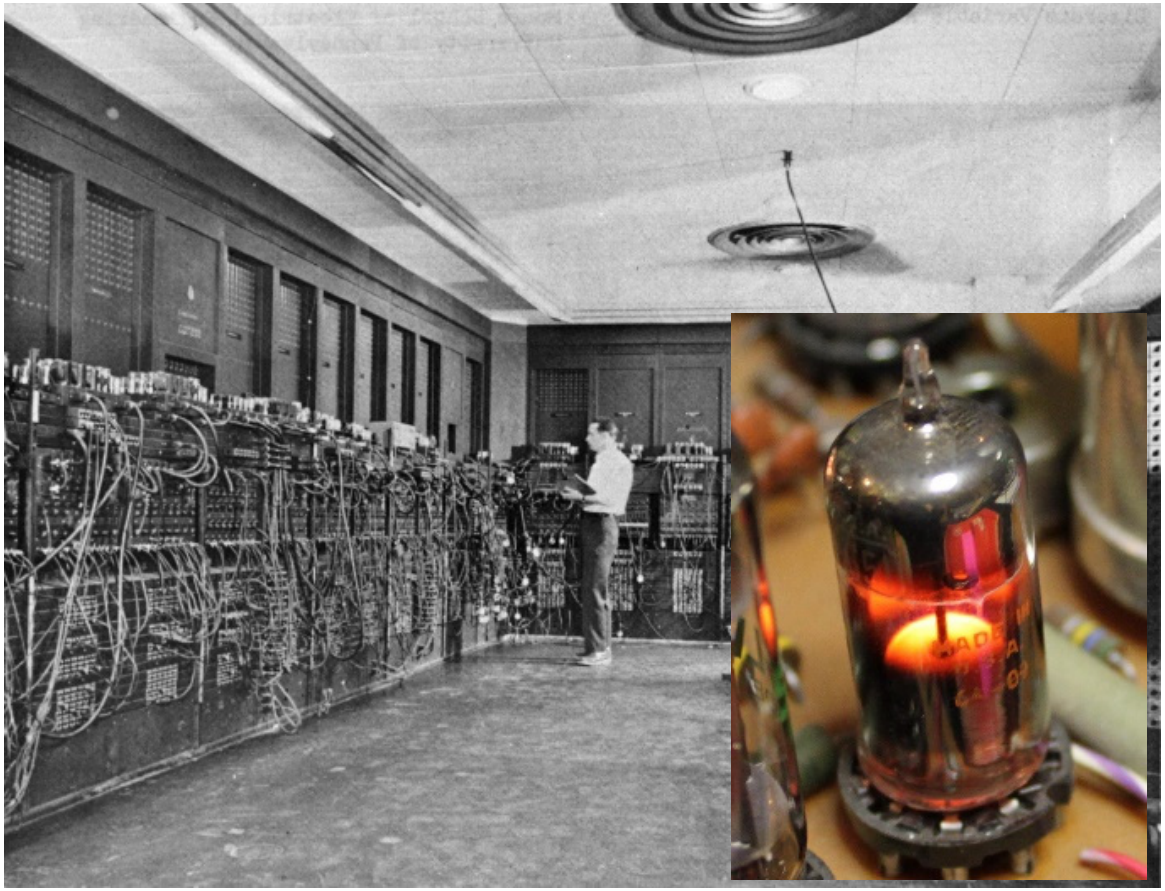


COMPUTATION

The FIRST COMPUTER

Von Neumann, János (1903-1957)

