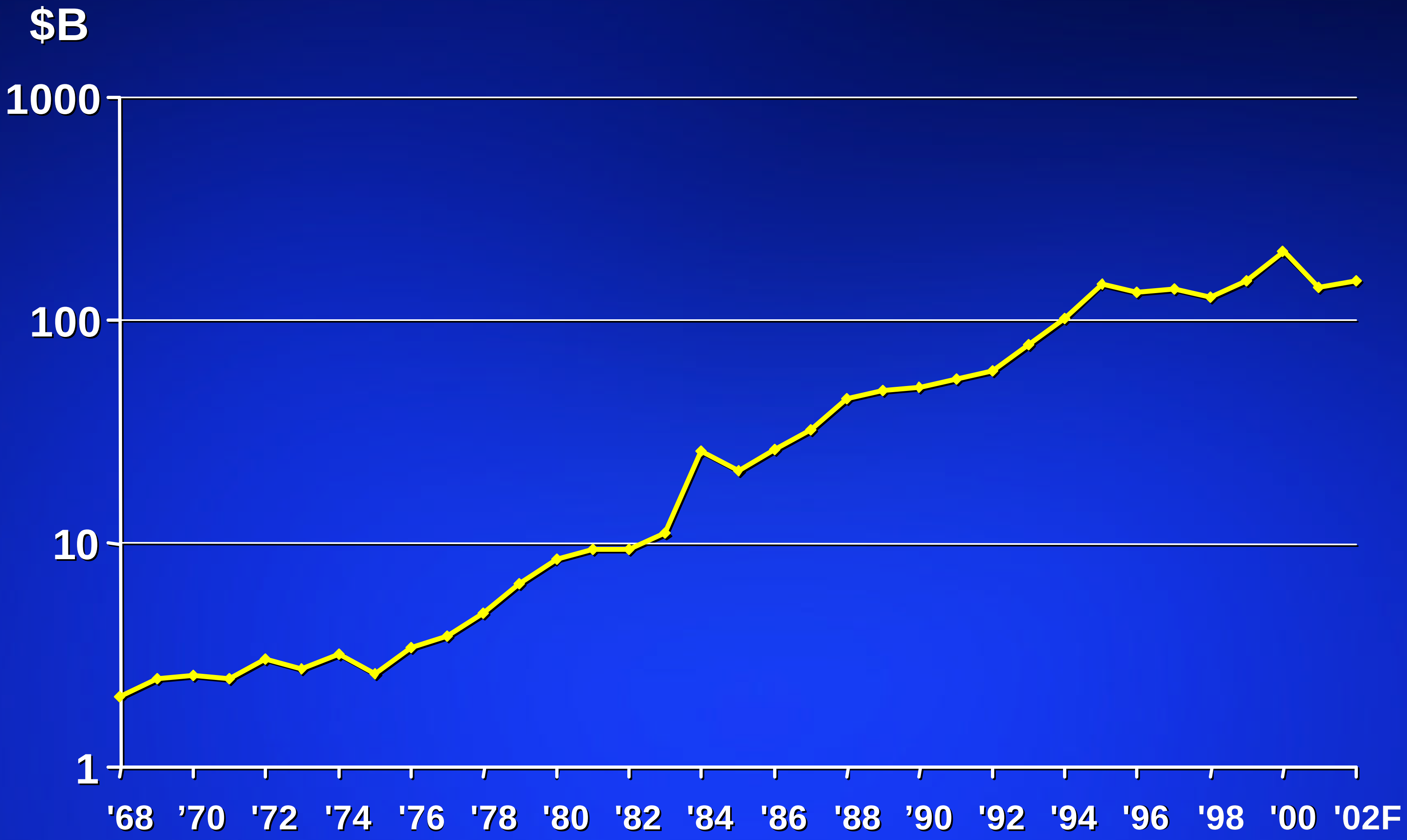
Our Revolution

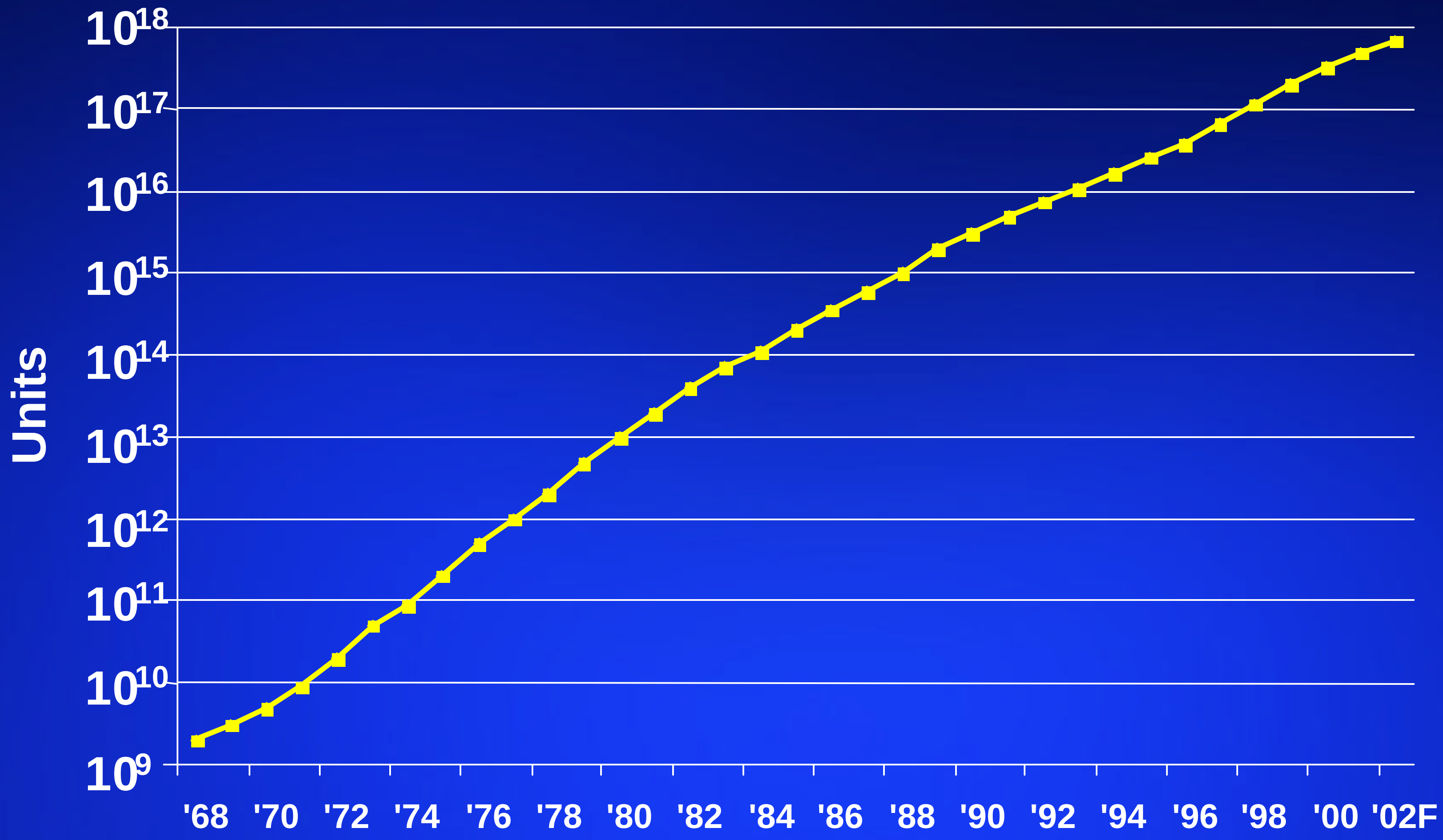
Gordon E. Moore

Worldwide Semiconductor Revenues



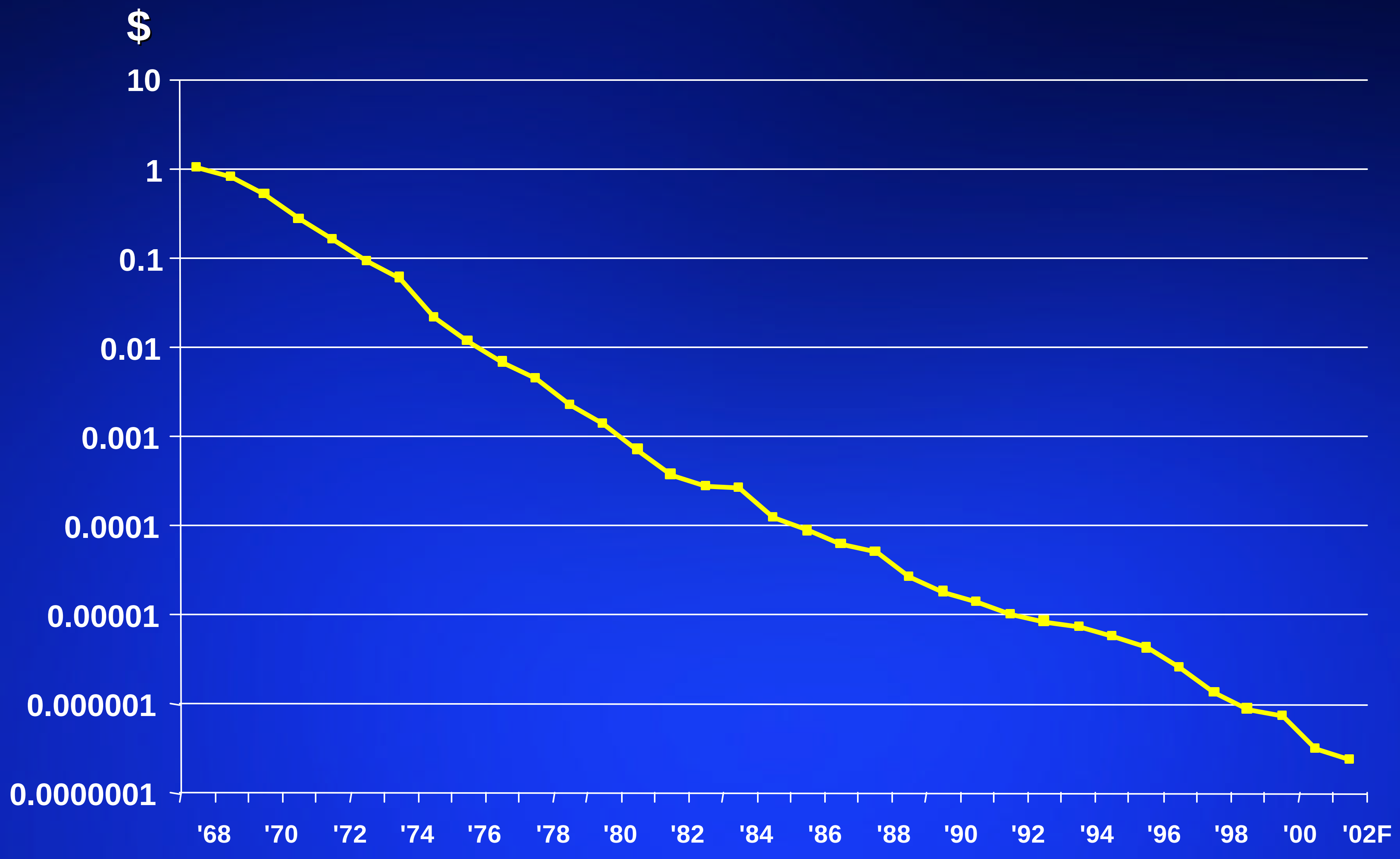
Source: Intel/WSTS, 8/02

Transistors Shipped Per Year



