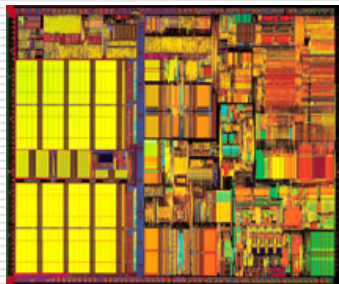
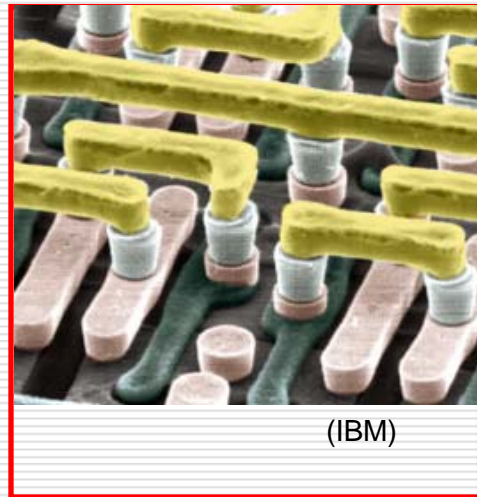


Transistors and Microelectronics

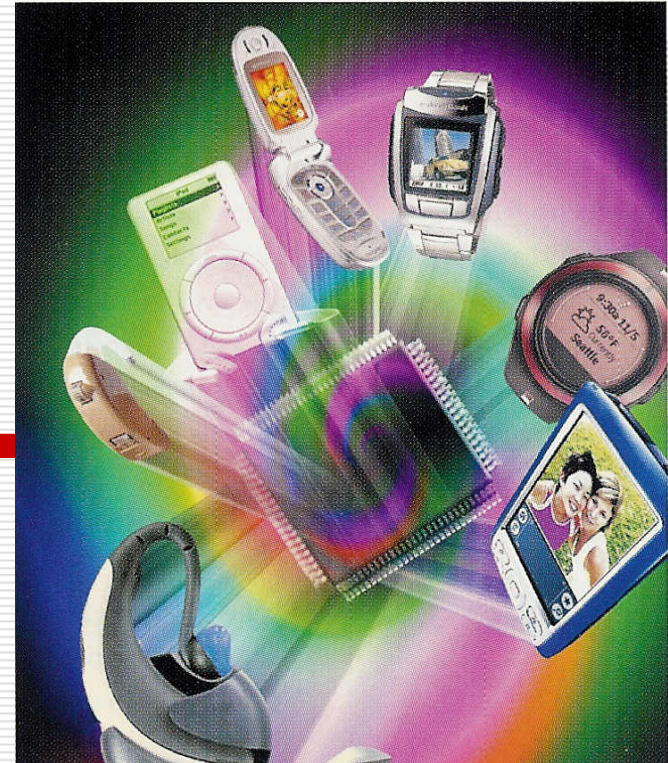
ESE216



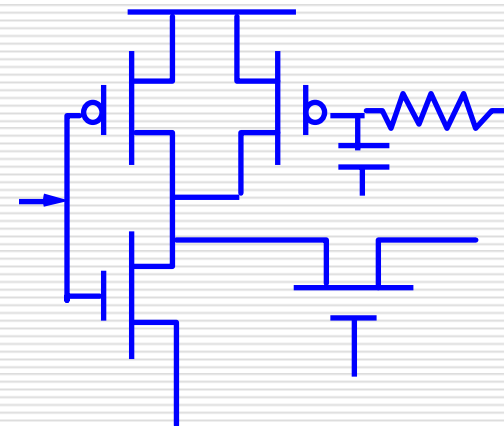
Pentium, Intel



(IBM)



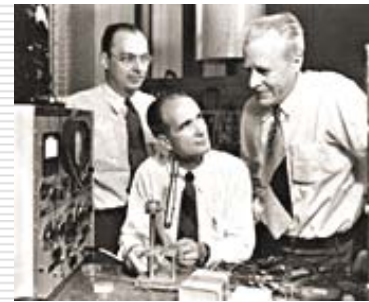
EE Times, Berkeley Design Tech.
(D. Rommel)