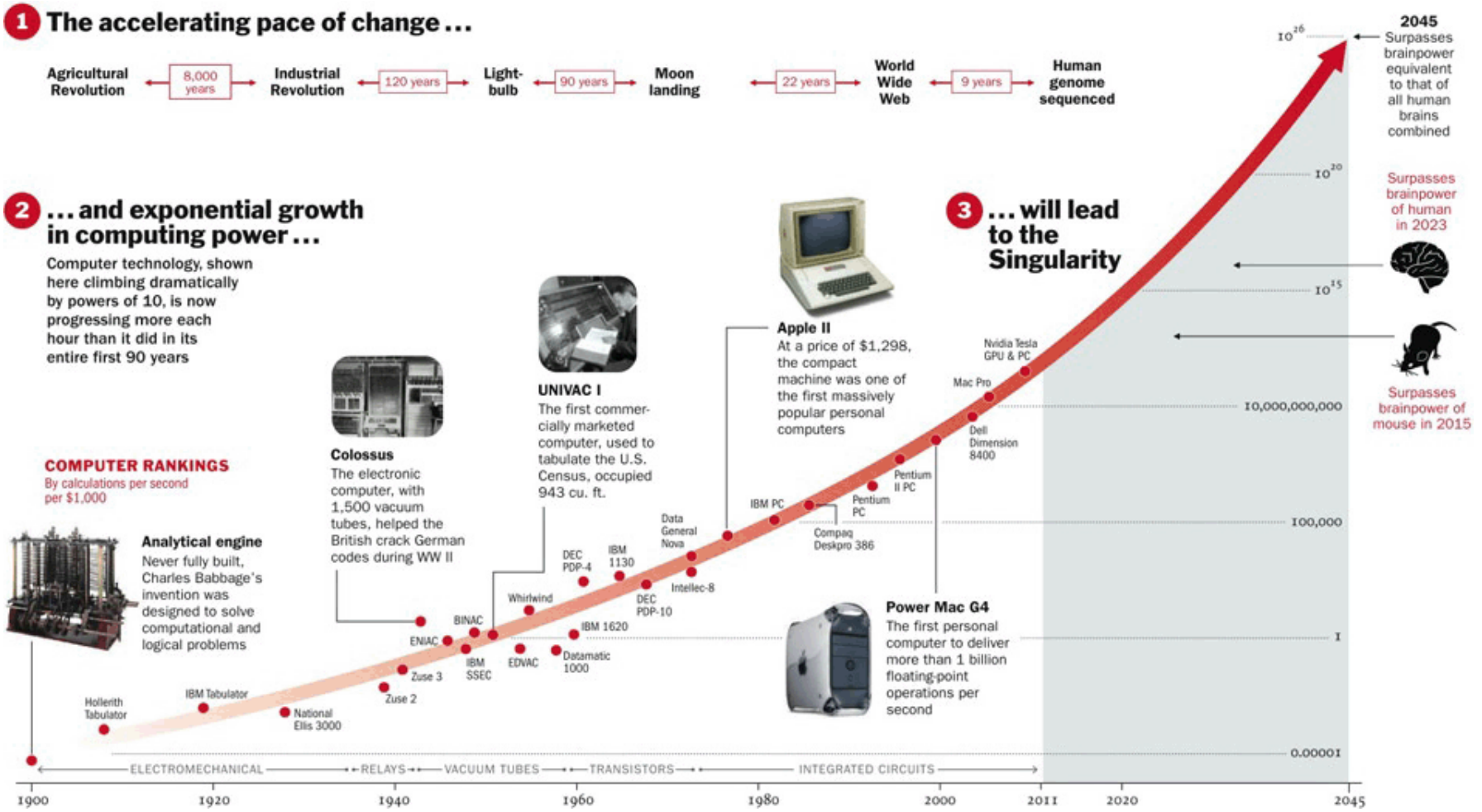
ENIAC



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

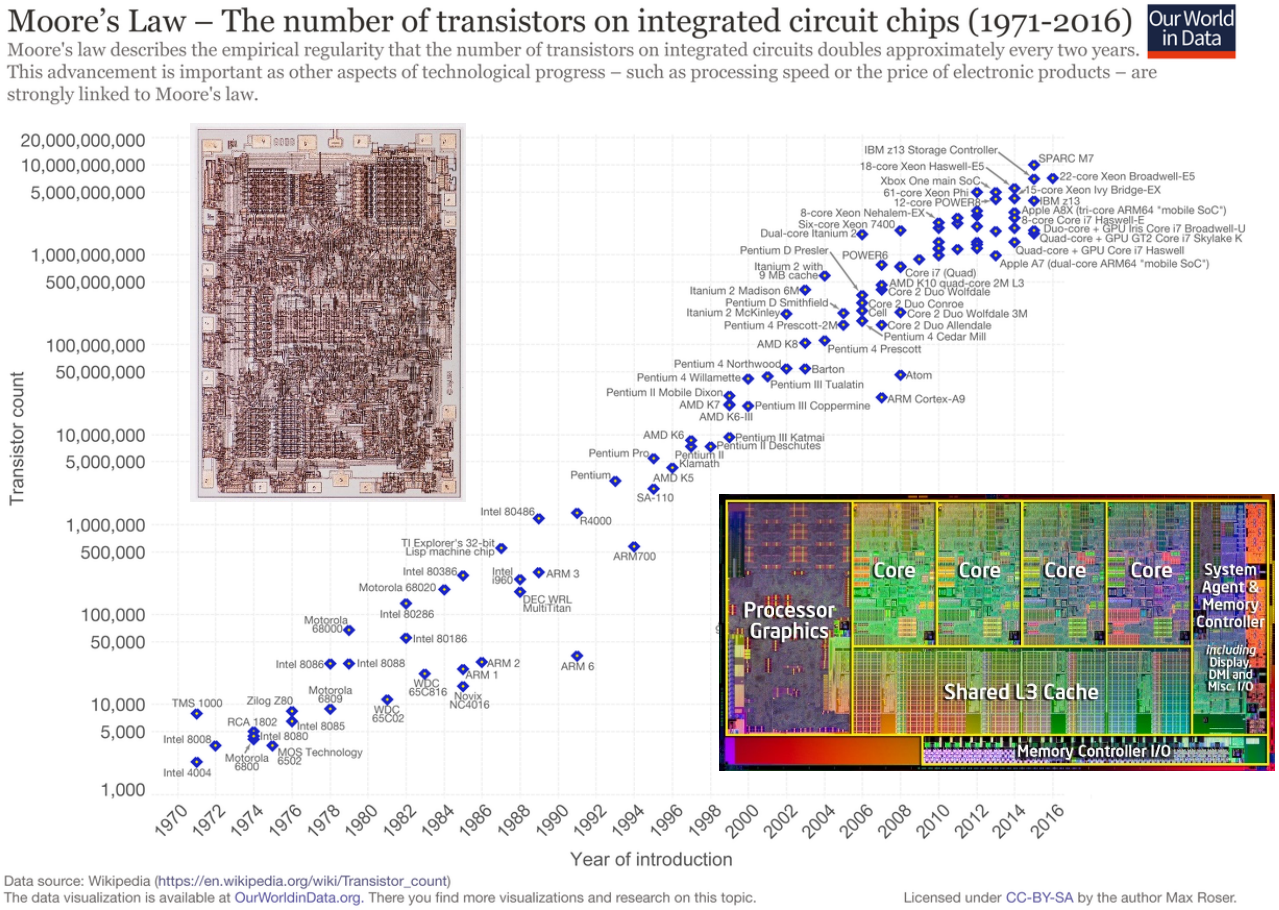
Basic elements: memory, program storage, command system

