ROTARY CLUB
VICTORIA - COCO DE MER
SEYCHELLES

ROTARY INTERNATIONAL
District 9220

A brief history of microelectronics

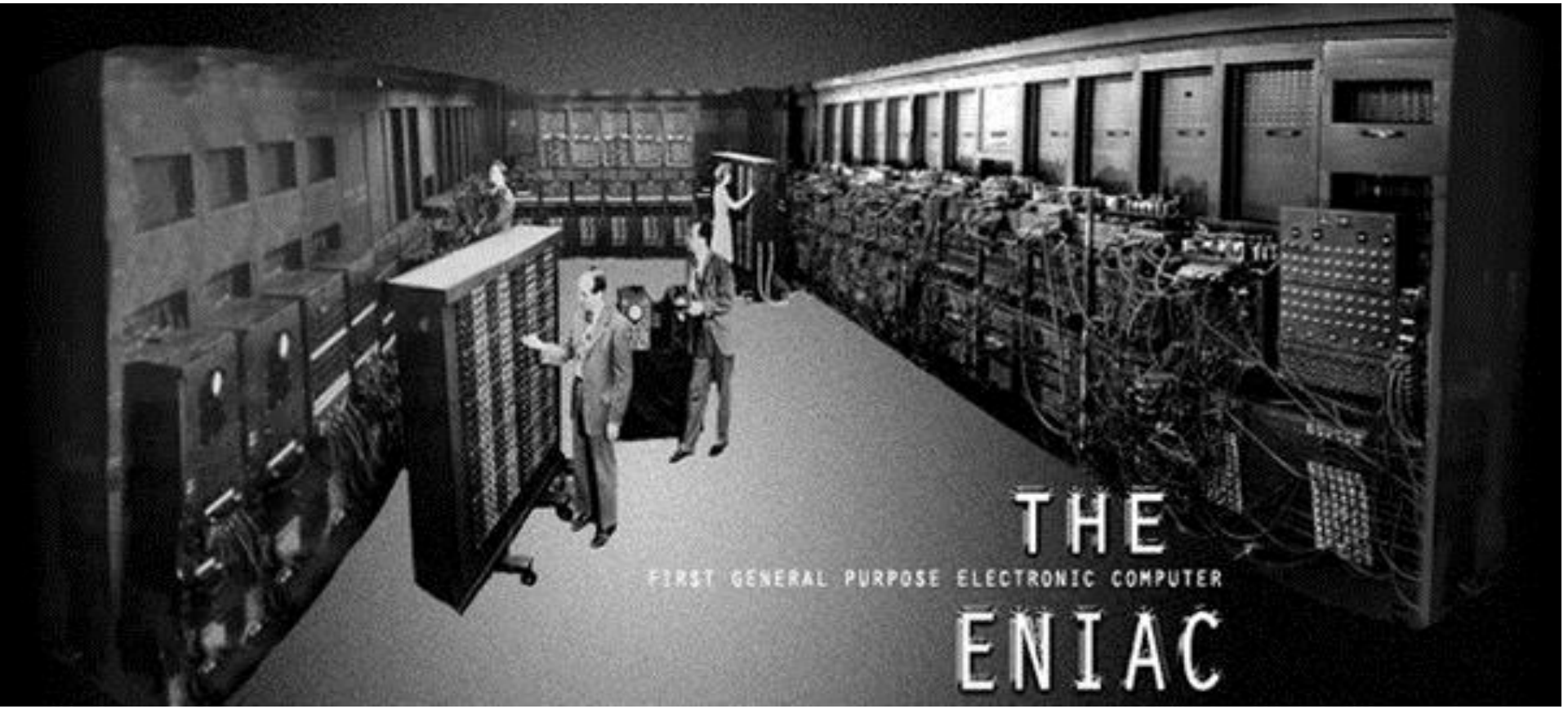
Jean-Pierre

cobalt	lithium	nitrogen	germanium
27	3	7	32
Co	Li	N	Ge
58.933	6.941	14.007	72.61

leti
ceatech

First computer: ENIAC (1945)

ENIAC was completed in 1945 and is regarded as the first successful, general digital computer. It weighed more than 27,000 kg (60,000 lb), and contained more than 18,000 vacuum tubes.

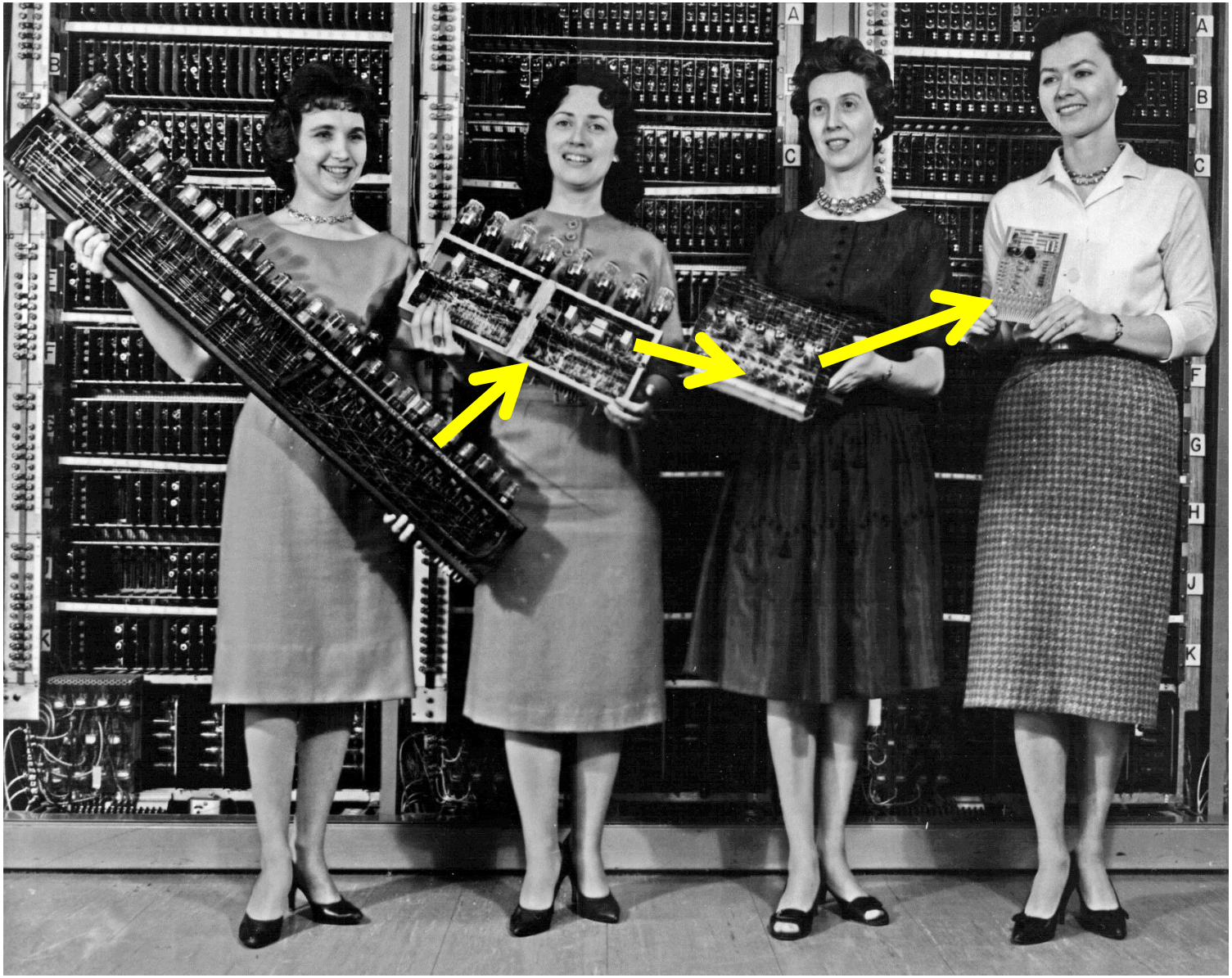


http://www.ideafinder.com/history/inventions/comeniac.htm

Vacuum tubes

http://3dprint.com/89780/darpa-vacuum-tube-research/

Beginning of miniaturization …



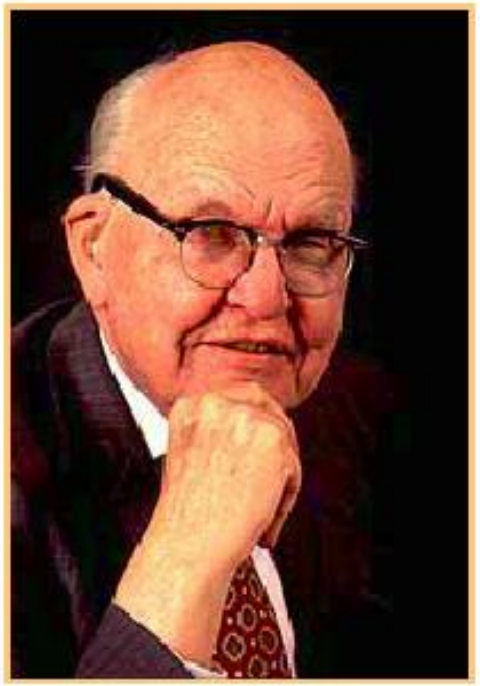
First transistor (Bell Labs, USA, 1947)

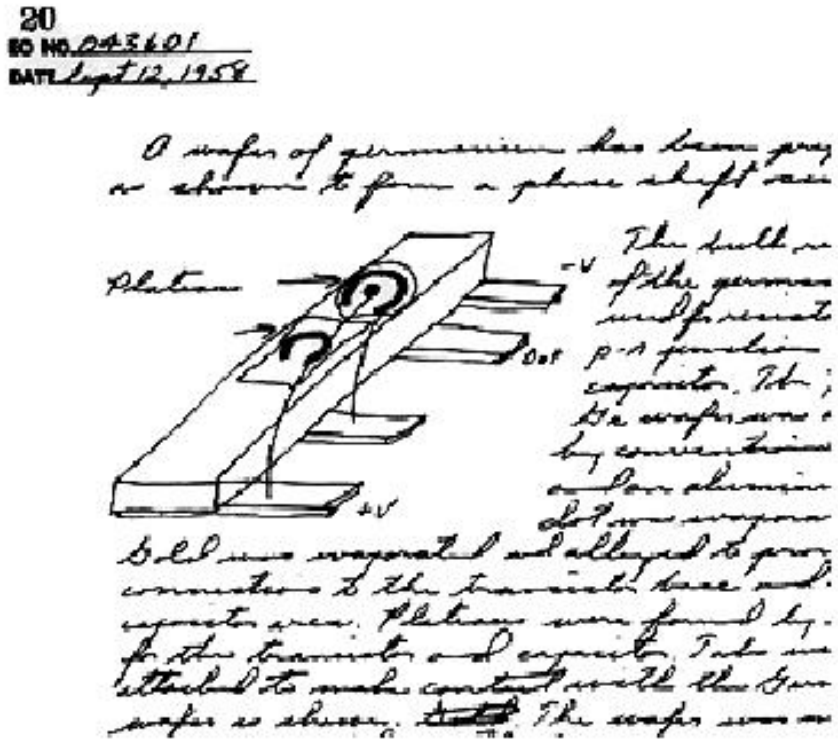
From November 17, 1947 to December 23, 1947**,** John Bardeen and Walter Brattain at AT&T's Bell Labs in the United States performed experiments and observed that when two gold point contacts were applied to a crystal of germanium, a signal was produced with the output power greater than the input. Solid State Physics Group leader William Shockley saw the potential in this, and over the next few months worked to greatly expand the knowledge of semiconductors. The term transistor was coined by John R. Pierce as a contraction of the term transresistance

In acknowledgement of this accomplishment, **Shockley, Bardeen, and Brattain** were jointly awarded the 1956 Nobel Prize in Physics "for their researches on semiconductors and their discovery of the transistor effect."

