Introduction to Semiconductor Manufacturing Technology

Chapter 1, Introduction

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Objective

After taking this course, you will able to

- Use common semiconductor terminology
- Describe a basic IC fabrication sequence
- Briefly explain each process step
- Relate your job or products to semiconductor manufacturing process

Topics

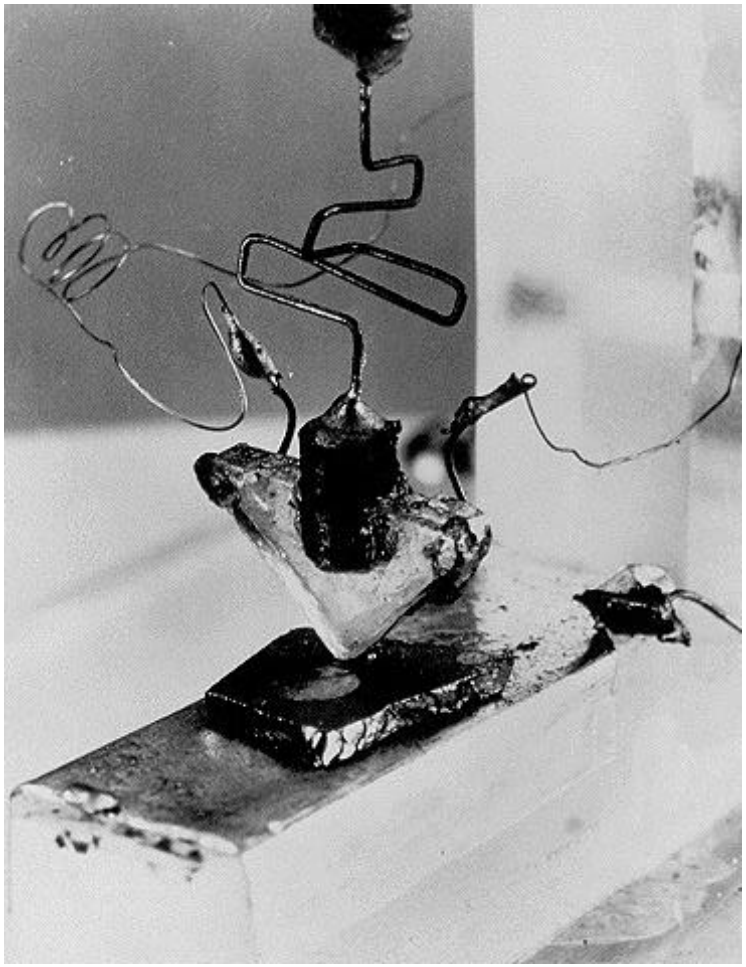
- Introduction
- IC Device and Design
- Semiconductor Manufacturing Processes
- Future Trends

Introduction

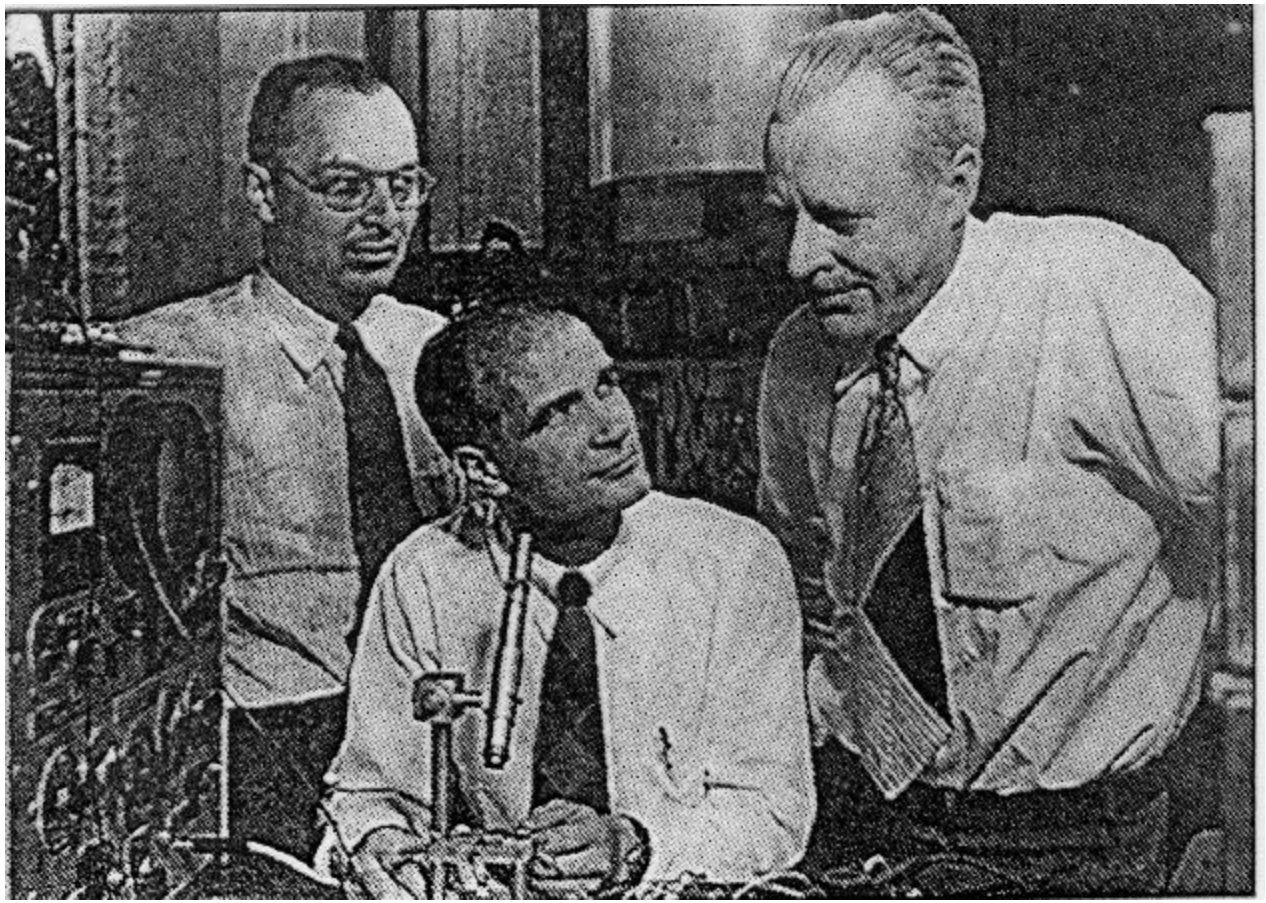
- First Transistor, AT&T Bell Labs, 1947
- First Single Crystal Germanium, 1952
- First Single Crystal Silicon, 1954
- First IC device, TI, 1958
- First IC product, Fairchild Camera, 1961