DEVELOPMENT of THE COMPUTATIONAL CAPACTY

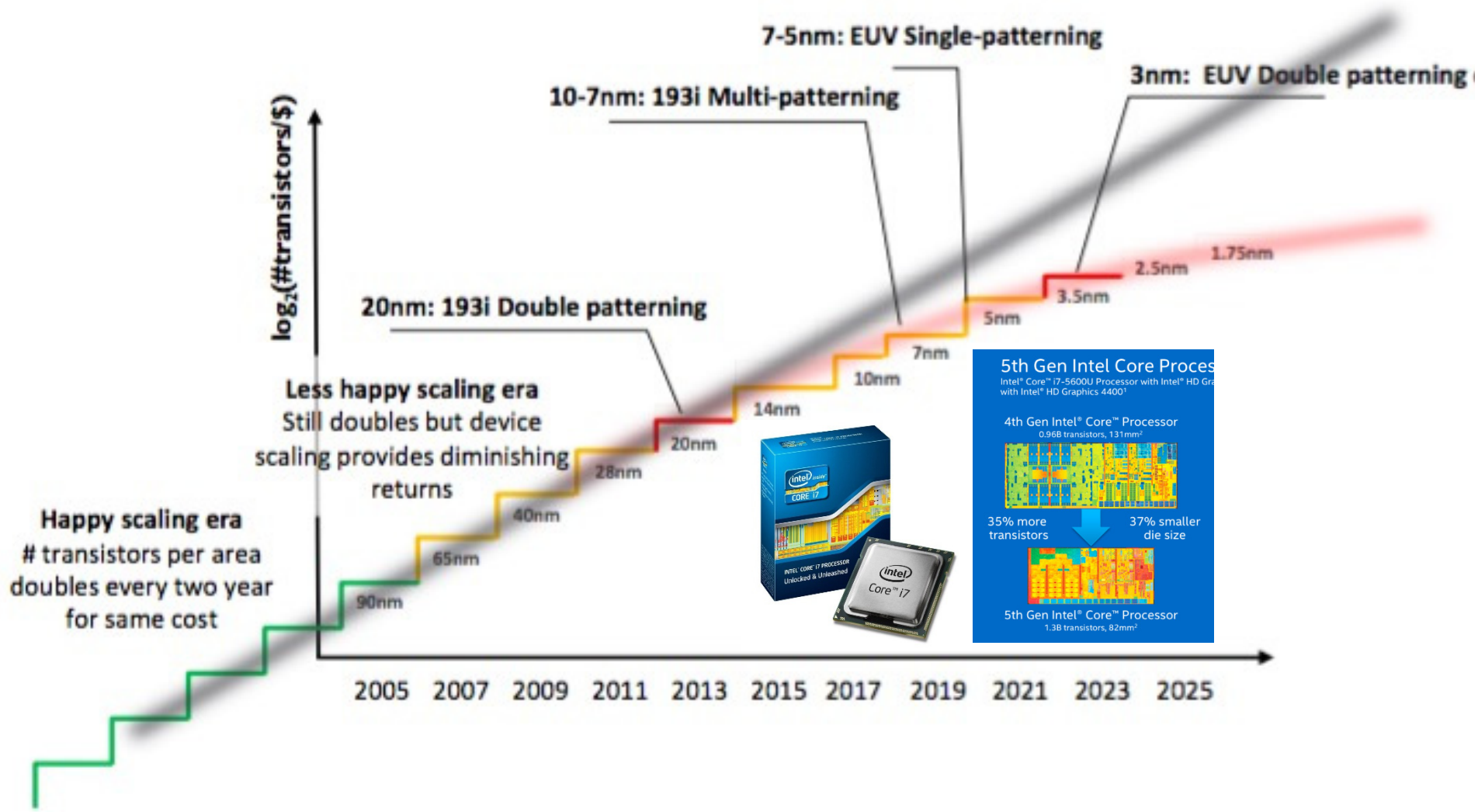


HOW MANY TRANSISTOR CAN BE PLACED ON A CHIP?

Gordon Moore (1965)

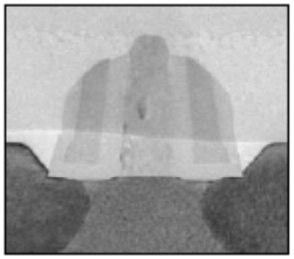
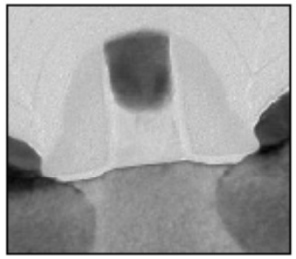
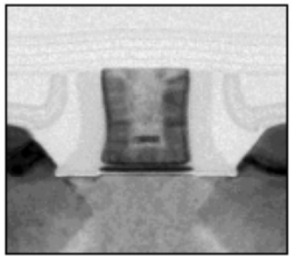
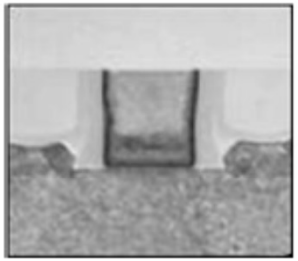
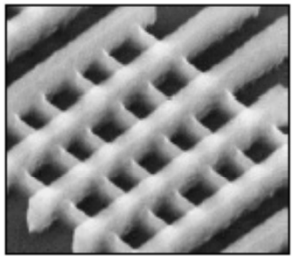


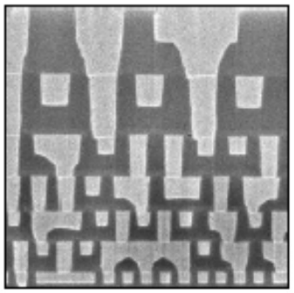
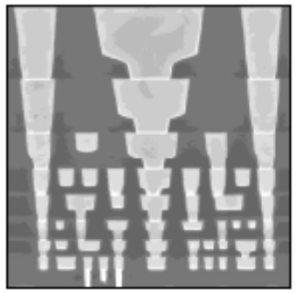
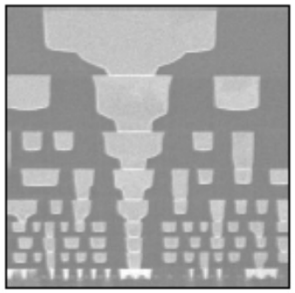
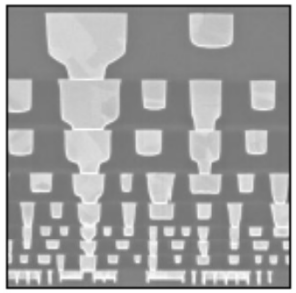
TECHNOLOGY DEVELOPMENT