Electronics evolution: micro to nano



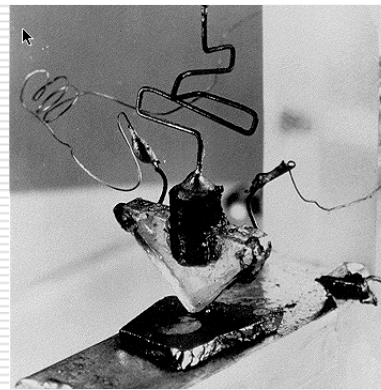
1946 - ENIAC



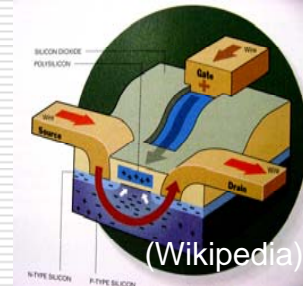
Bardeen, Brattain and Shockley



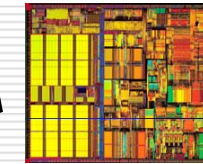
Mauchly and Eckert



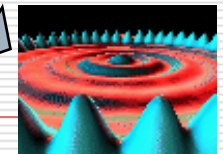
1947 - Transistor



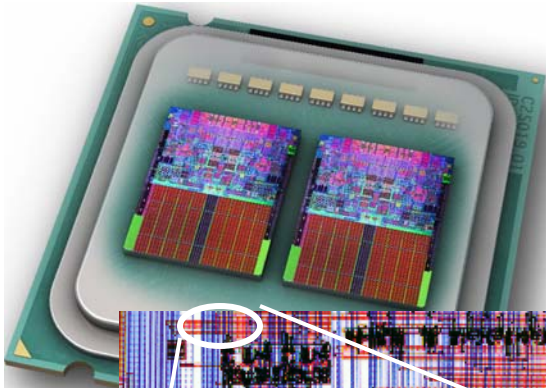
MOSFET



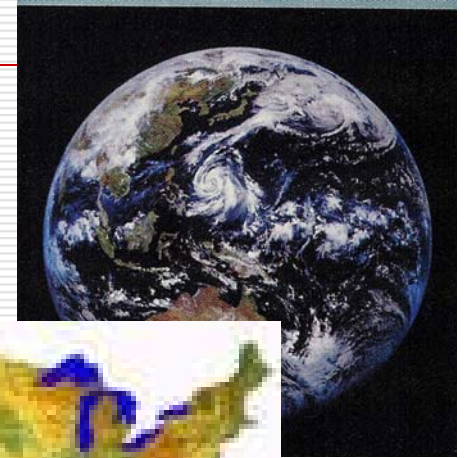
2000 - IC



Chip complexity



(Intel Quad Core
291M transistors)