First Transistor, Bell Lab, 1947

Photo courtesy:
AT&T Archive



First Transistor and Its Inventors



John Bardeen, William Shockley and Walter Brattain

Photo courtesy: Lucent Technologies Inc.

First IC Device Made by Jack Kilby of Texas Instrument in 1958

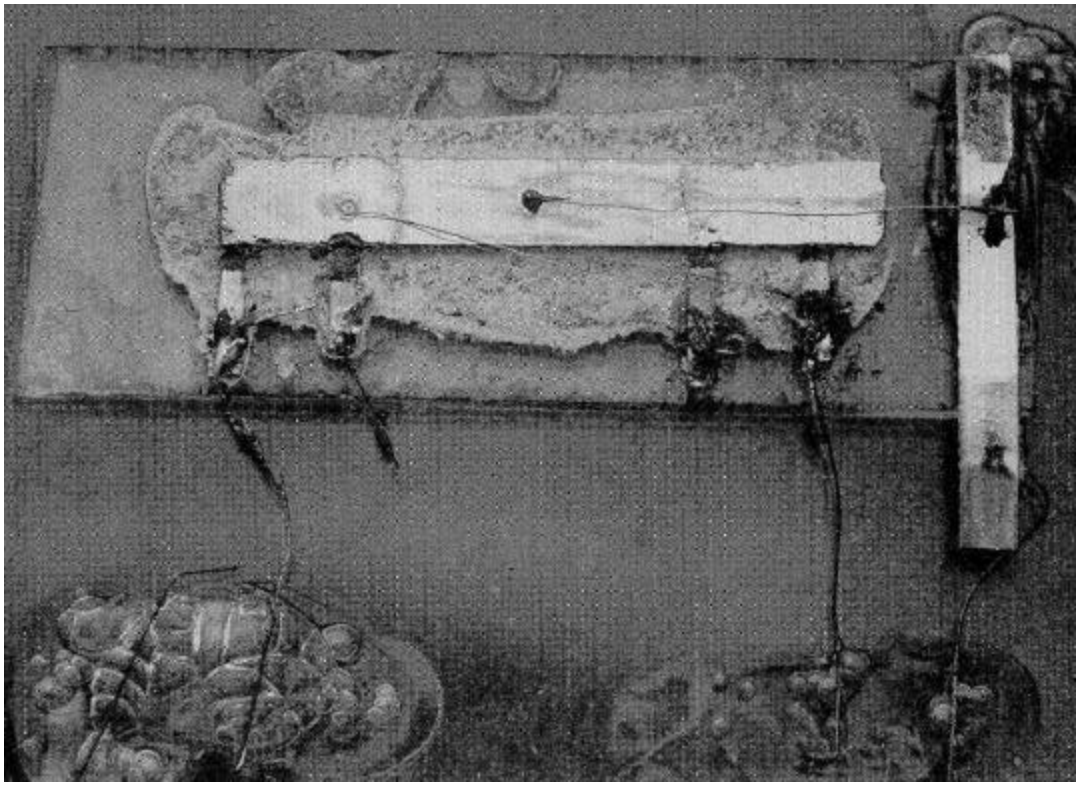


Photo courtesy: Texas Instruments

First Silicon IC Chip Made by Robert Noyce of Fairchild Camera in 1961