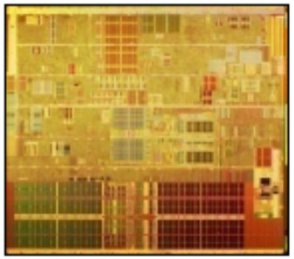
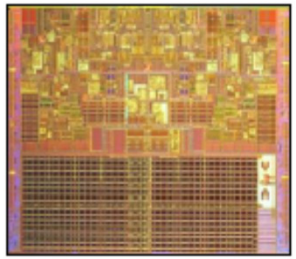
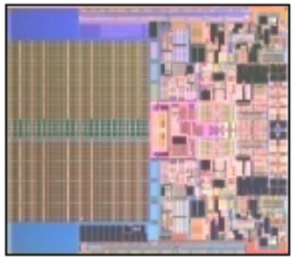
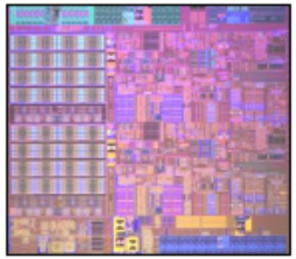
INTEL 2003 - 2011

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

3D TRI-GATE transistor

TECHNOLOGY: from SAND to PROCESSOR

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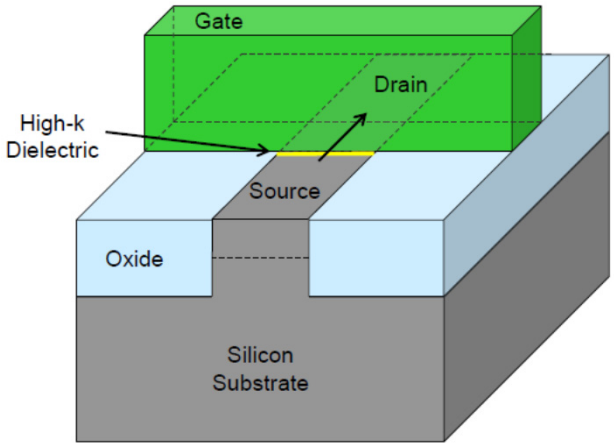
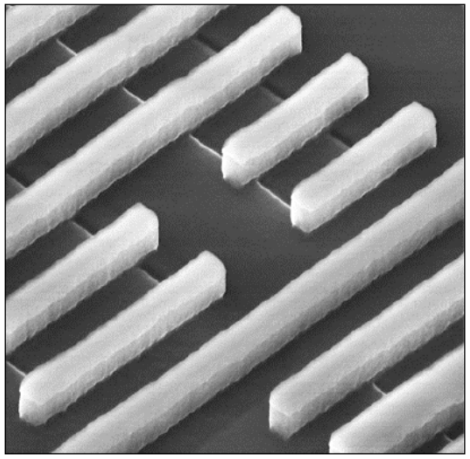
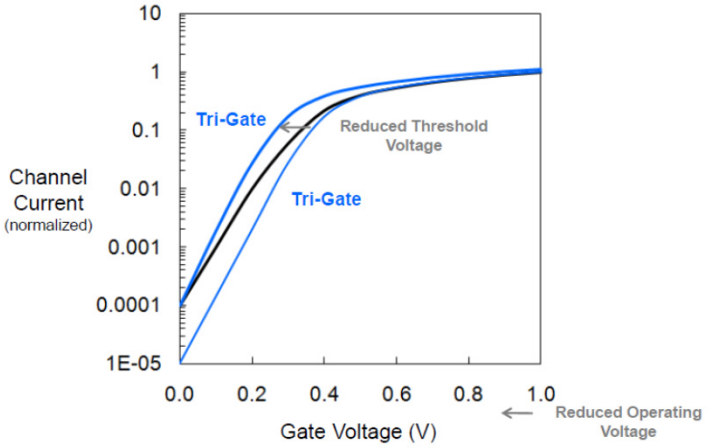
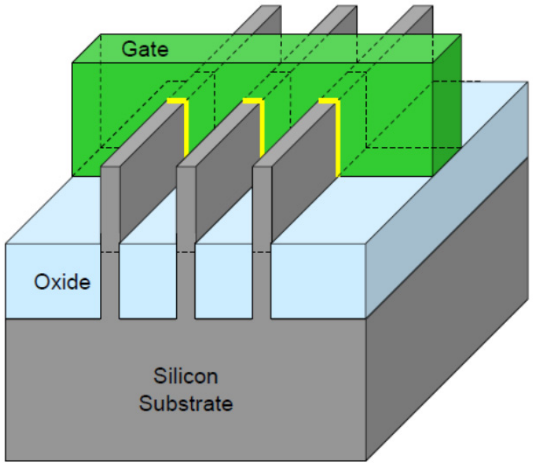
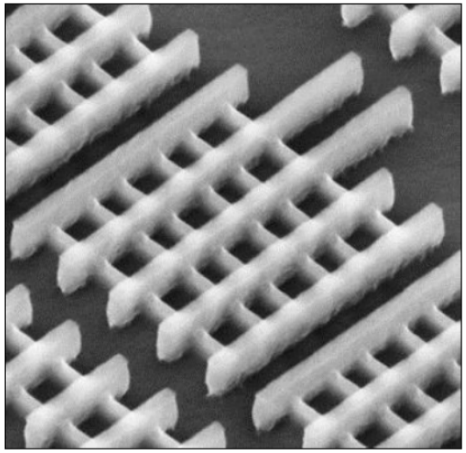
PLANAR vs. 3D TRANSISTOR

