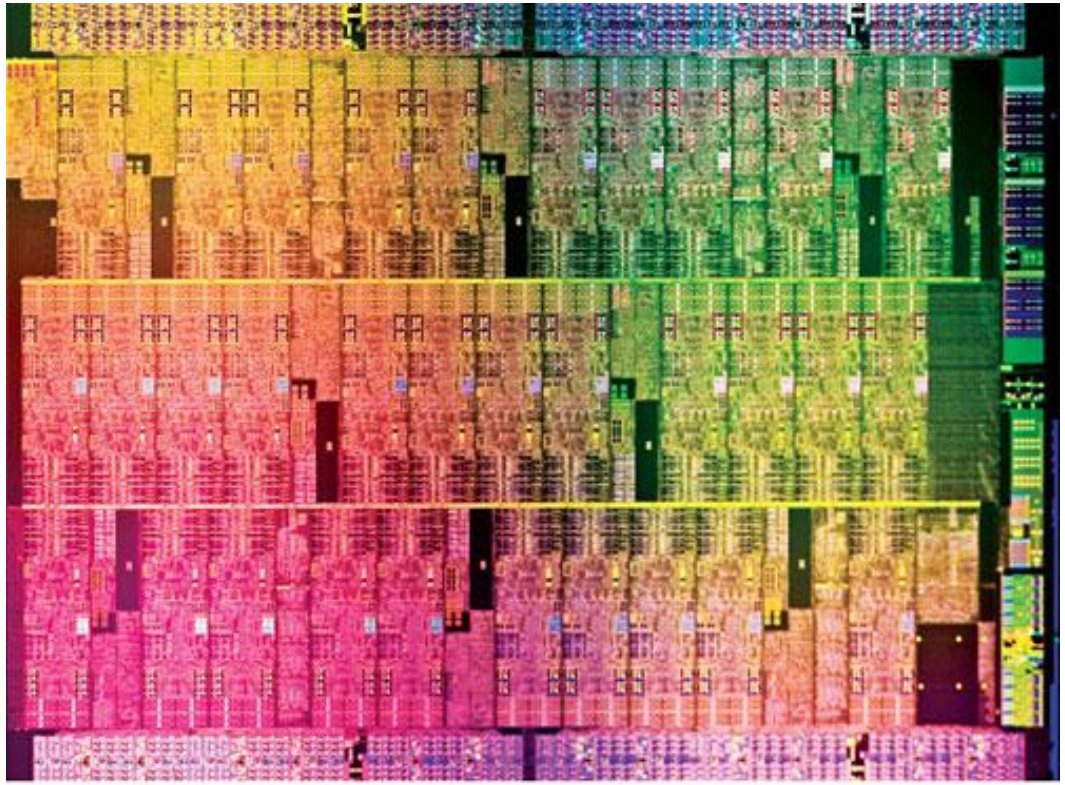
Welcome to ChE 384T/323

- **Chemical Engineering for Micro/Nano Fabrication**



Intel 22nm chip technology

Grant Willson

http://willson.cm.utexas.edu

Course Information

- Please read the syllabus carefully
- Class web site is http://willson.cm.utexas.edu
- Lecture notes and announcements will be posted on our site
- This is a lecture Course…
  - Please ask questions…..many questions!
  - Make every effort to attend each lecture and presentation
  - There is no text but there will be reading assignments
- Undergrad course (323) vs Grad Course (384T)
  - Oral Presentation for grad students.
  - Undergrads and Graduates will be graded separately
- Periodic Quizes
  - Start at 1100AM…drop lowest score
- Grade
  - (UG) = 0.5(final)+0.4(best midterm)+0.1(quiz)
  - (Grad) = 0.1(presentation)+0.4(best midterm)+0.4(Final)+0.1(Quiz)
- Teaching assistant: Mr. Wontae Joo
  - See the syllabus for office hours

Course Information

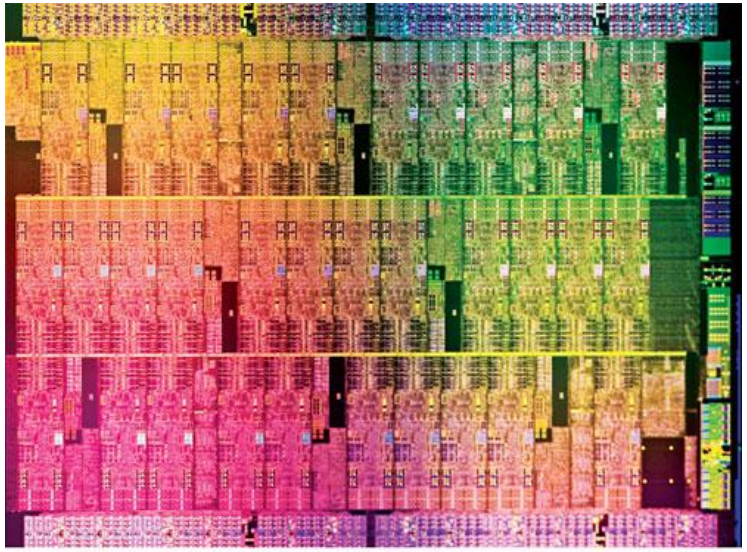
- Note the dates of the exams. If you miss and exam that will be your dropped score. There is really no way to make up these exams.

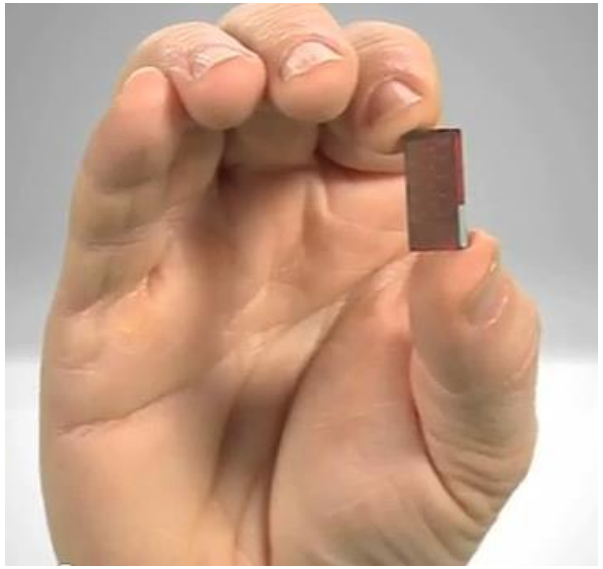
- Students with disabilities may request appropriate academic accommodations from the Division of Diversity and Community Engagement, Services for Students with Disabilities, 512-471-6259, http://diversity.utexas.edu/disability/

- Occupants of buildings on The University of Texas at Austin campus are required to evacuate buildings when a fire alarm is activated. Alarm activation or announcement requires exiting and assembling outside and across the bridge to assemble between ECJ and RLM.
  - Familiarize yourself with all exit doors of each classroom and building you may occupy. Remember that the nearest exit door may not be the one you used when entering the building.
  - Students requiring assistance in evacuation shall inform their instructor in writing during the first week of class.
  - Do not re-enter a building unless given instructions by the following: Austin Fire Department, The University of Texas at Austin Police Department, or Fire Prevention Services office.

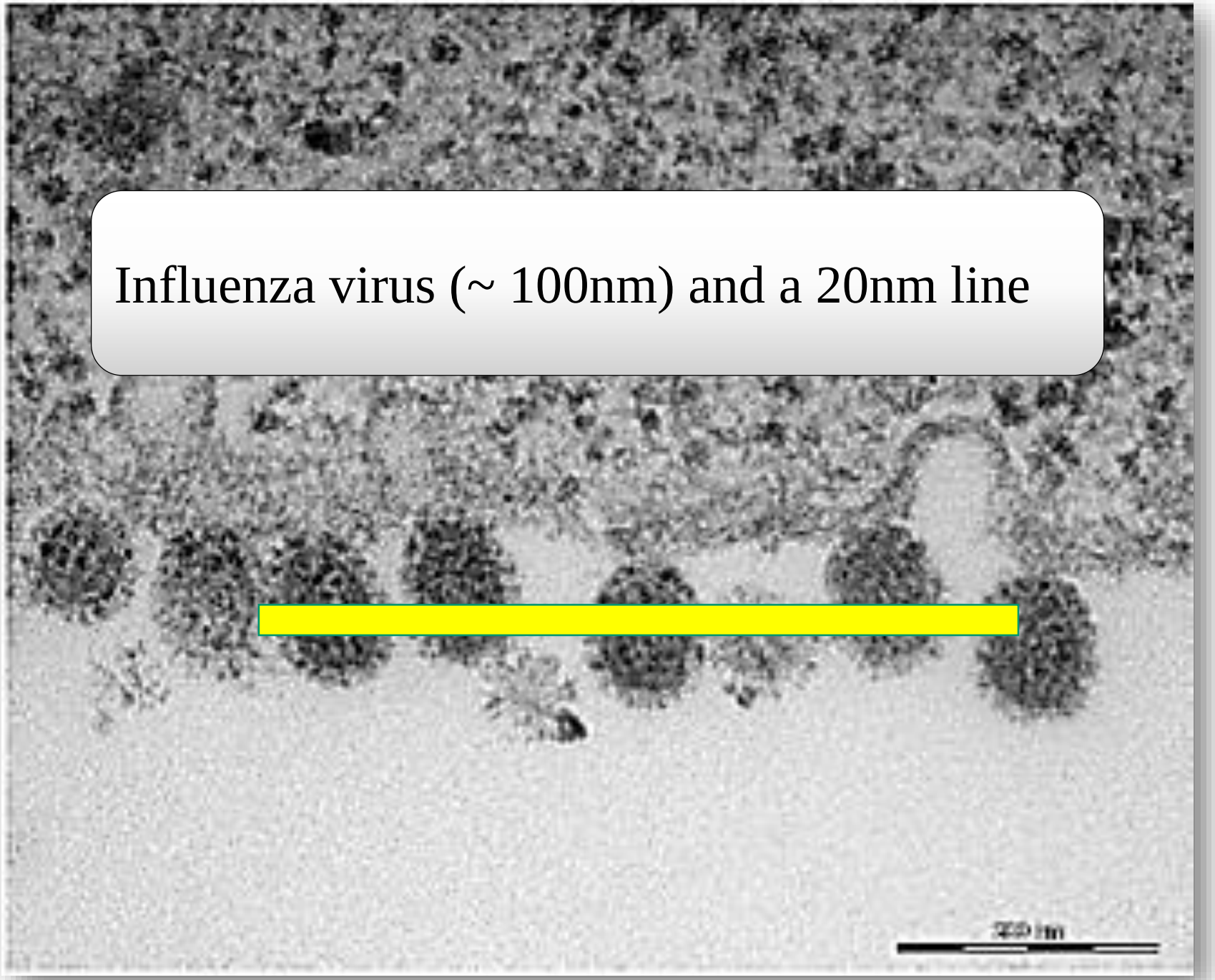
Evacuation Route

Integrated Circuits Today
1.4 Billion Transistors


Intel 22nm chip technology



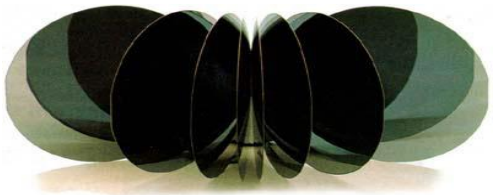
- Intel microprocessor with **22 nm** minimum features
  - Features are smaller than a virus!
- One of these transistors costs less than one printed character in the Austin American Statesman!