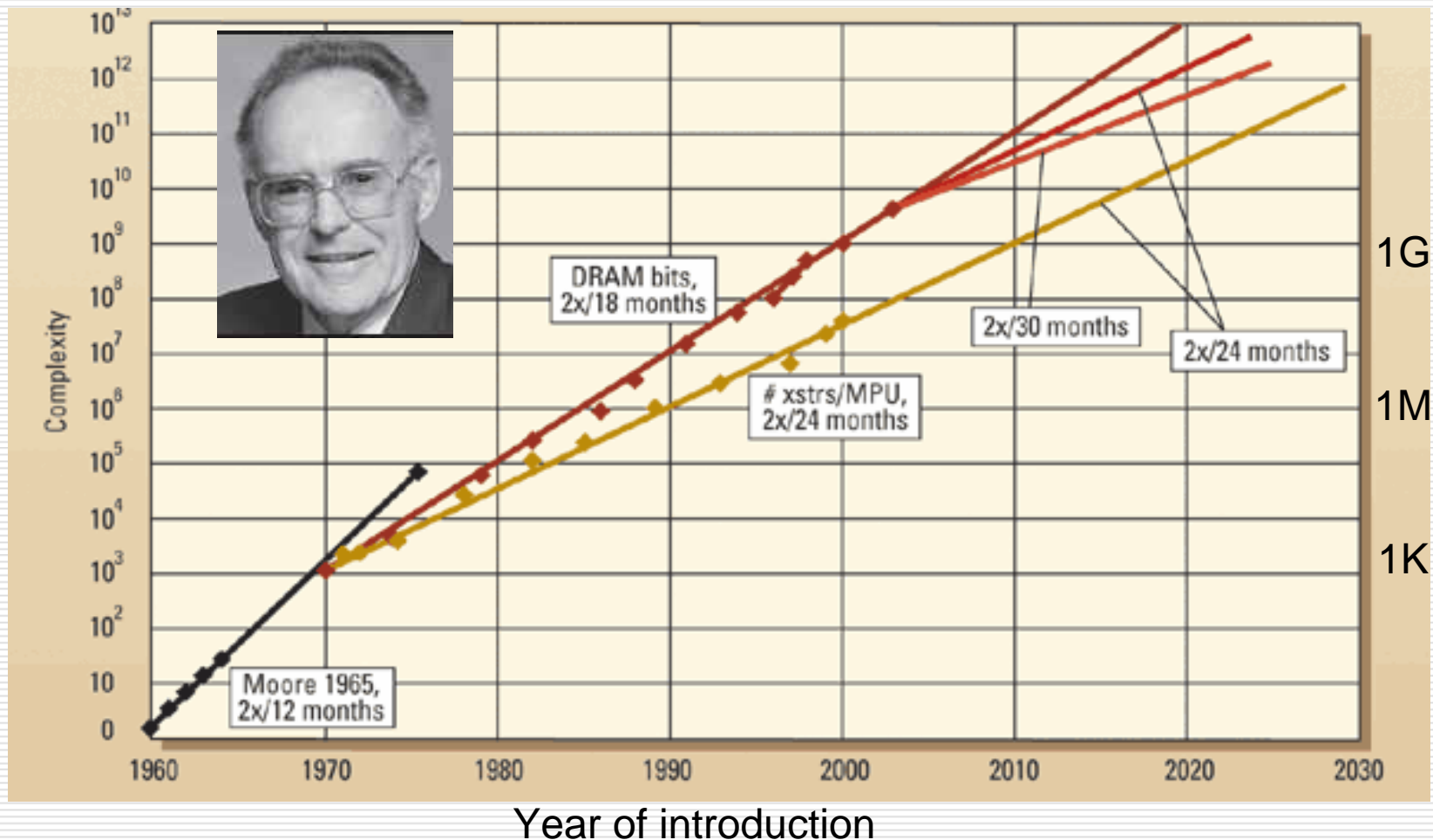


Complexity of the USA

Submicron and nanoscale dimensions

Compare to a street map
ESE216/JVdSpiegel

Moore's Law

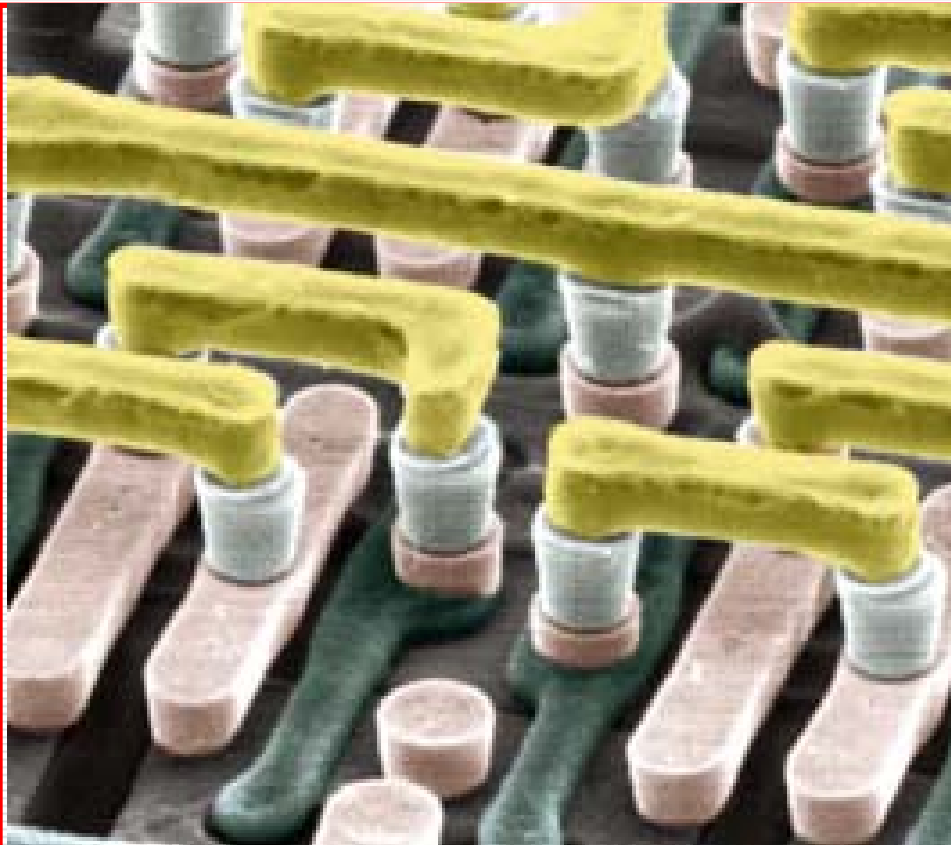