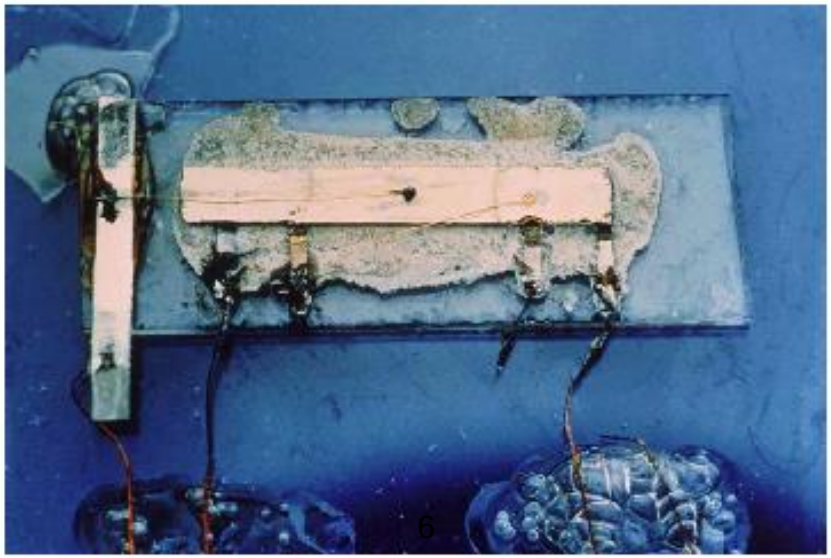
INTEGRATED CIRCUIT - 1958

- Jack Kilby, inventor of the integrated circuit
- Nobel prize in Physics, 2000

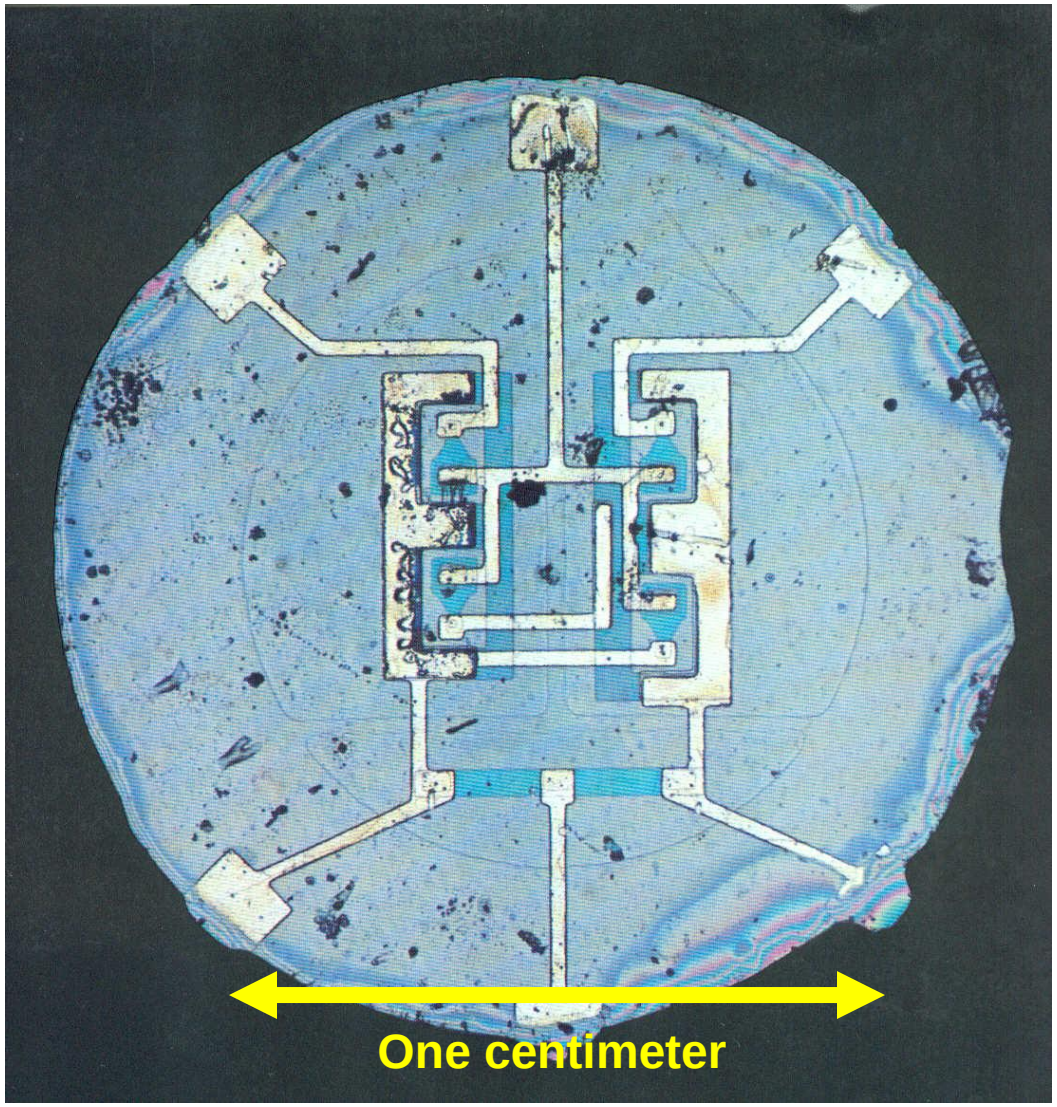




- US Patent # 3,138,743 filed Feb. 6, 1959



Early Integrated Circuit (4 transistors), 1959

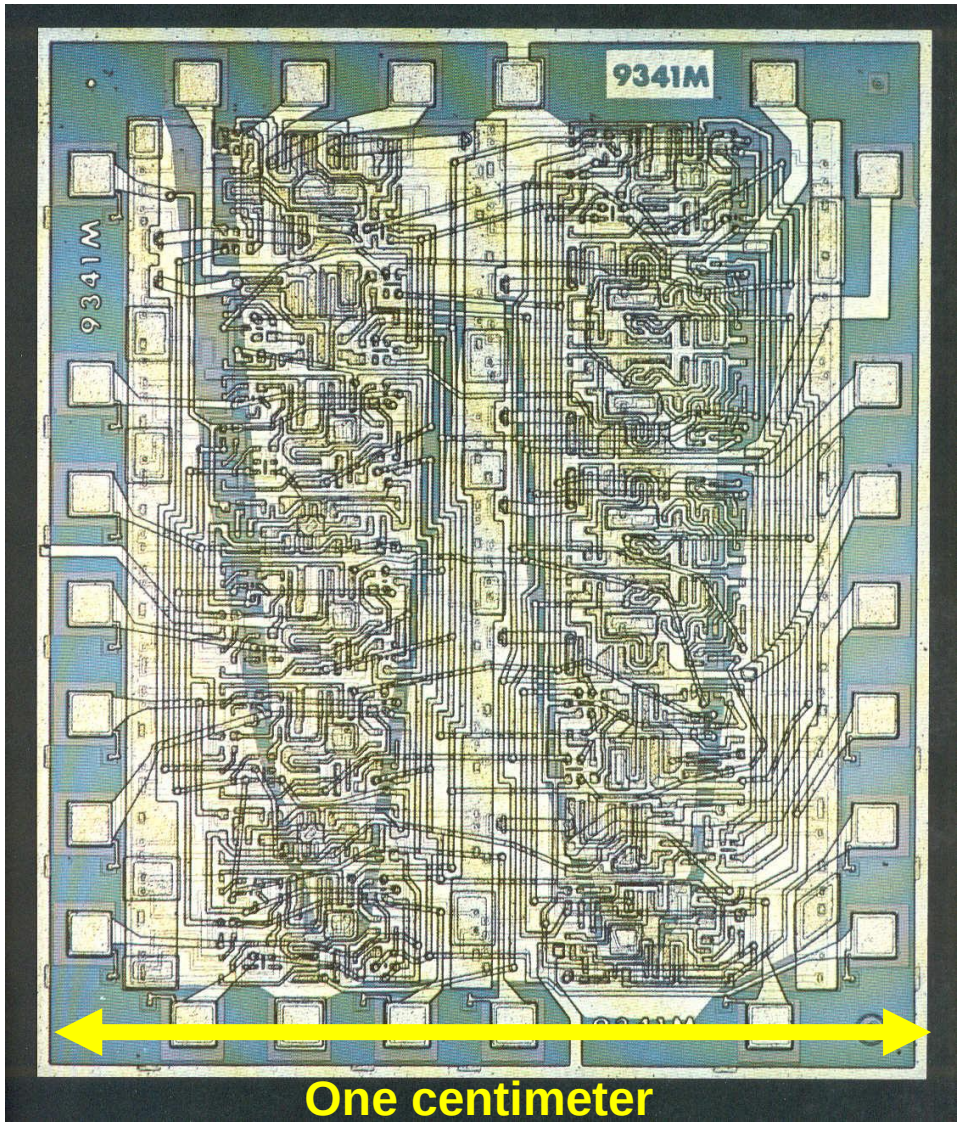


Contains only
4 transistors !

(Bipolar
transistors)

Same
year: first
Barbie doll
presented
at a show
in NYC

Early Integrated Circuit (200 transistors), 1969



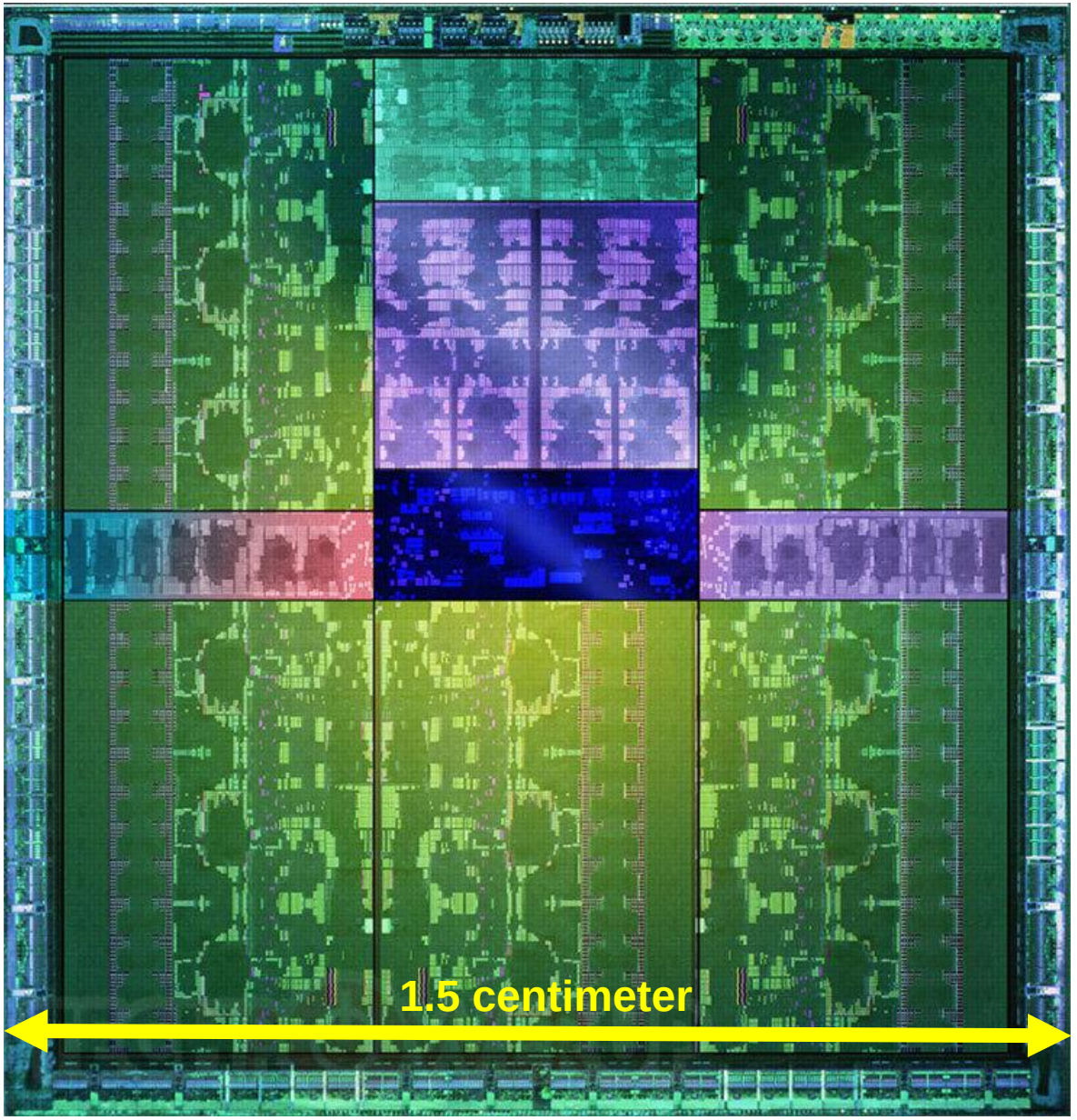
(MOS transistors)

Same year:

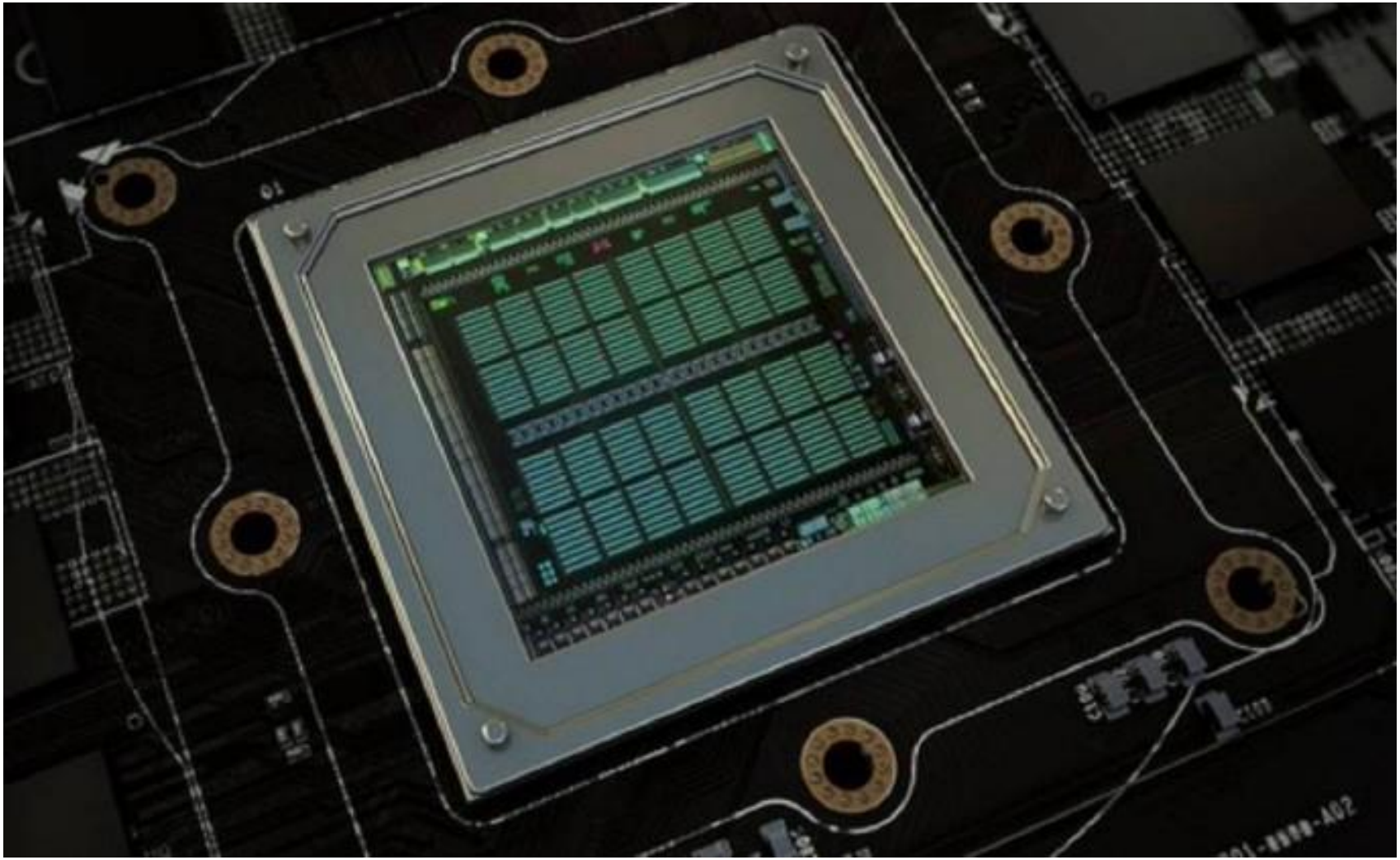
First man on the Moon

Woodstock festival

NVIDIA's Tesla K20 (7,000,000,000 transistors), 2012



NVIDIA’s Pascal GPU (17,000,000,000 transistors), 2016



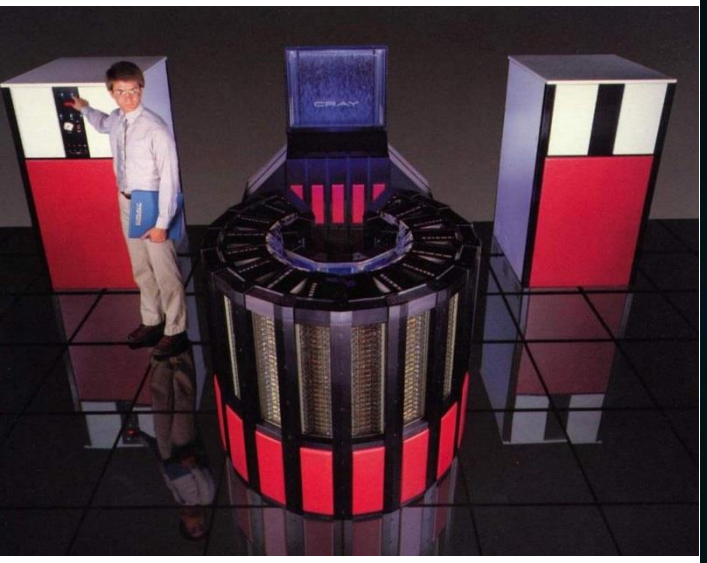
Samsung 1Tb (128 TB) VNAND Flash (2017)

$1Tb \div 4 = 256 \times 10^9$ transistors

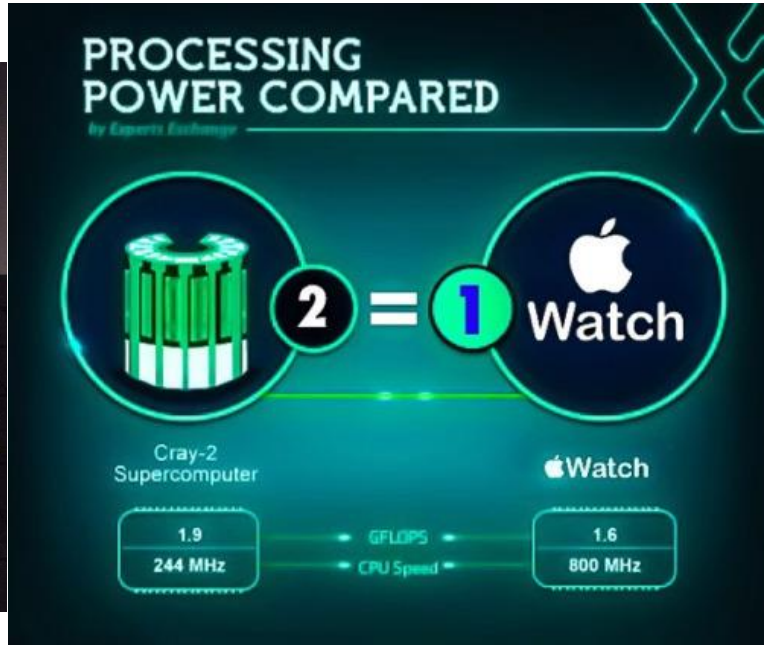
Samsung has now also announced their fifth-generation V-NAND, which will increase the layer count further to 96 layers with relatively few other changes to the design. The fifth generation will include Samsung's first QLC NAND flash (four bits per cell), with a capacity of 1Tb (128GB) per die.

http://www.anandtech.com/show/11703/samsung-at-flash-memory-summit-96layer-vnand-mlc-znand-new-interfaces

2015 Apple watch has twice the processing power as 1985 Supercomputer

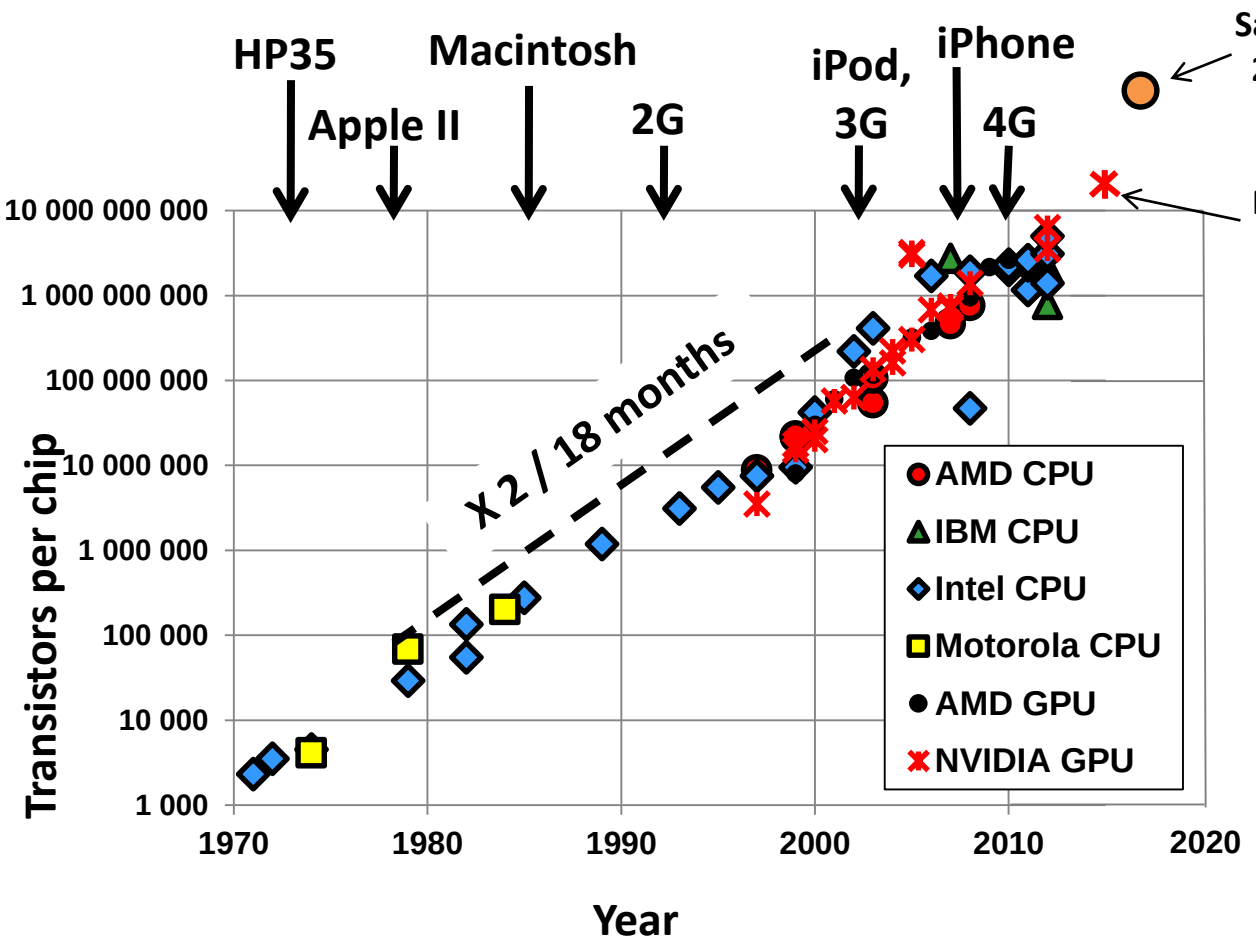


Cray II Supercomputer
With liquid cooling
1985



Apple Watch
2015

Moore's law (1965 – 2017)



Gordon Moore, 1965

Figure 1.1 Evolution of the number of transistors per chip with time. Central processing units (CPU) or microprocessors and graphics processing units (GPU) or graphics processors from different vendors are shown. The top of the chart shows the date of introduction of some landmark products: HP-35 pocket calculator, Apple II and Macintosh computers, iPod, iPhone, and the introduction second, third and fourth-generation mobile phone networks (2G, 3G, 4G).