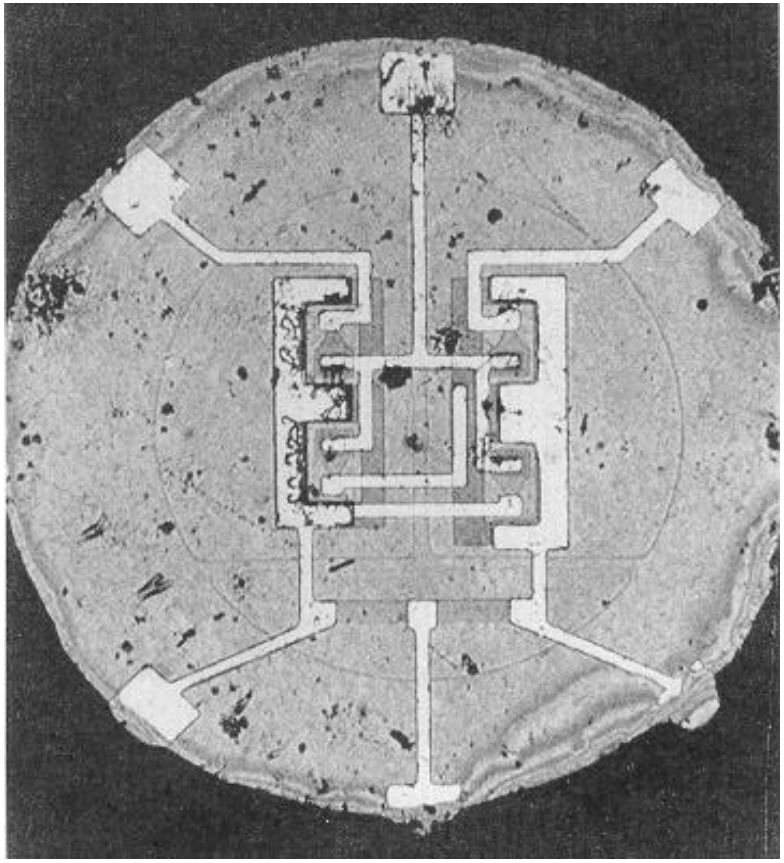
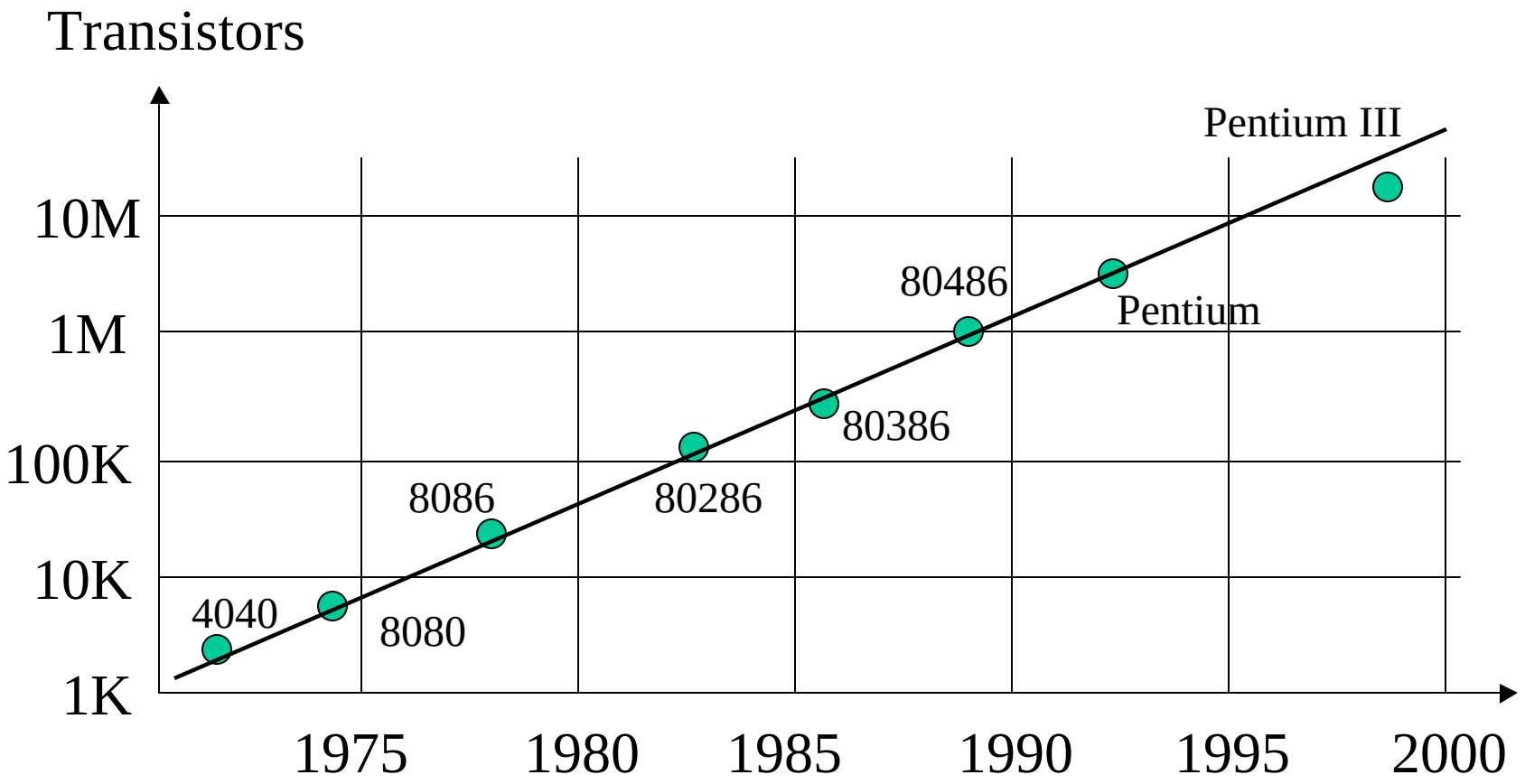


Photo courtesy: Fairchild Semiconductor International

Moore's Law

- Intel co-founder Gorden Moore notice in 1964
- Number of transistors doubled ever 12 months while price keeping unchanged
- Slowed down in the 1980s to every 18 months
- Amazingly still correct, likely to keep until 2010.