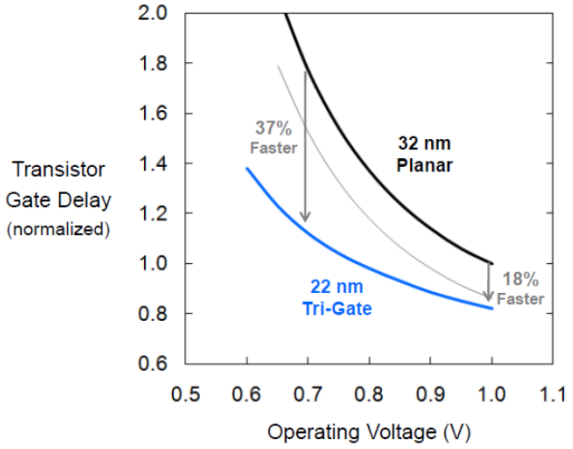












TECHNOLOGY: from SAND to PROCESSOR (2011)

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INFRASTRUCTURE – MICRO / NANO – INTEL FAB

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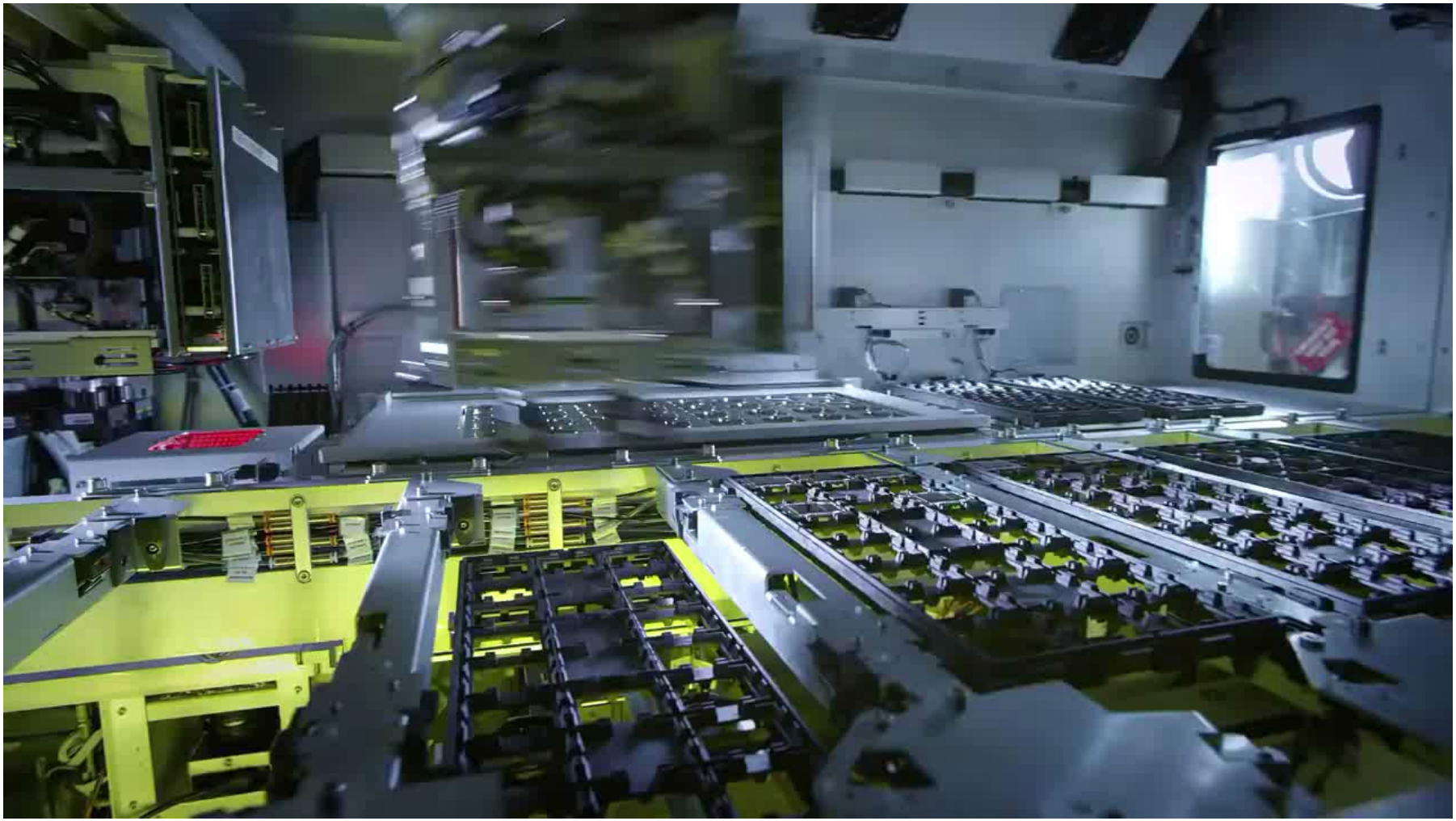