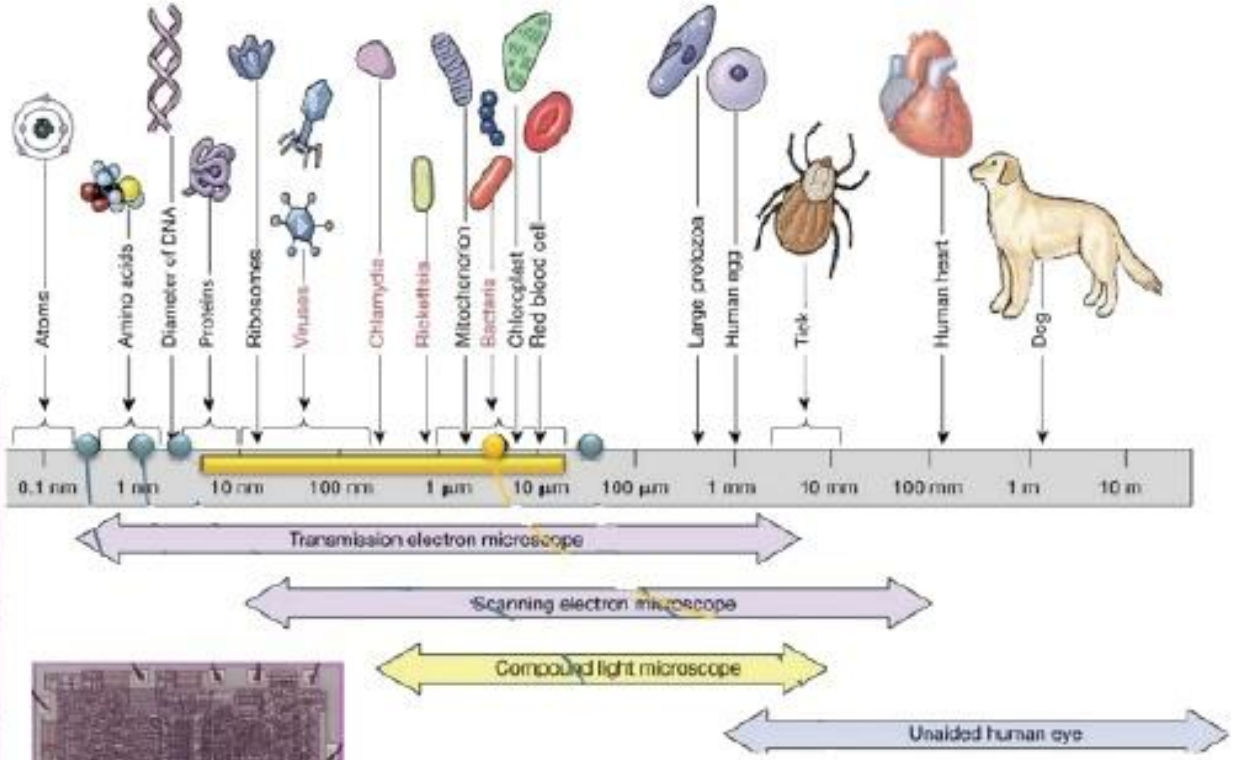
Moore's law

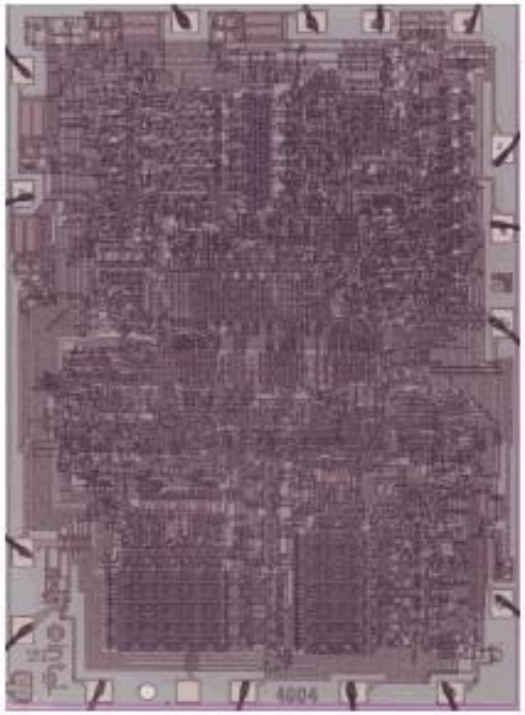
In 2014, semiconductor production facilities made some **250 billion billion** (250×10^{18}) transistors. This was, literally, production on an **astronomical scale**.

Every second of that year, on average, 8 trillion transistors were produced. That figure is about **25 times the number of stars in the Milky Way** and some 75 times the number of galaxies in the known universe.

Transistor scaling

Transistor Scaling i4004

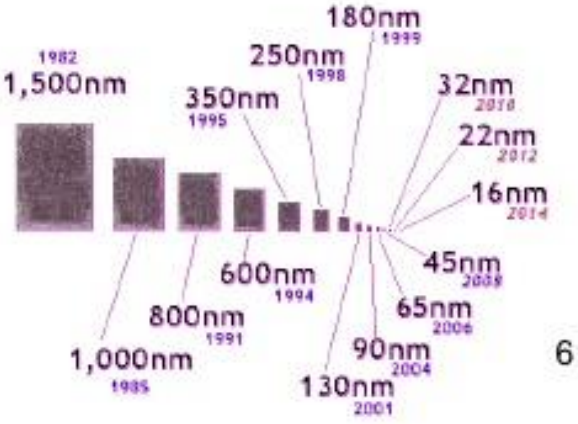




10,000nm
1971

6,000nm
1974

3,000nm
1976

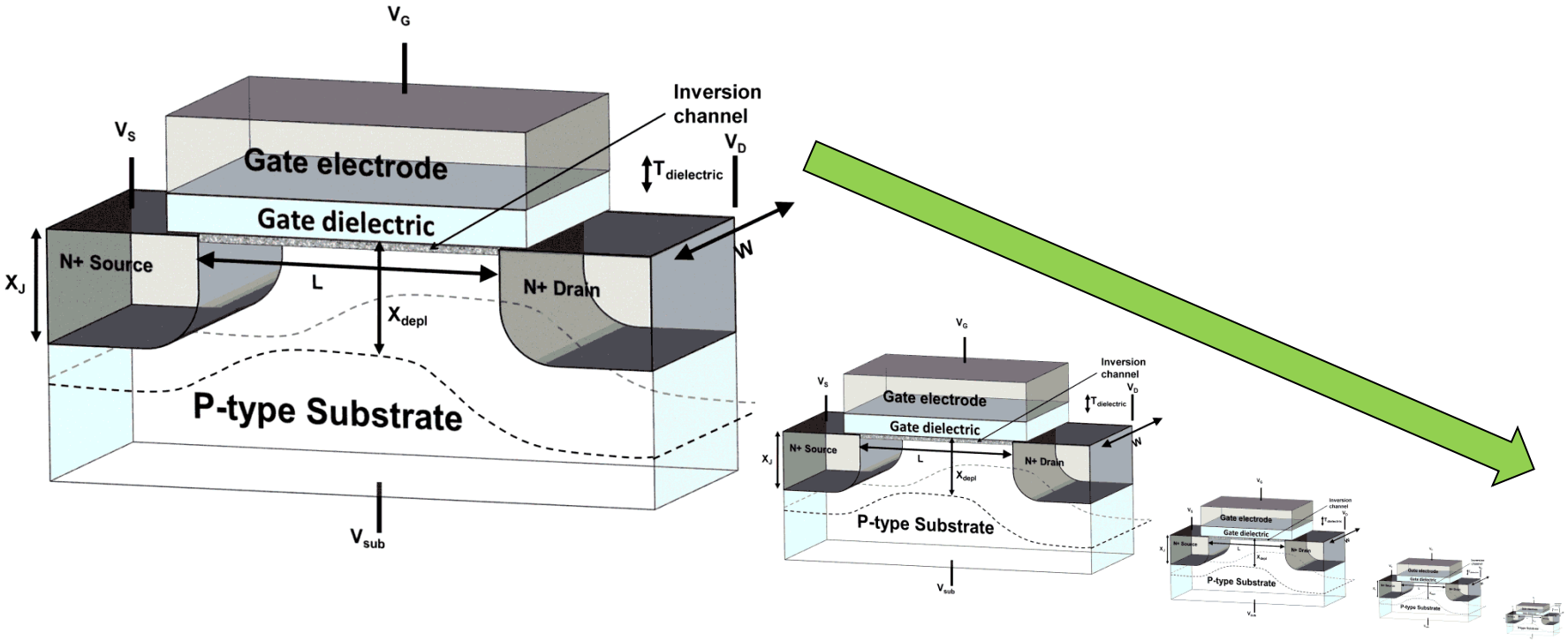


Dec 26, 2010

Year Color Legend
In use *In future*

6

Scaling: continuous reduction of transistor size



To boost performance: Elements used in Silicon processing

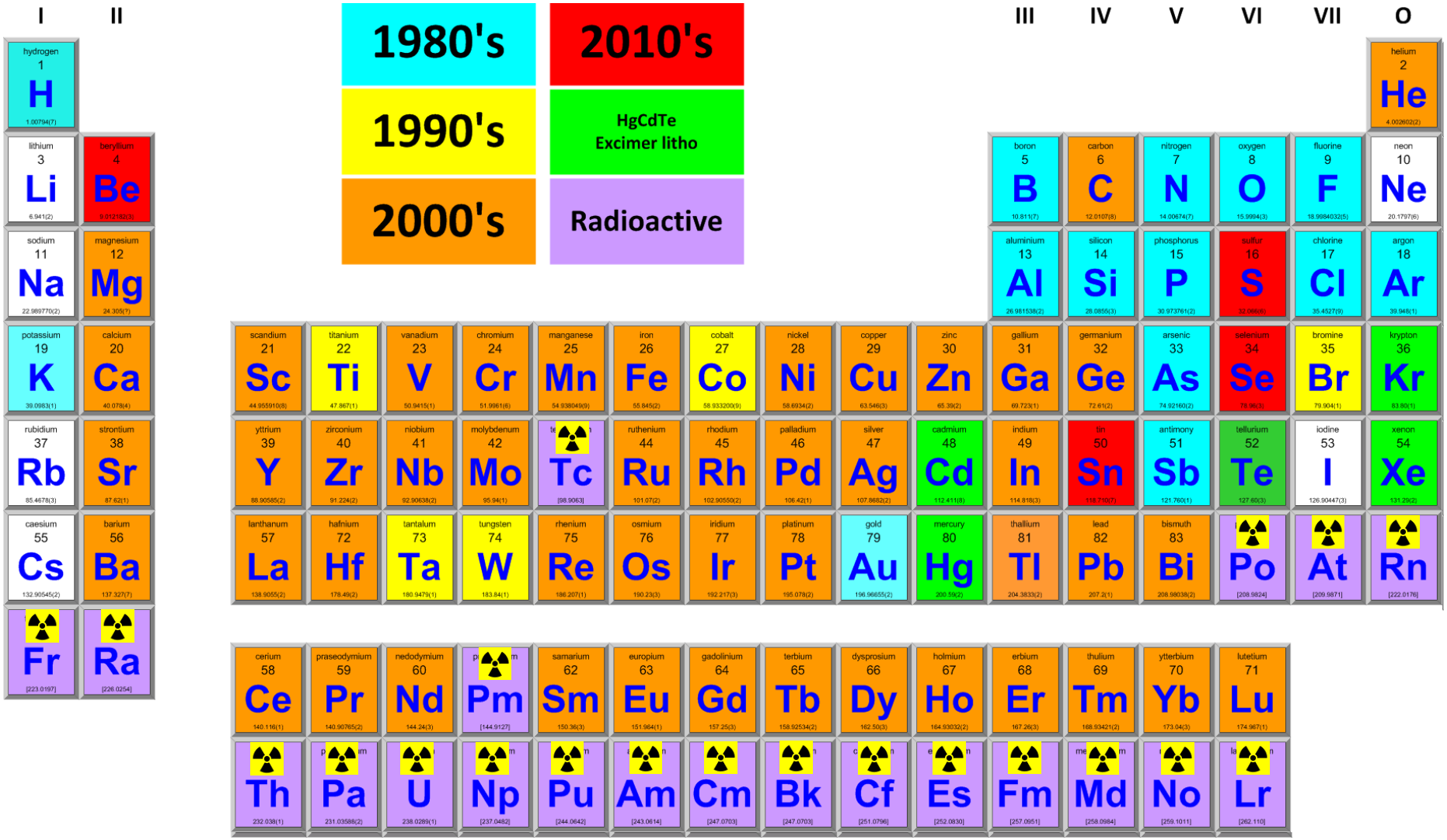
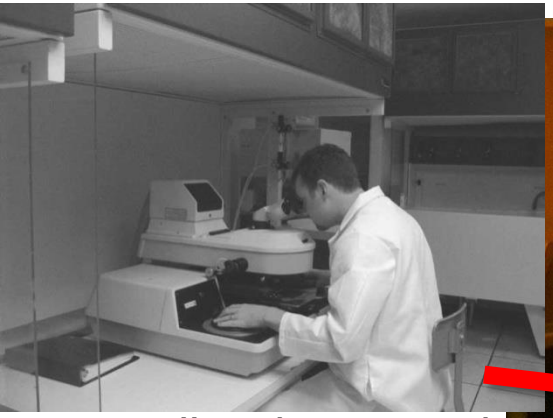


Figure 1.7 Elements used in semiconductor (silicon) industry. Radioactive elements cannot be used for obvious reasons.