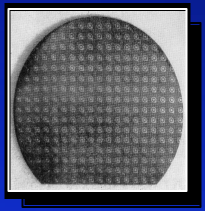
Source: Dataquest/Intel, 8/02

Average Transistor Price by Year

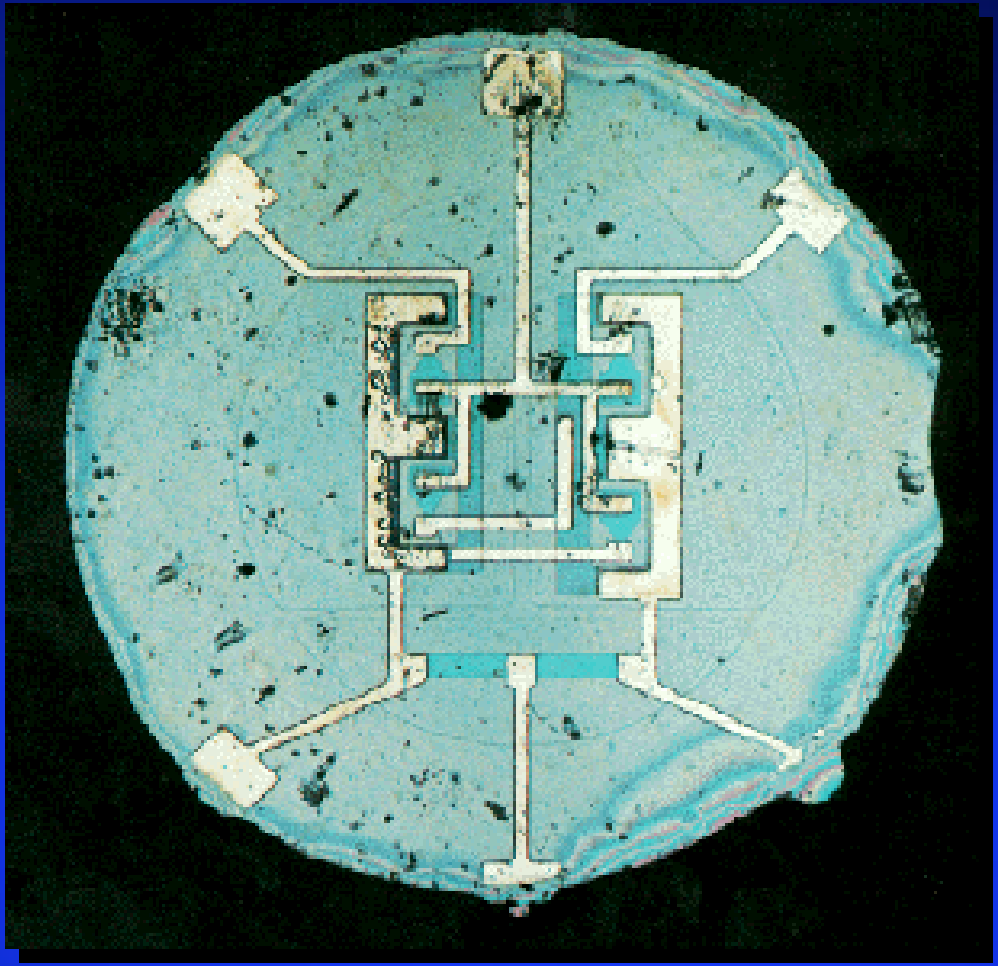


Source: Dataquest/Intel 8/02

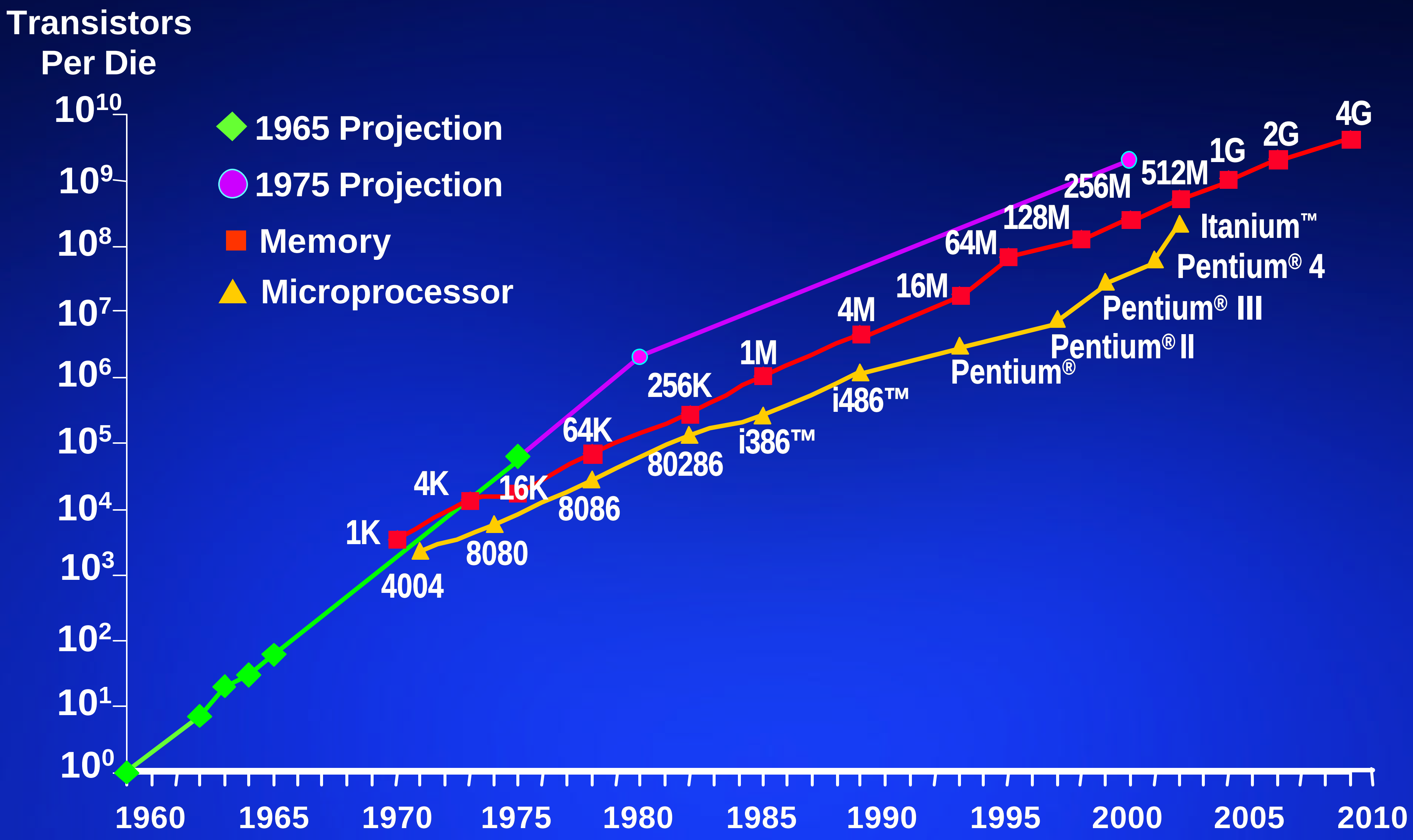
1” Wafer of Planar Transistors, ~1959