**Moore's Law: chip complexity doubles every two years
(expected to go on for another 20yrs)**

ESE216/JVdSpiegel

(Source: Semic. Int., April 2004)

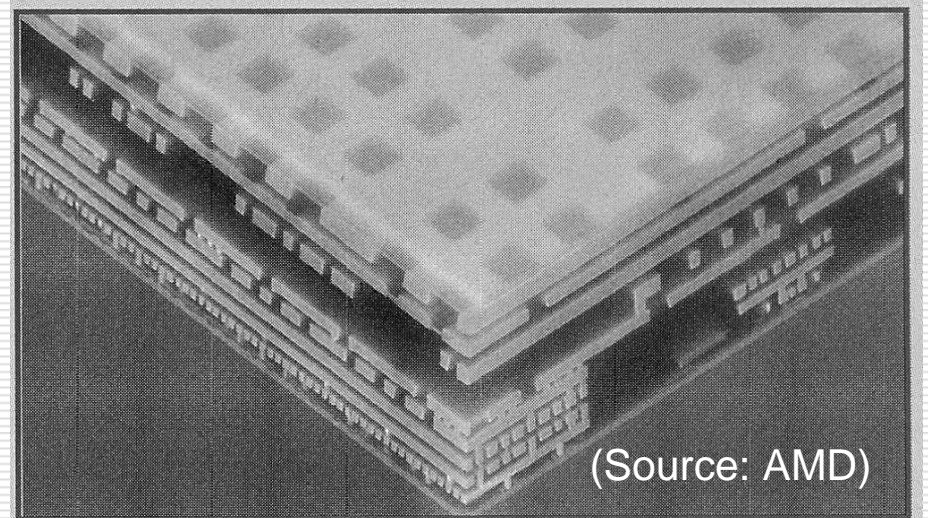
Nanometer feature sizes



(IBM)