Influenza virus (~ 100nm) and a 20nm line

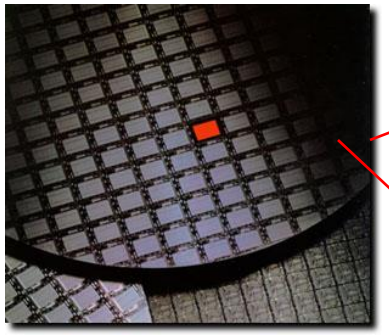
We will discuss the materials and processes used to make these tiny structures

sand

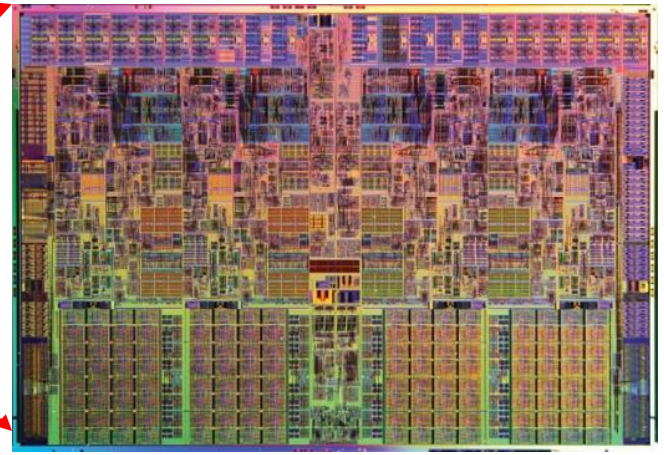
Single crystal Si Ingot



Polished Si Wafers



Device Wafer

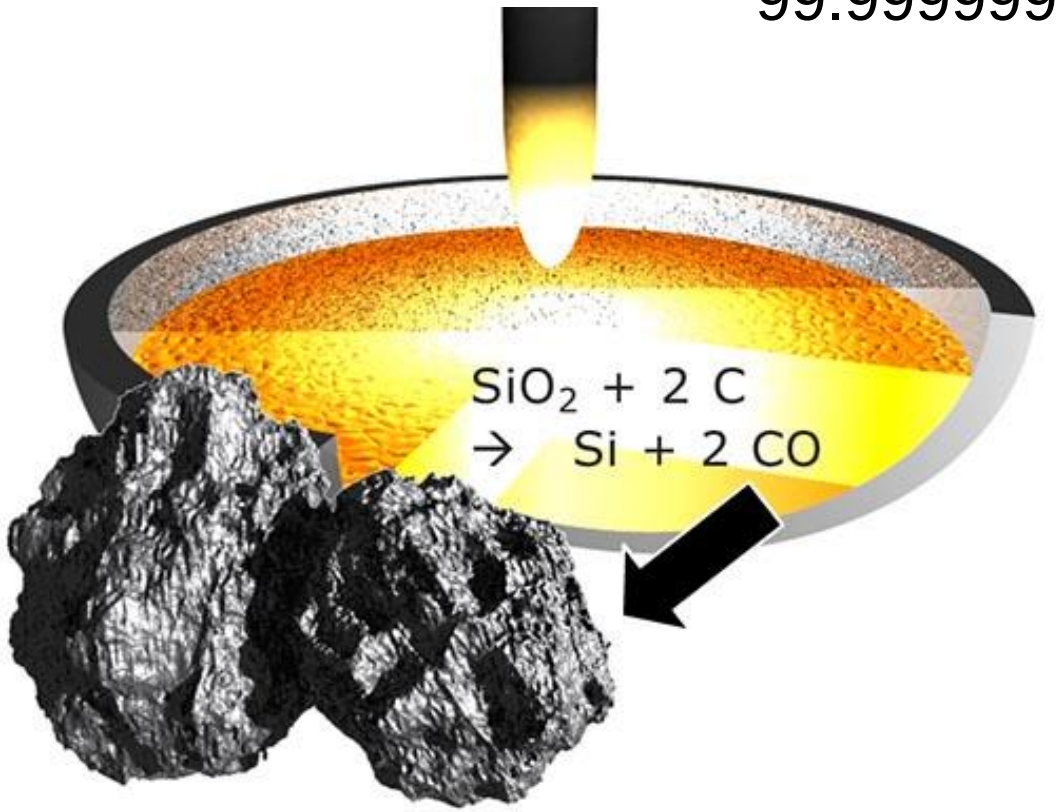


“Chip”

Packaged devices

SiO_2 to Poly Silicon

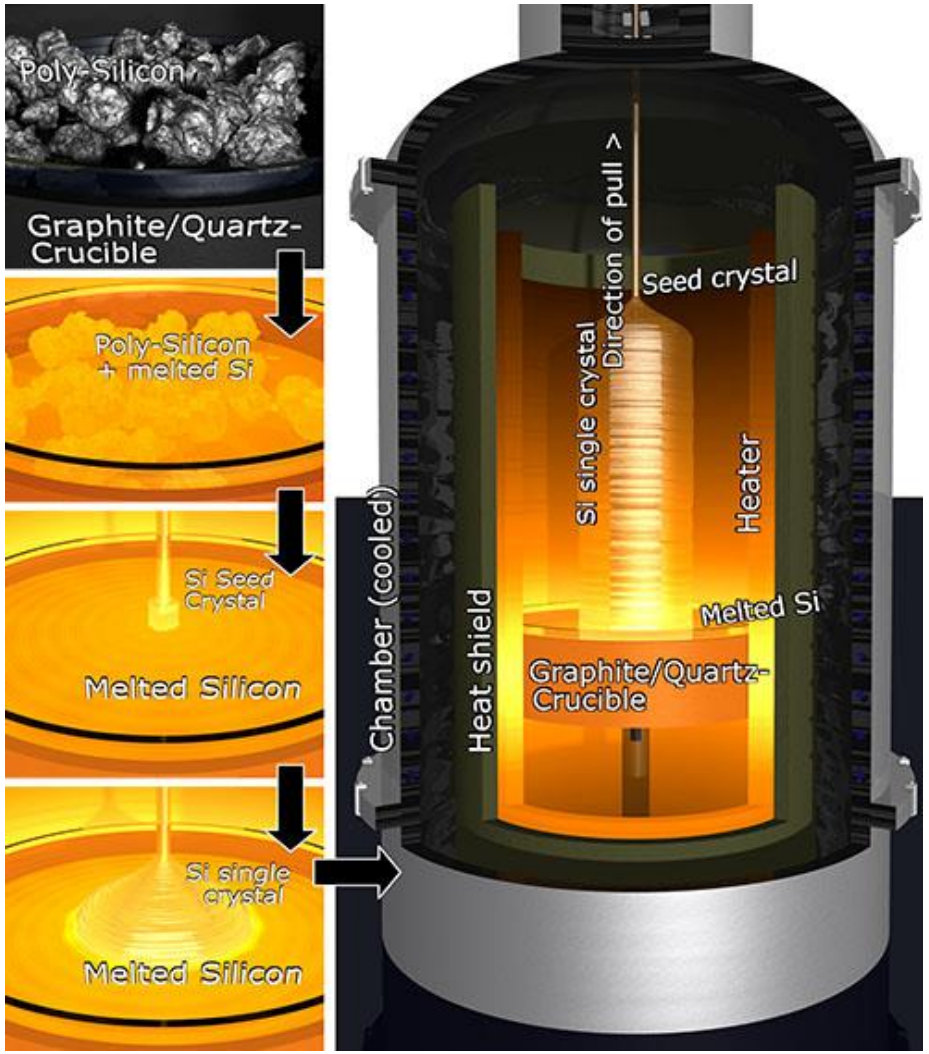
Purification as $HSiCl_3$ produces 99.9999999% purity