The First Planar Integrated Circuit, 1961

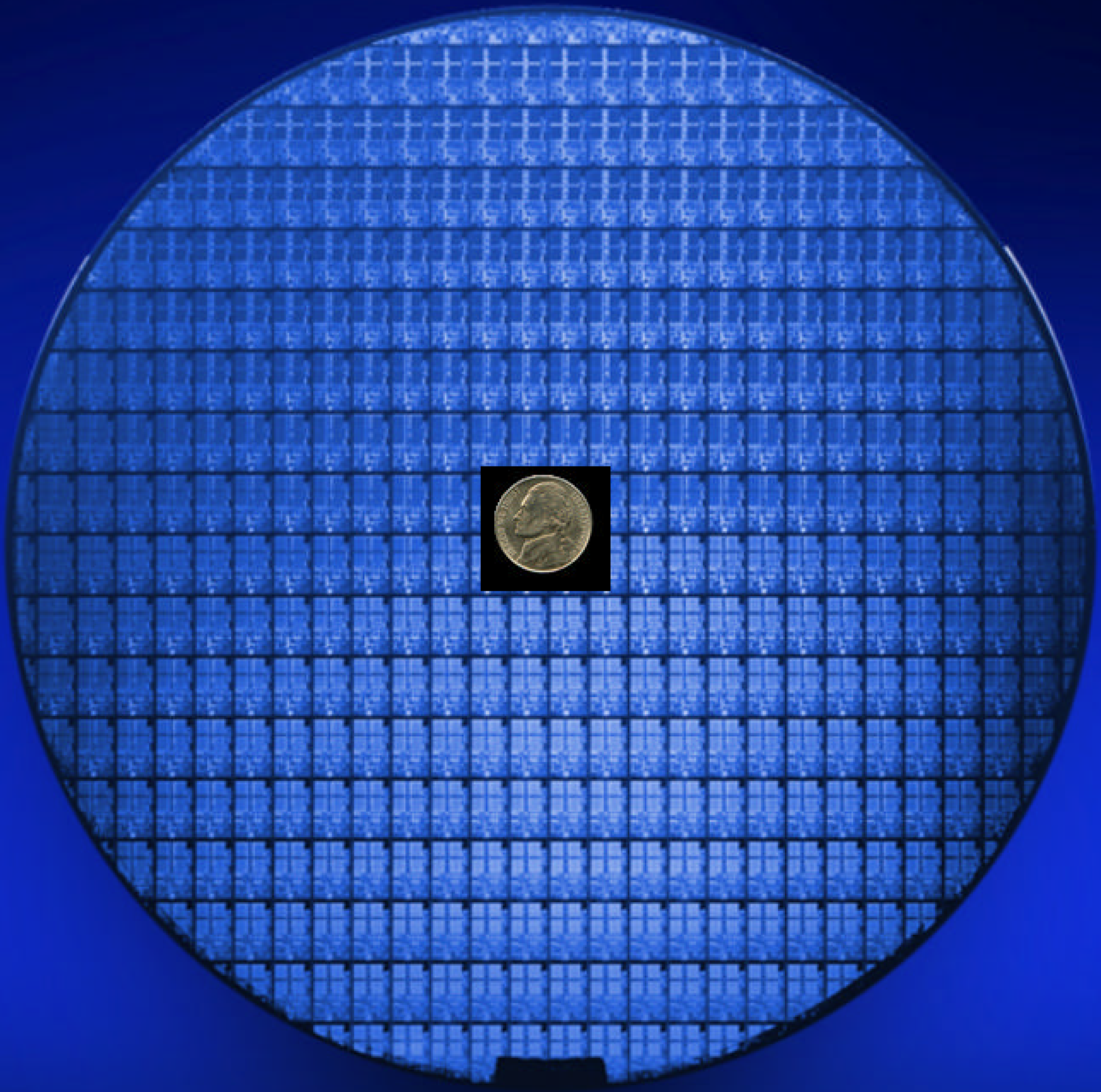


Integrated Circuit Complexity

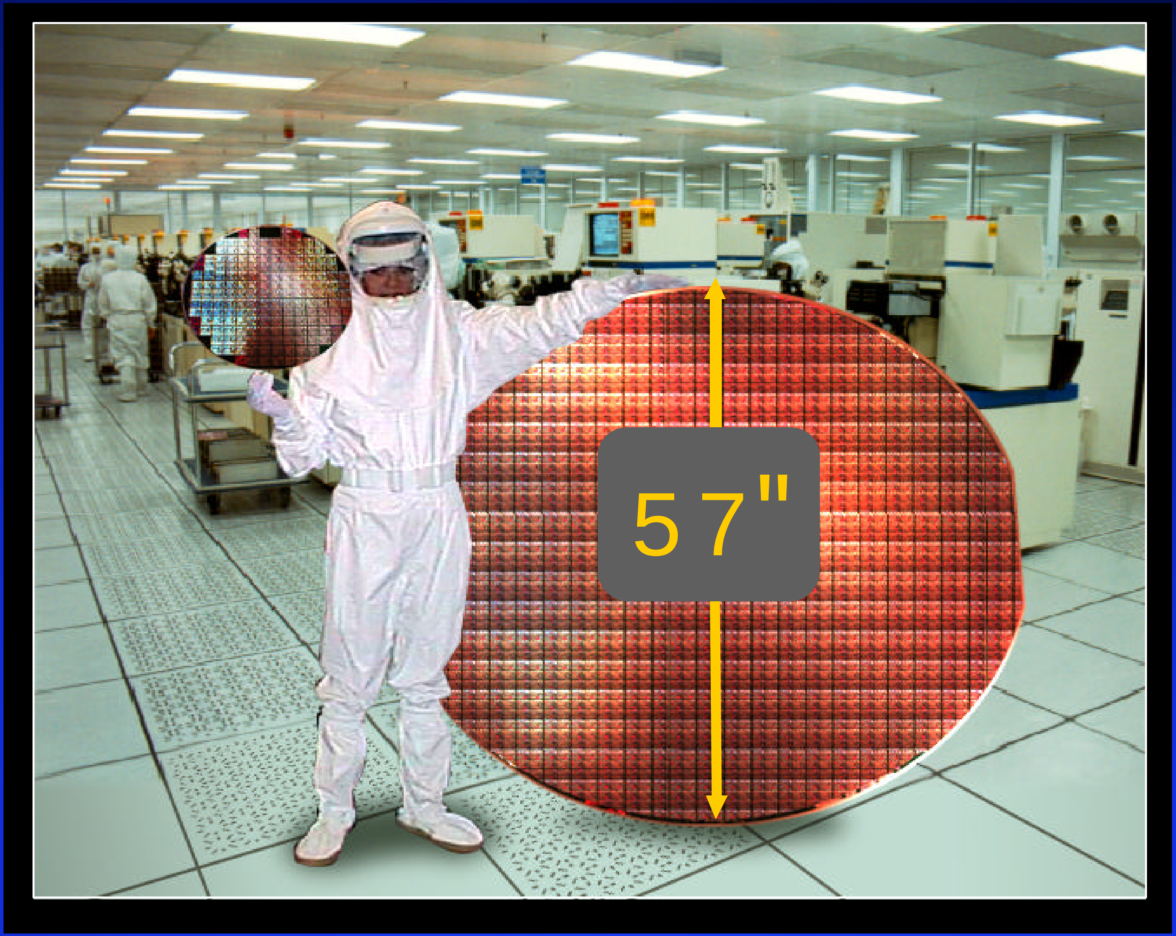


Source: Intel

300mm Wafer

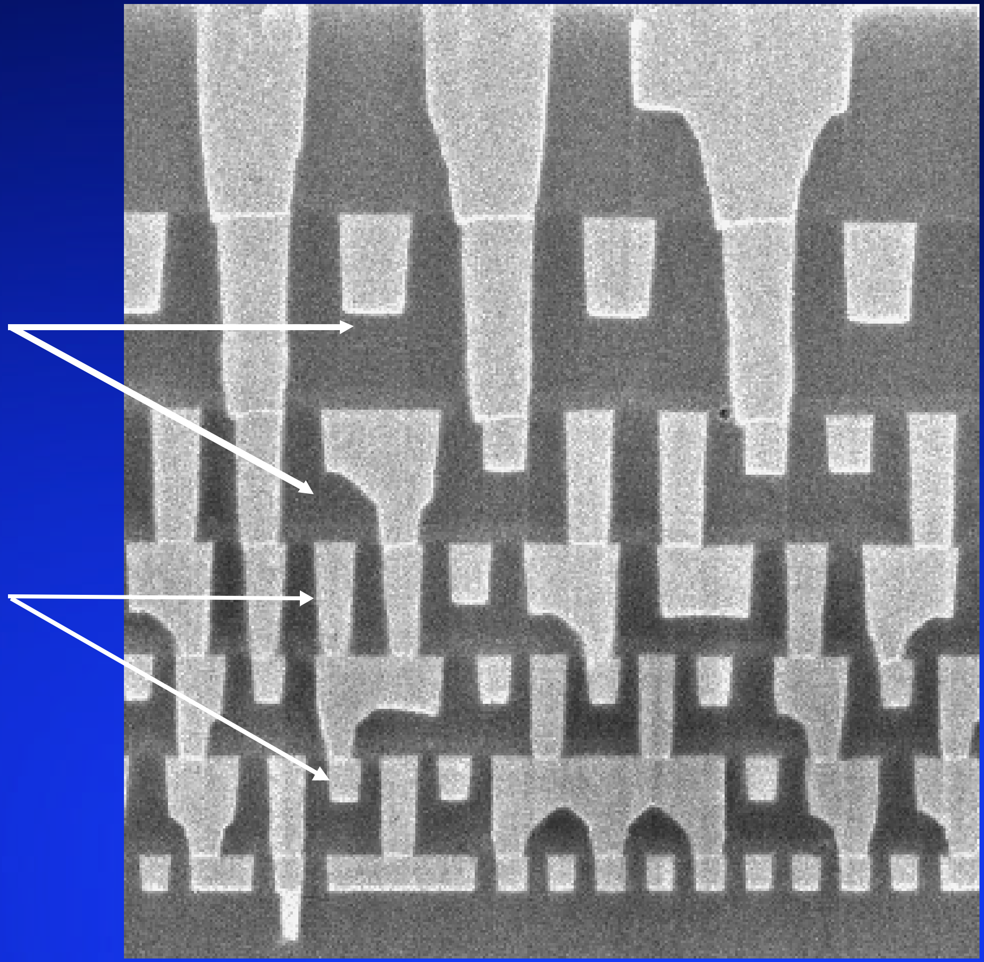


Gordon Moore Prediction Circa 1977