Moore's Law, Intel's Version



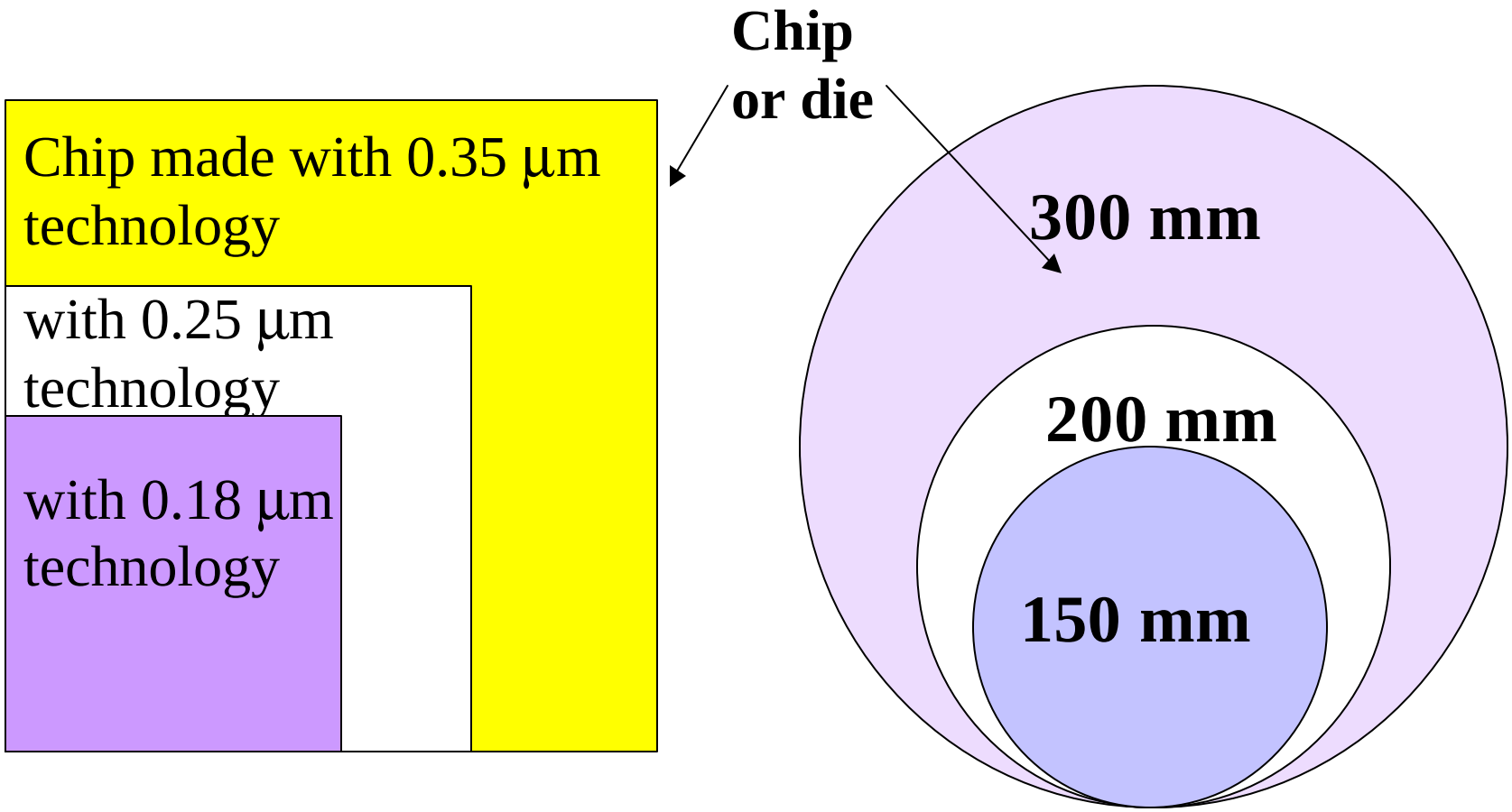
IC Scales

Integration level	Abbreviation	Number of devices on a chip
Small Scale Integration	SSI	2 to 50
Medium Scale Integration	MSI	50 to 5,000
Large Scale Integration	LSI	5,000 to 100,000
Very Large Scale Integration	VLSI	100,000 to 10,000,000
Ultra Large Scale Integration	ULSI	10,000,000 to 1,000,000,000
Super Large Scale Integration	SLSI	over 1,000,000,000