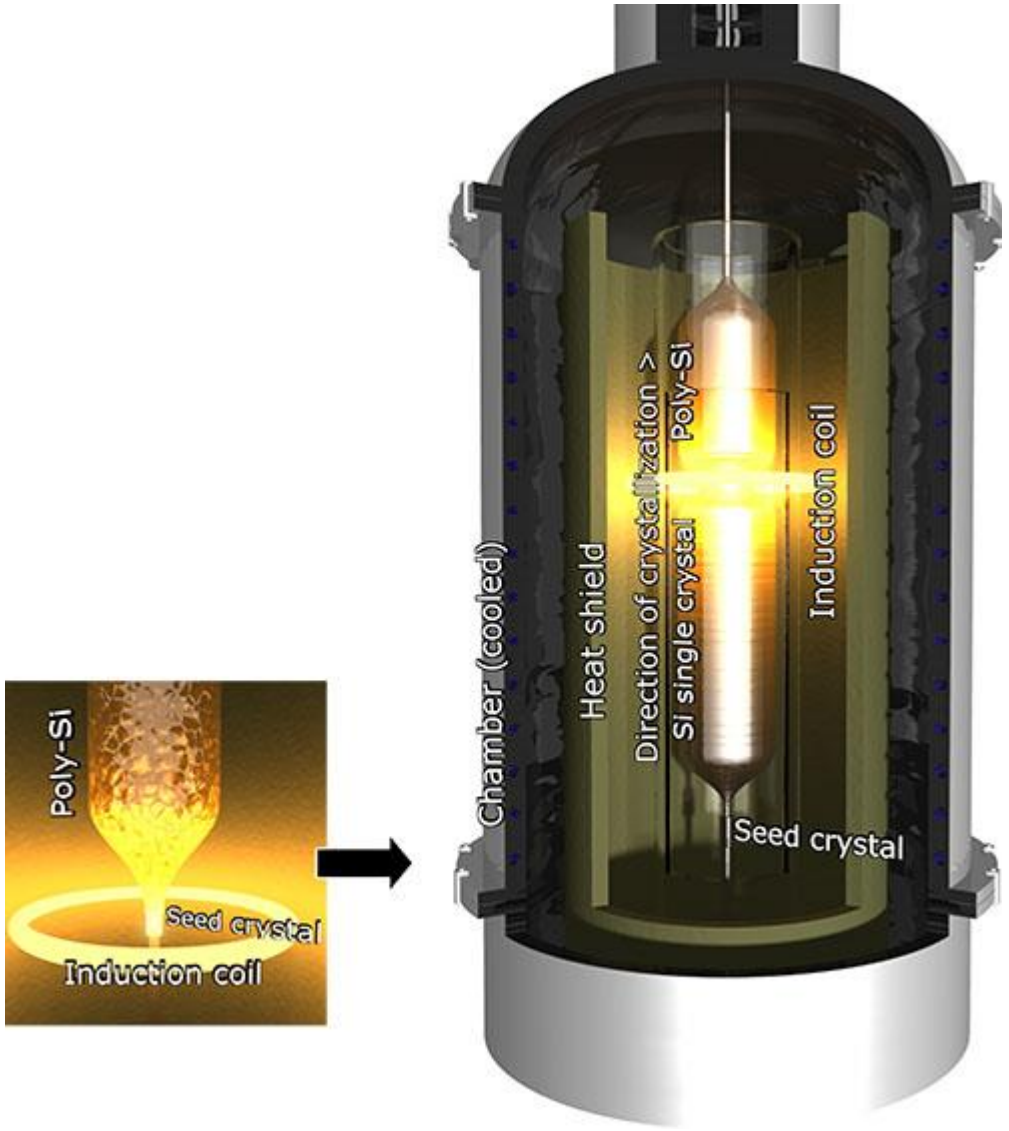
Reduction with Carbon

$Si + 3\,HCl \leftrightarrows HSiCl_3 + H_2$

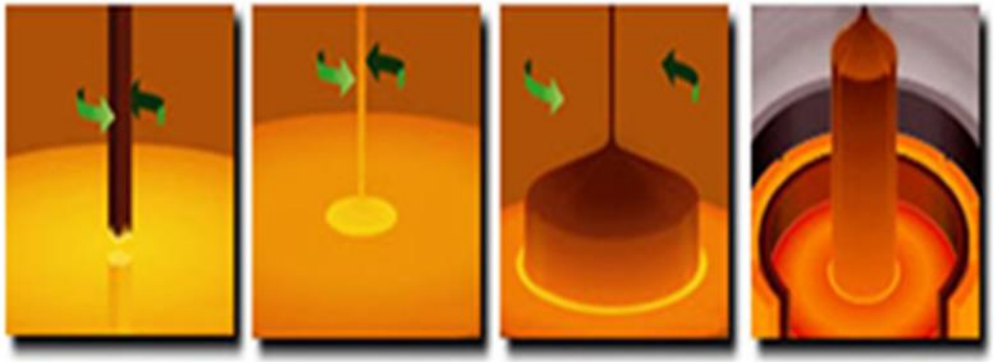
Silicon Crystal Growth

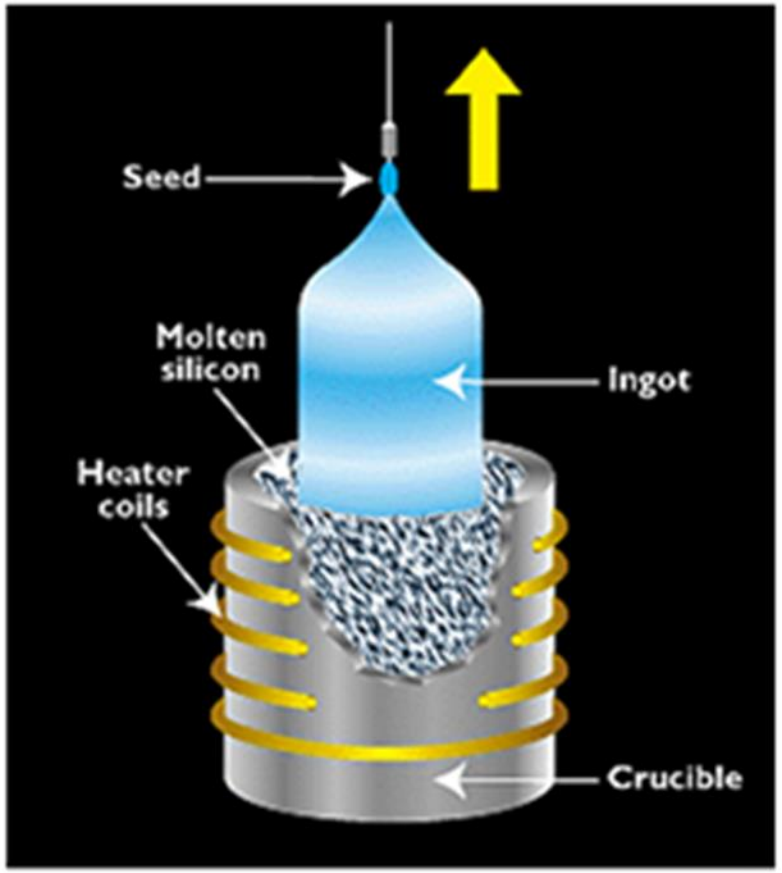


Czochralski-Technique:

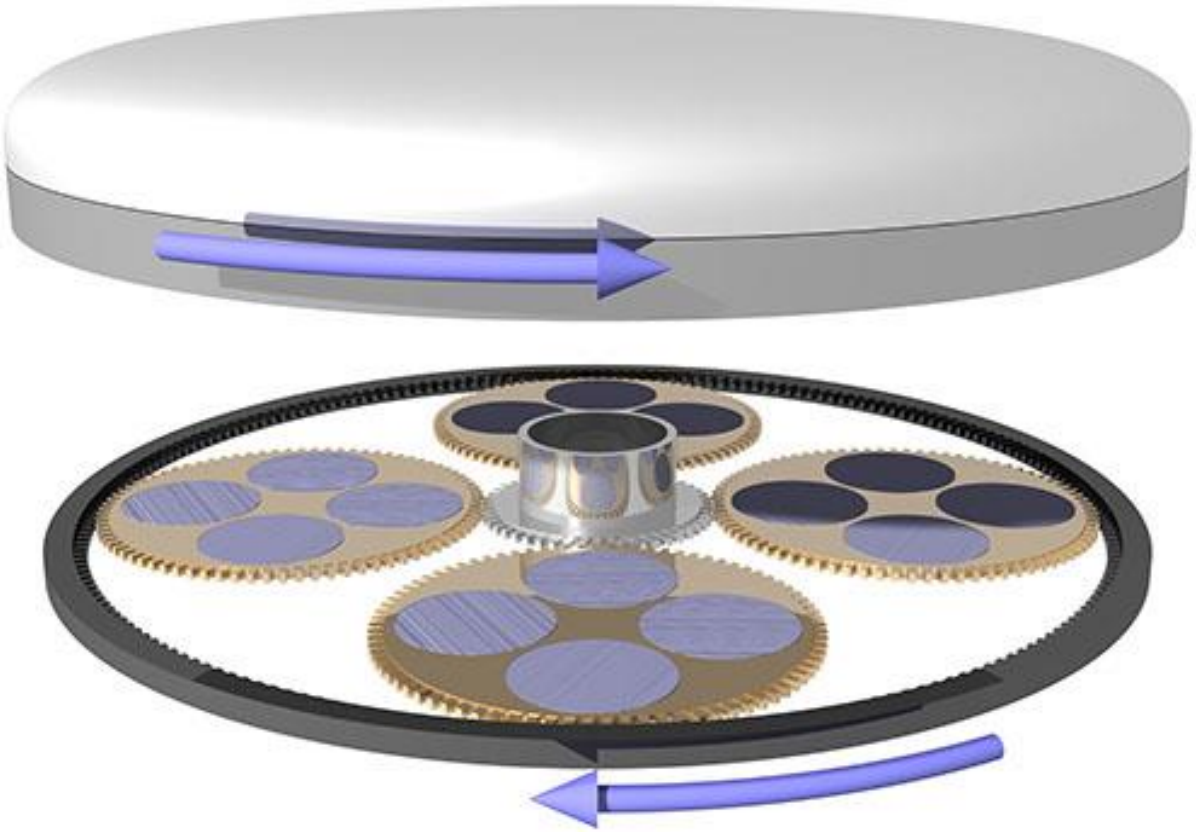


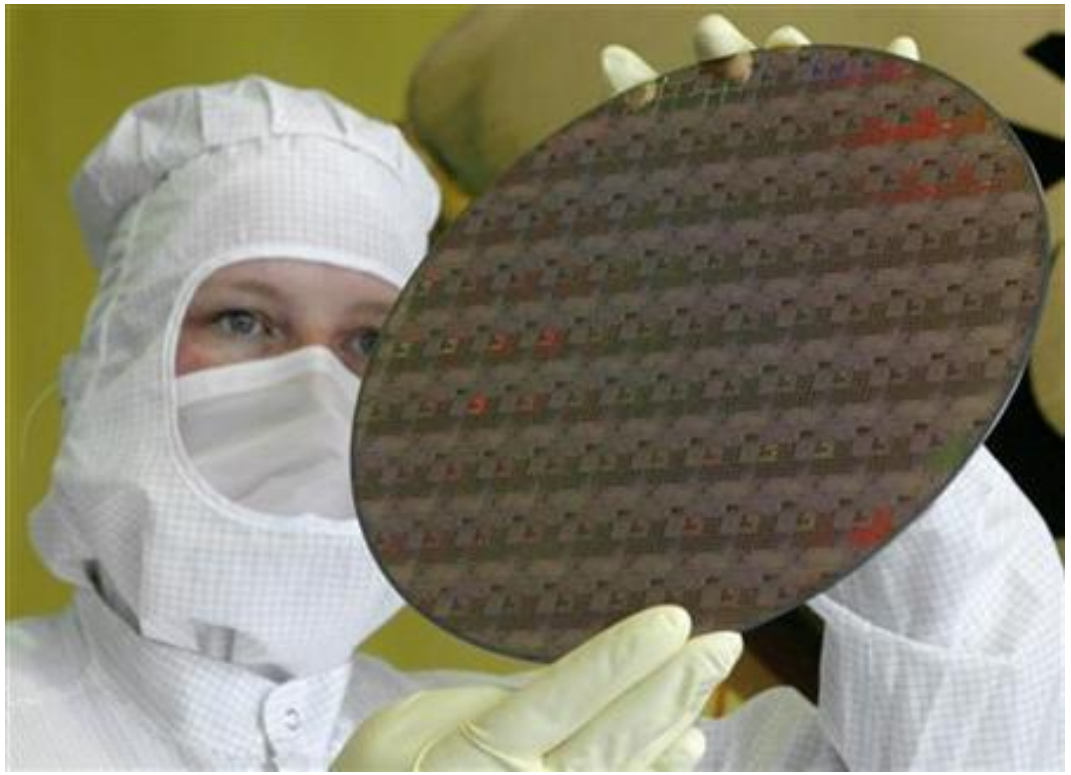
Float-Zone Technique:




Seed
Molten silicon
Ingot
Heater coils
Crucible

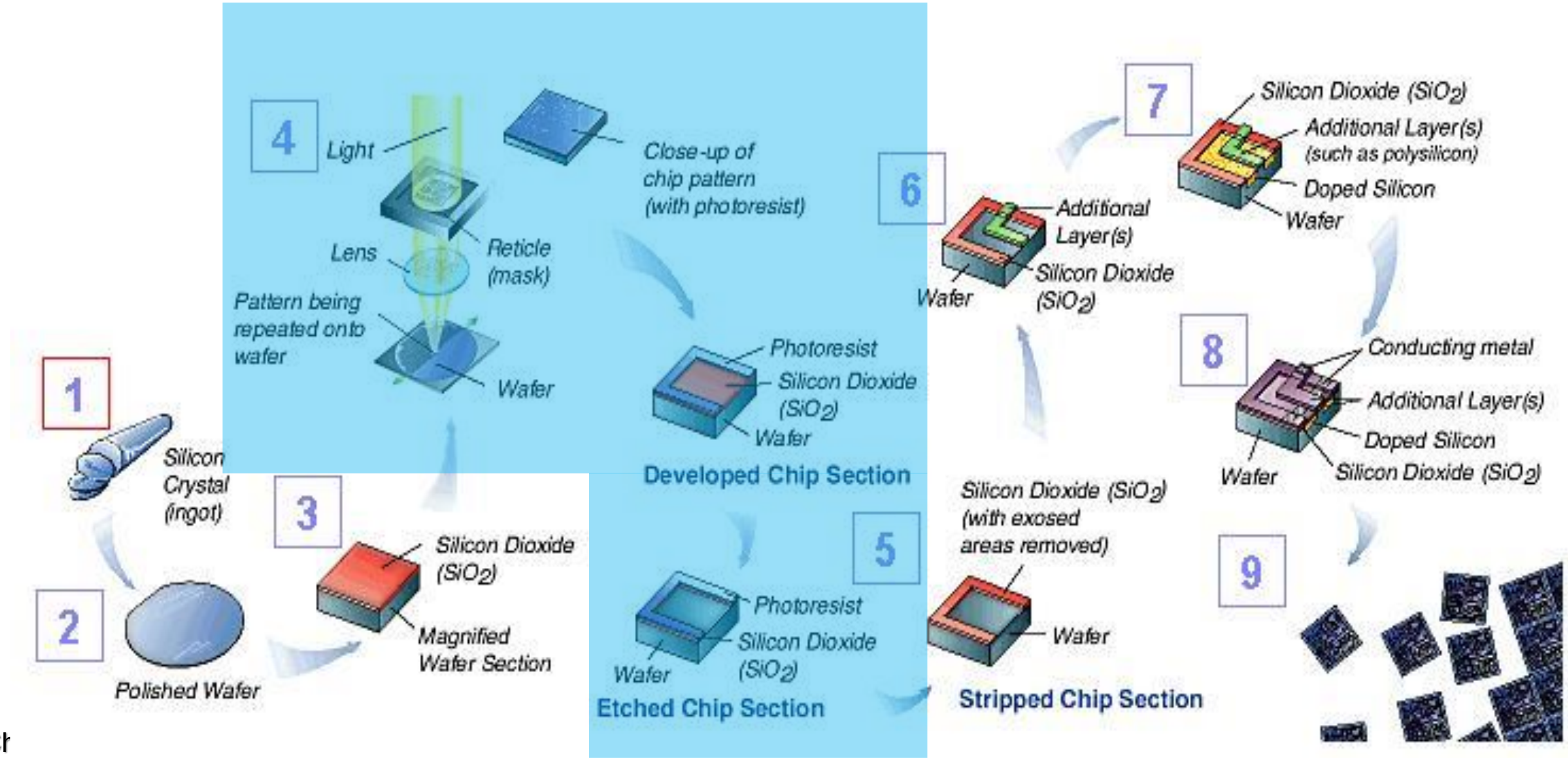
Lapping to Smooth the Wafer





450 mm Wafer

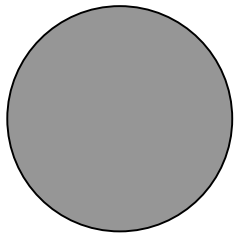
~400 Unit Processes are required



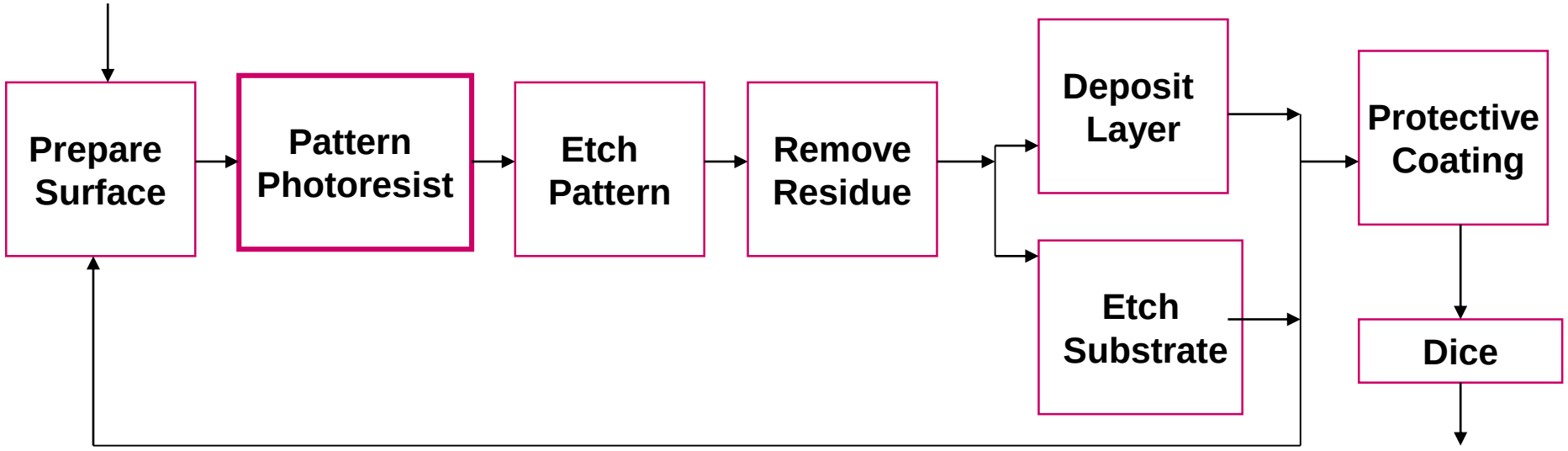
Ch

Integrated Circuit Fabrication

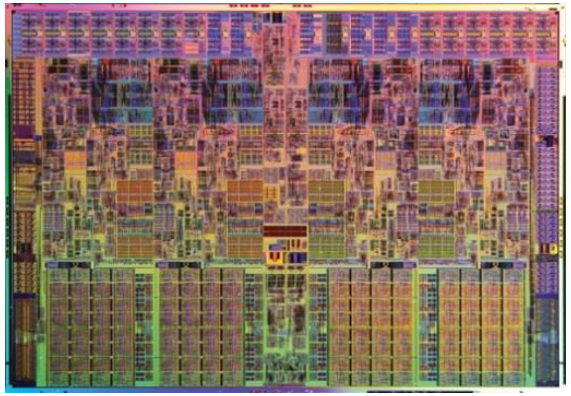
The fabrication of an integrated circuit requires hundreds of sequential process steps involving:



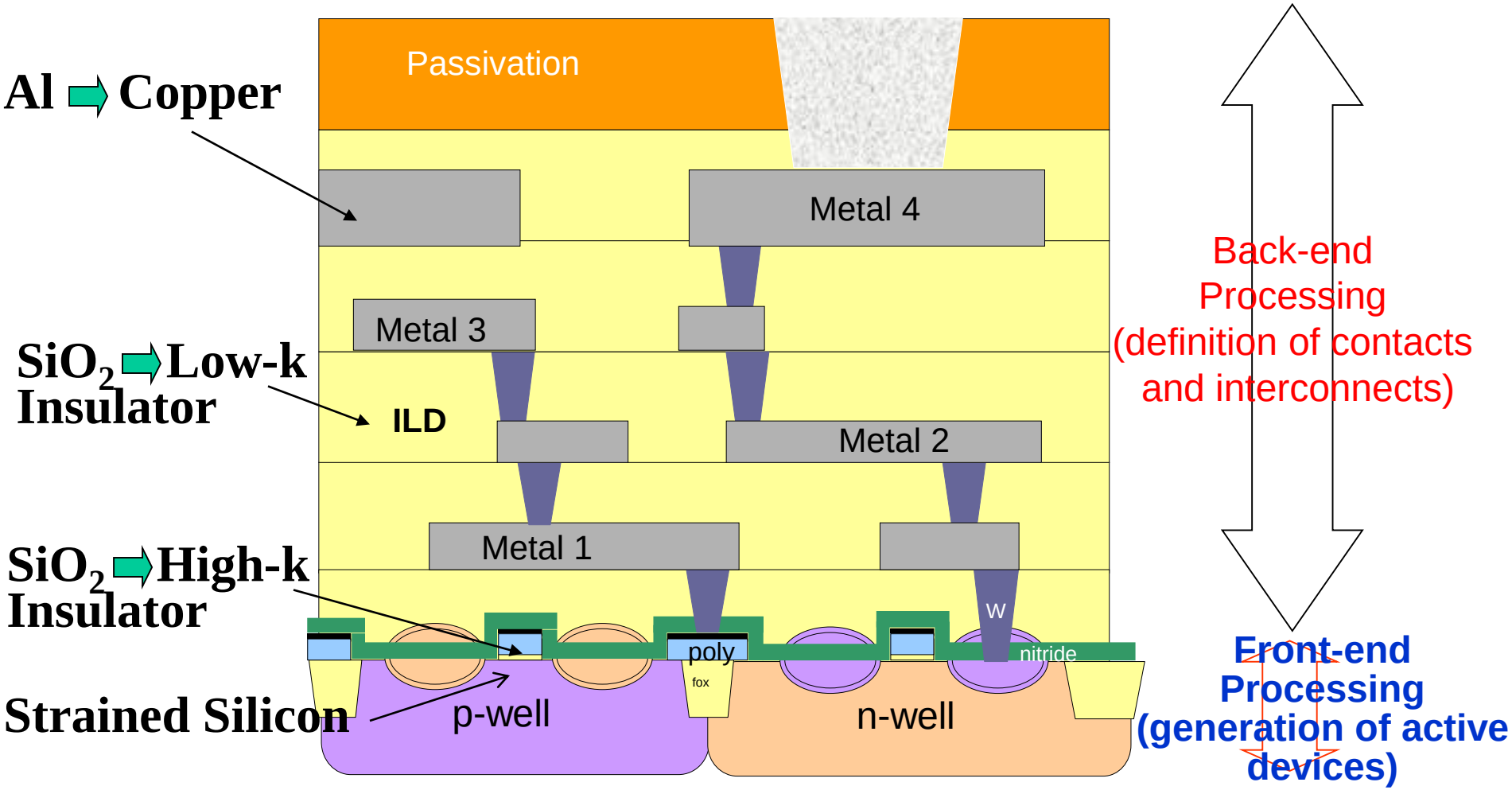
Silicon Wafer

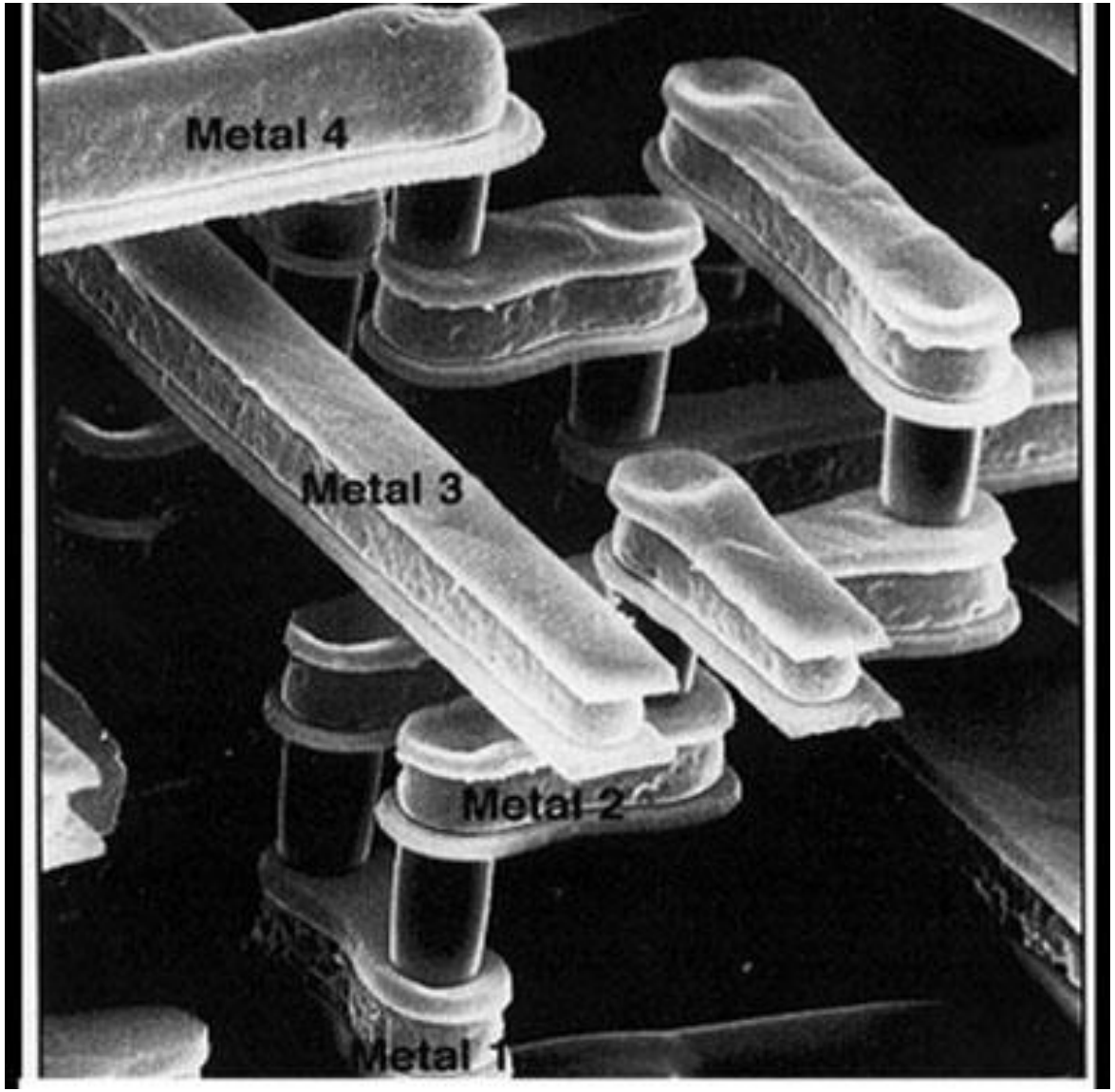


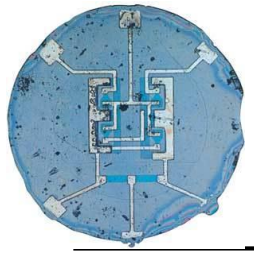
Chip



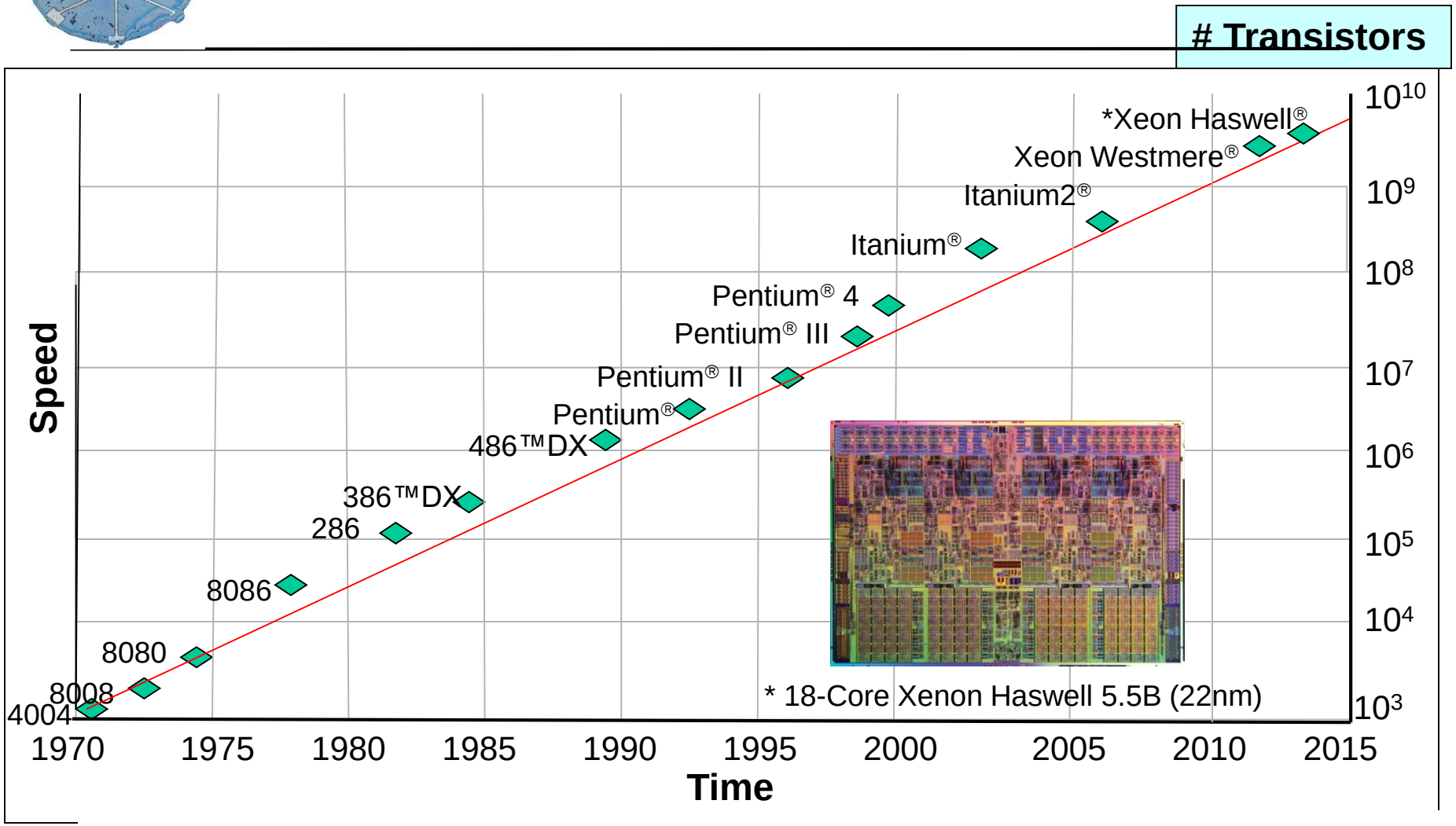
Chip Schematic




Metal 4
Metal 3
Metal 2
Metal 1

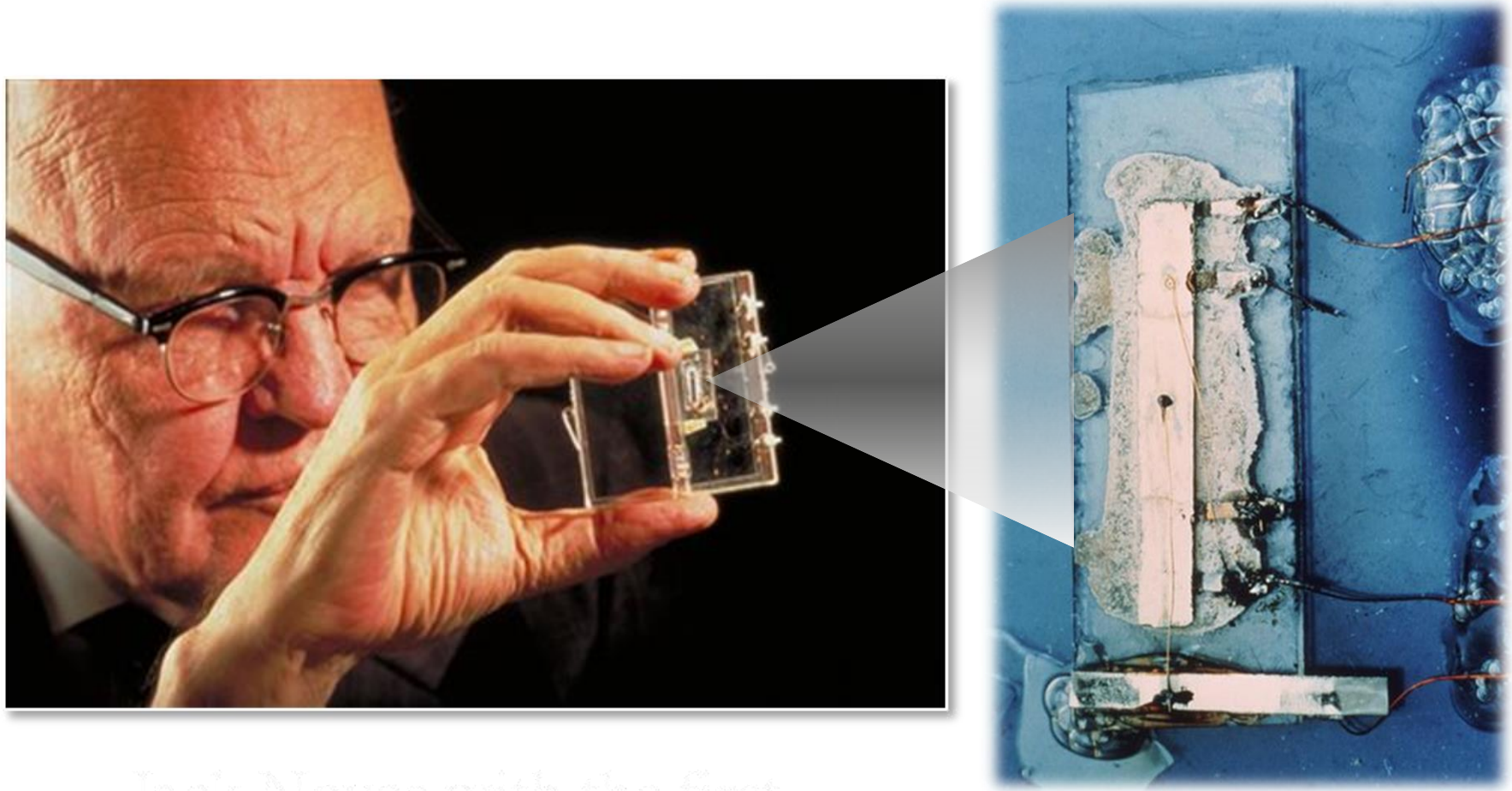


Microprocessor Evolution



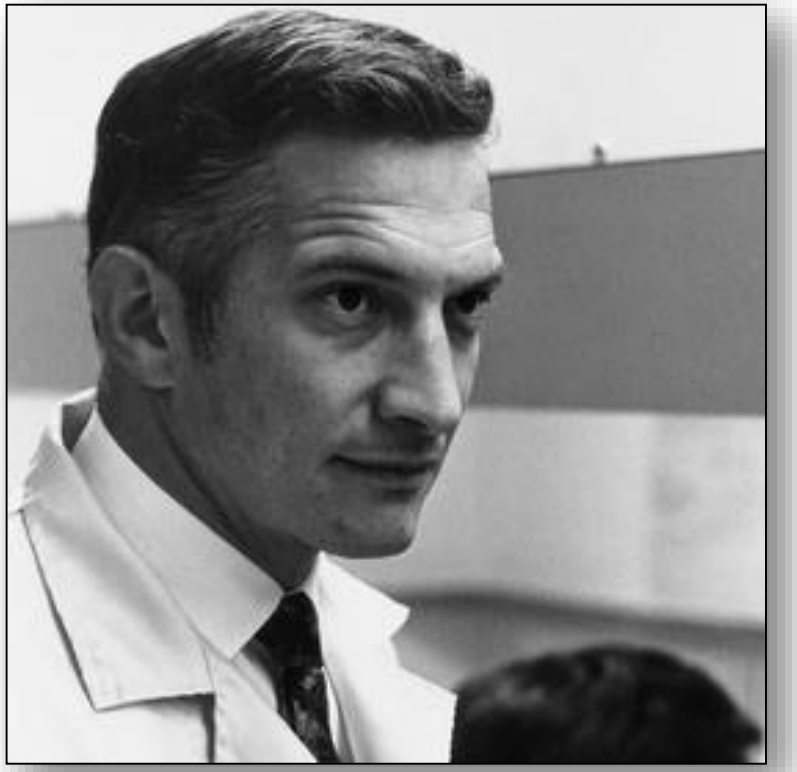
Intel claims that by 2026 processors will have as many transistors as there are neurons in a brain