Moore was not always accurate

90 nm Generation Interconnects



Low-k CDO Dielectric

Copper Interconnects

M7

M6

M5

M4

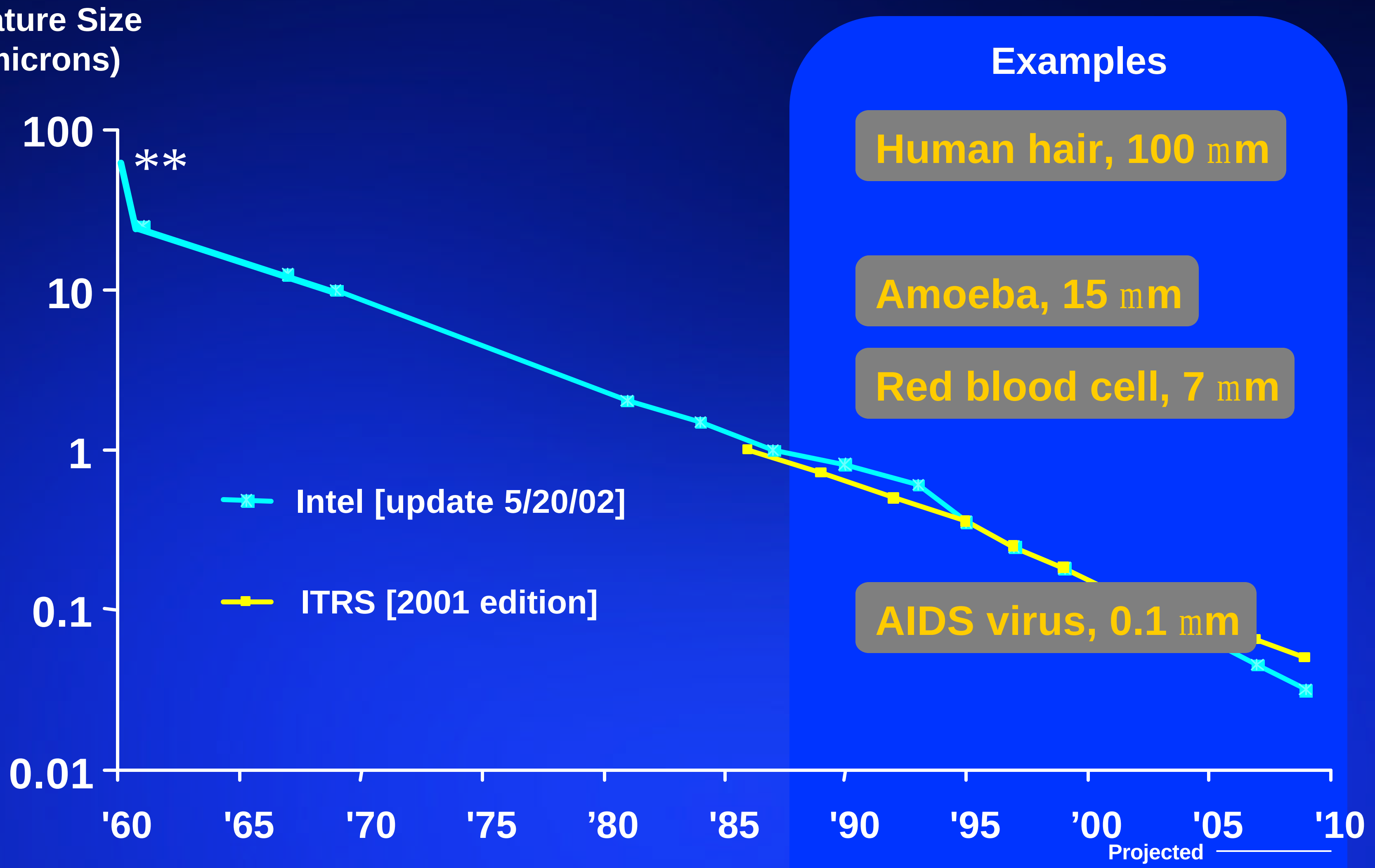
M3

M2

M1

Combination of copper + low-k dielectric now meeting performance and manufacturing goals