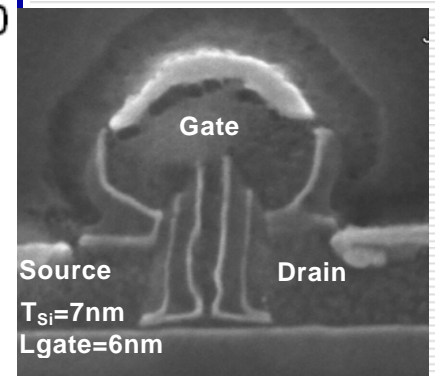
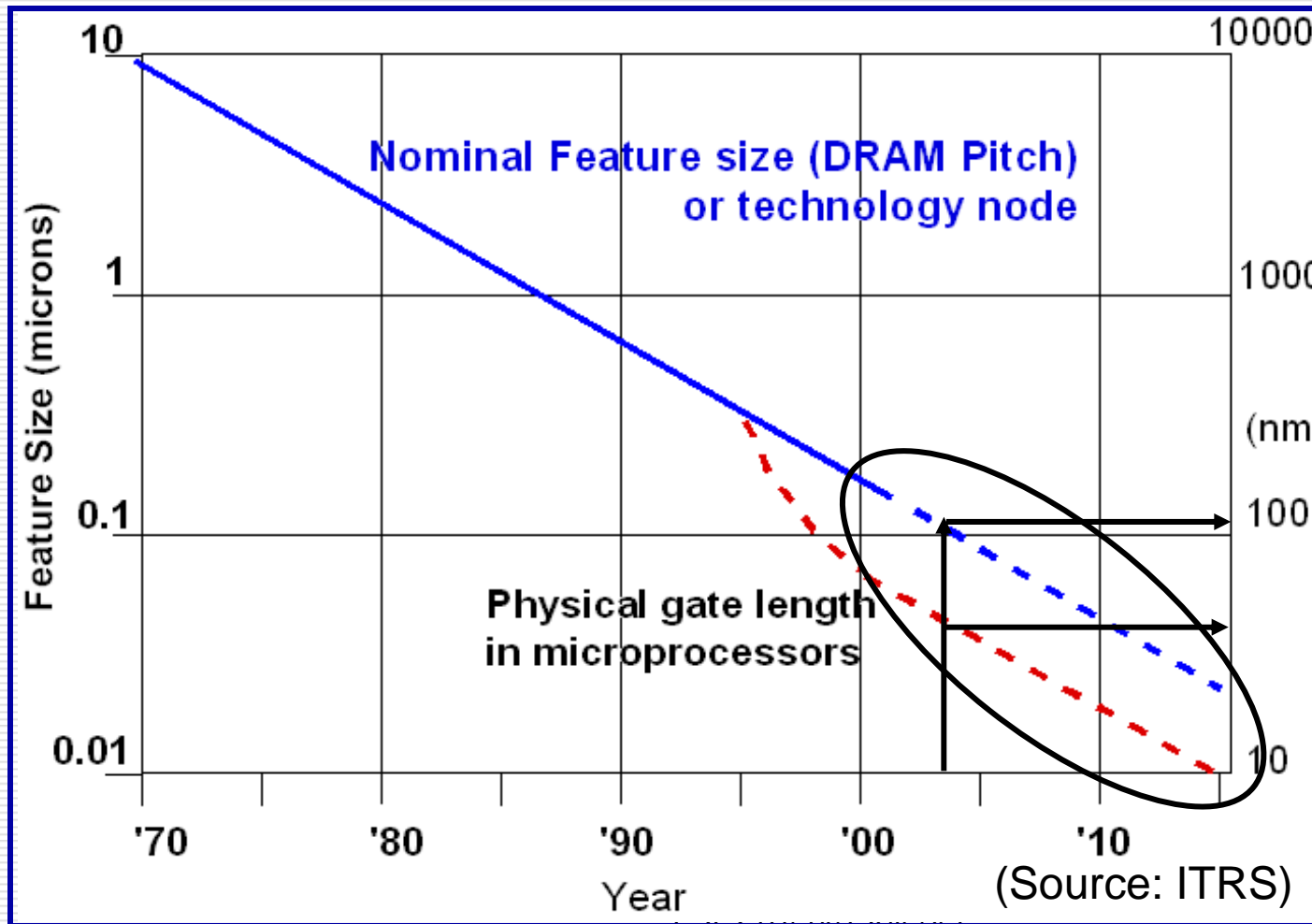
SEM picture metallization

Nine levels of metallization
(with low-k dielectric and SiC-based barriers)



(Source: AMD)

Evolution of Transistor's Feature Size



Two types of transistors

- Bipolar junction transistor (BJT): npn and pnp
- Metal Oxide Semiconductor Field Effect Transistor or MOSFET: nmos, pmos and cmos