First Integrated Circuit



Jack Kilby with the first integrated circuit - 1958
Nobel Prize 2000

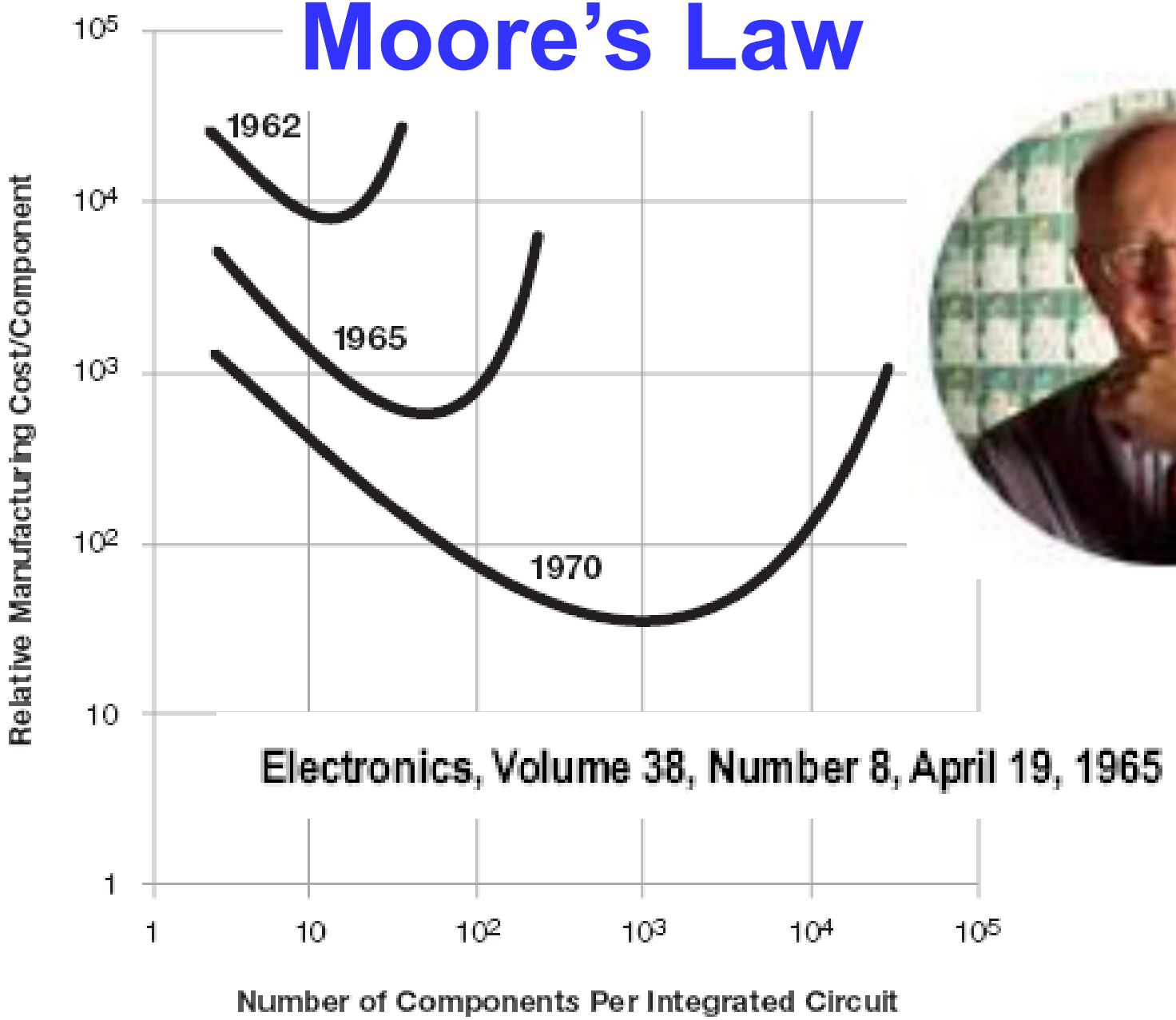
Founders of Intel Corp 1968



Robert Noyce

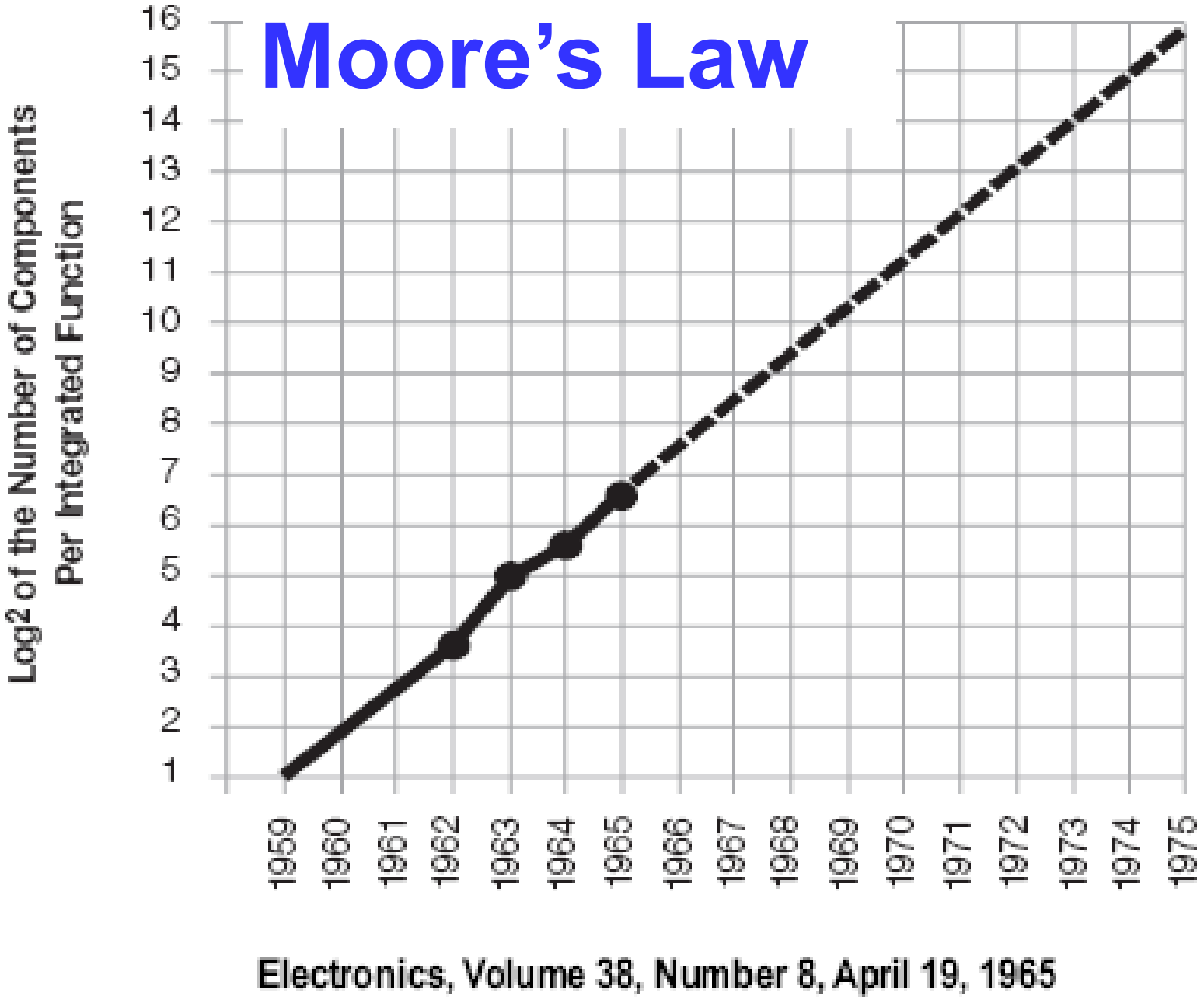
Gordon Moore

Moore's Law