Minimum Feature Size



Examples

Human hair, 100 μm

Amoeba, 15 μm

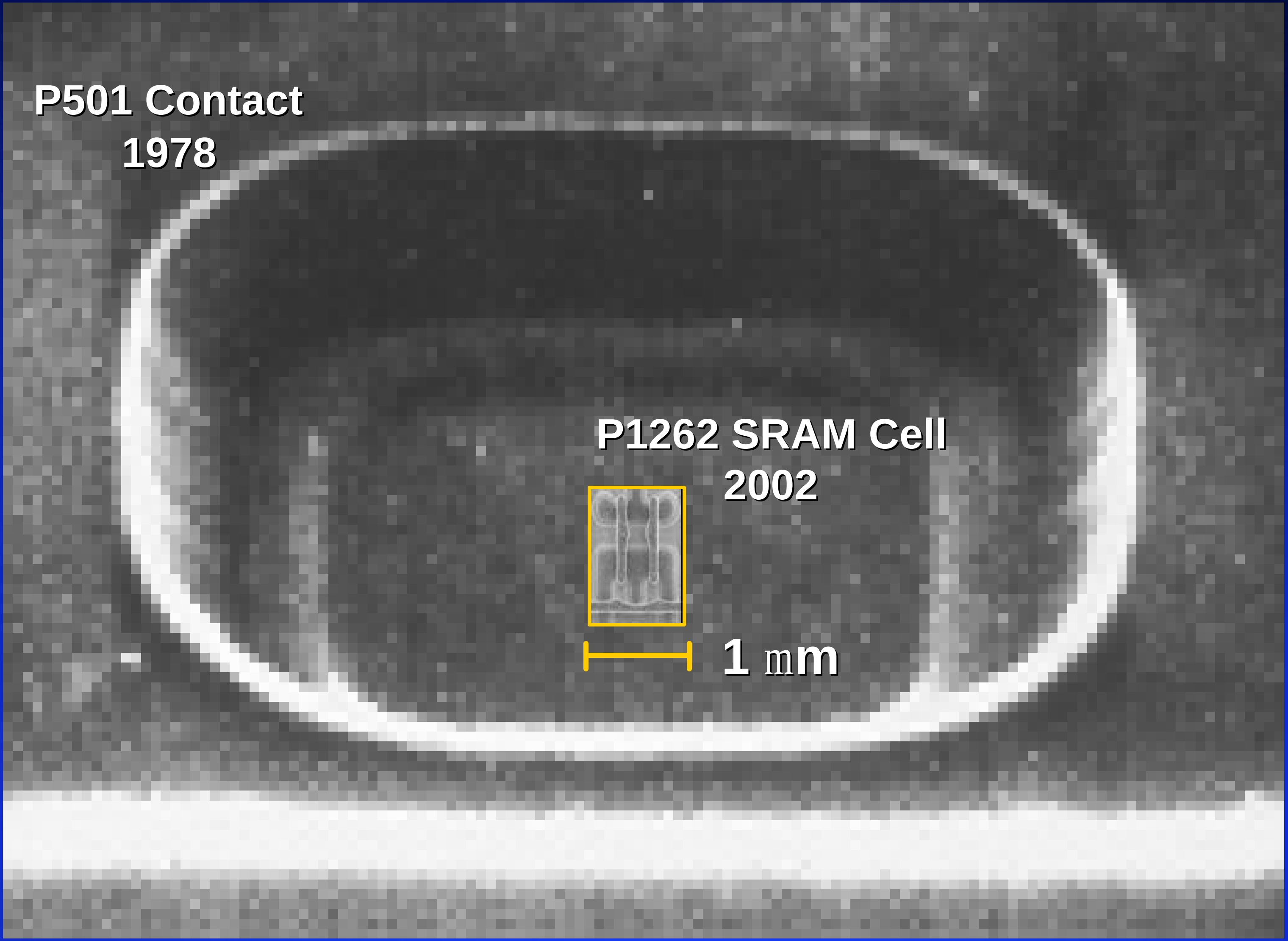
Red blood cell, 7 μm

AIDS virus, 0.1 μm

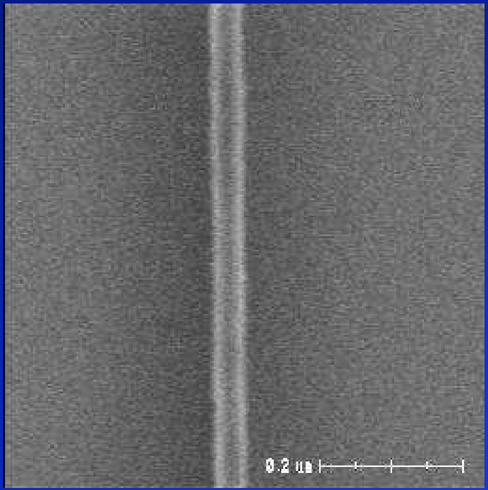
Buckyball, 0.001 μm

** Planar Transistor; remaining data points are ICs.
Source: Intel, post '96 trend data provided by SIA
International Technology Roadmap for Semiconductors (ITRS)
^ [ITRS DRAM Half-Pitch vs. Intel "Lithography"]

$1\ \mu m^2$ SRAM Cell

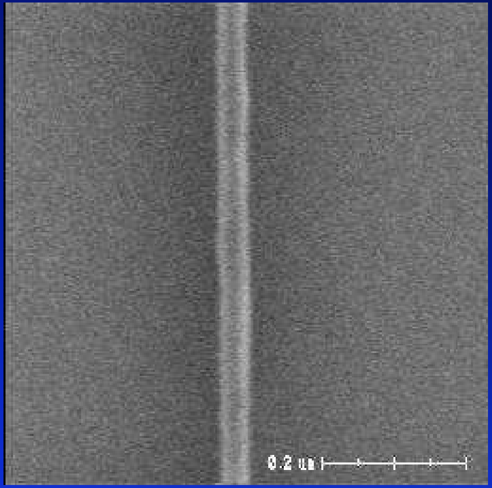


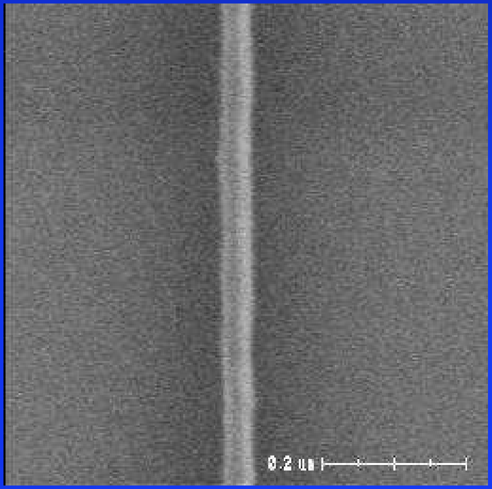
50nm Resist Lines With 193nm Light



“best focus”