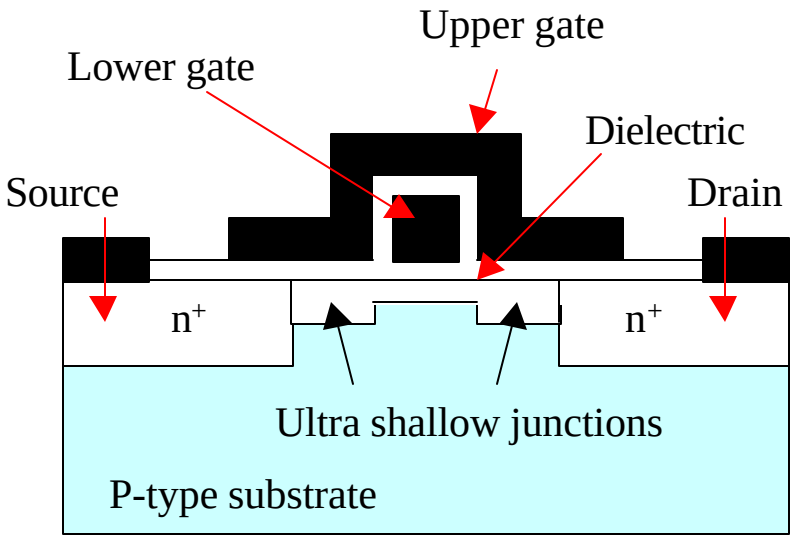
Road Map Semiconductor Industry

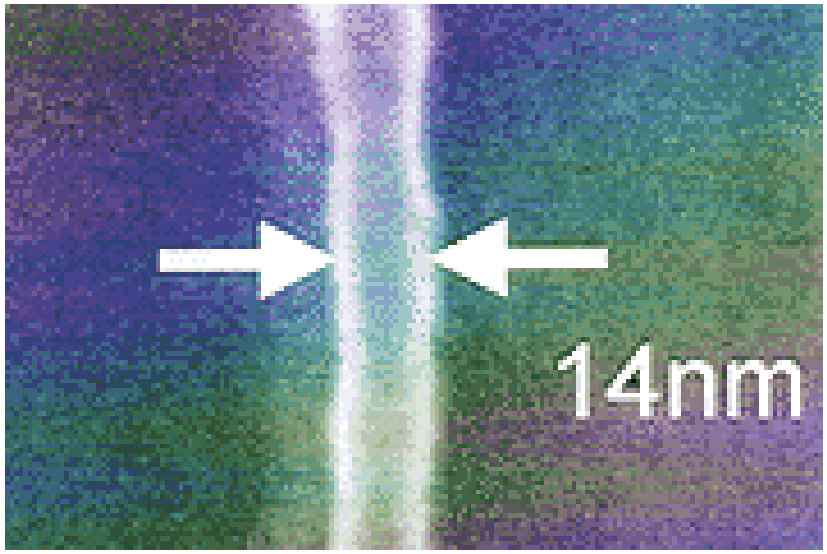
	1995	1997	1999	2001	2004	2007
Minimum feature size (μm)	**0.35**	**0.25**	**0.18**	**0.13**	**0.10**	**0.07**
DRAM Bits/chip Cost/bits @ volume (millicents)	64 M 0.017	256 M 0.007	1 G 0.003	4 G 0.001	16 G 0.0005	64 G 0.0002
Microprocessor Transistors/cm^2 Cost/Transistor @ volume (millicents)	4 M 1	7 M 0.5	13 M 0.2	25 M 0.1	50 M 0.05	90 M 0.02
ASIC Transistors/cm^2 Cost/Transistor @ volume (millicents)	2 M 0.3	4 M 0.1	7 M 0.05	13 M 0.03	25 M 0.02	40 M 0.01
Wafer size (mm)	200	200	200 - 300	300	300	300 – 400 (?)

Feature Size and Wafer Size



Smallest Known Transistor Made by NEC in 1997



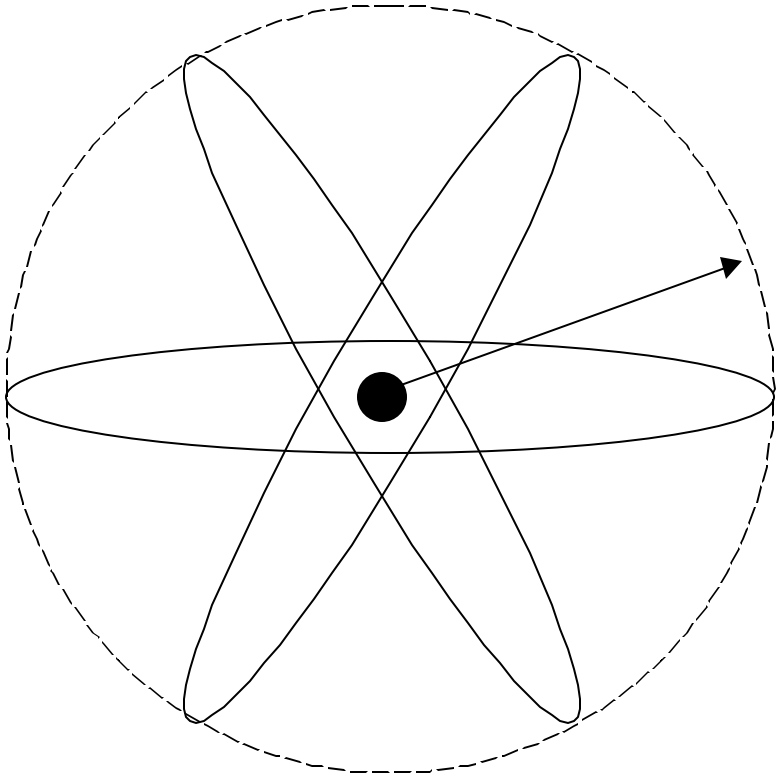


0.014 micron lower gate width

Photo courtesy: NEC Corporation

Limit of the IC Geometry

Size of the atom



Limit of the IC device

- Atom size: several Å
- Need some atoms to form a device
- Likely the final limit is around 100 Å or 0.01 micron.
- About 30 silicon atoms