- **Comparison**

- **BJT**

- Larger
 - Needs more power
 - Complex to fabricate

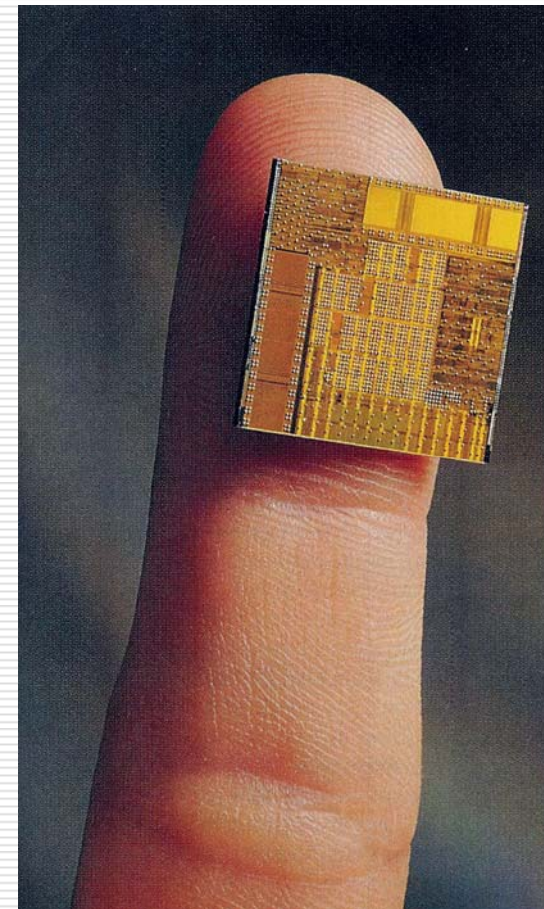
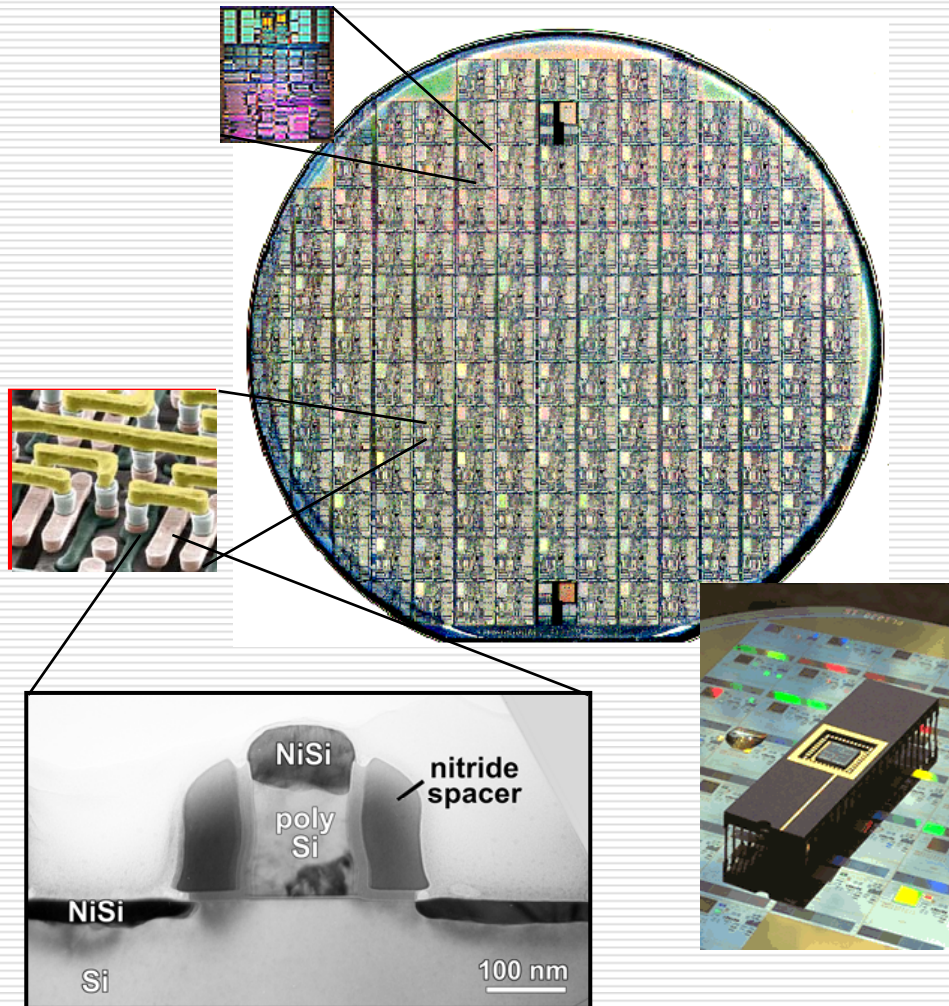
 - Faster
 - Lower noise