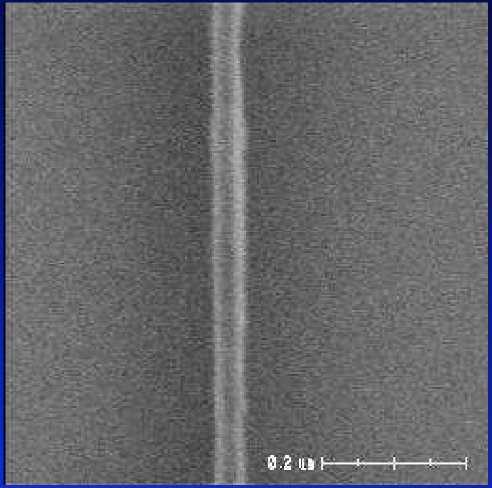
-0.2um focus

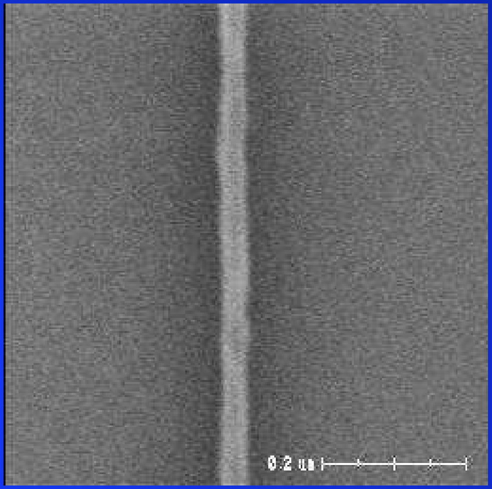




+0.2um focus

-0.3um focus

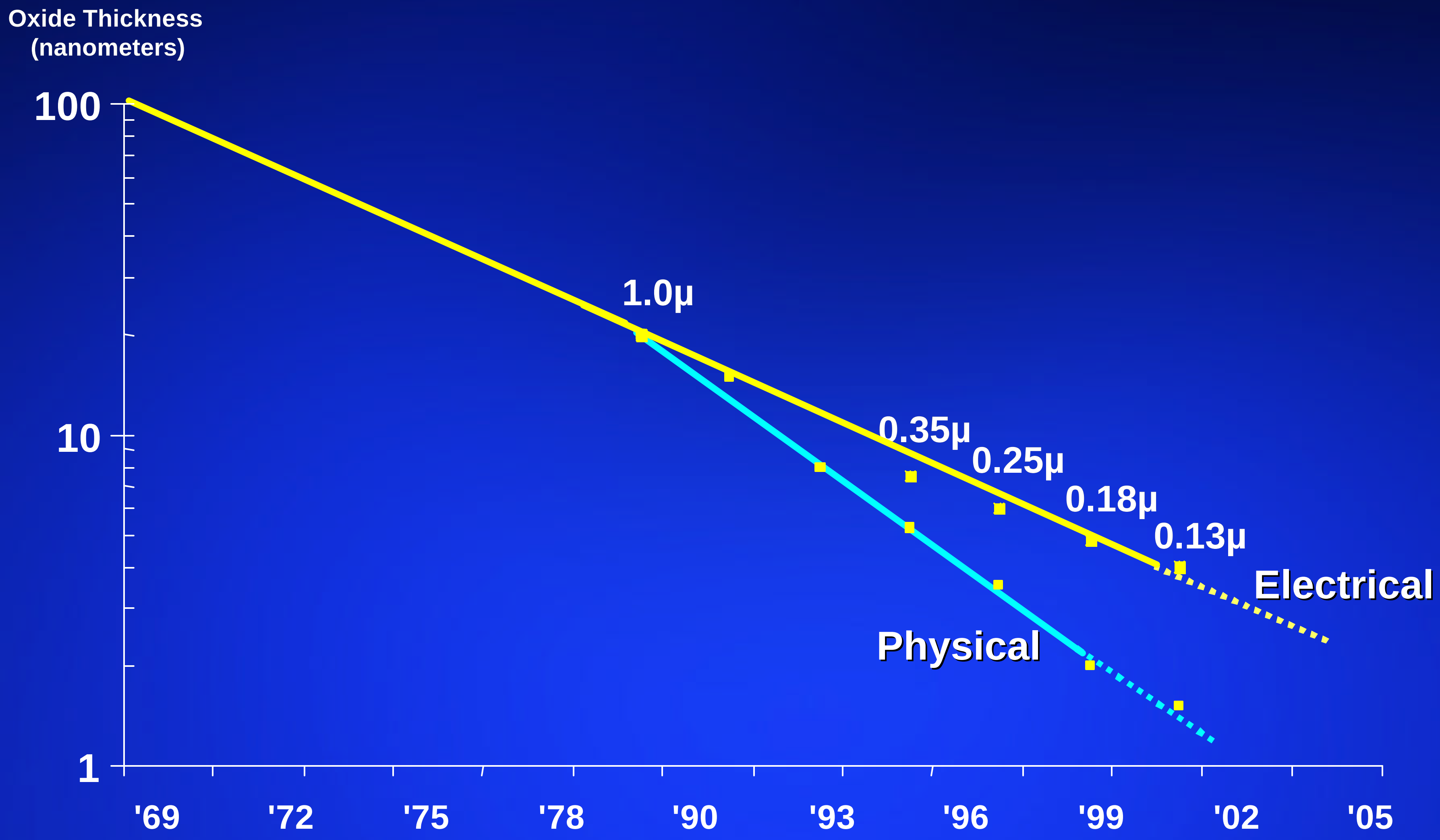




+0.3um focus

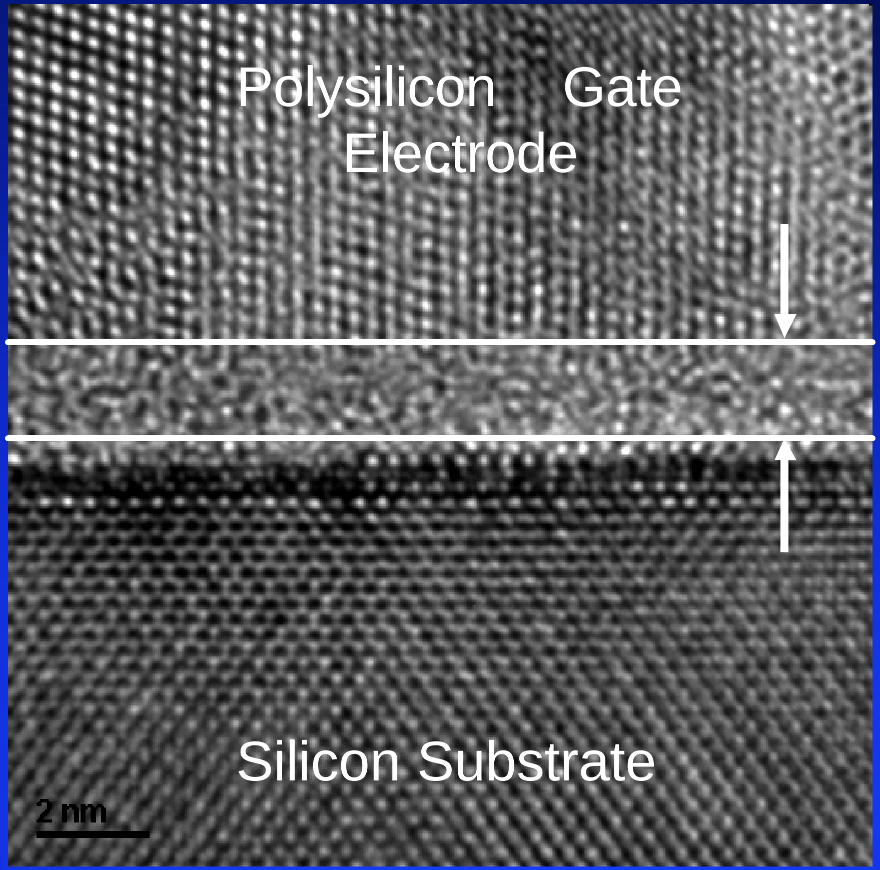
193nm Step and Scan Production Tool

Minimum Insulator Thickness vs Time



Source: Intel

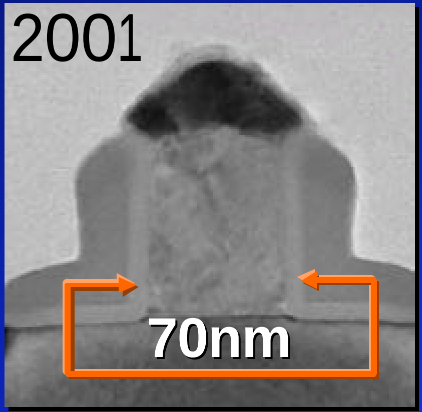
90 nm Generation Gate Oxide



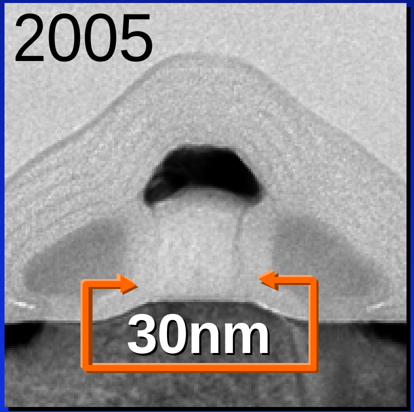