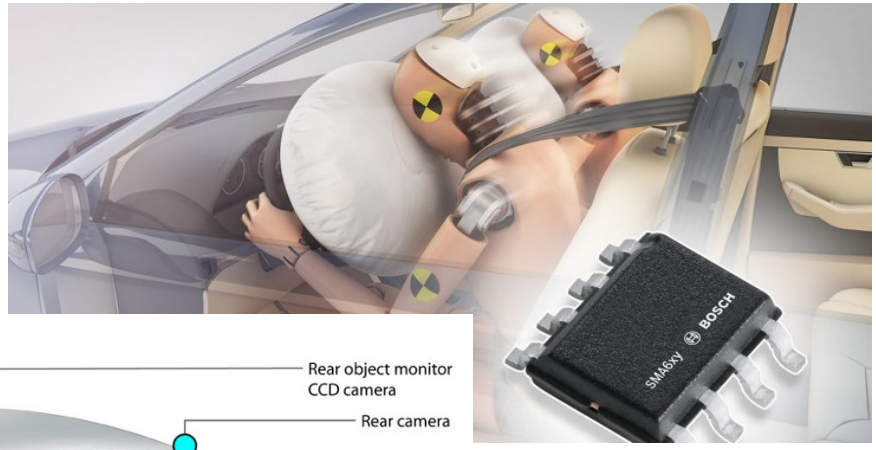
MORE THAN MOORE

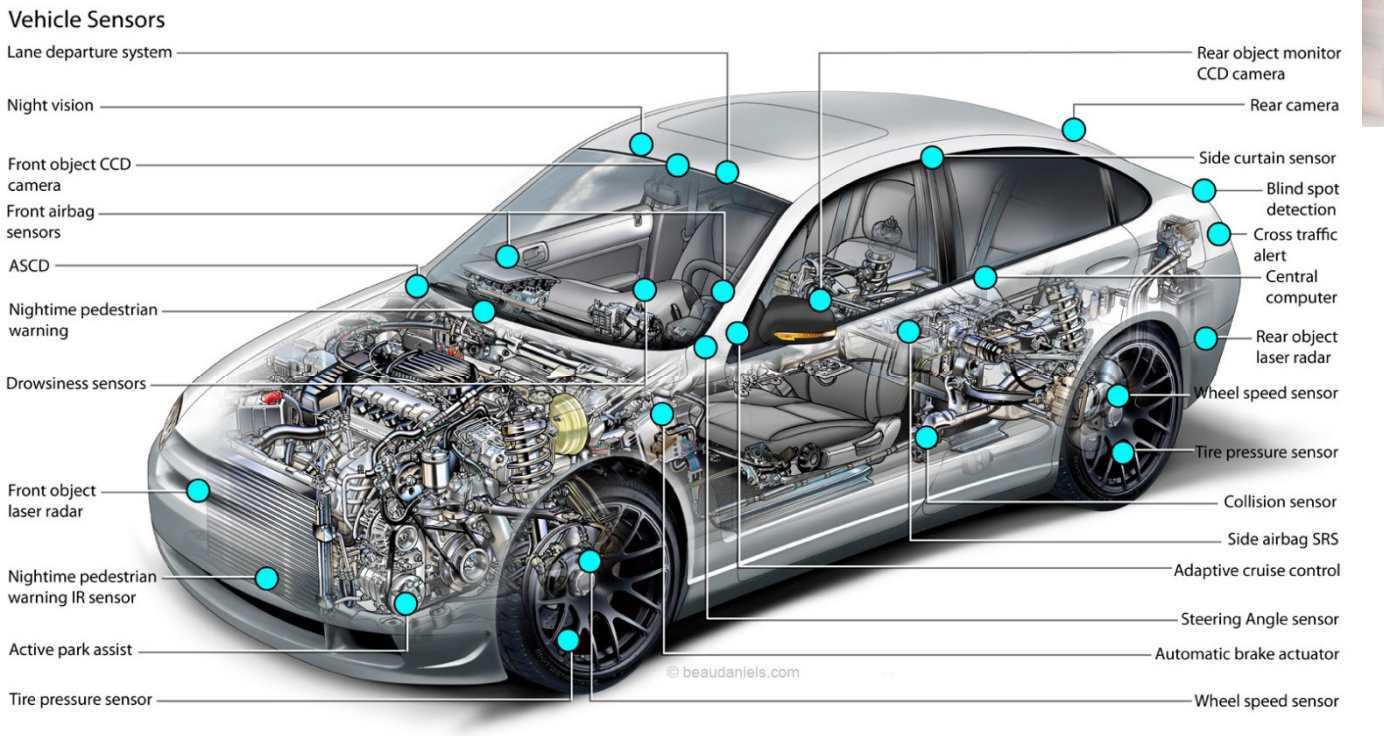
MEMS:
Revolution of SENSORS

MEMS: micro-electromechanical systems

Example: automotive applications

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





GUESS WHO?