IC Design: First IC

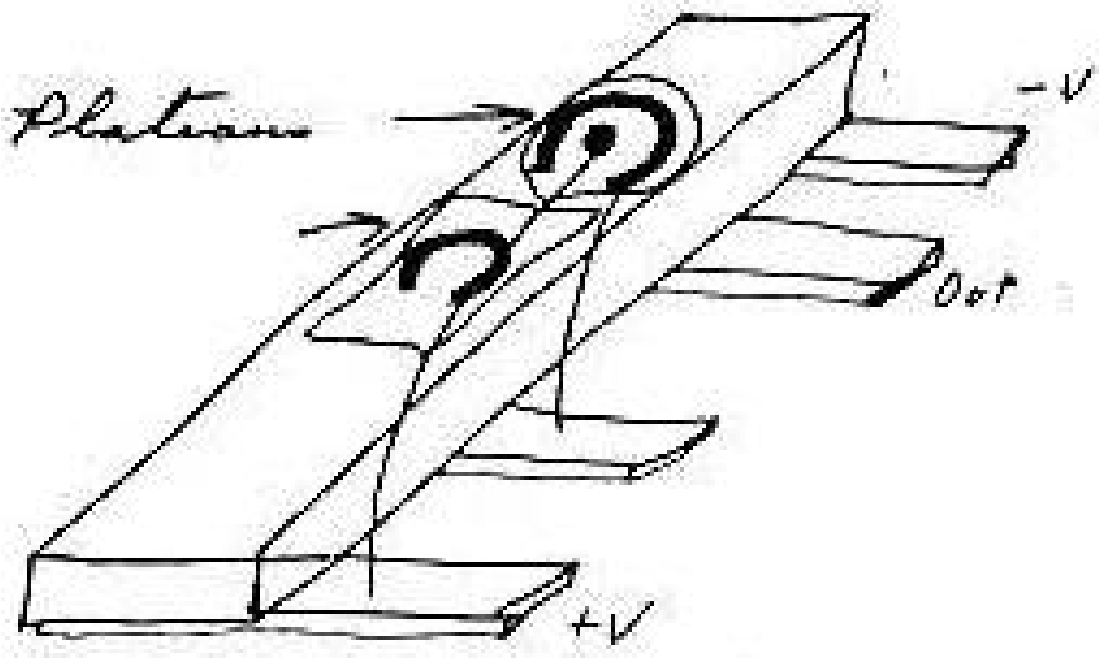
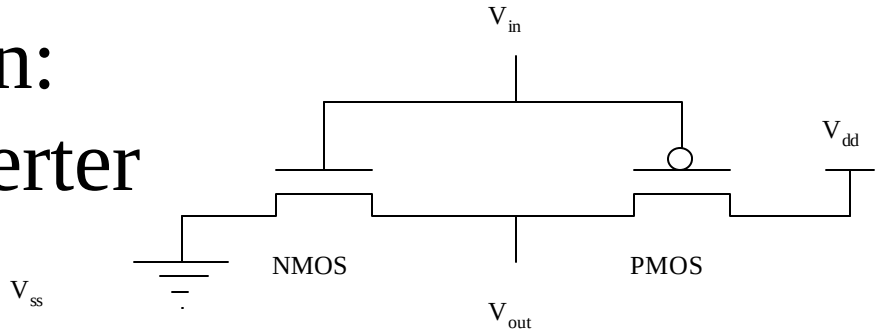