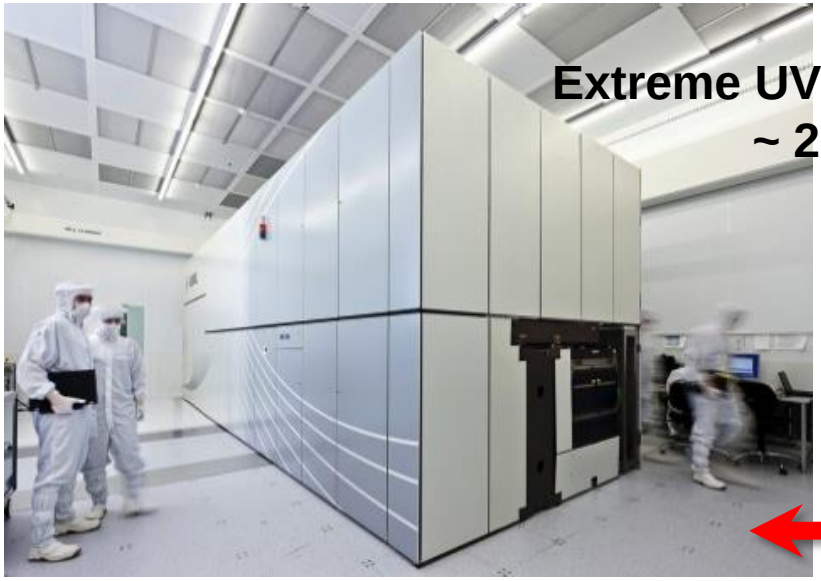
Printing small things: Photolithography



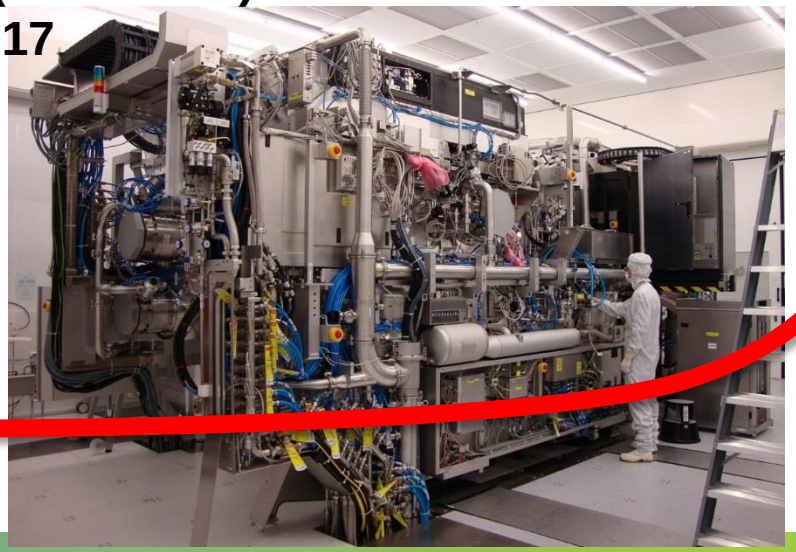
UV G-line (λ=436nm)
~ 1975

UV I-line (λ=365nm)
~ 1982

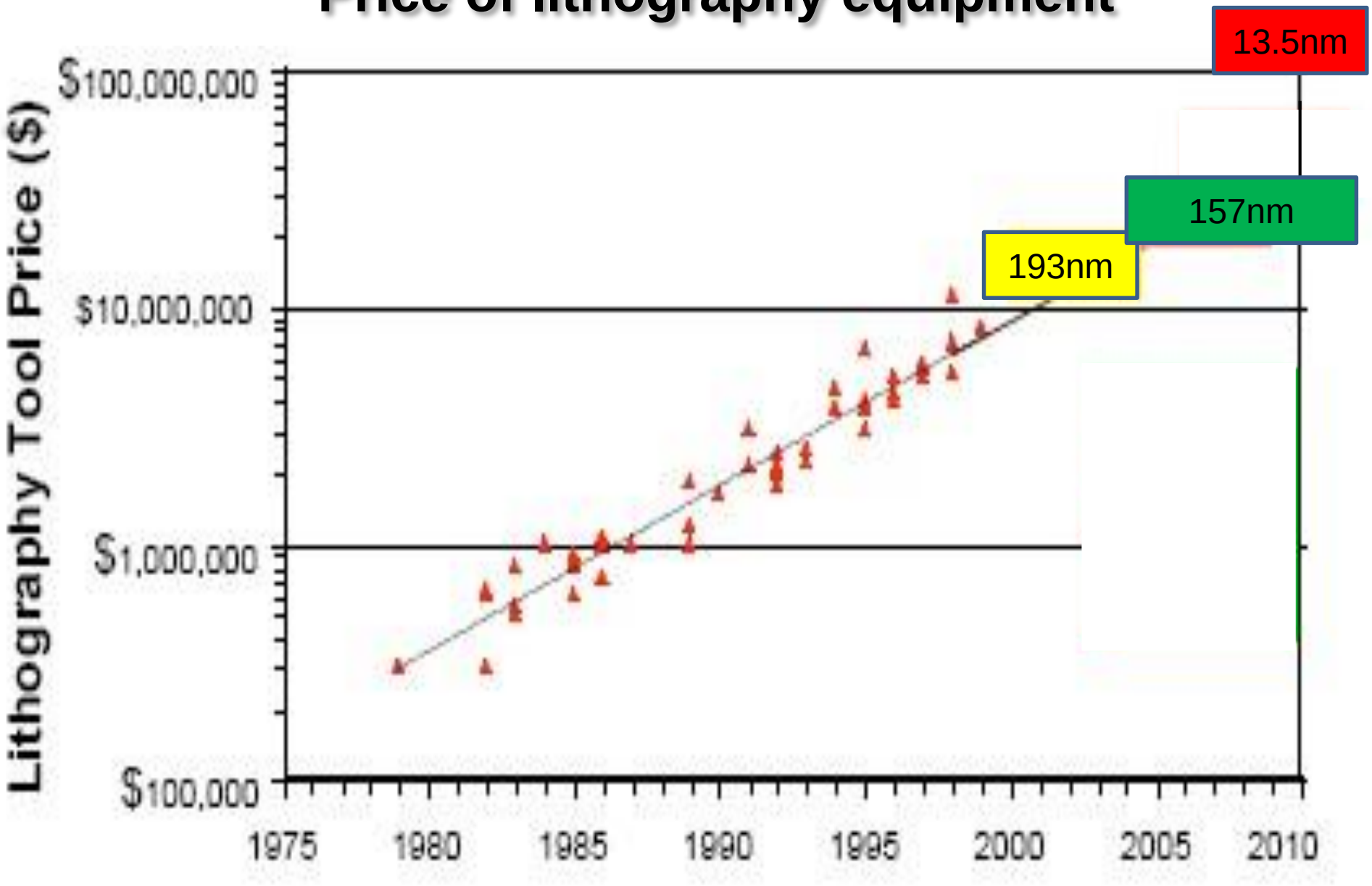
Deep UV (λ=193nm)
~ 1992



Extreme UV (λ=13.5 nm)
~ 2017

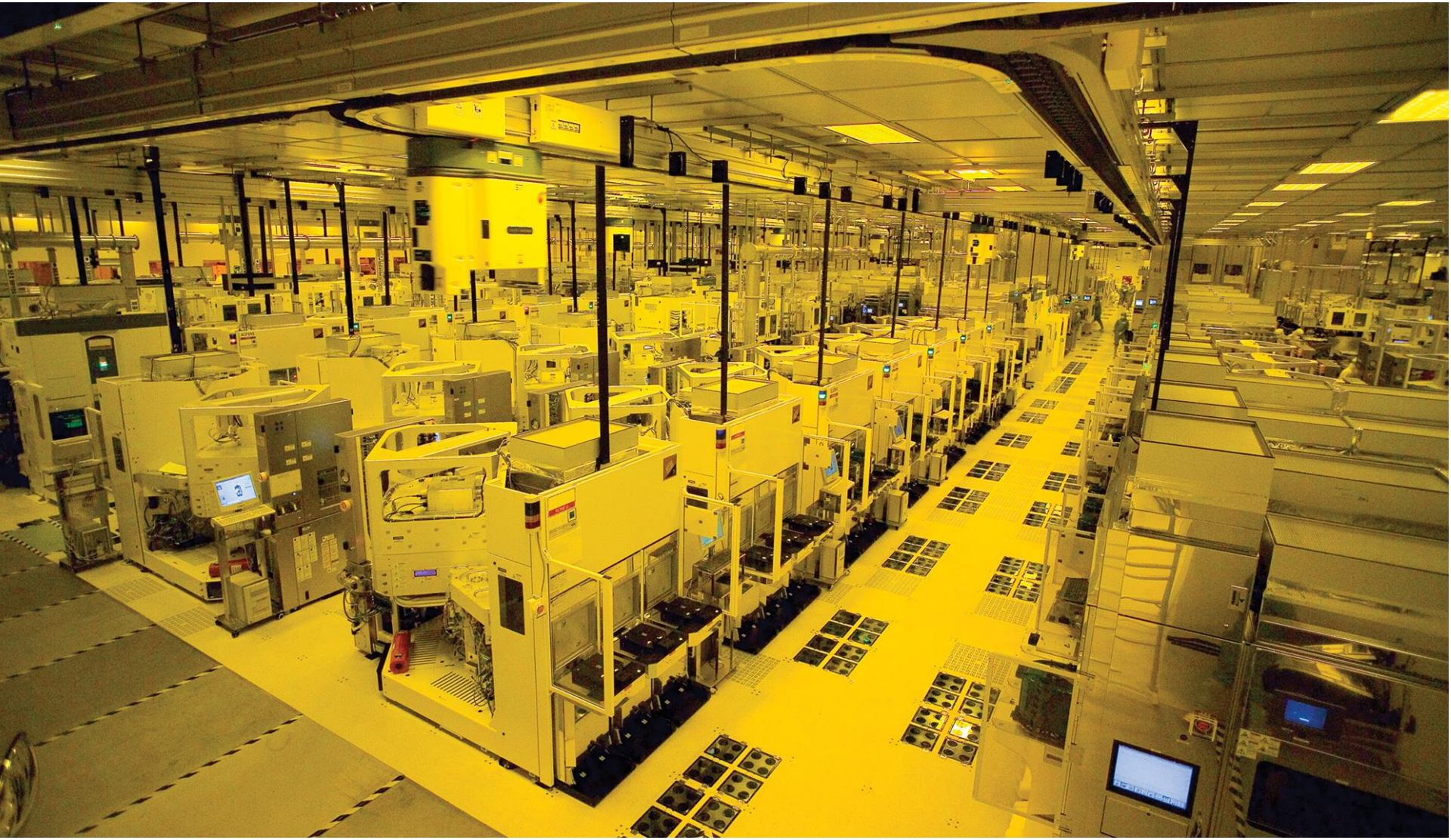


Price of lithography equipment

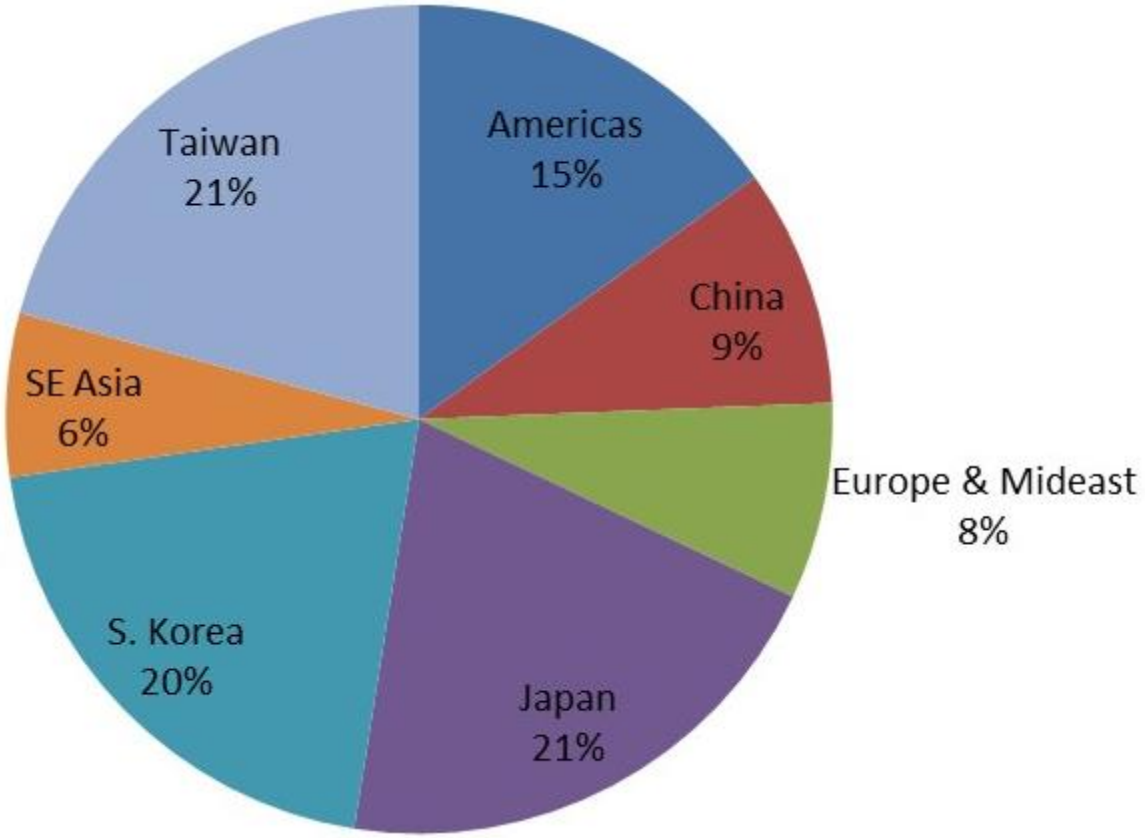


Cost of Semiconductor Fabs (> $10 Billion)