- **MOSFET**

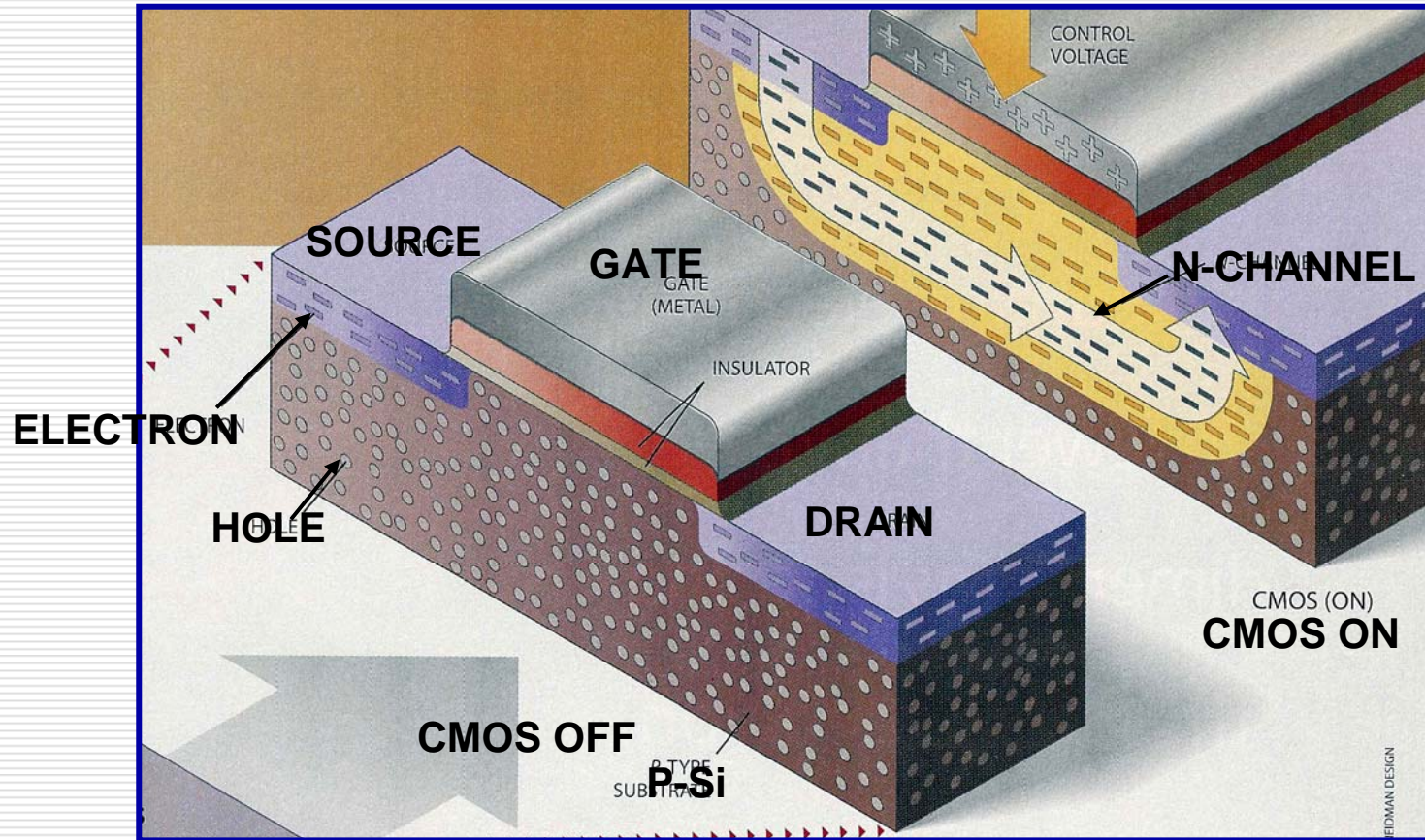
- Smaller
 - Low power consumption
 - Easier to fabricate (to a certain extent)