Photo courtesy: Texas Instruments

IC Design: CMOS Inverter

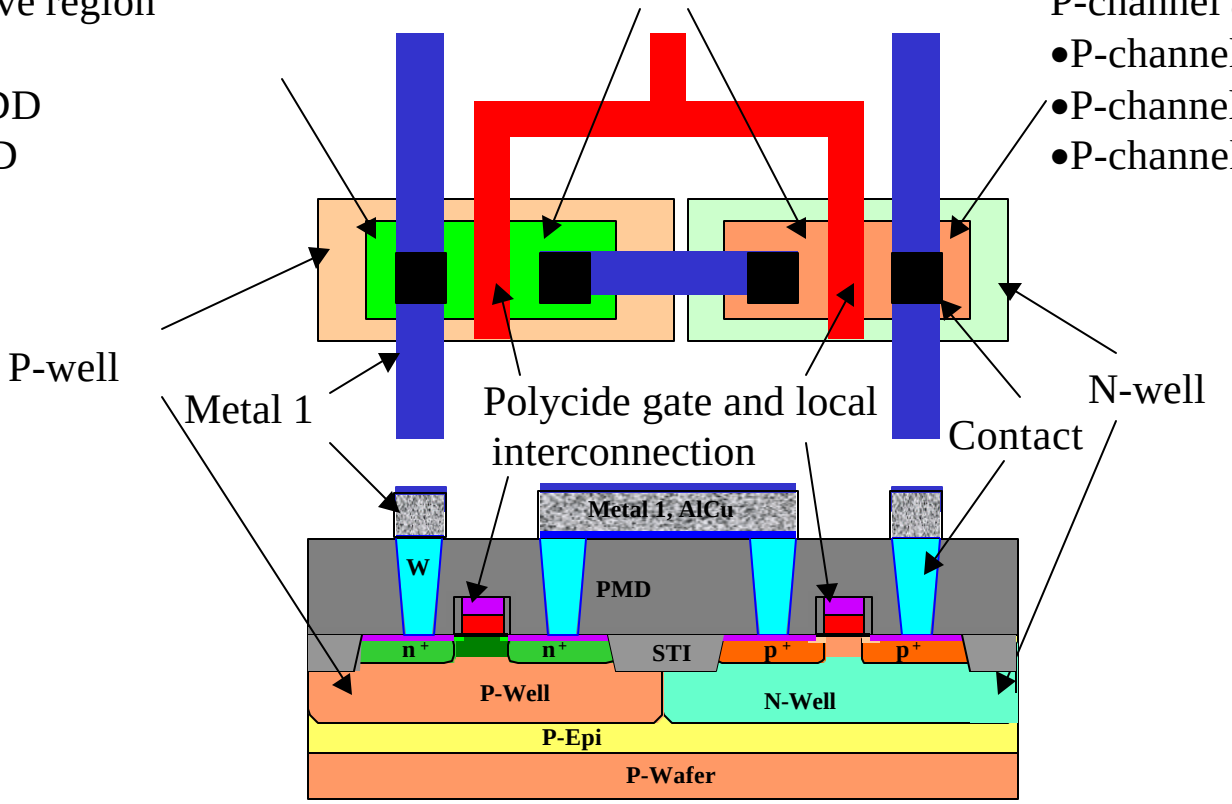


(a)

Shallow trench isolation (STI)

N-channel active region
- N-channel Vt
- N-channel LDD
- N-channel S/D

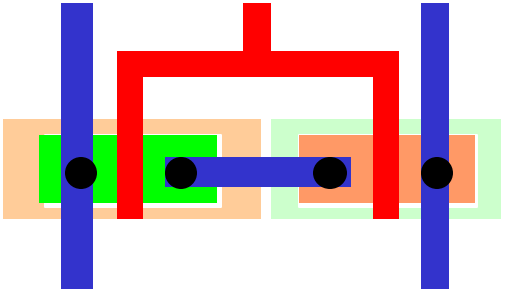
P-channel active region
- P-channel Vt
- P-channel LDD
- P-channel S/D



(b)

(c)

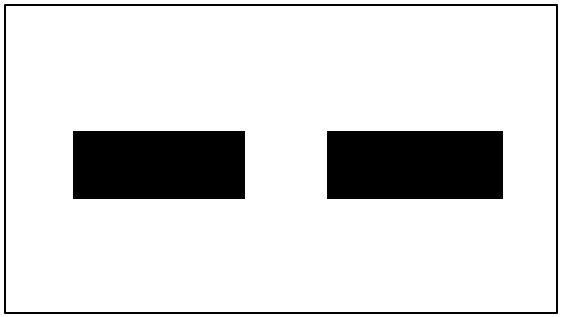
IC Design: Layout and Masks of CMOS Inverter