Cost of Semiconductor Fabs (> $10 Billion)

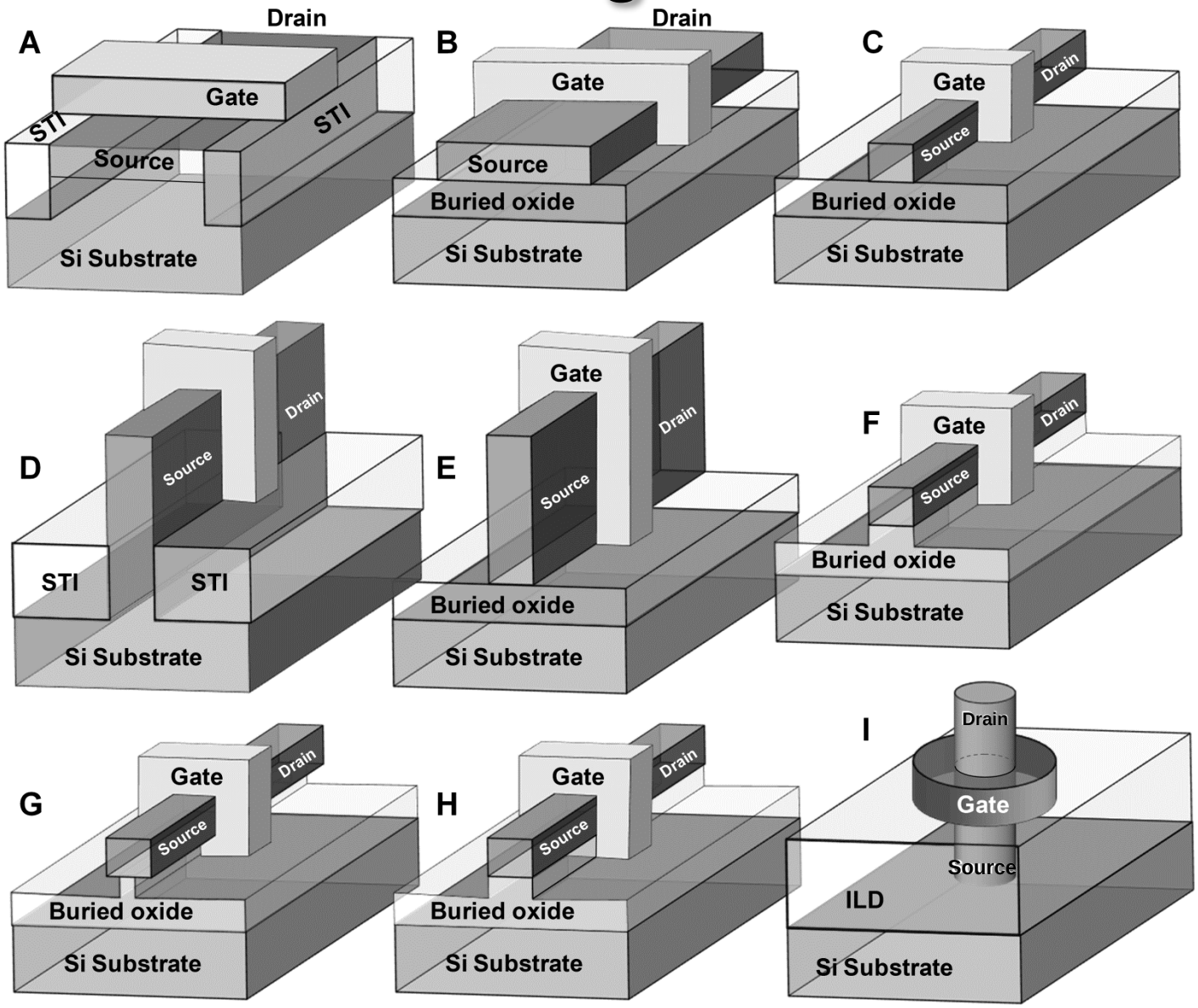


Semiconductor manufacturing per country



China + Taiwan + Japan + Korea + SE Asia
= 77% of world production

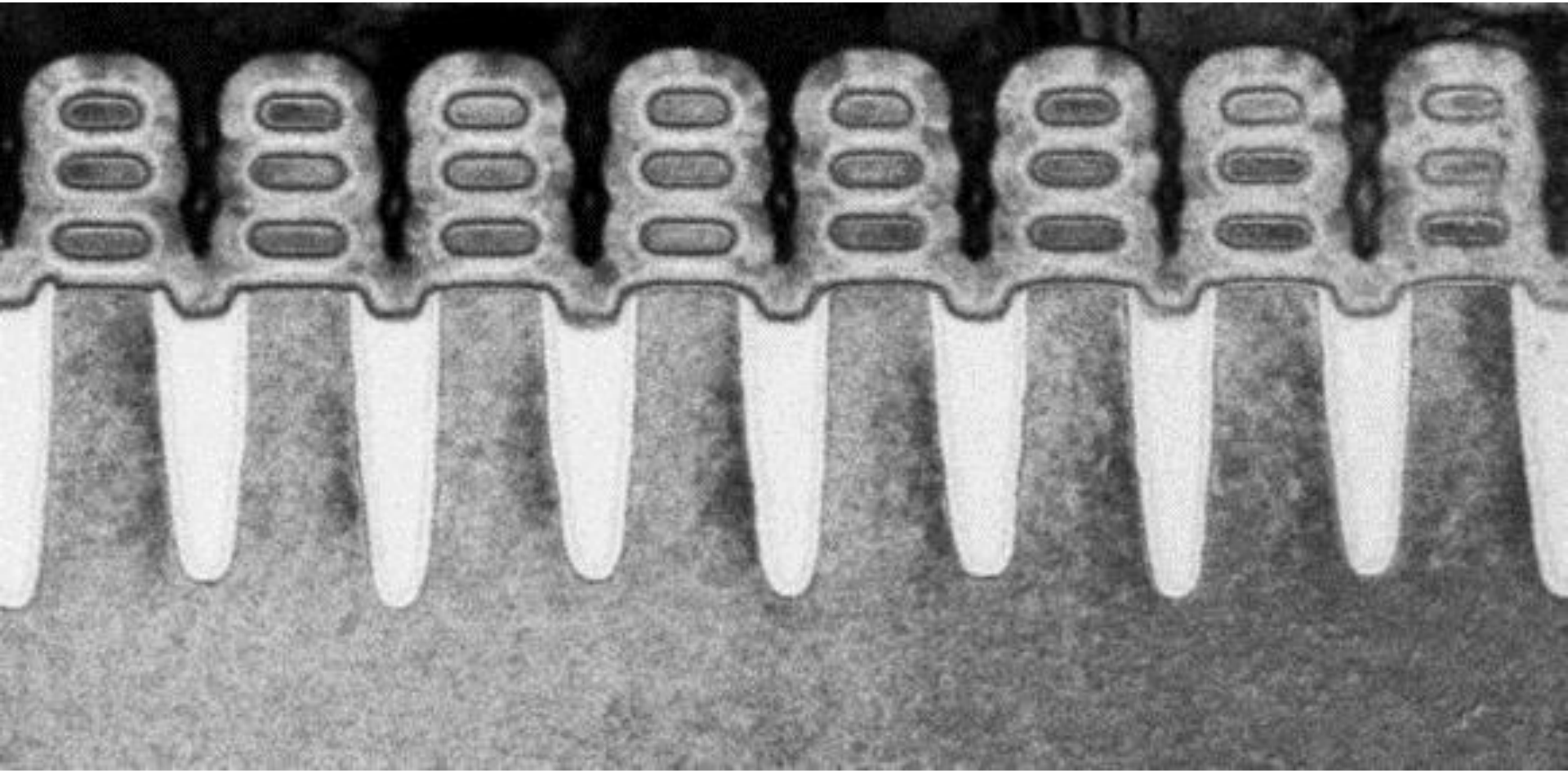
Multigate transistors



- **A: Single-gate planar bulk MOSFET.**
- **B: Single-gate SOI MOSFET with mesa isolation.**
- **C: Triple-gate (trigate) SOI nanowire MOSFET with square cross section.**
- **D: Bulk trigate MOSFET with high aspect ratio (bulk FinFET).**
- **E: SOI trigate MOSFET with high aspect ratio (SOI FinFET).**
- **F: Pi-gate (Π-gate) SOI nanowire MOSFET.**
- **G: Omega-gate (Ω-gate) SOI nanowire MOSFET.**
- **H: Horizontal gate-all-around (GAA, quadruple-gate, quad-gate) nanowire transistor with square section.**
- **I: Vertical gate-all-around (GAA) nanowire MOSFET with circular cross section).**

Figure 2.1 Different types of MOSFETs sorted by gate configuration.

Stacked GAA nanowire transistors



IBM/GF/Samsung Claims 5nm Nanosheet Breakthrough (2017 VLSI Symposium)
https://www.wired.com/2017/06/ibm-silicon-nanosheets-transistors/