Electronics, Volume 38, Number 8, April 19, 1965

Moore's Law



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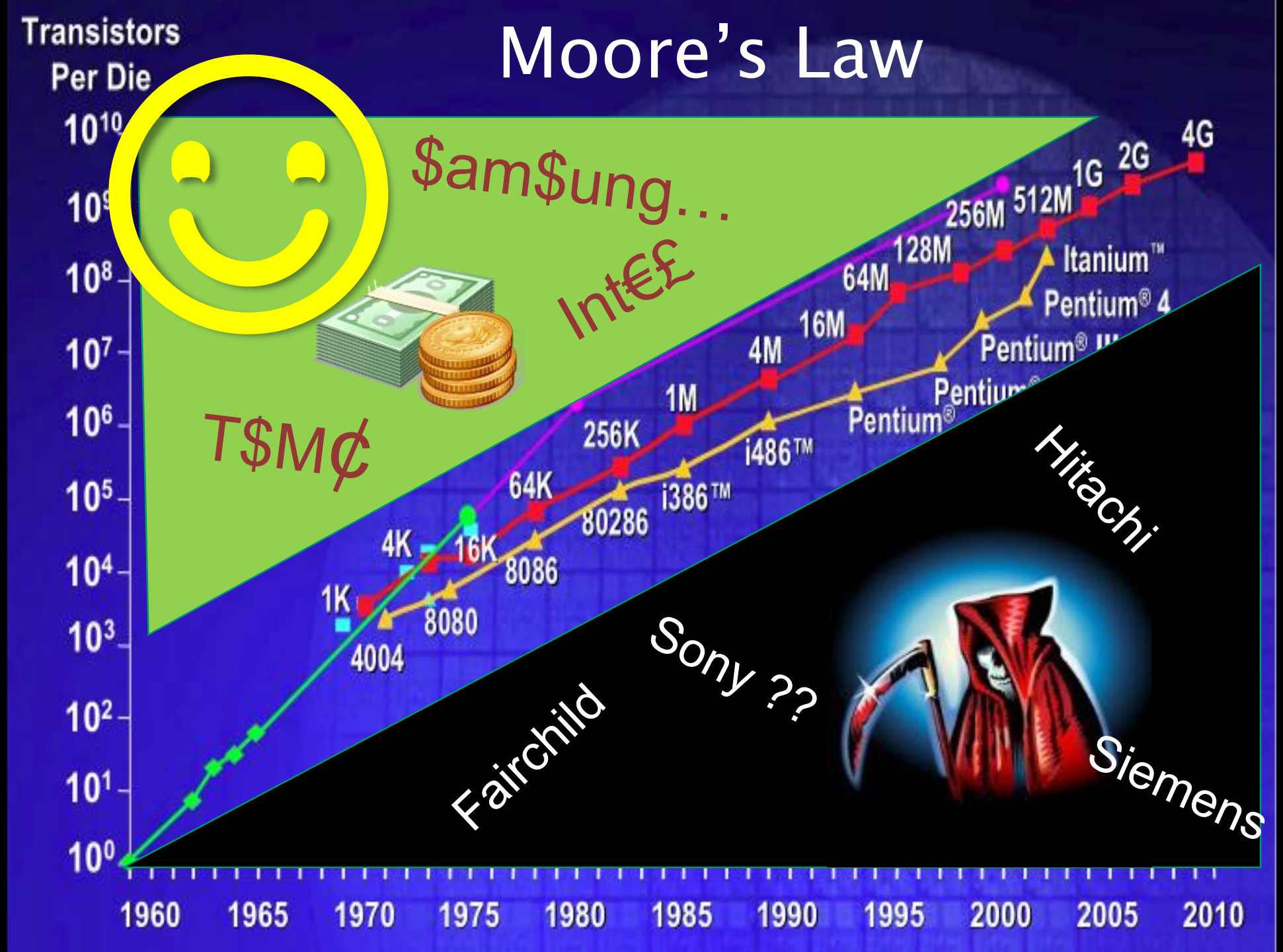
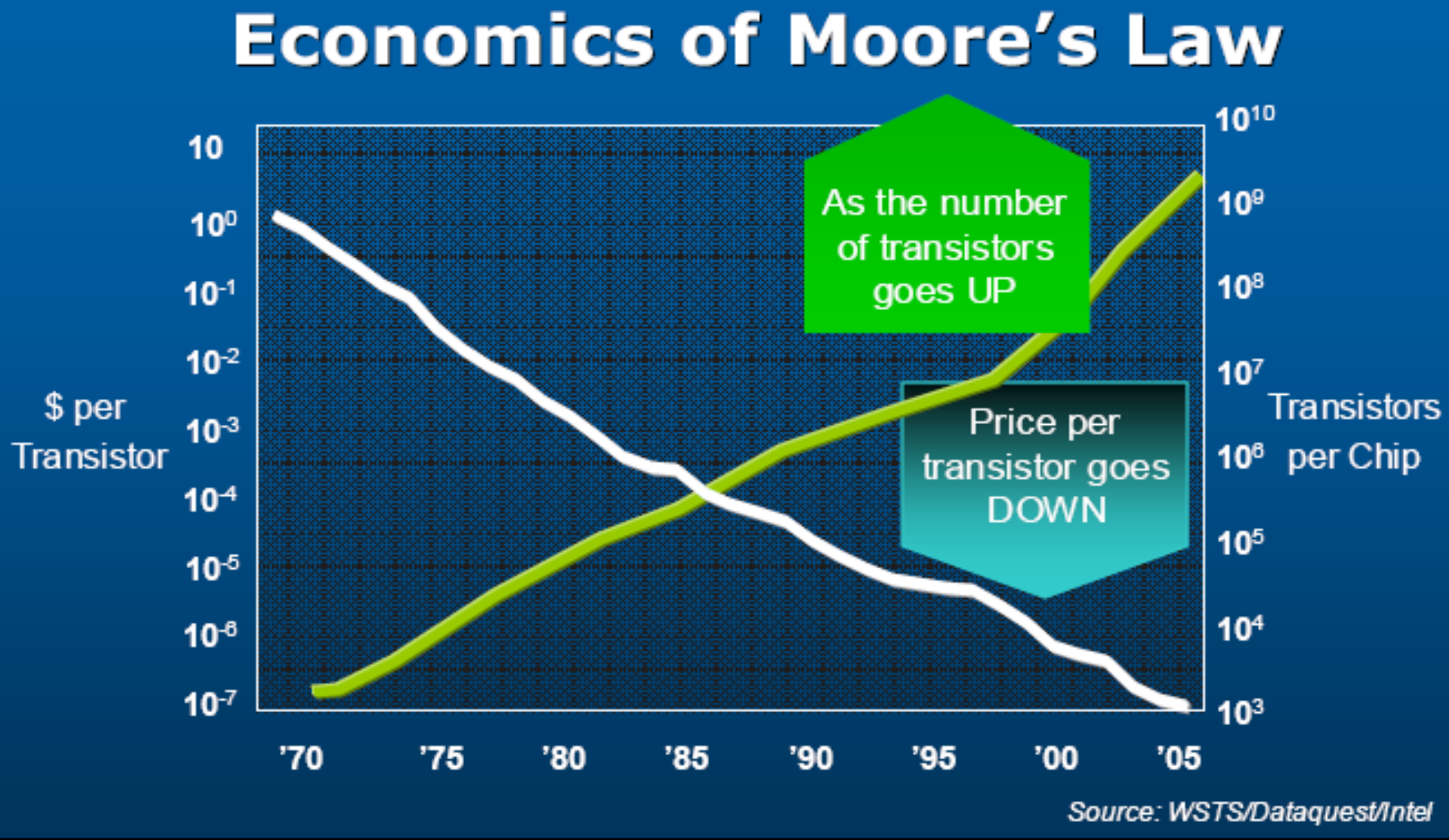
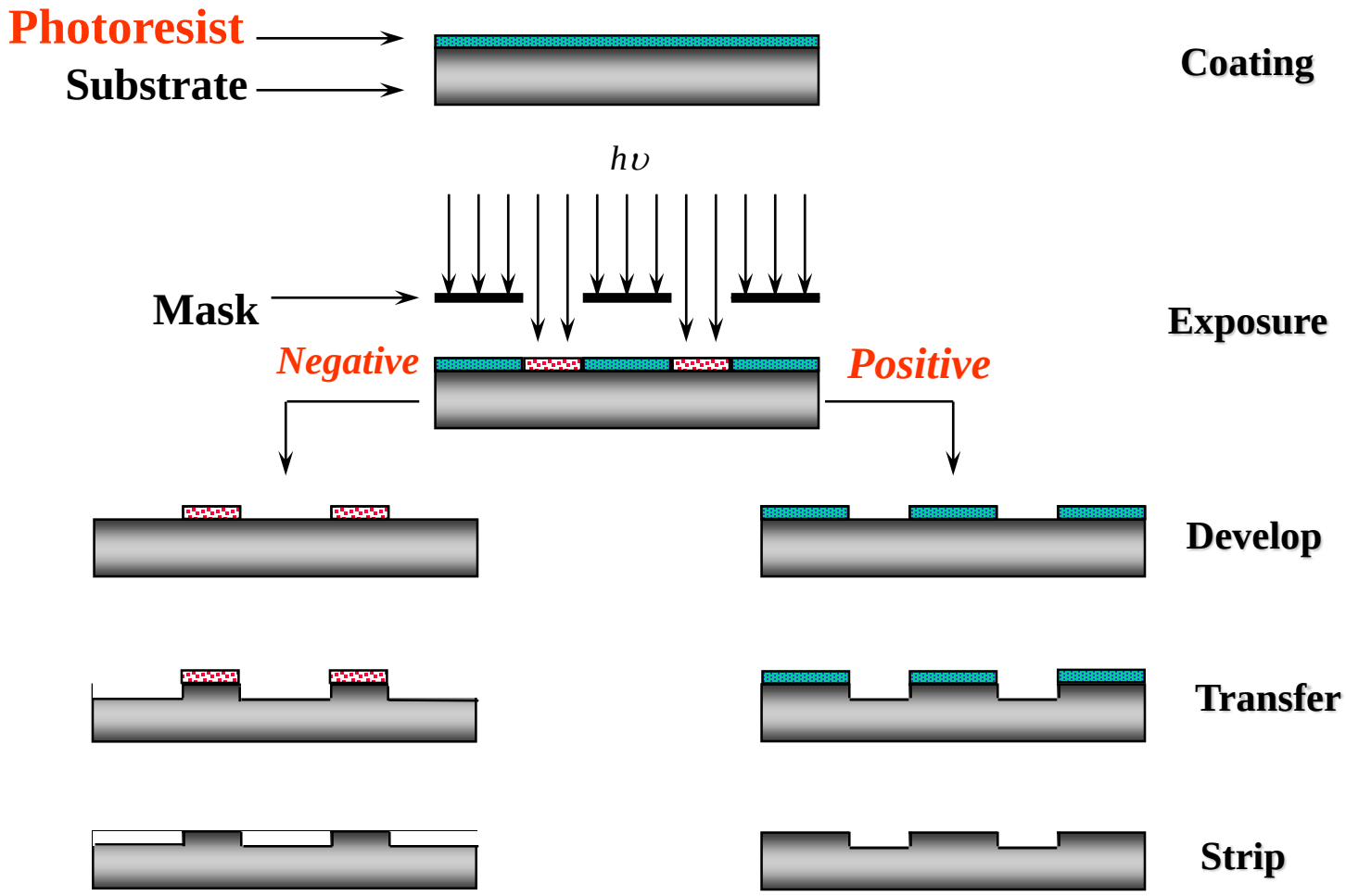