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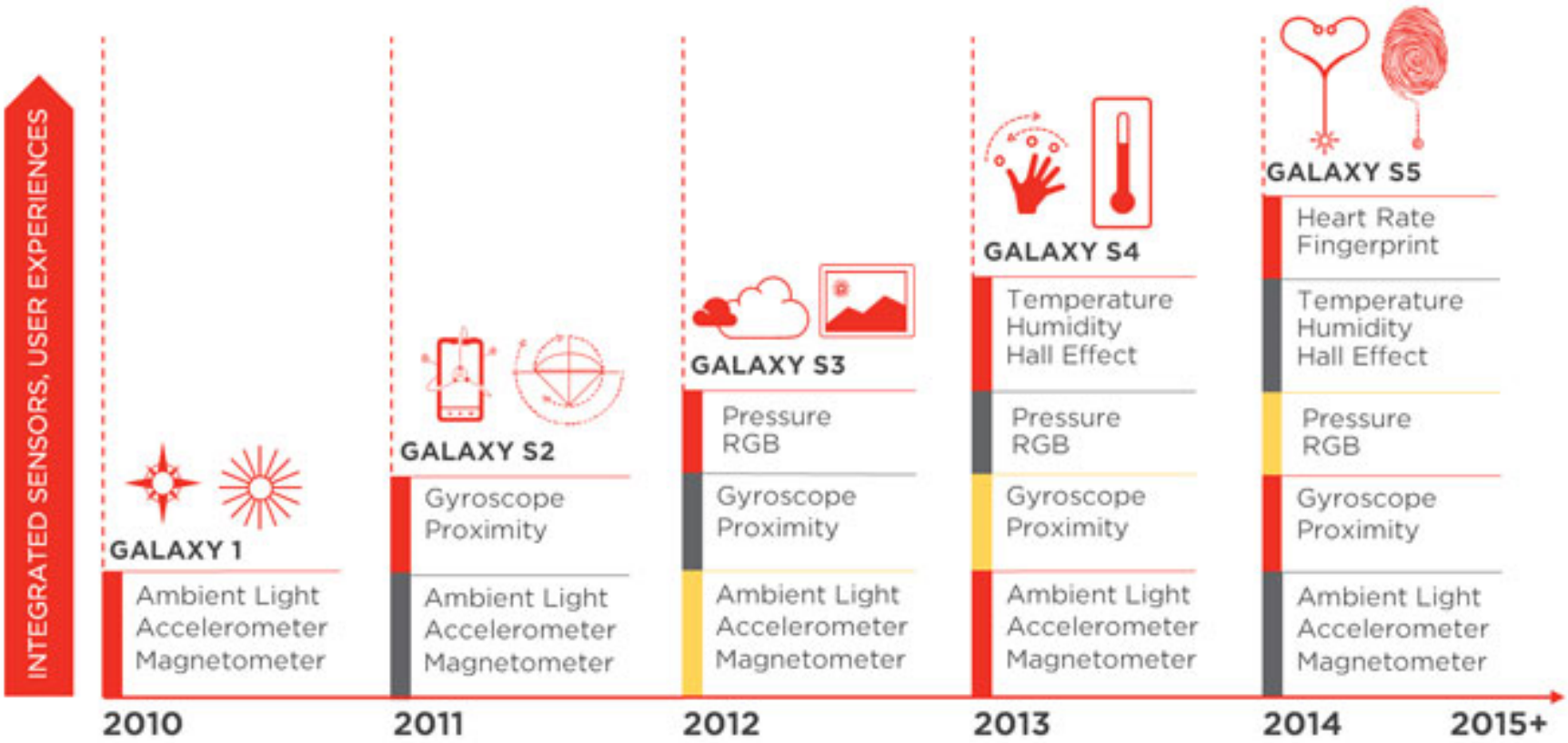
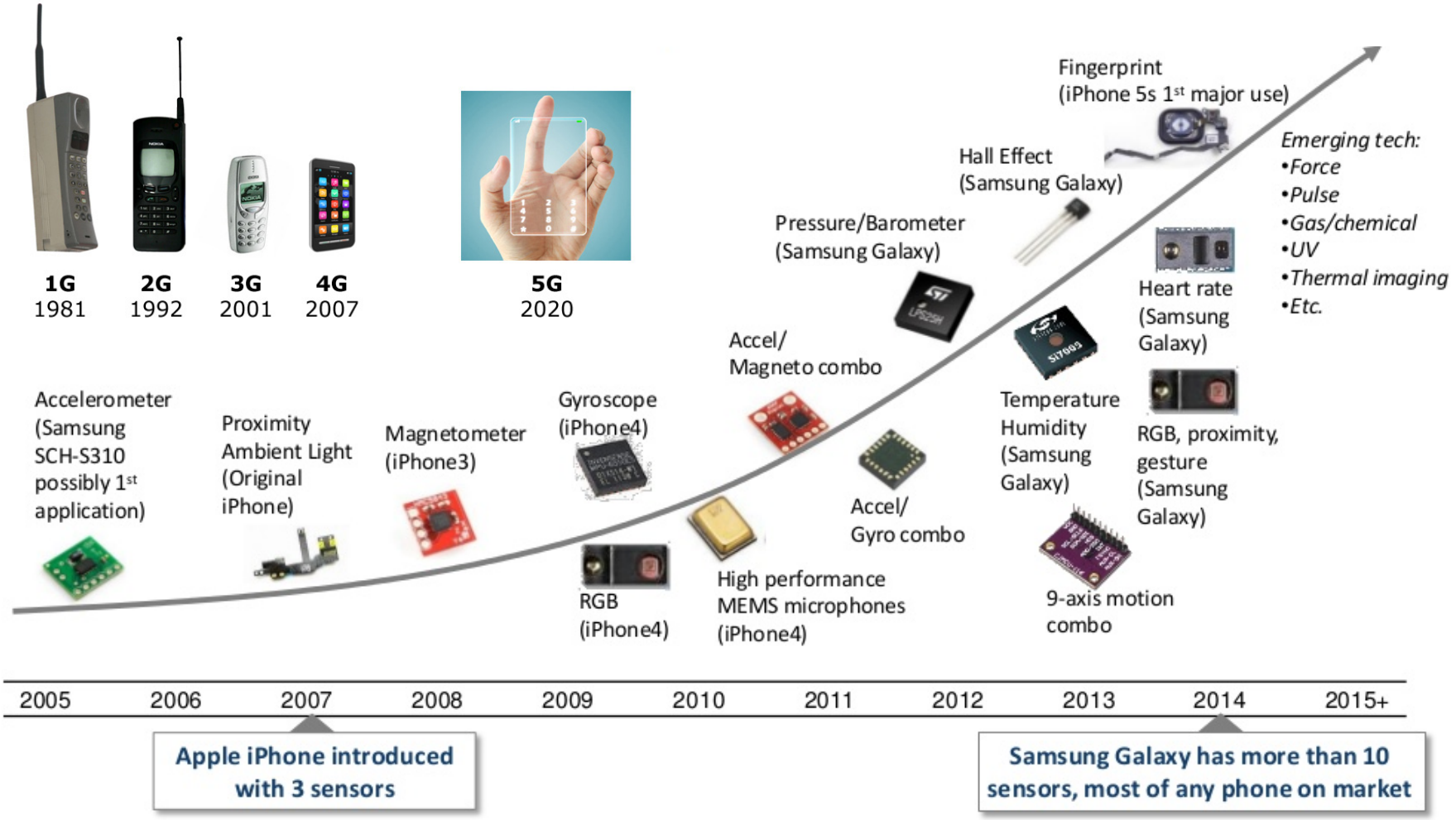
DISASSEBLE OUR VIRTUAL SMARTPHONE