Three-dimensional (3D) monolithic integration

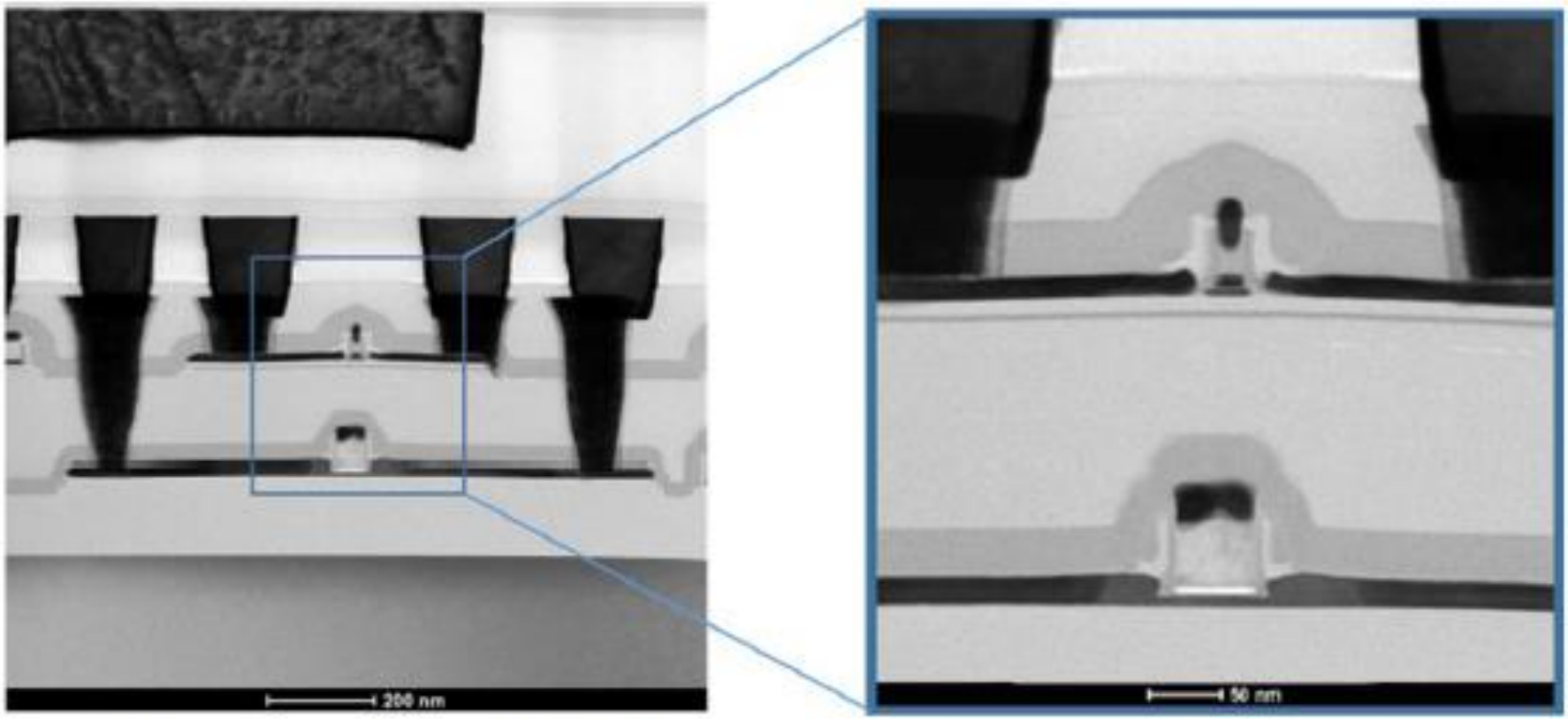
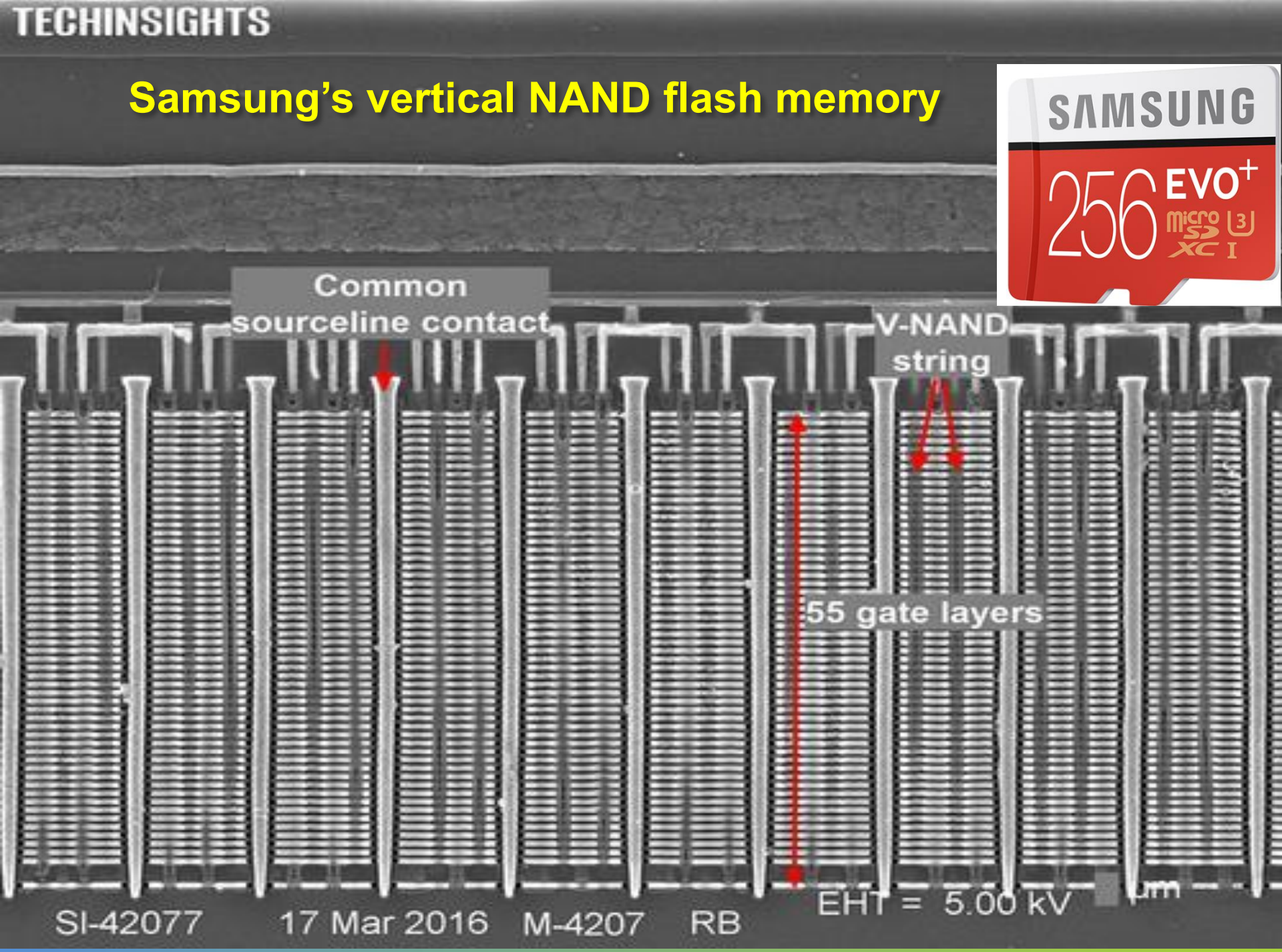
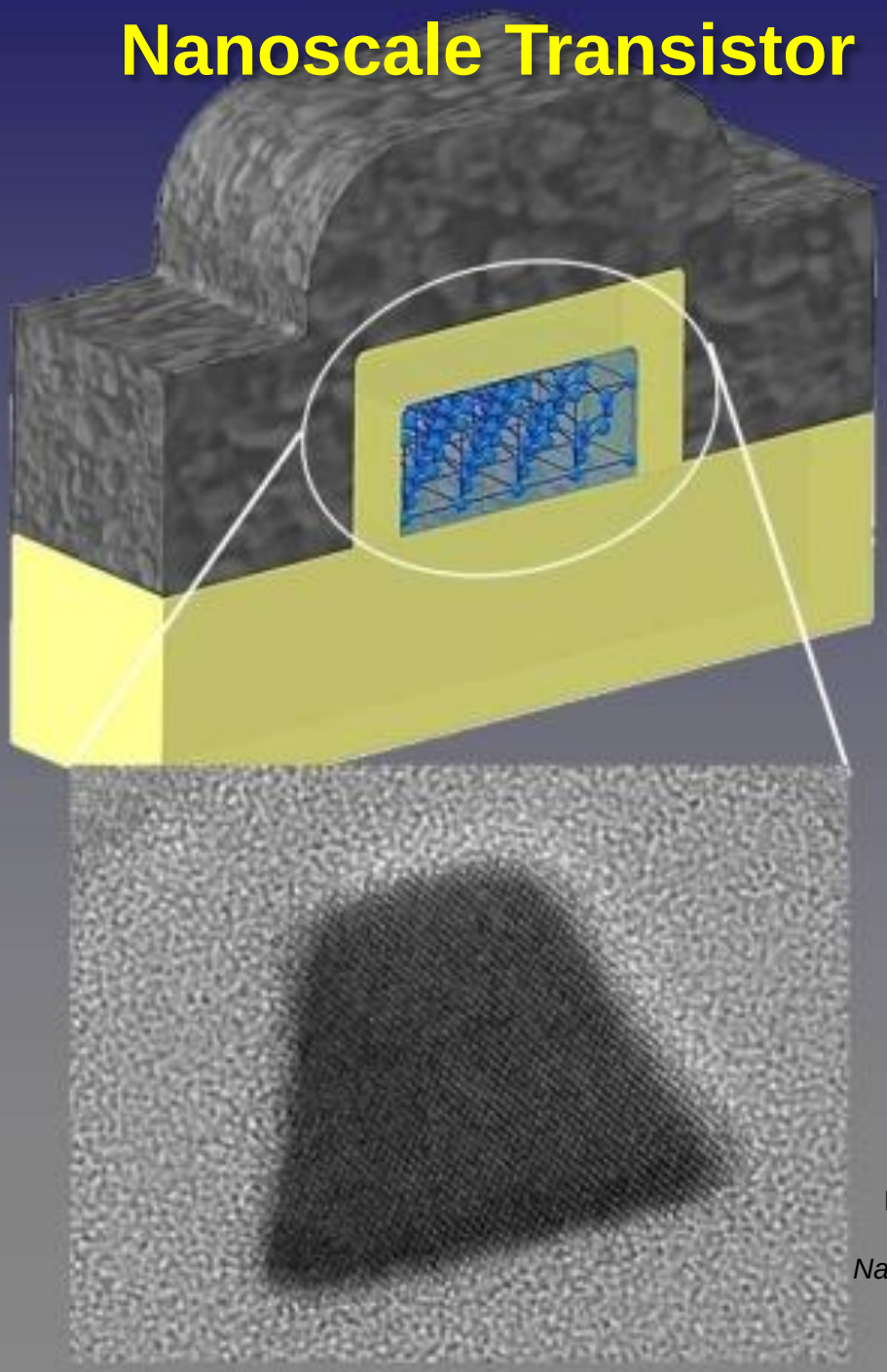


Fig.2: TEM cross-section of the 3D sequential structure up to M2 line. Nanometric top and bottom transistors alignment is observed.

http://www.advancedsubstratenews.com/2016/05/fd-soi-in-short-courses-papers-and-talks-at-upcoming-vlsi-symposia-16/


TECHINSIGHTS
Samsung's vertical NAND flash memory
SAMSUNG
256
EVO+
Common sourceline contact
V-NAND string
55 gate layers
EHT = 5.00 kV
SI-42077
17 Mar 2016
M-4207
RB

Nanoscale Transistor



Nanowire transistors without junctions
JP Colinge et al.
Nature Nanotechnology **5**, 225–229 (2010)

Where are we going?

(good side)


STAR TREK


NCC-1701
STAR TREK

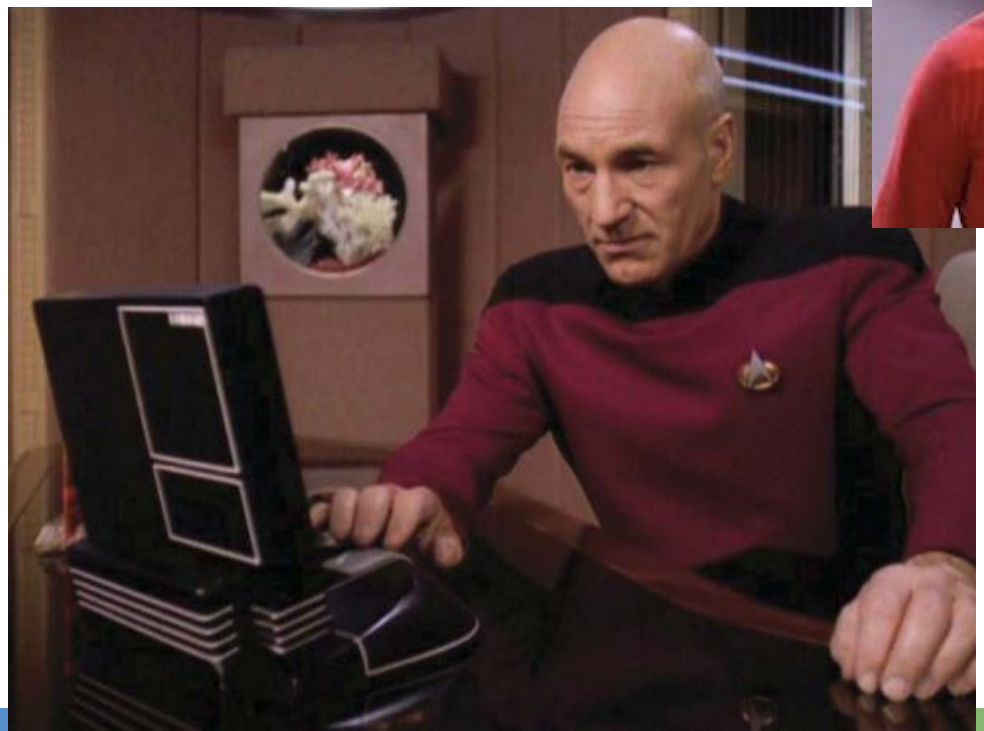
STAR TREK

Tablet

Universal translator

Laptop

Cell phone



STAR TREK

Where are we going?