Transistors
Per Die
10^{10}
10^{9}
10^{8}
10^{7}
10^{6}
10^{5}
10^{4}
10^{3}
10^{2}
10^{1}
10^{0}
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
amung...
Int€£
T$M¢
1K
4K
16K
64K
256K
1M
4M
16M
64M
128M
256M
512M
1G
2G
4G
4004
8080
8086
80286
i386™
i486™
Pentium®
Pentium® 4
Itanium™
Fairchild
Sony ??
Hitachi
Siemens

The Driving Force for Progress is $$$



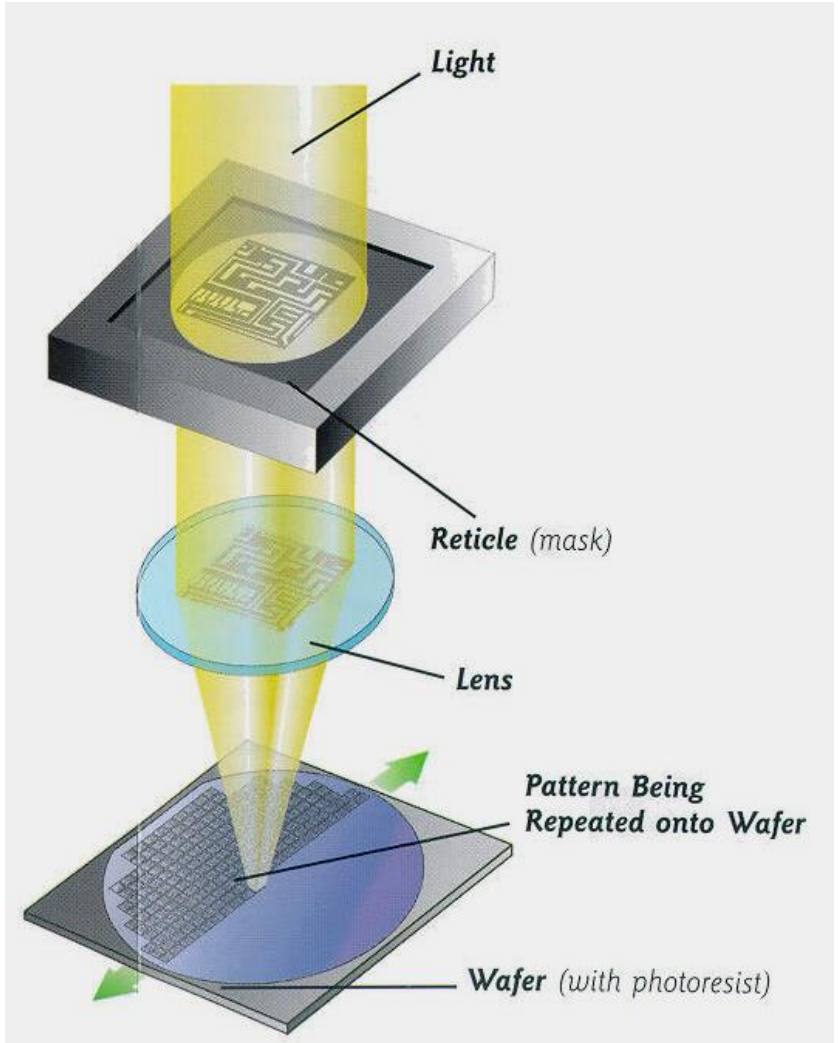
Photolithographic Process



Photoresist

Exposure Systems

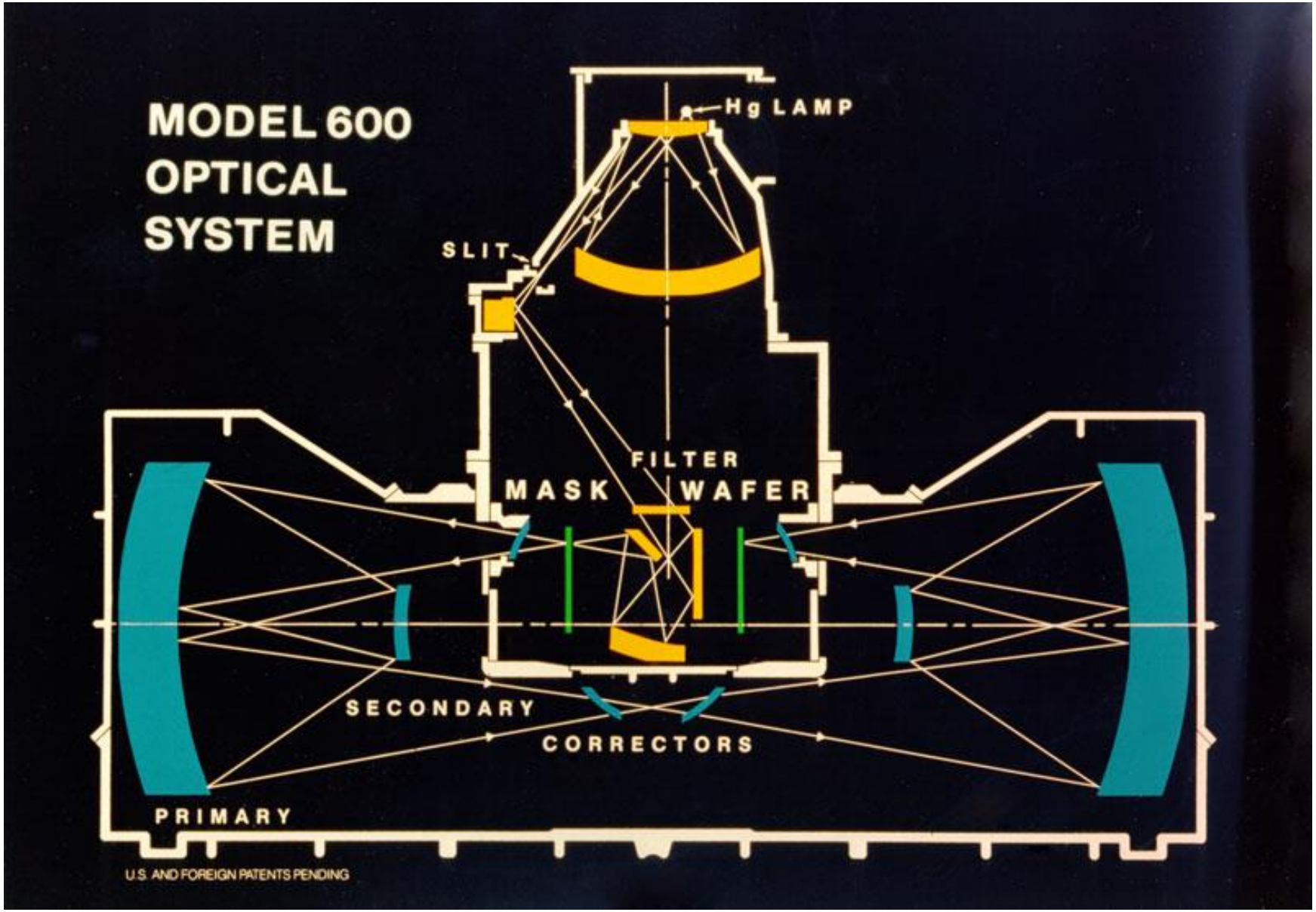
$$R = k\frac{\lambda}{NA}$$



Printing tools / Aligners

Contact Aligner

Pprojection Printer


MODEL 600
OPTICAL
SYSTEM
Hg LAMP
SLIT
FILTER
MASK
WAFER
SECONDARY
CORRECTORS
PRIMARY
U.S. AND FOREIGN PATENTS PENDING

State of the art, 193 nm immersion tool