1.2 nm SiO_2

Gate oxide is less than 5 atomic layers thick

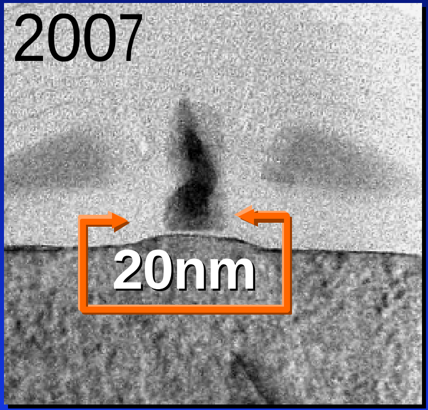
Future Transistors



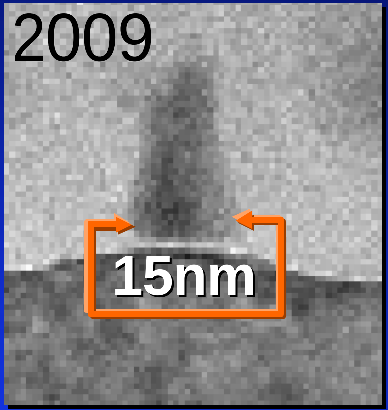
0.13µm process



65nm process

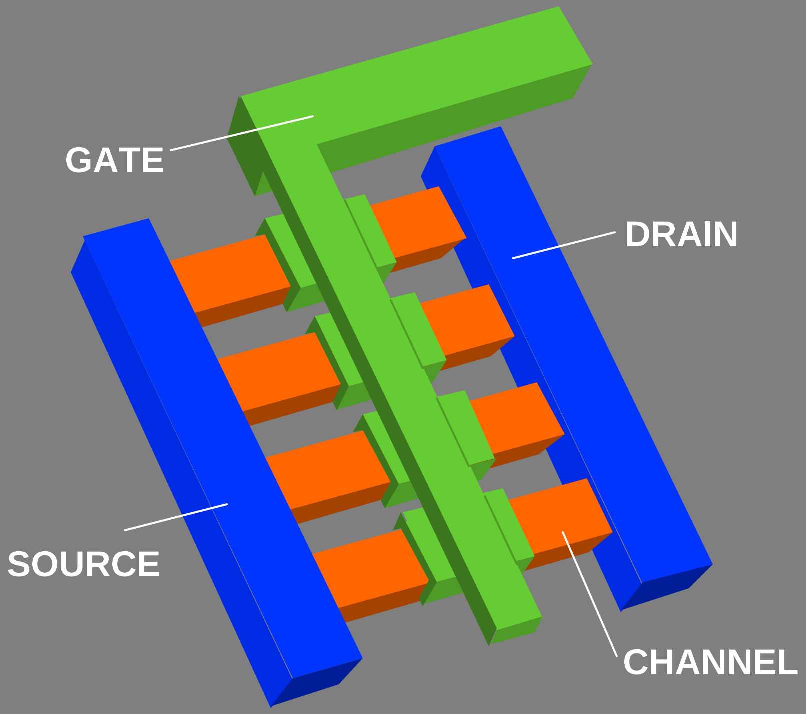


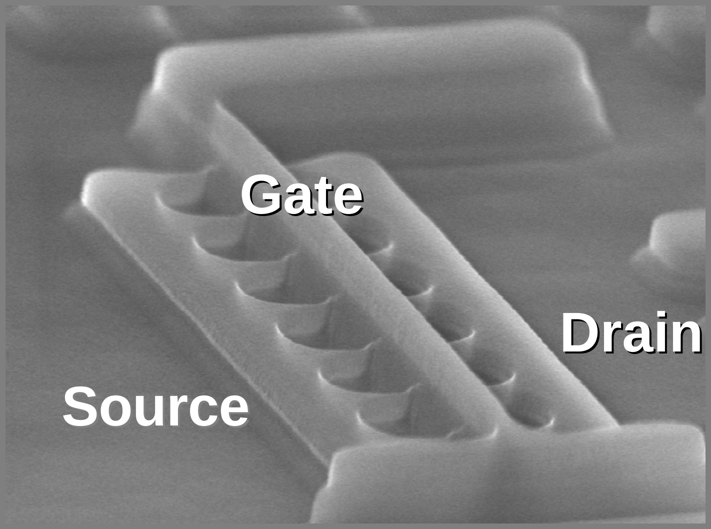
45nm process



32nm process

Experimental Tri-Gate Transistor





Source: Intel

Technology Generations to Come

Double the Density
Reduce Line Width by 0.7x