(not so good side)


YOUR
PHONE
IS
WATCHING
YOU

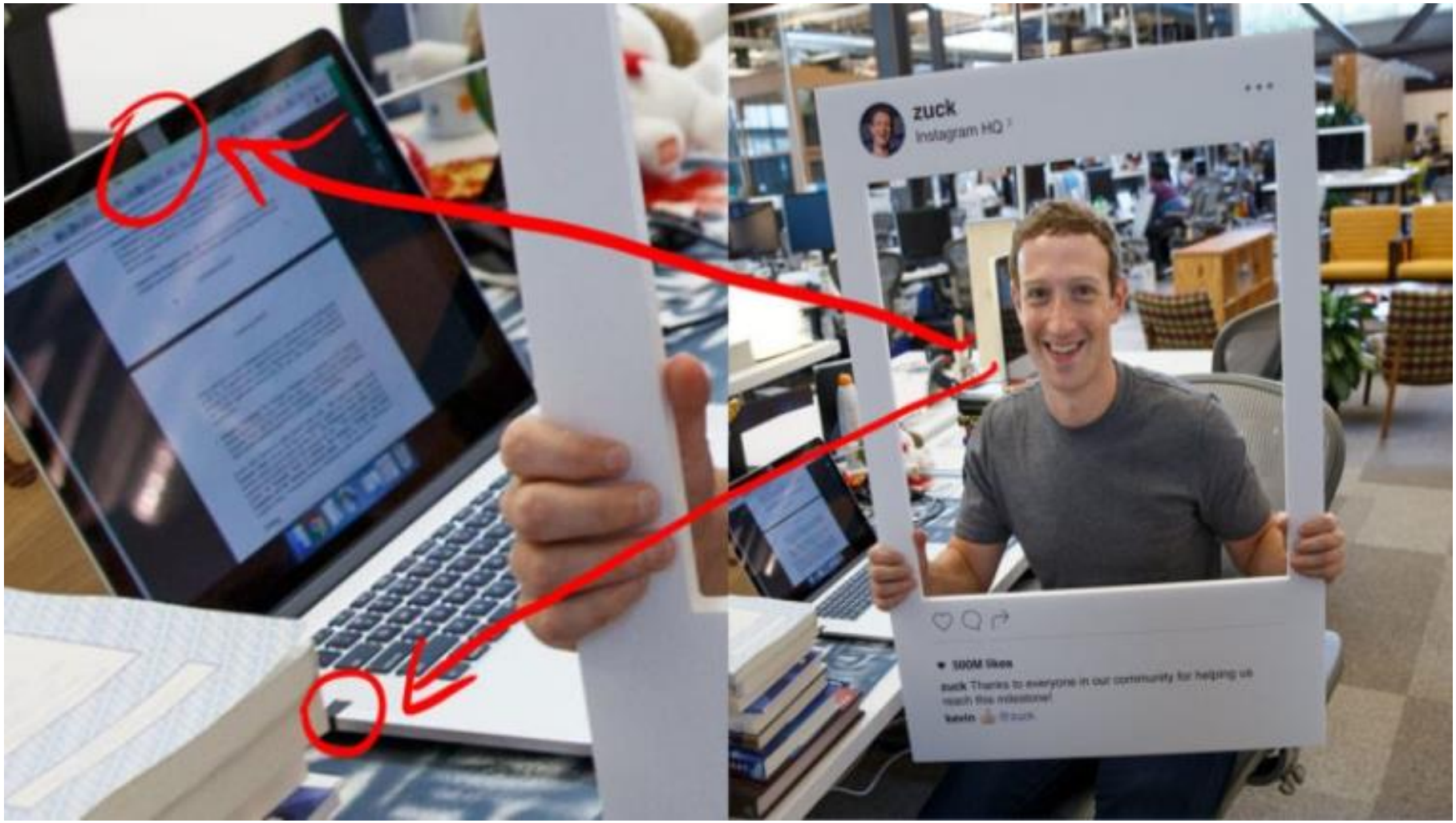

NSA IS WATCHING YOU


Google
IS WATCHING
YOU


facebook
IS WATCHING
YOU

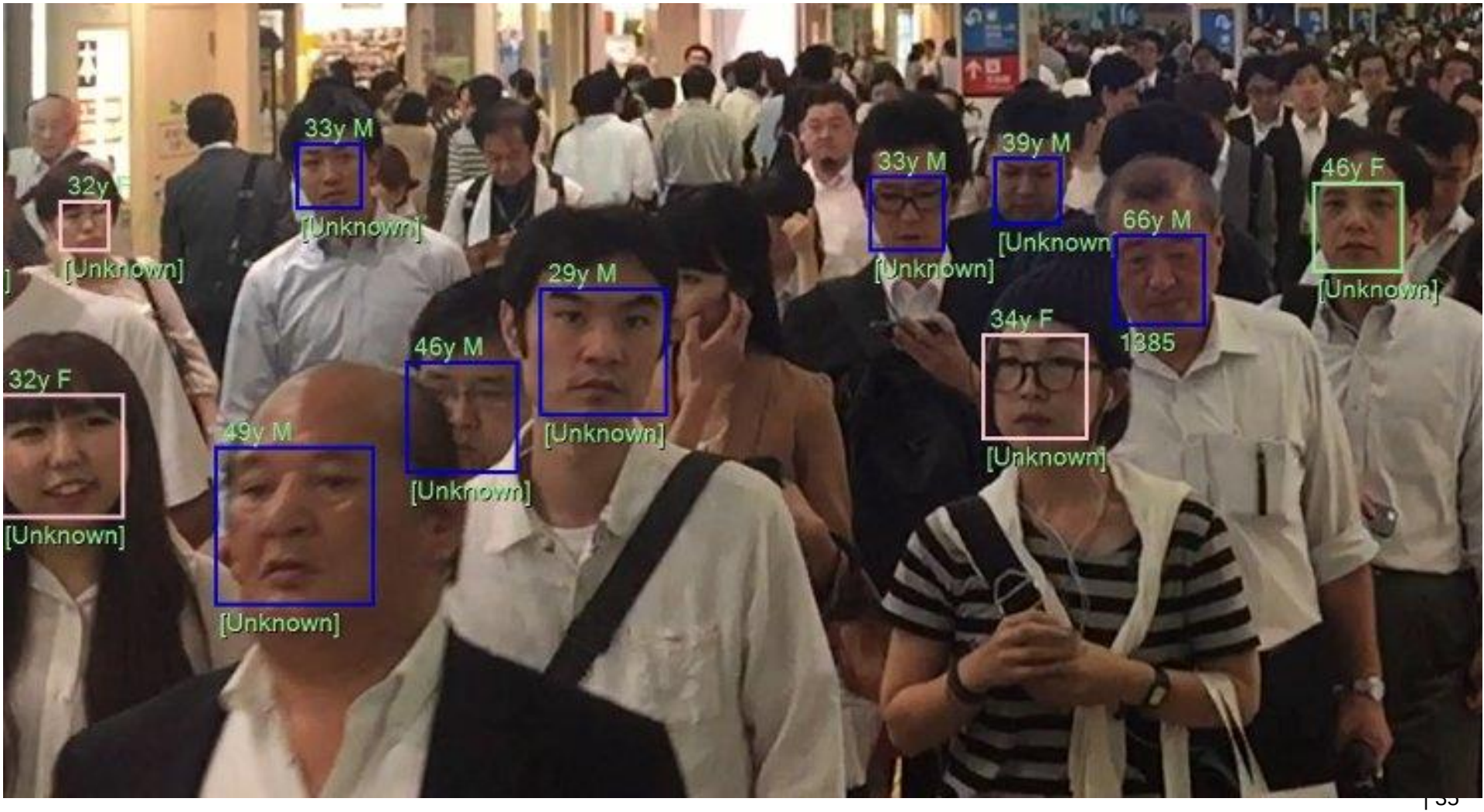

Windows 10
BIG BROTHER IS
WATCHING YOU

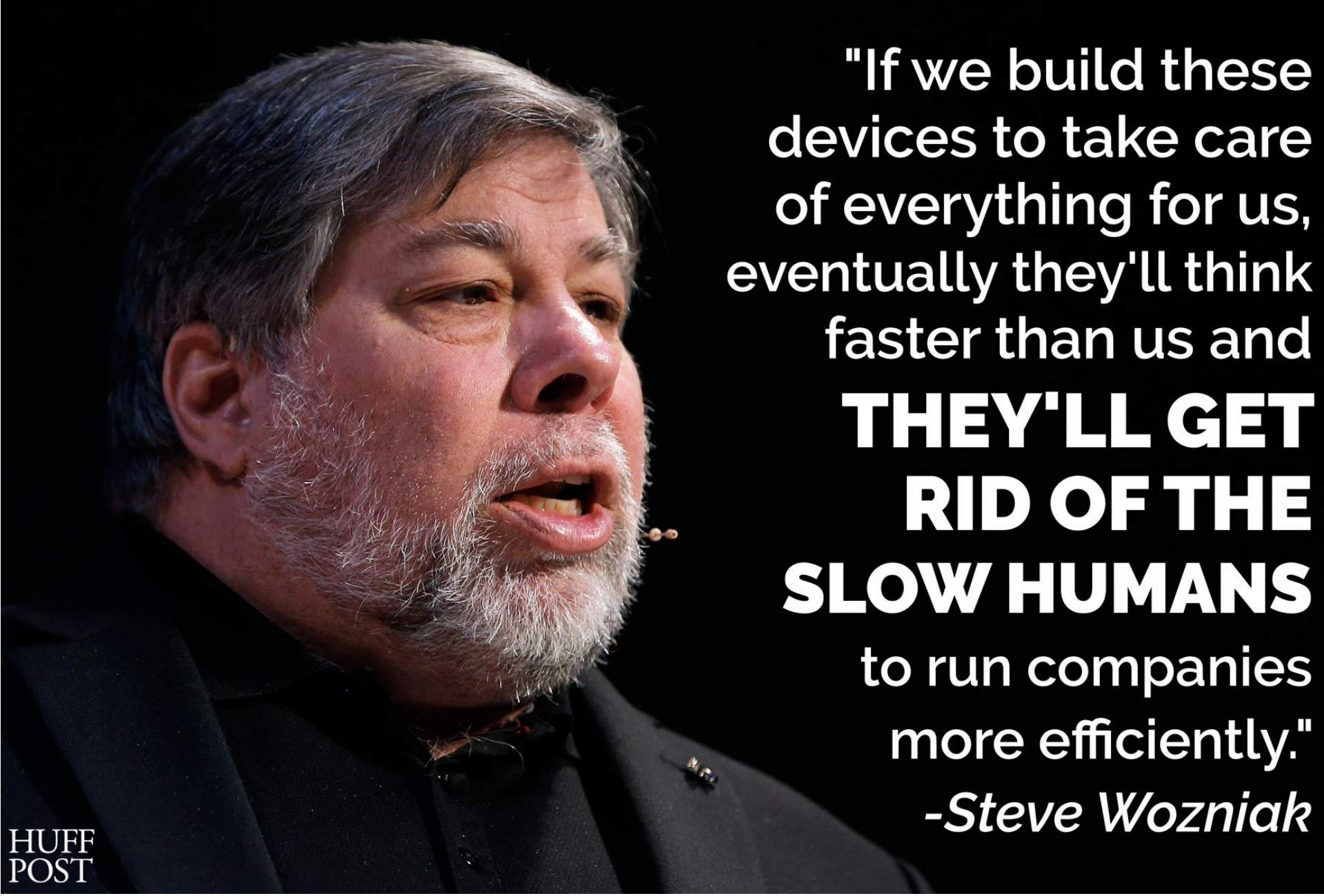
Mark Zuckerberg (Facebook) puts tape on his laptop camera and a phone jack into his microphone input



https://www.hackread.com/wp-content/uploads/2016/06/Mark-Zuckerberg-Tape-Facebook-Instagram-1-796x398.jpg

By some estimates, as many as a million CCTV cameras are installed in London, making it the most surveilled metropolis on the planet. Boris Johnson, who before becoming Britain's Foreign Secretary served as the city's mayor, once said, "When you walk down the streets of London, you are a movie star. You are being filmed by more cameras than you can possibly imagine." http://www.newyorker.com/magazine/2016/08/22/londons-super-recognizer-police-force




"If we build these devices to take care of everything for us, eventually they'll think faster than us and
THEY'LL GET RID OF THE SLOW HUMANS
to run companies more efficiently."
-Steve Wozniak
HUFF POST

Stephen Hawking, Elon Musk, and Bill Gates Warn About Artificial Intelligence

Some of the most popular sci-fi movies—*2001: A Space Odyssey, The Terminator, The Matrix, Transcendence, Ex Machina*, and many others—have been based on the notion that artificial intelligence will evolve to a point at which humanity will not be able to control its own creations, leading to the demise of our entire civilization. This fear of rapid technology growth and our increasing dependence on it is certainly warranted, given the capabilities of current machines built for military purposes.

Already, technology has had a significant impact on warfare since the Iraq war began in 2001. Unmanned drones provide sustained surveillance and swift attacks on targets, and small robots are used to disarm improvised explosive devices. The military is currently funding research to produce more autonomous and self-aware robots to diminish the need for human soldiers to risk their lives. Founder of Boston Dynamics, Marc Raiber, released a video showing a terrifying six-foot tall, 320-lb. humanoid robot named Atlas, running freely in the woods. The company, which was bought by Google in 2013 and receives grant money from the Department of Defense, is working on developing an even more agile version.

http://observer.com/2015/08/stephen-hawking-elon-musk-and-bill-gates-warn-about-artificial-intelligence/