CMOS inverter layout

Mask 1, N-well

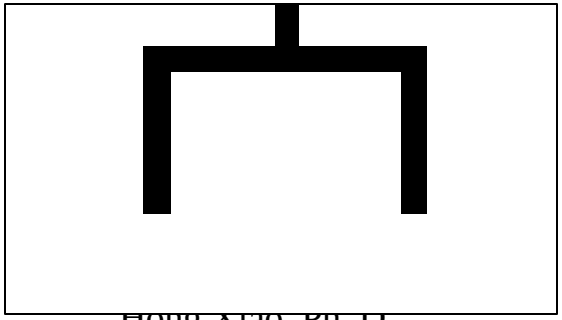
Mask 2, P-well



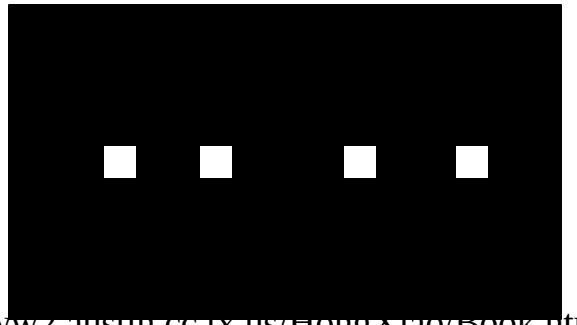
Mask 3, shallow trench isolation

Mask 4, 7, 9, N-Vt, LDD, S/D

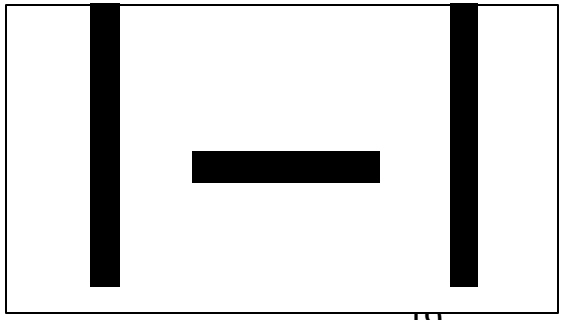
Mask 5, 8, 10, P-Vt, LDD, S/D



Mask 6, gate/local interconnection

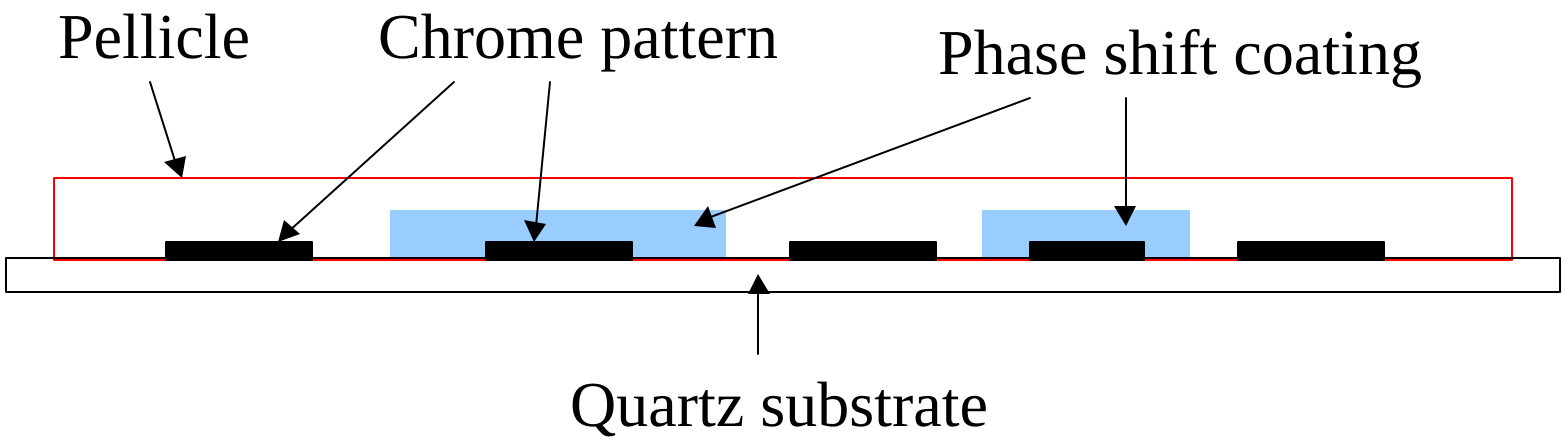


Mask 11, contact

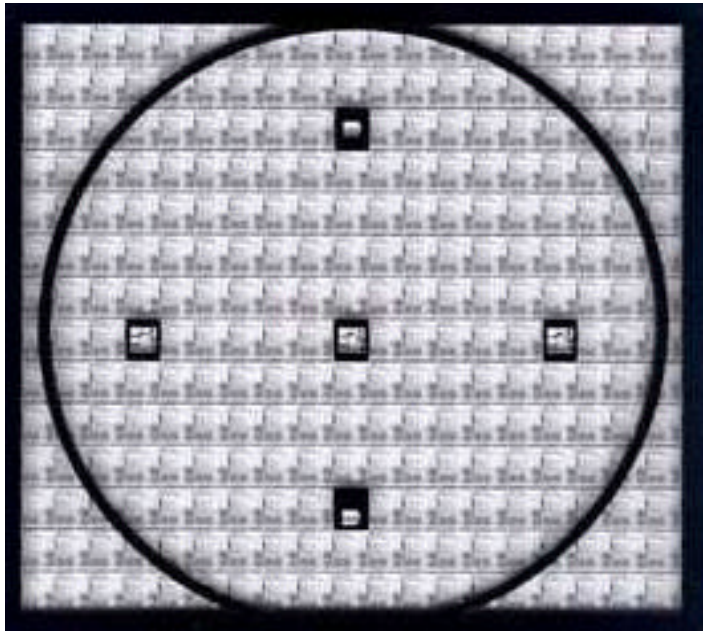


Mask 12, metal 1

Mask/Reticle



A Mast and a Reticle



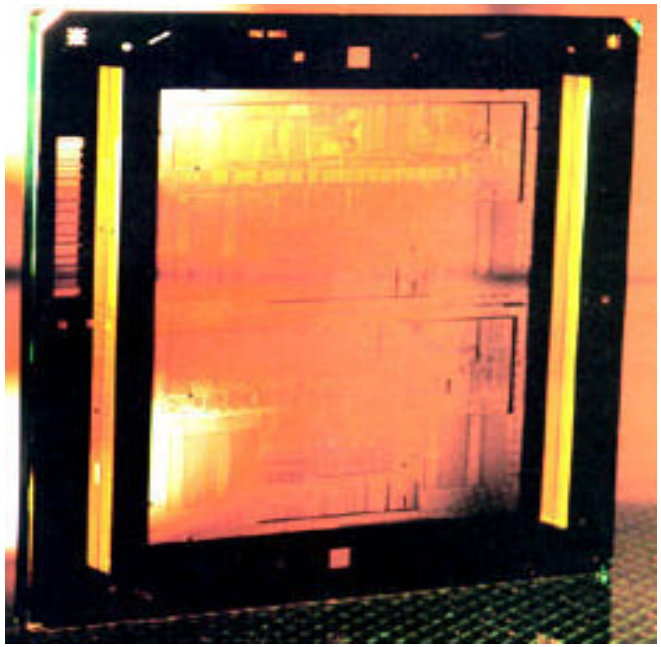


Photo courtesy: SGS Thompson

Wafer Process Flow