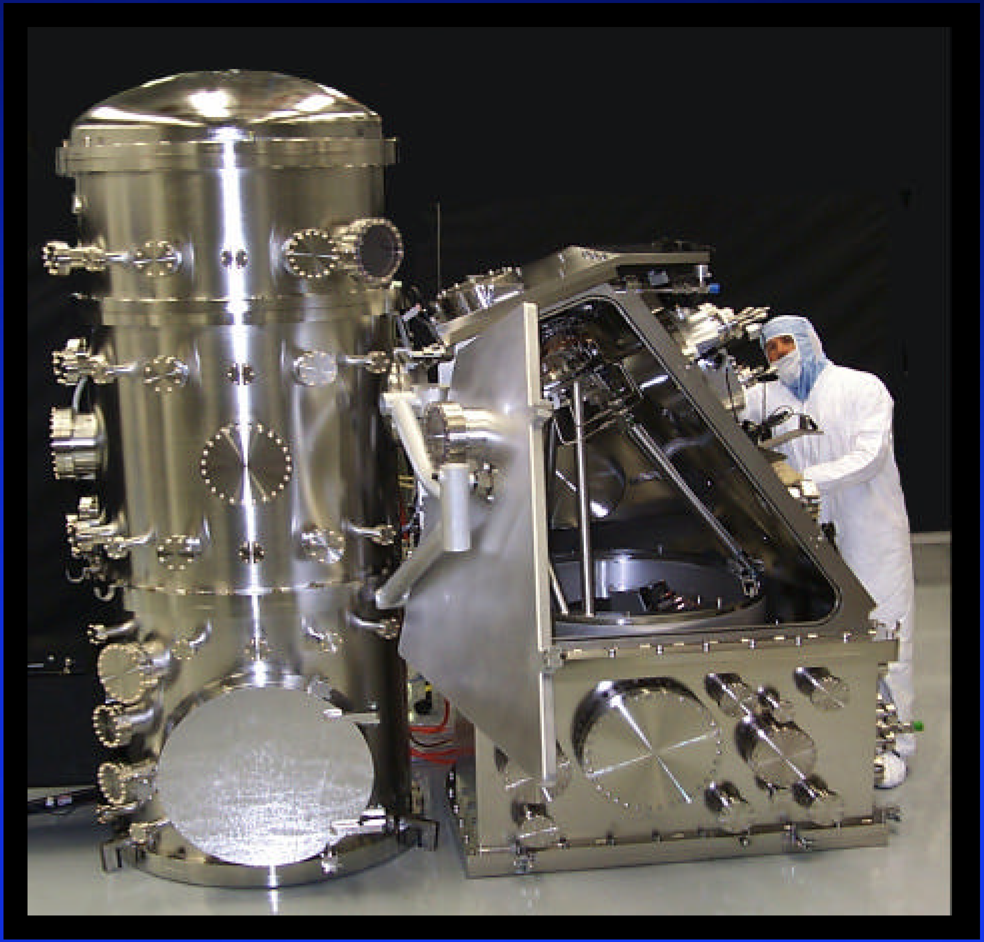
130nm→90nm→60nm→45nm→30nm

2 or 3 years between generations

∴

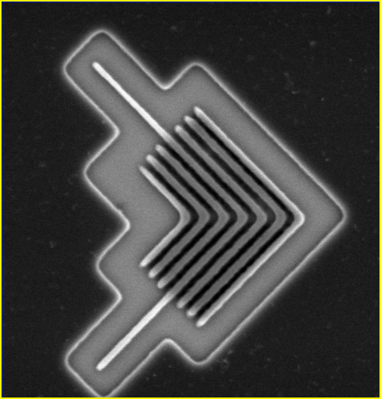
~10 ± 2 Years

Extreme Ultraviolet (EUV) Lithography

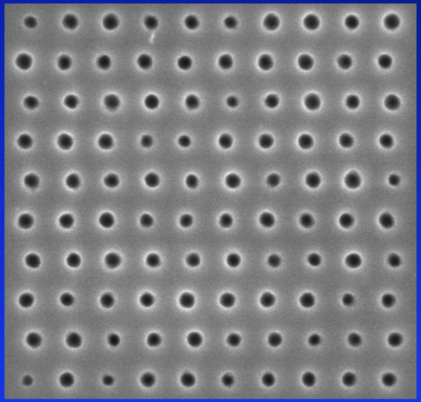


EUV Printed and Etched Lines

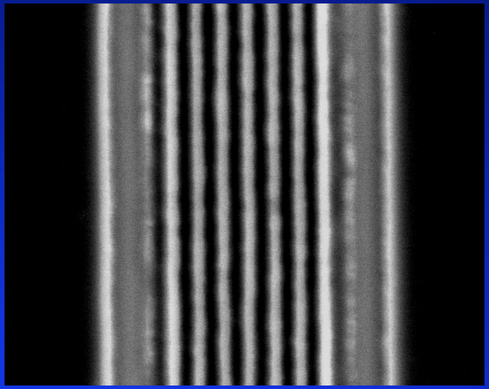
100 nm, k_1 = 0.75



80 nm, k_1 = 0.60



50 nm dense, k_1 = 0.37



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