SENSOR GROWTH IN SMARTPHONES



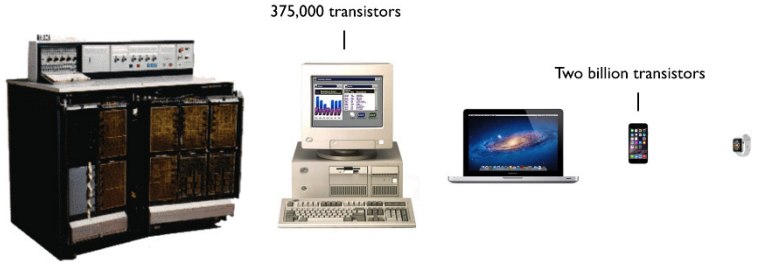
Sources: Driven by Apple and Samsung, Light Sensors Achieve Double-Digit Revenue Growth, IHS, June 30, 2013; MEMS: Looking back at 2014 and 5 years outlook, IHS, November 2014; Light and Proximity Sensors - A Market Ready for Explosive Growth, Tony Rizzo, Mobility TechZone, July 30, 2013; iPhone 6 Teardown,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

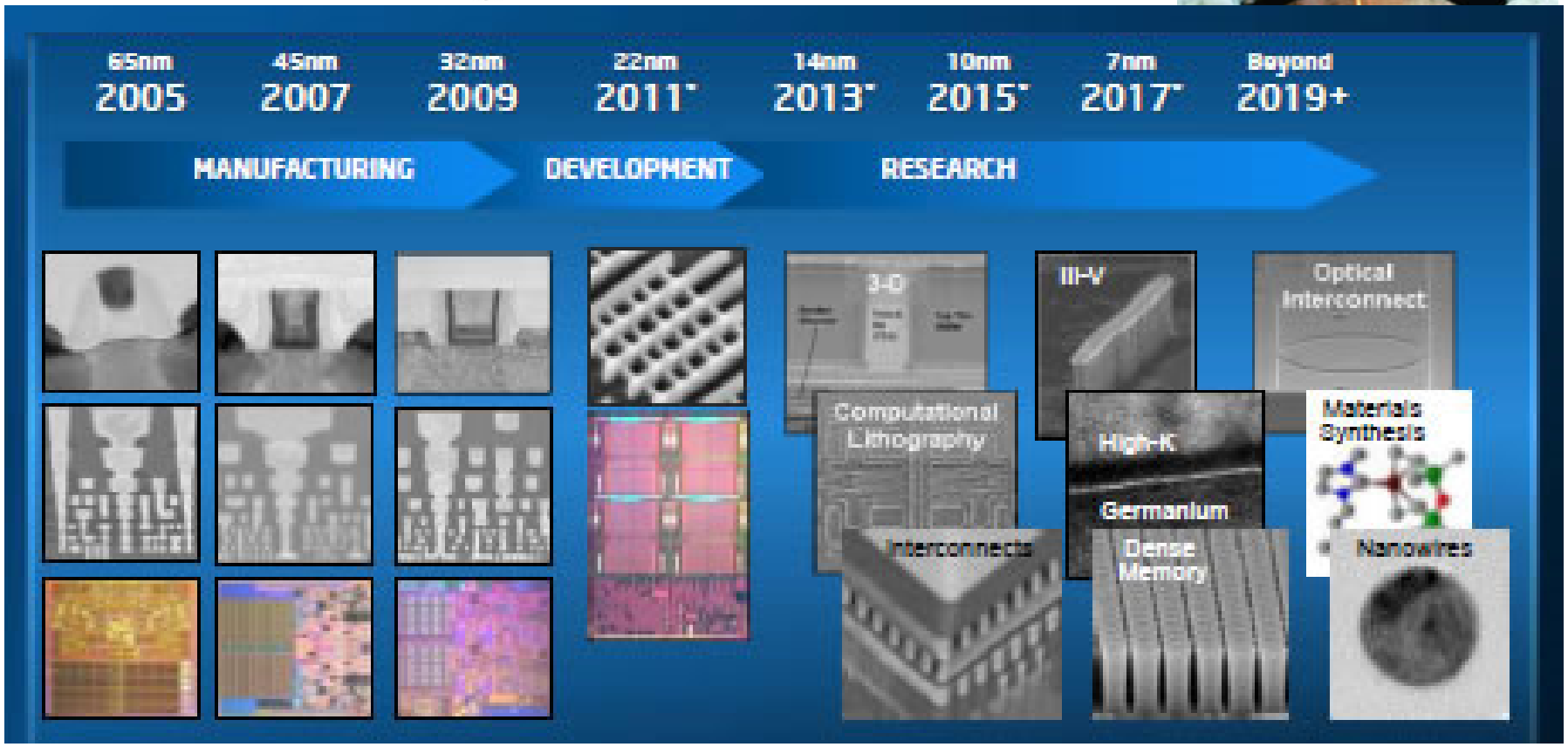
SMARTPHONE'S FUTURE



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

BEYOND MOORE LAW ???





BEYOND MORE THAN MOORE ???

GLOBAL TECHNOLOGY ROADMAP

Moore and beyond: from information to interaction and transformation