 - Slower
 - Higher noise

Wafer level fabrication: billions of transistors

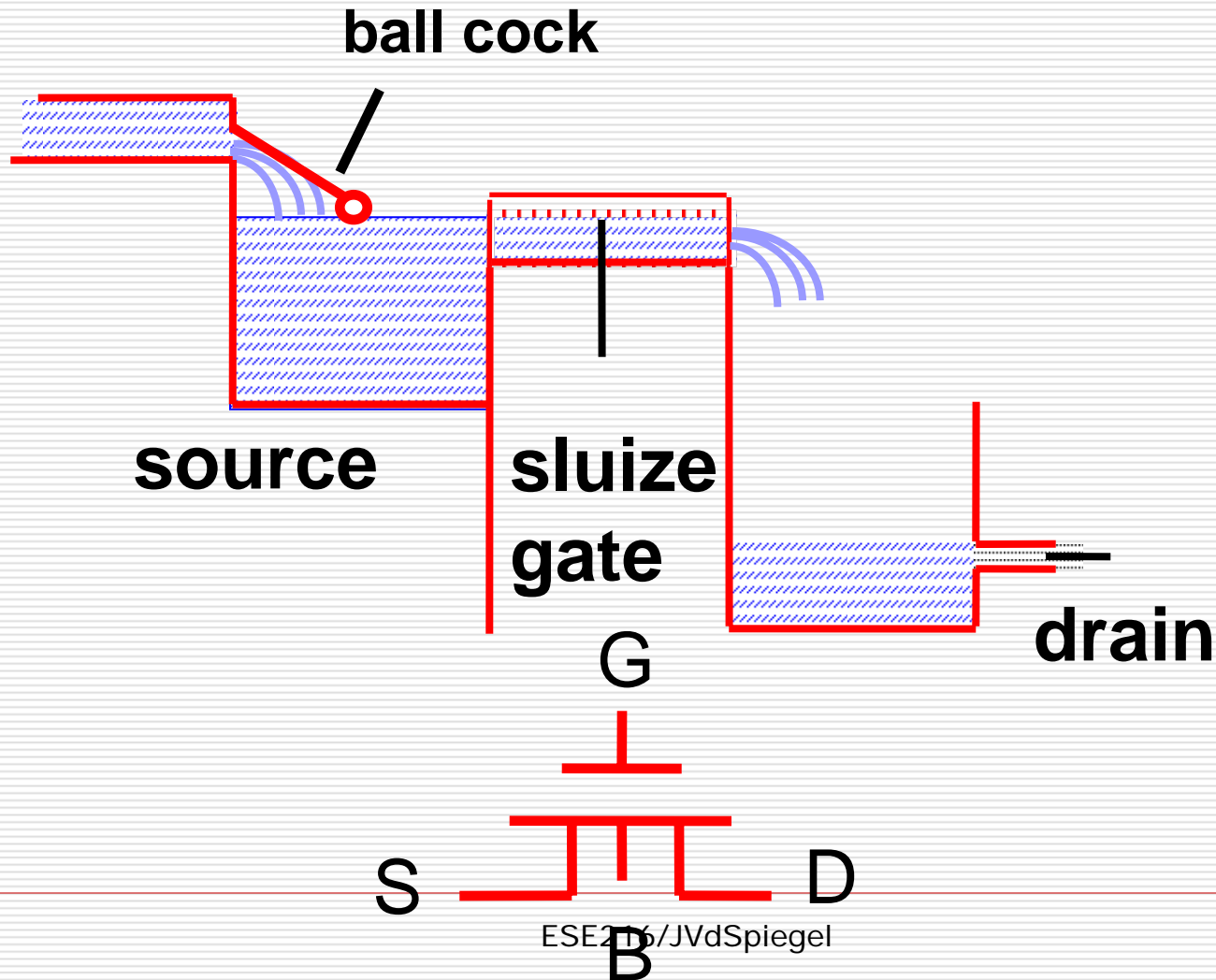


MOSFET: current flow



(Source: Scientific American, Solid-state Century, Jan. 98)

MOSFET: Hydraulic Equivalent



MOSFET as an Amplifier

